FABEC Vertical Flight Efficiency (VFE) Workshop Report

10 December 2020

Maastricht UAC / Online virtual meeting

DOCUMENT SUMMARY

Objective:	A workshop with FABEC ANSPs and industry stakeholders (mainly aircraft operators) to discuss vertical flight efficiency, to exchange views and to explore how to improve VFE and new VFE indicators.		
Origin:	FABEC SC ENV	**Audience**:	Members of the FABEC ANSP teams along with representatives from NM, airlines, CFSPs.

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1.0	Ilona Sitova	12/02/2021	
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1 INTRODUCTION

The meeting was opened at 10:00 am. All participants to the virtual meeting were welcomed by workshop moderator Marylin Bastin (Head of Aviation Sustainability at EUROCONTROL), John Santurbano (FABEC Champion Environment & CEO of MUAC) and Ilona Sitova (Chairwoman FABEC Standing Committee Environment).

John Santurbano opened the workshop by sharing following key messages:

- 2020 has been a year of trouble for all those working in the aviation industry.
- The recovery is expected around 2024, the critical determinant being the vaccine. Next summer may already show a good improvement.
- Everybody agrees that we must focus on a sustainable aviation recovery.
- There are currently many discussions about the shortest routes and Horizontal Flight Efficiency, but actually working on Vertical Flight Efficiency is equally important. In 2019, it accounted for approx. 30% of excess airborne emissions, or approximately 4.2 million tonnes of CO2.
- Main goals of the workshop:
    - Provide a **state-of-the-play** of the current situation concerning VFE (en-route + climb/descend).
    - **Show that ANSPs are working on improving VFE**, in particular now that traffic levels are low and that various aviation players (CANSO, IATA, A4E) are claiming their support to initiatives aiming to optimise flight profiles.
    - **Show that ANSPs are willing to continue to improve VFE**. This is a collaborative effort involving aircraft operators, ANSPs, CFSPs, etc., and as such, it should be recognised by all partners, as there are various interdependencies.
    - Better **understand the importance of VFE for aircraft operators**. Are there differences of views amongst operators and if so, why?
    - Better **understand how aircraft operators measure and monitor VFE**. Do they see an improvement over time, in particular during reduced traffic demand? Are there differences amongst operators and if so, why?
    - Identify **take-aways**: which actions can/should be taken by all stakeholders to improve VFE in the short & long term?
    - Show that ANSPs (within FABEC, DSNA in particular) are **working on energy-based metrics**, and briefly explain why these improved metrics are better indicators for VFE. We will also aim to detect real inefficiencies, monitor improvements and achieve real VFE improvements.

John Santurbano wishes all of us a productive workshop, and highlights that for us, in aviation, we quickly have to find solutions towards a more sustainable industry. It's in the interest of all generations.

Before starting presentations, Marylin Bastin informed and invited all attendees to participe to polls regarding their perception of VFE. The results of these polls will be available on FABEC website (https://www.fabec.eu/airspace-users/workshops).

2 AGENDA

The following agenda was sent prior to the workshop and agreed by the participants.

10:00-10:10	Welcome	**John Santurbano** FABEC Champion Environment, CEO MUAC
10:10-10:35	En-route VFE	**Jean-Michel Edard** OPS Performance Expert, ANSP FABEC Group
10:35-11:00	VFE during climb and descent	**David Brain** Chair European CDO/CCO TF, EUROCONTROL
	Coffee break 15 min	
11:15-12:45	View of aircraft operators on VFE	Wizz Air - **Jaime Waldhorn** Cargolux - **Jeffrey Huntoon** KLM - **Vincent Hilligers** Brussels Airlines - **Michaël Sanczuk**
	Lunch break 1 hour	
13:45-15:00	How to improve VFE?	Lufhansa - **Frank Lumnitzer** MUAC - **Theo Hendriks** Wizz Air - **Robert Sklorz** DSNA - **Sophie Baranes**
15:00-15:20	Exploration of new VFE indicators	**Gabriel Jarry** Environmental Data Scientist, DSNA
15:20-15:30	Wrap up / Follow up actions	**Marylin Bastin** Head of Aviation Sustainability, EUROCONTROL Moderator

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4 PRESENTATIONS

4.1 En-ROUTE VFE:

Jean-Michel Edard (FABEC OPS Expert) gave a presentation on the current state-of-the-art regarding VFE En-Route. Following key messages were highlighted:

En-Route VFE efficiency can be measured in different ways. Several tools were developed by ANSPs, by PRU, or by NM. For very detailed analysis in upper airspace, NEST tool is the most used tool, as it is shared by all European ANSPs.

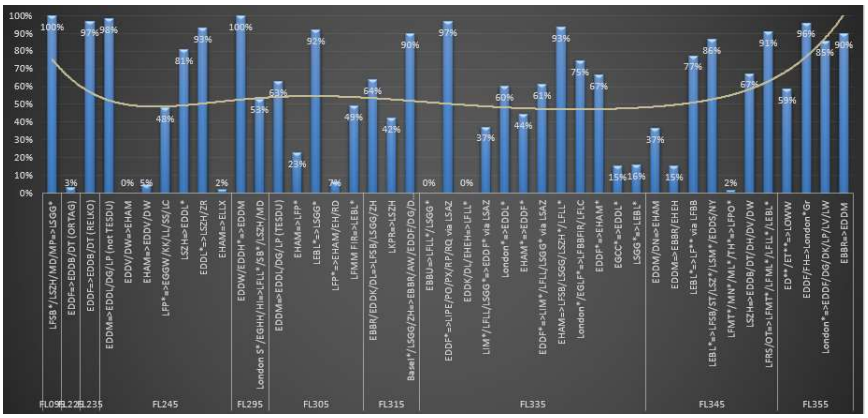
Amongst the 6% of inefficiencies on fuel (as reported in the 2019 Performance Review Report https://www.eurocontrol.int/sites/default/files/2020-06/eurocontrol-prr-2019.pdf), 0,5% of these inefficiencies are due to VFE in arrival phase, and 1% are due to VFE En-Route. Regarding departure phase, VFE inefficiency is insignificant.

FABEC ANSPs have a complex and dense airspace to manage, explaining the important number of restrictions on VFE. However, they are able to react quickly to adapt and offer improvements on VFE, with RAD relaxations, in order to offer better vertical profiles while maintaining a high level of capacity. As an example, 353 RAD measures improving vertical efficiency (in RAD App3) were implemented between March and October 2020.

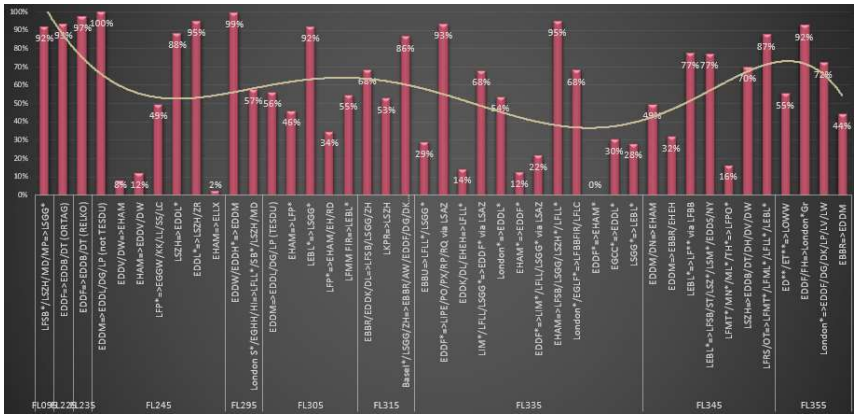
Nevertheless, it appears that RAD relaxations of last summer were not all taken into account by all AOs. A study based on the analysis of 43 RAD relaxations, representing 89 City Pairs and 5714 flights, showed that 62% of the traffic filed higher than the former constraint, and that 65% of the traffic flew higher than the former constraint. The benefit in fuel was estimated at 225 tonnes, but could have been potentially at 305 tonnes, meaning that approximately 25% of the potential was not used.

To illustrate how RAD relaxations were utilized, a comparison was made per City Pairs between former FL constraint (blue line in the picture below) and average filed FL after relaxation (red line). As a general remark, it can be said that AOs could file 4000 ft to 6000 ft higher in average. However, in some rare cases, filing was not optimized (yellow circles), either because it is not profitable for AOs (e.g. Hannover to Amsterdam), or because rejection messages were received by AOs (e.g. Brussels to Lyon/Geneva for which FPLs were not updated, but for which traffic could fortunately fly higher).

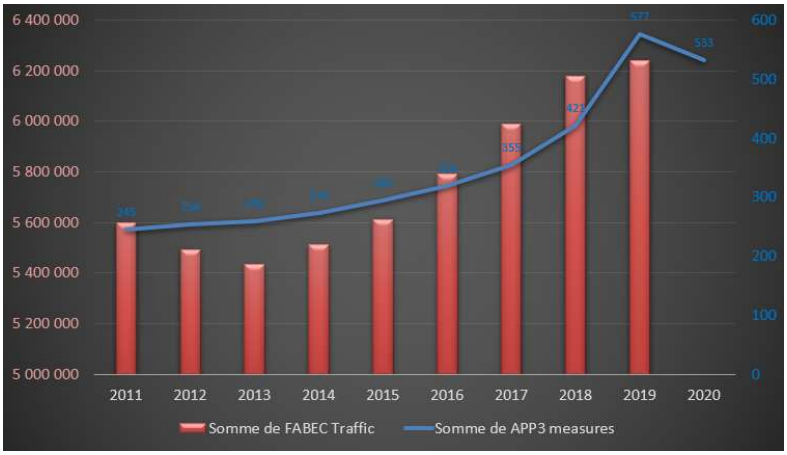
The study also showed that the percentage of optimization in planning (see graph below on rate of efficiency in planning) can vary a lot according to the City Pair. It can be explained by the distance between City Pairs, or by type of aircraft, or by the very high number of RAD relaxations that could not be all looked at.



The same phenomenon was observed for the rate of efficiency in flying (see graph below). Variations were quite important according to the City Pairs.



Interdependencies were also highlighted in this presentation. In particular, it was shown that more and more vertical constraints were implemented over the last 10 years, following the increase of traffic, in order to keep high level of capacity. However, in 2020, there are still many of them whereas traffic severely decreased.



Jean-Michel Edard ended his presentation in showing the impact of vertical constraint and its equivalence in terms of extra mileage. As an example, in the table below, it shows that for an aircraft with FL390 as optimum FL, one hour flown 10000 ft below optimal (FL290) equals 88NM of horizontal flight inefficiency on average.

FL	NM/1000kg	TAS	Kg/hr	% Diff FF	1 Hr NM equivalent
390	188,4	447	2374	0%	0
370	186,9	447	2396	-0,80%	4,1
350	181,7	450	2474	-3,58%	18,19
330	174,9	454	2596	-7,17%	38,82
310	166,4	458	2750	-11,68%	62,62
290	157,4	462	2932	-16,45%	87,92

Questions/remarks and answers. After the presentation, some questions or remarks were asked by the audience:

Remark was made by Matthias Loehr, Swiss representative, explaining that they are constantly looking at the best cost for each and every flight. Fuel price is constantly changing as well as for unit rates annually, and therefore choice of the route according to the level capping may vary from one year to another. Example was given for London-Zurich, which is not level-constrained via MUAC, which is still constrained via Paris/Brest ACCs, but more cost-efficient due to French unit rate. Matthias admitted that it might lead to a certain unpredictability from an ANSP's perspective.

Answer was given by Aurore Bibard (DSNA), who said that it is important to know how choices are made, if we want collectively (AOs & ANSPs) to improve impact on environment.

There was also a remark from Vincent Hilligers, regarding one of the examples (EDDV-EHAM). He mentioned that they did not file higher, simply because their FPL systems did not suggest it.

Edward Rosado (CFSP) and David Martino (Cargolux) mentioned that the 'underusage' of RAD relaxations could also be due to weather (wind). The higher route would not necessarily be the most optimal one (in terms of wind).

Marylin Bastin concluded by confirming that it will be important to work in the future in a collaborative way to limit as much as possible the impact of vertical constraints when the traffic is back.

4.2 VFE DURING CLIMB AND DESCENT:

David Brain (Chair of the European CCO/CDO Task Force) gave a presentation on the current state-of-the-art regarding VFE during climb and descent. The following key messages were highlighted:

The European CCO/CDO Action Plan was released in November 2020. It provides an overview of the latest insights regarding CCO/CDO, related performance indicators, and actions to be taken by all stakeholders to improve VFE during climb and descent.

Along with the release of the Action Plan, a performance dashboard (https://ansperformance.eu/efficiency/vfe/) has also been developed together with an ATCO refresher training whilst a "sister" Pilot training course is currently under development.

As specified in Appendix H of the Action Plan, there are useful rules of thumb for trade-offs that might need to be made:

- If the option is a level-off in the climb or descent, for certain aircraft types, a level-off in the climb may result in a lower fuel penalty than the same distance level-off in the descent; and,
- If there is a choice between a track extension to facilitate CCO or a level-off without a track extension for a departure, a level-off may save more fuel than the CCO.

100% ATM network fuel efficiency is not achievable, neither desirable.

Currently level-off are the proxy for VFE inefficiency. However, this metric is not perfect: e.g. not all level-offs are inefficient, and not all descents are performed in idle therefore a level segment may be more efficient compared to a shallow descent, etc.

There is a need for harmonised CCO/CDO metrics for all stakeholders, not only to demonstrate performance changes over time, but also to ensure performance comparisons between stakeholders are based upon similar definitions. Furthermore, complementary fuel/CO2-based metrics would give a better view of the real environmental performance. Various initiatives have been taken in this perspective already: EUROCONTROL Network Manager, ICAO CAEP, ATM/ANS Environmental Transparency Working Group, etc…

Paul Scurr (European Air Transport - DHL) confirmed that promising initiatives are being taken for the moment. He outlined the "Green Flight" concept, performed in July 2020: all efforts were made to provide and fly the most efficient (shortest, optimal flight level) trajectory between Leipzig and New York. For this specific case, approximately 1500 kg of fuel was saved.

Marylin Bastin concluded by thanking Paul Scurr for sharing their feedback on fuel burn data, because from an ANSP perspective, ANSPs are using proxy that are showing some limitations, and therefore these kinds of feedback would help ANSP to improve the metrics they could use for measurement and give a better idea on the real inefficiencies.

4.3 VIEW OF AIRCRAFT OPERATORS ON VFE / WIZZ AIR:

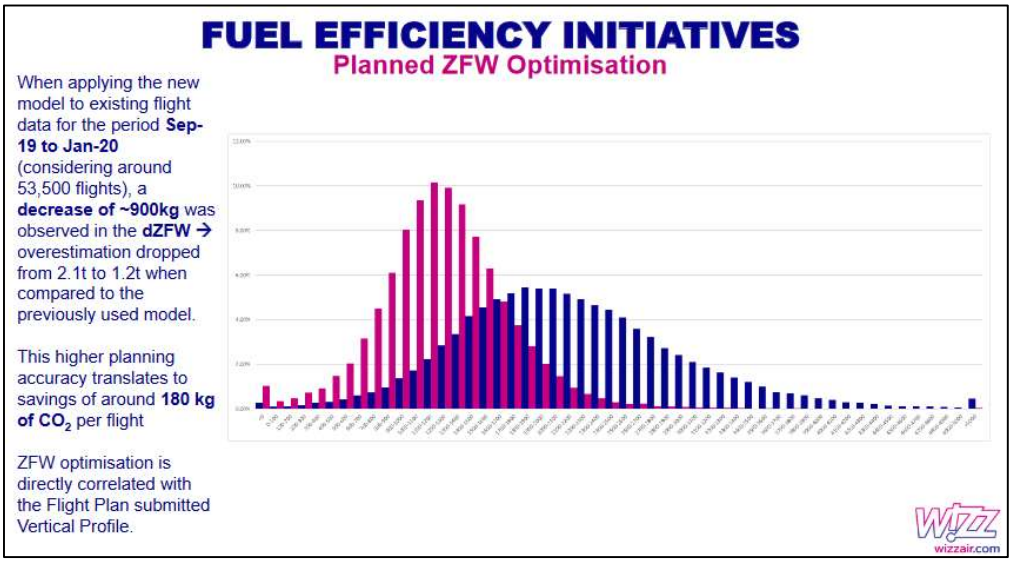
Jaime Waldhorn (Wizz Air) outlined the Zero Fuel Weight (ZFW) optimisation programme within Wizz Air. The importance of a more accurate ZFW is twofold:

- Optimised Flight Planning (e.g. requested flight level, speeds, etc)
- Optimised Fuel Calculation: using a better ZFW estimation, the fuel calculation is improved. This way, the overestimation of ZFW dropped from 2,100 kg to 1,200 kg (compared to the previously used model). This results in the so-called snowball effect: the lower the overestimation, the lower the required fuel, the lighter the aircraft, the less fuel required, etc

The optimisation model was developed with machine learning algorithms, and trained based on actual flight data. By correlating different parameters for each flight (e.g., city pair, seasonality, time of the day, etc), the model is able to predict:

- Luggage weight
- Passenger no-show rate
- Same-day bookings

Jaime Waldhorn showed that, using the model and its increased ZFW estimates, approximately 180 kg of CO2 per flight has been saved. See picture below.



Questions/remarks and answers:

Patrick De Rooij (Ryanair) and Paul Scurr (European Air Transport - DHL) mentioned that a similar ZFW optimisation takes place within the respective airlines.

Matthias Loehr (Swiss Airlines) and Thomas Smeets (Brussels Airlines) indicated to apply ZFW optimisation methods. They specified that, whenever possible, these changes are also included in the flight plan. However last-minute flight plan changes are avoided to avoid a 'late filer' issue with the Network Manager. If these 'late filer' issues can be avoided, also last-minute changes to the flight plan could be implemented.

4.4 VIEW OF AIRCRAFT OPERATORS ON VFE / CARGOLUX:

Jeffrey Huntoon, Christophe Klees and David Martino (Cargolux) presented how VFE during descent is measured and monitored within Cargolux.

Because Cargolux operates across various continents, at calmer and busier airports, in low- and high-density airspaces, it is a challenge to define a methodology that can be applied for all arrivals. Therefore, the measurements focus from 10,000 ft down to 2000 ft, and use actual fuel burn as a metric.

These criteria applied are referred to as 'Energy Management Operations' (EMO). The EMO methodology can be applied on all arrivals worldwide, regardless of the approach type. As a result of the EMO initiative, Cargolux experienced:

- 62% increase in fuel efficient approaches, within the EMO-defined segment (10,000 ft - 2000 ft)
- 44% reduction of fuel burn within the EMO-defined segment

In order to illustrate the potential of reducing long level-offs, Cargolux compared two arrivals towards Luxembourg Airport. The CDO flight consumed approximately 4 times less fuel with respect to a non-CDO flight (ca. 20 nm level-off at 3000 ft).

Proper energy managed arrivals significantly improve flight efficiency, and therefore also the overall environmental impact. It is acknowledged that ATC instructions are needed for e.g., safety, capacity & sequencing. However, it was observed that the more 'freedom' the flight crews get, the better they can optimize the descent profile and achieve maximum fuel gains.

Cargolux highlights that a better mutual understanding between ATC and flight crews, in each other's operations and procedures, is essential to obtain increased flight efficiencies. It is essential that both stakeholders know the (potential) impact of their actions and instructions on the other party. Experience shows that only with close coordination, working hand in hand, ATC and flight crews can achieve maximum CDO/EMO advantages, regardless of the approach flown.

Questions/remarks and answers:

After the presentation, various interventions were made:

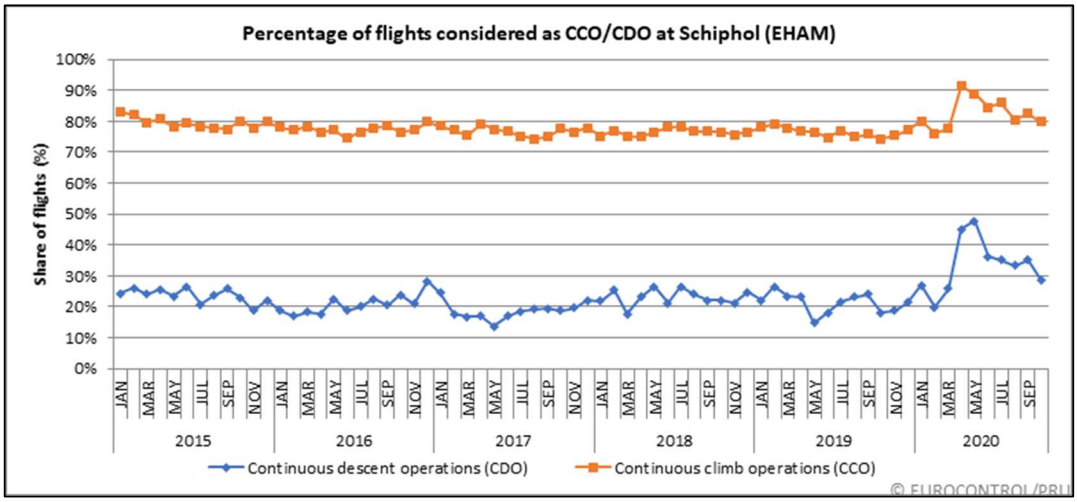
Bernard Erreca (ATM Consultant) indicated that, in order to achieve maximum fuel gains, 'closed' PBN procedures below FL100 - with no ATC intervention - should be implemented.
Matthias Loehr (Swiss Airlines) mentioned that trade-offs need to be made. ATC performs vectoring for capacity purposes, so it is essential that vectoring instructions are given when needed.
Christian Thein (Luxair) provided his views on the recent PBN implementation (RNAV STARs and transitions with RNP Approaches) at Luxembourg Airport. He explained that such a big programme and change is a continuous (learning) process for all parties. Training and mutual understanding is crucial, and efforts are being made to reduce unclarities and improve flight efficiency.

The discussion was concluded by highlighting that fuel metrics help us to better locate and understand the real inefficiencies. For this purpose, insights obtained using operator's fuel data is crucial.

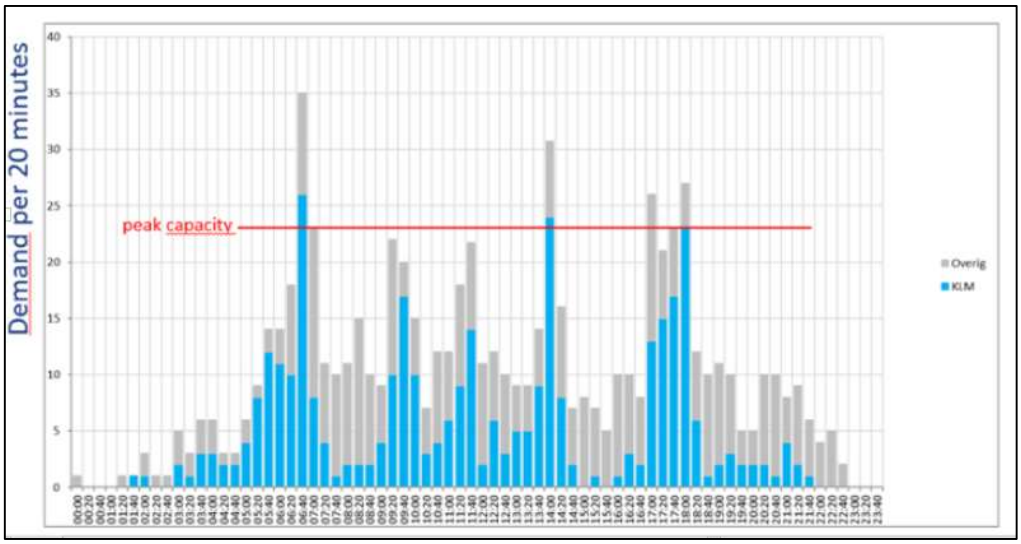
4.5 VIEW OF AIRCRAFT OPERATORS ON VFE / KLM:

Presentation was made by Vincent Hilligers, on how KLM is perceiving VFE at Schiphol.

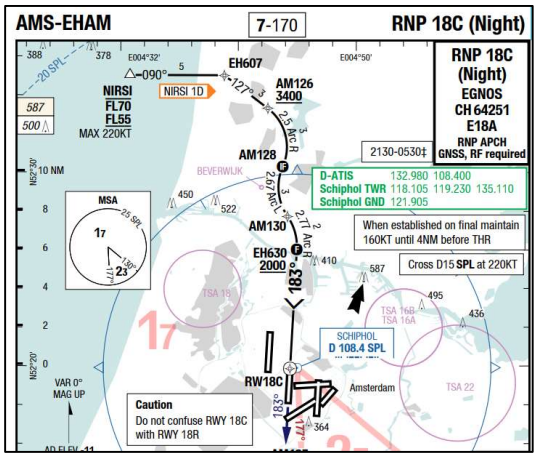
He started with a feedback on the percentage of flown CDO at Schiphol, and mentioned that 30% of trajectories are flown under CDO procedure, which is quite a good performance, taking into account the fact that Schipol is a very busy airport. See graph below (source PRU data https://ansperformance.eu/data below).

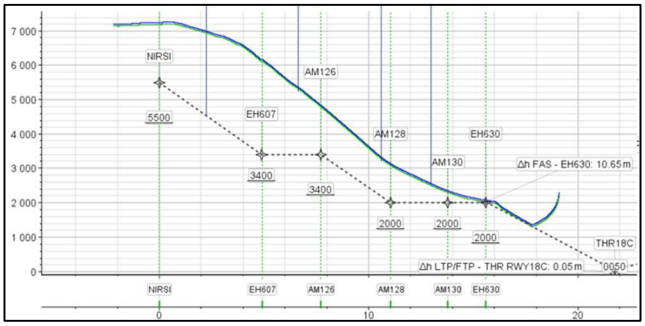


During the Covid crisis, the percentage of CDO even increased up to 50%, but this figure dropped down again to lower level because even with less traffic, Schiphol is still operating in hubs (shown in the following picture), hence generating radar vectoring.



Looking more into details, he mentioned the benefits observed on the new RNP approach on RWY18C, used at night, and overflying less people while offering a better vertical profile. Therefore, the RNP procedure is more than simply an ‘overlay’; it is a way to actively reduce noise hinder for the local communities.





However, bearing in mind the PCP target of implementing PBN, KLM is investing in research with LVNL and university for improvement in RP1 implementation in the future.

Regarding challenges for the long term, Vincent quoted the move of RNP1 requirement from CP1 to PBN regulation, effectively postponing 2024 to 2030. He expressed his hope to overcome and he thinks that airports are still keen for improvements on that way.

Questions/remarks and answers After the presentation, some questions or remarks were asked by the audience:

Q: Marylin Bastin highlighted that the new procedure is 0.5NM longer. Did you measure fuel impact due to this route extension?

Vincent Hilligers replied in saying that procedures have to be appreciated globally, meaning that this extension is acceptable when it is compensated by a CDO procedure

Marylin Bastin: Do you have your own fuel metrics, and addition to metrics provided by PRU?

Vincent Hilligers: Yes, KLM is also using level flight metrics

Marylin Bastin Did you measure noise reduction on this new RNP APCH?

Vincent Hilligers: Yes, it has been measured in terms of number of people impacted by the procedure (200 less people impacted at night)

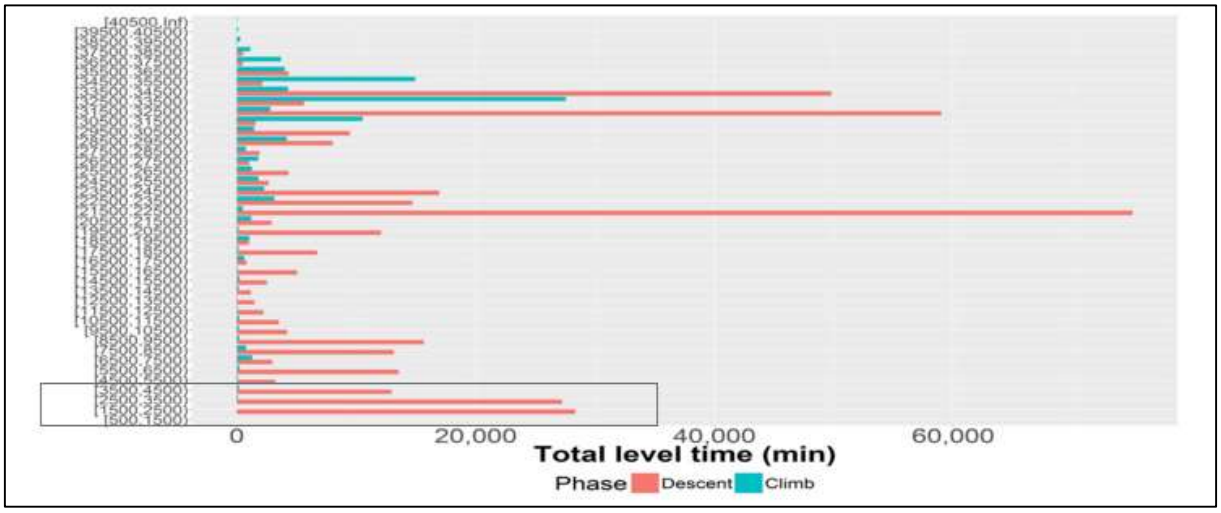
In addition, a remark was made by Swiss, saying for their fleet, pilots prefer flying on RNP APCH rather than on ILS because flight is then more accurate.

Sebastien Dorat (FedEx) also mentioned that radar vectoring is needed for preserving capacity, especially during peak times. Improving CDO is good, but it should not result in unacceptable trade-offs.

4.6 VIEW OF AIRCRAFT OPERATORS ON VFE / BRUSSELS AIRLINES.

Presentation was made by Michaël Sanczuk, on the effects of early descent restrictions on the suboptimal VFE into Brussels.

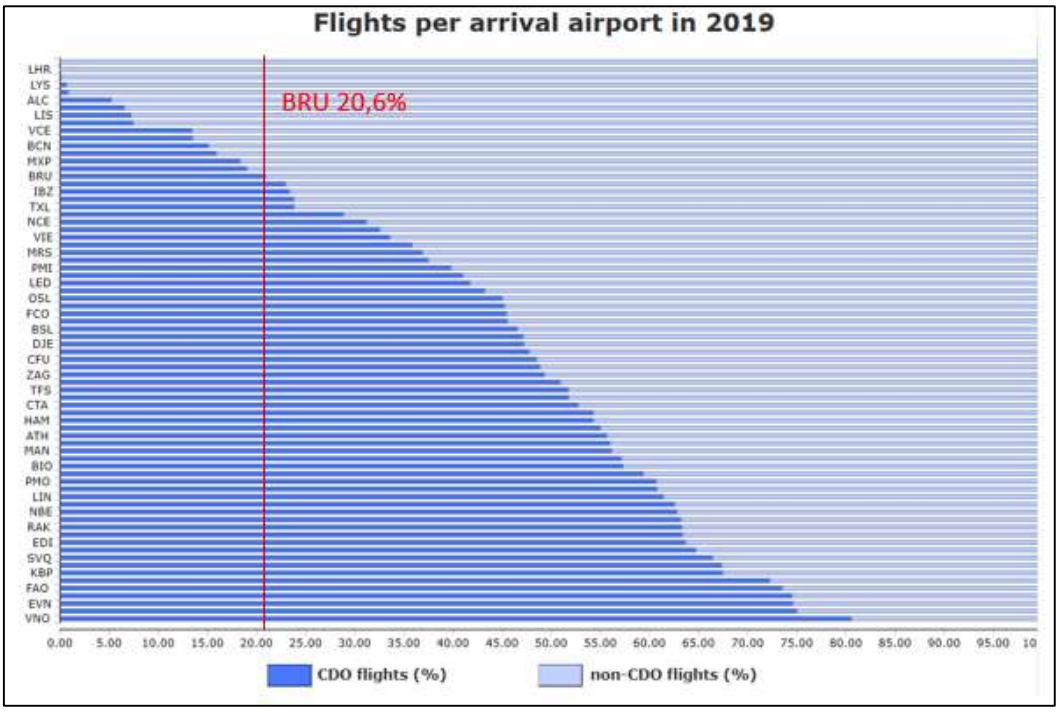
Michaël Sanczuk started his presentation in saying that Brussels Airlines is quite impacted by early descents from all directions, and is looking for partnering for improvement into BRU, in particular in terms of level off in descent (e.g. FL240/FL260), that are quite numerous and penalizing, such as shown on red bars on the graph below.



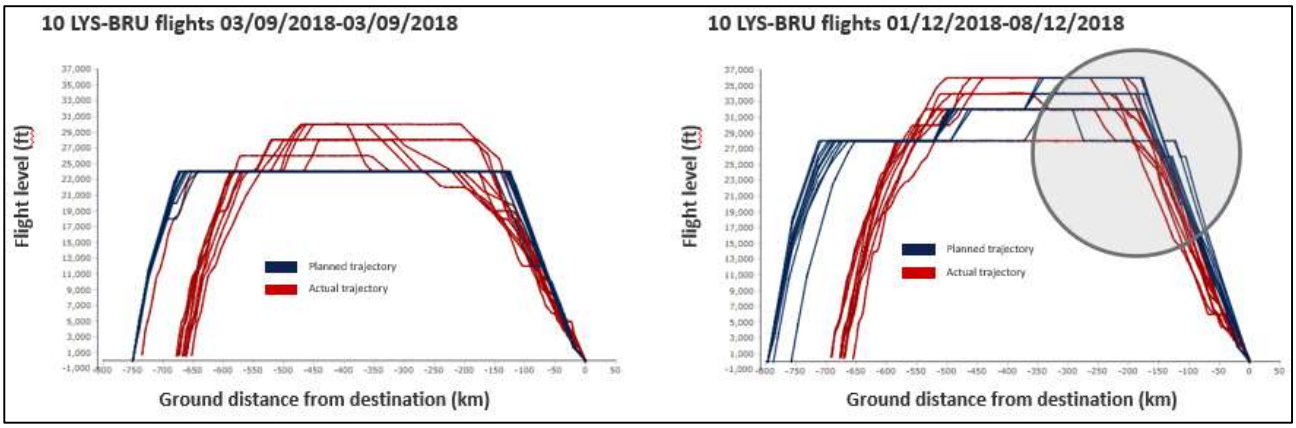
For what they consider in the use of CDO, Brussels Airlines focusses on what happens in the last 100NM before destination, on slopes between 2,7° and 3,3°. This is Brussels Airlines' main KPI. Other criterium to check the descent could be the average rate of descent. For example, in 2018, the average rate of descent from the cruising level into BRU was of 1133ft/min whereas their best profile from cruising level to the threshold would be of 1500ft/min.

Regarding the percentage of Brussels Airlines operating CDOs at BRU, Michaël stated that 17% of their fleet used CDO in 2018, for which he considers that improvement could be made, for instance in the early morning for their fleet of A330, when traffic demand is not yet that high in Brussels sectors of MUAC. However, he observed an improvement over time, with a percentage of 20,6% in 2019, and around 28% in 2020 (because of Covid crisis low traffic).

Compared to other airports, he highlighted the fact that Brussels Airlines performance in CDOs at BRU is globally less efficient compared to other European airports. Comparison was made with Roma, Athens or Manchester, with a ratio of more than 50%. See picture below.



Michaël Sanczuk also mentioned the effects of RAD restrictions, impacting efficiency of profiles, and leading sometimes to a certain gap between planned and actual trajectories, as shown in picture below. The high number of RAD restrictions might also be a source of inefficiency, with some missed opportunities.



Vertical flight inefficiency has therefore a cost for Brussels Airlines. Potential fuel saving on early descent in 2019 was estimated at around 5800 tonnes of fuel, corresponding to 18000 tonnes of CO2 emissions.

Michaël Sanczuk ended his presentation with a proposed action plan, summarized in the 3 following bullets:

- Agree on CDO measurement principle between MUAC, Skeyes and airlines: Definition, KPI
- Regular follow up on vertical efficiency evolution
- Reduce network restrictions: planning and operation (capacity management)

Marylin Bastin thanked Michaël Sanczuk for his presentation in reminding the importance on the way CDO and VFE could be measured, and in the collaborative process between AOs and ANSPs that have to be continued.

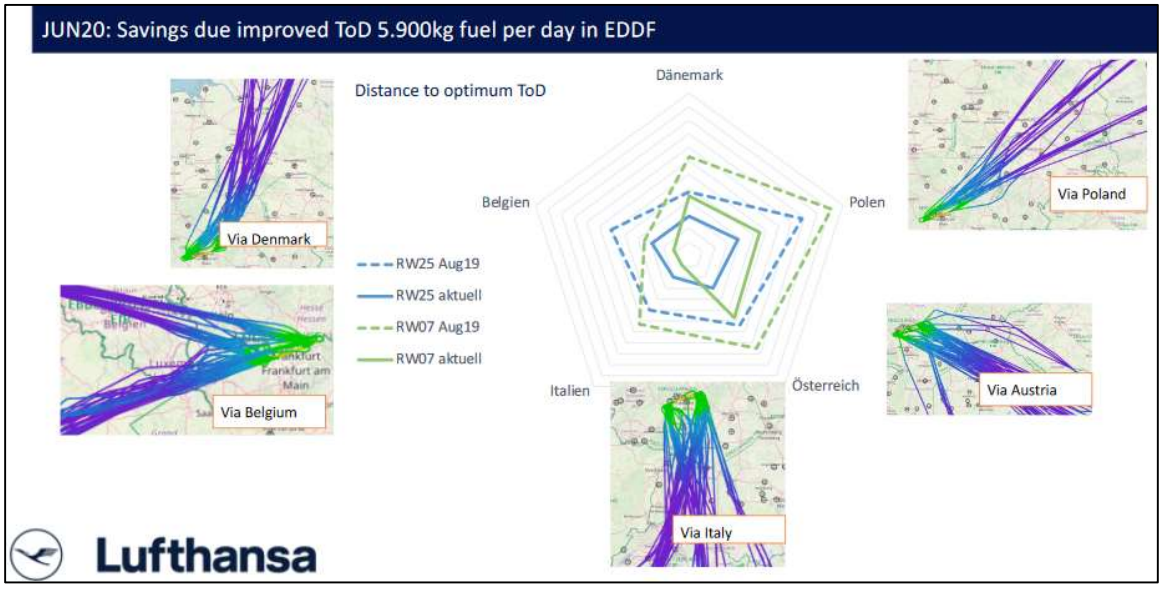
4.7 HOW TO IMPROVE VFE? / LUFTHANSA

Frank Lumnitzer (Lufthansa) presented how Lufthansa, in strong collaboration with DFS, has actively improved VFE during the recent months of reduced traffic demand. Low traffic volumes generate an environment to facilitate long though concepts.

In order to optimise the 3D trajectory, a two-step approach is used:

1. Define the most optimum lateral trajectory
2. Create the best vertical profile for the selected lateral trajectory

During the past months, aircraft entering German airspace have requested descents from the optimum Top of Descent (ToD). Due to this, savings of approximately 5,900 kg of fuel per day, for Frankfurt Airport (EDDF), were recorded. The ToD shifted by approximately 30 nm, with average fuel savings up to 181 kg (Frankfurt Airport) and 192 kg (Munich Airport) per long-haul arrival. See picture below.



In addition, he said that an enhanced collaboration with DFS led to fuel savings, with the provision by DFS of expected altitudes over specific waypoints, enabling a better management of the vertical profiles. See examples below.

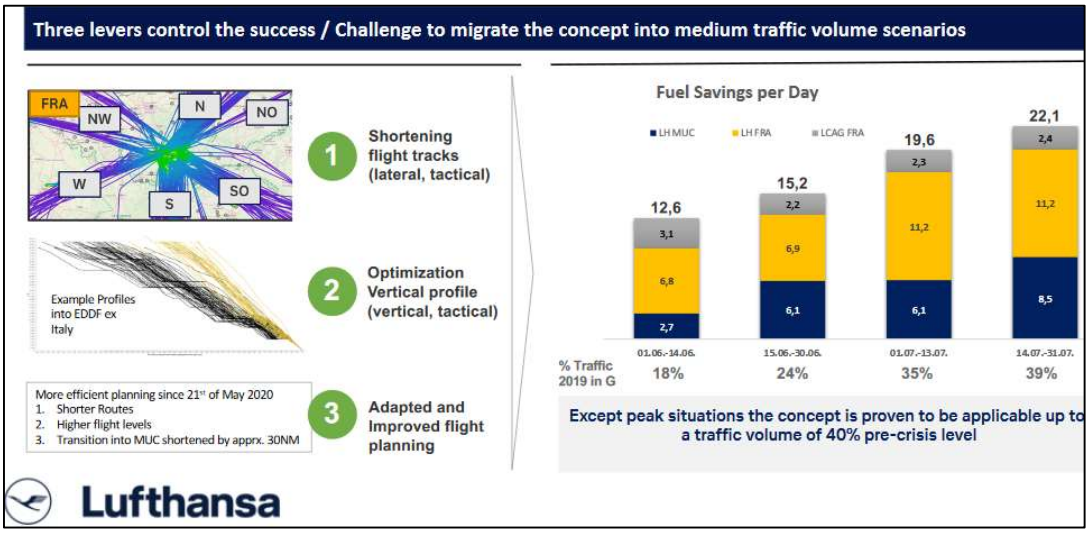
Ex	EDDF RWY07	Expected FL	EDDF RWY25	Expected FL
Maastricht UAC	DCT **DF652**	4000FT	DCT **DF411**	FL 70
	DCT **COL**	FL 200	DCT **MTR**	FL 100
	DCT **KERAX**	FL 80	DCT **KERAX**	FL 110
Rhein UAC	DCT **DF635**	FL 100	DCT **SPESA**	FL 100
Munich ACC	DCT **KERAX**	FL 130	DCT **KERAX**	FL 110
	DCT **DF635**	FL 100	DCT **DF623**	4000FT
			DCT **SPESA**	FL 110

These fuel savings were not calculated using Lufthansa fuel data. Instead, a model estimating fuel burn - using radar data - was used by DFS to calculate fuel savings. By applying a fuel modelling instead of analysing actual airline fuel data, fuel savings for all arrivals can be deduced almost real-time.

Frank Lumnitzer also highlighted the interdependencies between horizontal flight efficiency, VFE, capacity, etc. In order to continue improving VFE, three topics should be looked at:

- Airspace structure and sectorization
- Revise Letters of Agreement between sectors
- Relax RAD restrictions when possible.

As a result, Frank Lumnitzer indicated that thanks to this close coordination with DFS, up to 40% of pre-crisis traffic volume could benefit from these coordinated measures, as shown in the graph below.



Because ToD optimization shows a large fuel gain potential, the moderator asked if sharing (optimal) ToD to ATC would help improve VFE during descent. Aurore Bibard (DSNA) confirmed that this would help, however it is not enough. More information (e.g. descent profile) would allow an even better understanding of the aircraft's optimal descent, as it is different for each arrival.

At the end of the presentation, Marylin Bastin highlighted the excellent cooperation between DFS and DLH.

Questions/remarks and answers:

Marylin Bastin: Why, instead of using your own Fuel Burn data, do you use radar data from DFS on which you applied fuel modelling, and why do you use average time in level off used by European CDO/CCO TF?

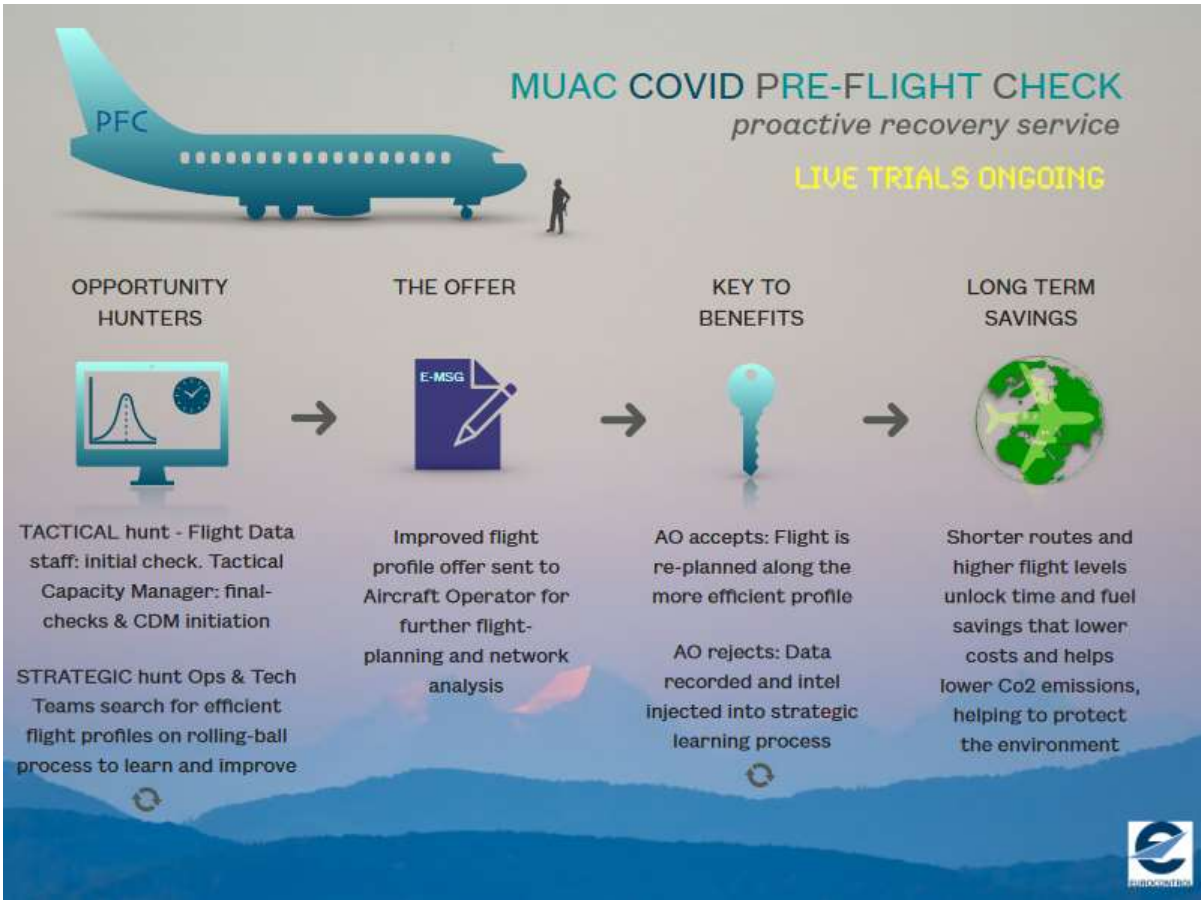
Frank Lumnitzer: It comes from a long cooperation process with DFS ("Optimized Flying" working group, in association with other German AOs), in a kind of working platform to implement changes in our airspace.

4.8 HOW TO IMPROVE VFE? / MUAC

Presentation was made by Theo Hendriks, from MUAC, on Pre-Flight-Check (PFC) procedure.

This procedure is an on-going trial, and was developed during Covid crisis, when MUAC started to think about how to contribute to a better vertical efficiency.

A quite clear concept was presented, and is summarized with the picture below.



Theo presented then a platform on which flights that could potentially be improved laterally and vertically. More in details, the aim of PFC is to offer alternatives to AOs between 2 to 6 hours before departure. The proposals can be made on the current restricted airspace structure, but also can be made in contradiction with some actual restrictions. In that case, MUAC makes sure that no rejection message will be delivered to AOs.

Once airlines have accepted the PFC proposal, they are invited to refile their FPL accordingly.

Questions/remarks and answers After the presentation, some questions or remarks were asked by the audience:

Q: Patrick de Rooij (Ryanair) asked about a possibility of automatic function where rerouting, once accepted, would be transposed automatically in the FDPS system, in order to reduce workload from airlines' side.

A: Theo Hendricks replied that MUAC is still in a trial phase, he understood AO's point of view, and confirmed that work has started to address that issue. In current phase, AOs need to re-file to take the benefit and achieve the environmental effect.

4.9 HOW TO IMPROVE VFE? / WIZZ AIR

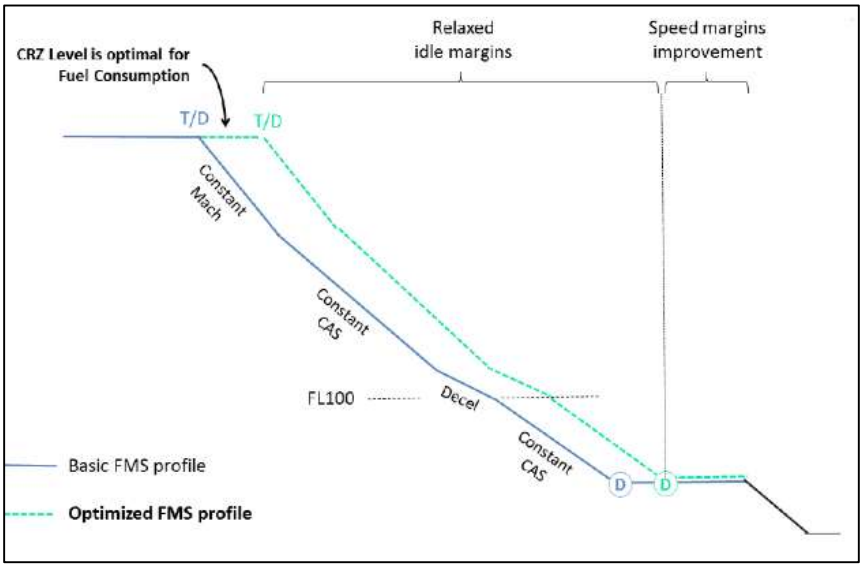
Piotr Ciolko and Robert Sklorz (Wizz Air) presented the initiatives being taken by Wizz Air to optimize descents.

Numerous good practices were shared; various of these items are included in the European CDO/CCO action plan:

- Level segments during climb results in lower emissions penalty than during descent.
- Climb and descent rate restrictions normally result in fuel penalties, unless they fit the optimum profile (very rarely the case).
- Speed reductions below 250kts during climb and descent will lead to increase in emissions & cost of time.
- Higher acceleration (climb) and earlier deceleration (descent) results in emissions penalty
- Imposing early steep continuous descent gradient results in increase of emissions and cost of time
- Comparison of descent profiles using indicators defined by altitude windows or from the ToD result in incorrect conclusions. These comparisons will only give meaningful results if they are made for fixed geographical areas or air distance.
- From operational perspective, crew training and feedback providing tools are key
- FMS optimum climb and descent speed calculations are overly simplified. Still margin for optimization and fuel gains.
- FMS descent flight path calculation is not optimal.

Initiatives taken by Wizz Air:

- In-house derived ECON descent speeds help saving, on average, 50 kg CO2 per flight.
- FMS modifications helped in bringing the FMS vertical profile closer to the optimum profile. Descent Profile Optimization (DPO) is an FMS software modification, which allows a more accurate ToD point for the most efficient descent path. Initial analysis showed that there is a potential saving of 94 kg of CO2 per flight during unrestricted descent. See picture below.



Source: https://services.airbus.com/en/flight-operations/system-upgrades/fuel-efficiency/descent-profile-optimisation-dpo.html

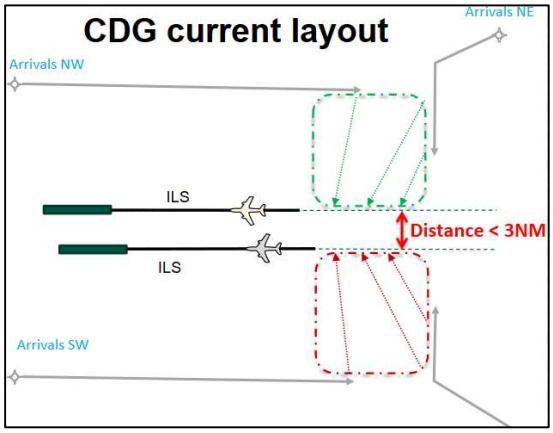
Dedicated flight operations procedures, as well as providing feedback to pilots, improved VFE during descent.

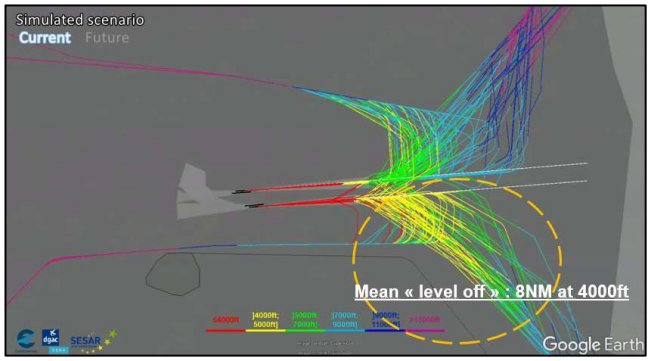
4.10 HOW TO IMPROVE VFE? / DSNA

Presentation on project PBN to ILS, was made by Sophie Baranes, deputy head of Environment department at DSNA.

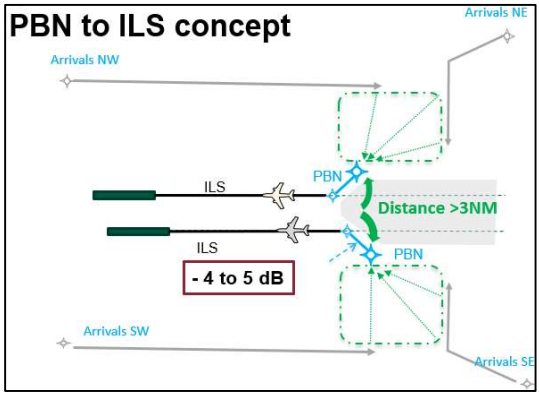
The aim of the project is to fly more CDO at Paris CDG on both parallel runways. After initial guarantees given on safety and noise, project was launched and a trial phase will start as from January 2021.

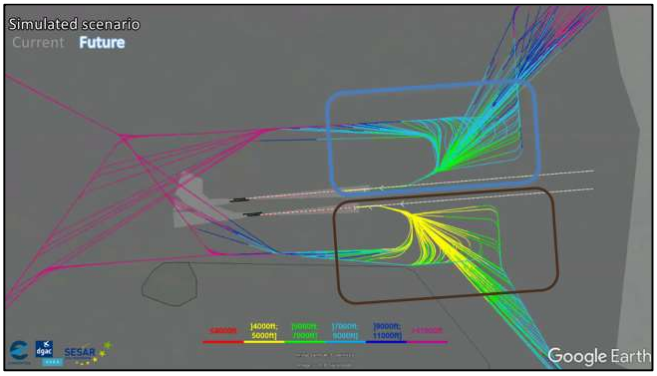
Sophie Baranes started to present the current layout in which vertical separation leads to a level off of 8NM at 4000 ft, on one of the runways, as shown in pictures below.





In the future situation, traffic will follow RNP1 legs to final, enabling independence of the runways, thus better profiles, as shown in pictures below.





From an environment perspective, 70% less population will be overflown, and a decrease of noise by 3 to 5 dBA is expected.

Sophie ended her presentation with the roadmap, saying that environmental consultation will take place in 2022, leading to an intermediate implementation in April 2023, and a final implementation in December 2023.

Questions/remarks and answers After the presentation, some questions or remarks were asked by the audience:

Marylin Bastin: Agenda looks quite ambitious and will take time. Is it due to environmental processes in France?

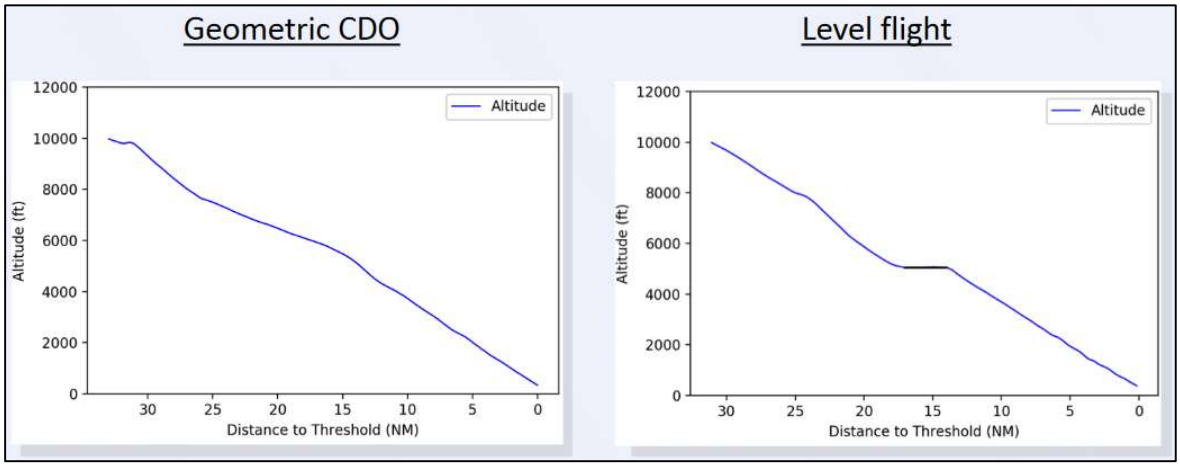
Sophie Baranes: Not only. It's also a matter of size of changes, including new flight paths based on RNP1, safety cases, and political aspects are also very important in this very densely populated area.

4.11 EXPLORATION OF NEW INDICATORS / ENAC-DSNA

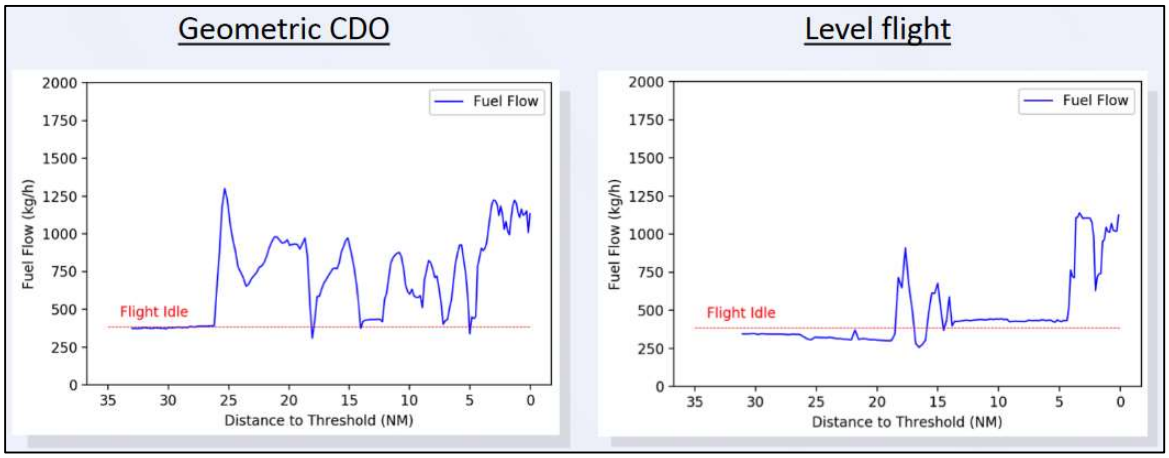
Presentation was made by Gabriel Jarry, data scientist from ENAC.

Gabriel started his presentation on machine learning in saying that current metrics (based on the measurement of level off) are efficient but have some limitations. As an example, illustration of comparison between geometric CDO and profile with level flight shows that profile with level flight may be less fuel consuming than CDO profile, as shown below.

Profiles:



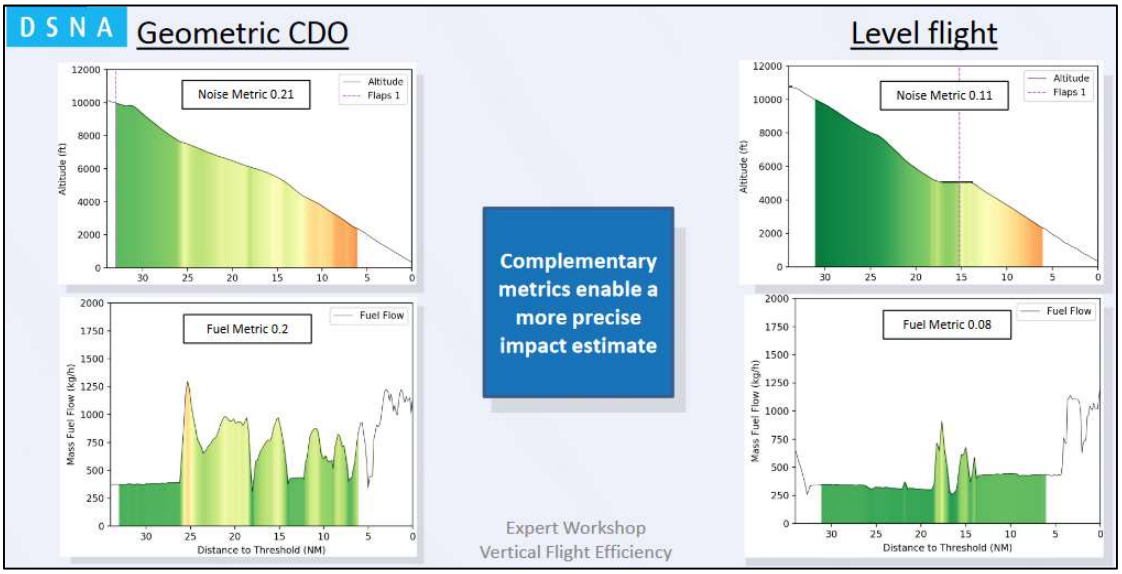
Fuel consumption:



Then Gabriel Jarry explained that a better evaluation of the impact could be enhanced with the use of complementary metrics, using on-board data (e.g. fuel consumption, aerodynamic configuration, etc).

Therefore, during the project, investigation was made in the use of machine learning in order to provide models able to estimate the on-board parameters.

Gabriel Jarry then presented some machine learning models they worked on. A data set of 15000 flights was used on the A320. Neural network model was used, and was provided for each minute of radar trajectory (each 4 seconds) with altitude, ground speed, and vertical speed as input parameters. Output parameters consisted in fuel flow, engine power, flaps and gear positions, and the use of speed brake. Extension of this model could be for noise. As a result, complementary metrics are enabling a more precise impact estimate, as shown in the picture below.



Gabriel Jarry ended his presentation with an interesting animation, which could be used to give to the ATCOs additional information, including fuel flow, aerodynamical configuration, and environmental measures for fuel and noise. He concluded his presentation on machine learning with these 2 points:

- Machine learning could enable the improvement of system evaluation metrics such as environmental metrics.
- >Machine learning could contribute to a collaborative ground/on-board improvement of the overall efficiency of the ATM system.

A remark was made by Gregor Thamm (DFS), explaining the similarity with the method used jointly between DFS and Lufthansa, and was happy to see both studies are going in the same direction.

Positive reaction was also given by Marylin Bastin, expressing her confidence in the future to have metrics on fuel and noise that could be used by ANSPs to better identify inefficiencies.

5 WRAP UP / TAKE AWAY

Moderator Marylin Bastin concluded the workshop by highlighting the **key take-aways** of the day:

- **State-of-the-art - VFE En-Route**
  - FABEC ANSPs have a complex and dense airspace to manage, but are able to **react quickly** to adapt and offer improvements on VFE
  - Very large number of RAD relaxations and their nature might explain why **1/3 of RAD VFE measures have been disregarded by AOs** during COVID crisis
  - However, the RAD remains the main tool to **maintain globally high sector capacities**, and to distribute vertically traffic to avoid overloaded sectors
  - Meteorological aspects (wind, jetstreams) and costs (fuel, route charges, delay) play an important role for AO when filing cruise flight levels

- **State-of-the-art - VFE during climb/descent**
  - **Collaboration between ANSPs and aircraft operators** is a crucial enabler, as highlighted in the recently released European CDO/CCO Action Plan.
  - **100% ATM network fuel efficiency is neither achievable, nor desirable.**
  - Level-off is currently the proxy for inefficiency. Beware: no metric is perfect. There is a need for harmonised CDO/CCO metrics.
  - **Complementary fuel/CO2-based metrics** would give a better view of the real ENV performance.
  - **Promising collaborative initiatives** (e.g. green flight) taking place for the moment, with substantial fuel savings as a result.

- **View of aircraft operators on VFE**
  - Initiatives presented by airlines show that improving VFE requires **strong collaboration between operators, ANSPs and CFSPs.**
  - Airlines launched initiatives to improve the flight planning process. Case study presented by **Wizz Air** shows the impact of improved **Zero Fuel Weight (ZFW) optimisation** on flight planning and VFE. In addition, a set of good practices has been shared on improving **descent management.**
  - VFE improvements can be achieved by ensuring close collaboration between aircraft operators, ANSPs and CFSPs:
    - Case study by **KLM: PBN** deployment at runway 18C
    - Case study by **Lufthansa**: takes advantage of reduced traffic demand to **optimize flight trajectories**
  - Some airlines observe **improved VFE performance** during reduced traffic demand period. Other operators (e.g. **Brussels Airlines**) highlight the large number of restrictions and constraints on numerous flights due to central (busy) location of Belgium within FABEC area.
  - Continuous efforts need to be made by all partners to **relax unnecessary constraints (if possible)**, and one should monitor whether these relaxations are effectively taken into account in the use of their full potential.
  - **Cargolux** case study highlighted that **proper energy managed arrivals significantly improve efficiency**, and reduce overall environmental impact. Better mutual understanding between pilots and ATC of each other's procedures would benefit both. Fuel gain potential is big.

- **How to improve VFE?**
  - MUAC's COVID **Pre-Flight Check** has proven to be very successful. The ANSP actively proposes and guides operators towards the most fuel-efficient route, but the operator remains in charge.
  - Case studies at **Paris CDG** show the ENV gains that can be achieved by applying advanced technologies (e.g. PBN), if ANSPs & operators work together.
  - **PBN and 'closed' procedures** have a great potential to increase predictability, and hence improve CDO performance. The more "freedom" the operators receive, the better they can optimize their flight profile. However, there are interdependencies, as mentioned by multiple operators.
    In numerous cases, the use of 'conventional vectoring' is required for sequencing and capacity purposes.

- **Exploration of new VFE indicators**
  - New VFE indicators are needed to measure the real inefficiencies. The better the indicator, the better we are able to measure and quantify improvements being made by all stakeholders.

  - Machine learning brings us to the 'next level' when identifying environmental metrics. It could contribute to a collaborative ground/on-board improvement of the overall efficiency of the ATM system.

6 ACTION LIST

The next steps are summarized below:

AI#	Date	Action	Owner	Deadline	Status
01	10.12.20	AOs & ANSPs: Understand why certain RAD relaxations are not actively used	All	Q2 2021	Open
02	10.12.20	Set up collaborations between AOs (e.g. Brussels Airlines) and FABEC to assess particular case studies, with the aim to improve VFE	AFG	Permanent	Open
03	10.12.20	Promote awareness & training on VFE within organization (AO's, ANSPs, CFSPs, etc)	All	Q1 2021	Open
04	10.12.20	Follow-up workshop(s) coming up	AFG	Q3 2021	Open

Marylin Bastin thanked all presenters and participants for their active participation in the workshop.

MEETING ENDED AT 15:30.