The Role and Effectiveness of Continuous Descent Operations In Aviation and How It Can Be Verified

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Abstract

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The subject of this thesis was to investigate what is the role of Continuous Descent Operation (CDO) to aviation in terms of importance, how effective it is in relation to environmental realities, and how could the current indicators be verified to be correct. CDO has been found to deliver undeniable benefits to environment in form of less CO_2 emissions and noise and for aircraft operators in a form of savings.

This thesis researched the different stakeholder's objectives on CDO and their responsibilities towards the success of CDO trajectory. Research considered the obstacles that would hinder the opportunities presented by CDO and how they could be influenced. Research also investigated the different structures of Standard Arrival Route (STAR) and their possible opportunities, advantages or downfalls and the effects of using Required Time of Arrival (RTA) as a sequencing measure for arriving air traffic.

Parameters made for measuring the effectiveness of CDO by Eurocontrol CDO Task Force were explored, especially the attribute for level segment, which would appear to be the most influential parameter that could affect the results of measurement. Atmospheric conditions were found not to be considered as an affective parameter measuring the success of CDO approach from Top of Descent (ToD) to final approach track. Also flight technical solutions, such as holding or vectoring, was found to be following the same reasoning even though they have been identified among other studies to be an affective factor. The importance of Distance To Go (DTG) information to flight crew was considered in a situation, where approaching aircraft was pulled out from a STAR and continued under vectoring.

Two Eurocontrol databases were investigated through a case study, which used data from both databases to compare the CDO results between two network airports. The aim was to find out whether the information would be usable for future development of airspace and a solid base of information concerning success of CDO in conjunction with aircraft operators and airports. Also, the case study took an interest on a question, whether there were different results on CDO with the same parameters within different regions and if so, what could be the factors behind them.

As a conclusion, the RTAs could be beneficial for the sequencing of arrival air traffic without compromising the capacity of an airport. Parameters for CDO should be reconsidered to widen the acceptable reasons for level segment to include weather conditions and flight technical solutions in more detail. Also, the Eurocontrol database discrepancies should be solved and make the information more transparent for the aviation society.

Key words
CDO, database, parameters, level segment, RTA, DTG

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1 Introduction

The topic of this thesis is of international importance and has an influence on the environment on a global scale. The role and effectiveness of CDO, also known as Continuous Descent Approach (CDA), has been a subject for many previous studies and it was chosen to be this thesis topic through my own interest and shared interest shown by thesis commissioner, Fintraffic ANS.

The verification of successful CDO is currently based on Eurocontrol CDO Task Force harmonised parameters, which are the most appropriate for the time being. However, according to the research done before on the subject, further examination of the parameters is applicable especially now, when further development of airspace is to be conducted in the next few years to come. Since many European countries are committed to these parameters, thesis will consider if there are possibilities to add transparency and user friendliness to the raw data on which the success rates of CDO towards individual countries, airports, and aircraft operators are based on. Furthermore, thesis will take a look on the other critical parameters that are not considered in the success of CDO.

Thesis will consider CDO measuring as a tool supporting actual performance targets on environmental benefits, noise abatement, fuel efficiency for aircraft operators and the overall necessity for air traffic flow. Thesis explores if the information received today is enough for the aircraft operators and Air Traffic Controllers (ATC) to create a framework for future development of their own procedures to fulfil their part of the green transition towards more sustainable aviation environment and get feedback about their aircraft fleet or ATC efforts success rate to improve their methods executing CDO.

Thesis questions	**Knowledge base (Chapter)**	**Results (Page number)**
The role and effectiveness of CDO in aviation and how they can be verified	4, 5, 6	4, 8, 12, 13, 14, 15
Eurocontrol parameters as a guideline for measuring effectiveness of CDO	5, 6	10, 11, 18, 19
The use of Eurocontrol database as a source of information for future development of aviation	6	18, 19, 20, 21

Coverage matrix will show the main questions and their location within the thesis.

2 Significance of the research

To be able to deliver most effectively, CDO procedure needs space and time to function to its full potential. This research compared a closed STAR to an open – ended STAR to find out if there would be need for consideration to keep them as they are or to convert open – ended STAR to closed one so that the predictability of the continuous descent would be more controllable for the ATC and for the flight crew. Furthermore, this research considered the implications of unnecessary limitations to CDO during approach and how may they affect the outcome.

In addition, research took a closer look on the available information and databases used to define the success of CDO and compared that information to each other to find out whether they would be useful for the planning of future airspace infrastructure or should there be any changes made to the parameters used today. Furthermore, thesis researched, if there were different results on CDO with the same parameters within different regions and if so, what could be factors behind them? Could the suggested parameters be used as a guidance to develop operations in Fintraffic ANS?

Thesis is commissioned by Fintraffic ANS, who provides air navigation and flight procedure design services in Finland in co-operation with its stakeholders. Aim of this thesis was to bring forth information on whether the current measuring parameters and procedures were valid to guide Fintraffic ANS on development of their operations and designing future flight procedures.

3 Research Methods

Thesis has been using Quantitative Research Method. It is a comprehensive study which uses numerical data to explore the reasons behind presented figures and aims to understand the meaning behind them and the usefulness on developing future airspace.

3.1 Subject of the research

The main subject of this study was to find out the role and effectiveness of CDO in aviation and how it could be verified.

3.2 Research Limitations

Since year 2023 had complete data on all 12 months of different weather seasons of the European, and more specifically Finnish, CDO tracking's, it was used as a reference for this study. This limitation served the purpose of the narrow focus on this thesis since it held the data needed to explore the parameters used to define the effectiveness of CDO.

3.3 Way of collecting data

Data used in this study was extracted from Eurocontrol databases, International Air Transport Association (IATA) and International Civil Aviation Organization (ICAO) publications. Additionally, theoretical data on the subject was collected from Helsinki – Vantaa airport releases, Eurocontrol publications, scientific thesis and articles and from literature and research material. As an introduction, research also used material from Fintraffic ANS own data to show how CDO trajectories are investigated in Finland. All material was extracted from the internet sites with prestige, except for Fintraffic ANS data, which was extracted from their own system. Also, author's 25-year experience on aviation and subject at hand was exploited.

3.4 Data analysis

Data was analysed by comparing numbers from different databases to each other through case study on three Finnish airports, Helsinki – Vantaa (EFHK), Pori (EFPO) and Kajaani (EFKI). Data was extracted from Eurocontrol controlled Dashboard and released Excel file.

4 Background on CDO

Even though statistically aviation is responsible for 3,5 % of the total atmospheric emissions (Lee D.S., Fahey D.W., Skowron A., Allen M.R., Burkhards U., Chen Q., Doherty S.J., Freeman S., Forster P.M., Fuglestvedt J., Gettelman A., De Leon R.R., Lim L.L., Lund M.T., Millar R.J., Owen B., Penner J.E., Pitari G., Prather M.J., Sausen R., Wilcox L.J. 2021, 2), the industry is still searching for different ways to improve its carbon footprint towards sustainability. Several studies have come to the same conclusion, that CDO is one of the biggest innovations that has really had an impact on aviation on many levels.

ICAO has defined CDO in Doc. 9931 (p. 11) as an operation, “in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix/final approach point”. In this phrase the low drag configuration means without use of flaps, speed brakes or gear and with engines on flight idle until the final descent to the runway begins. According to Eurocontrol (2020, 1) this procedure requires seamless co-operation between air traffic controller and flight crew to ensure predictability of the procedure for both parties.

4.1 Development

During 1970’s non-precision approaches, which do not have vertical guidance, were started to be replaced by Instrument Landing Systems, which had a vertical glide path to follow (Rosenkrans W. 2013). As Etienne Tarnowski (2007, 1) described in his paper, during non-precision approach the flight crew would use Step Down Approach method to intermediate altitudes and then perform steep descent towards the runway once the necessary visual elements were achieved. This technique would render the aircraft and flight crew to possibility of Controlled Flight Into Terrain (CFIT). According to Rosenkrans (2013), partly for this reason the continuous descent approach concept was introduced to aviation society. Both methods are presented in Figure 1.

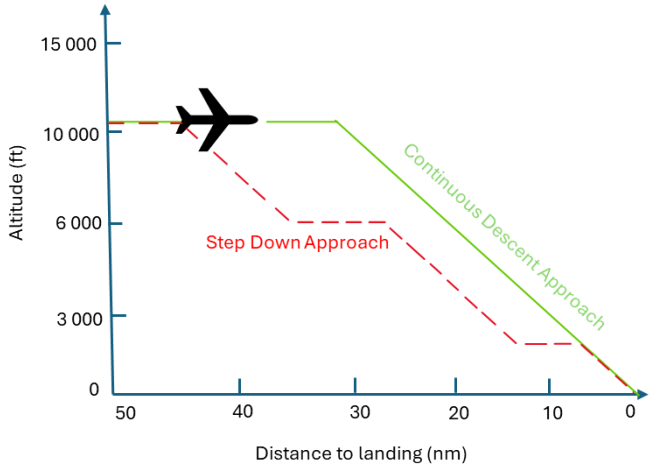


Figure 1 Step Down and Continuous Descent Approach

4.2 Environmental objectives

Sustainability is a key factor for the success of an airline to satisfy the growing concern about the environmental issues among the consumers. Sáez R. and Prats X. (2023) has stated in their research, that this has motivated the research into finding new methods for transition towards more greener solutions. Lee & al (2021, 2) further stated, that since the aviation industry is dependent on fossil fuel, more actions are required to prevent the growth of CO_2 emissions and its impact on the global warming.

According to Eurocontrol (2023, 24), the ReFuelEU regulation (EU) 2023/2405 will require the aircraft fuel suppliers to increase their distribution of SAF as shown in the Figure 2.

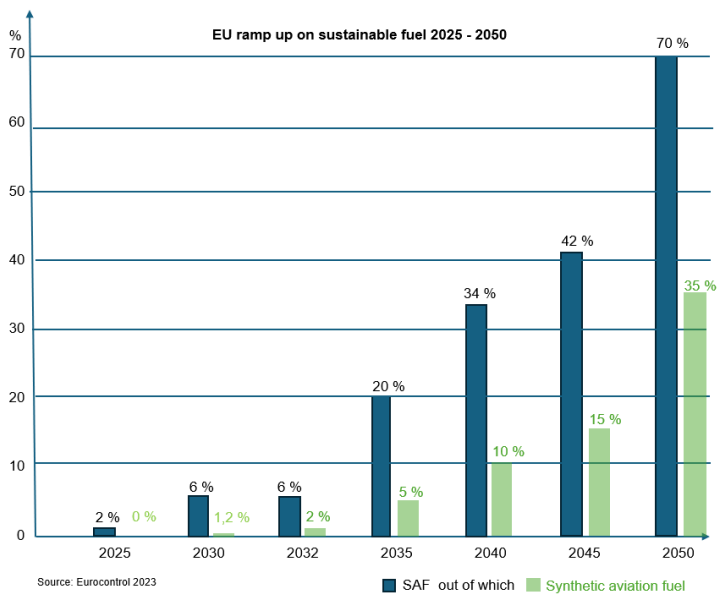


Figure 2 EU ramp up plan for sustainable fuel

4.3 Noise abatement objectives

Today residential areas have caught up with airport locations and the noise caused by air traffic has brought inconvenience to their inhabitants (Finavia 2024, 5). According to the same release (p. 6), Finnish airports are required to have an Environmental Permit which should include a Noise Abatement Plan as a requirement. Noise Abatement Plan should be in accordance with requirements of EU environmental directive 2002/49/EU.

Finavia has further stated (p. 4), that the departure and arrival routes have made it possible to reduce the air traffic noise by circumnavigating the Helsinki-Vantaa air traffic around the intensely populated areas. In the future part of these routes will be constructed only for aircraft producing less noise (p. 2). These routes have been developed by Fintraffic ANS in co-operation with Finavia and CDO is used as a noise abatement procedure in this context.

4.4 Opportunity for airlines

On average an airline has used about 30 % of its revenue on purchase of fuel (IATA 2024, 1). According to Finavia's statistics (2024) during the year 2023 at Helsinki-Vantaa airport, the most used medium size aircraft types in airline fleets were ATR-72, Airbus 321 and Embraer 190 among which the airspace distribution per year was 20,8 %, 18,9% and 16,8% respectively. The following table, Figure 3, will show in general the average amount of fuel savings per flight based on aircraft type using CDO.

Aircraft Type	**Fuel savings / flight using CDO**
Airbus 321 (Sáez S., Prats X. 2023)	50 kg
ATR 72 (ATR Customer Services, 2011)	33 kg
Embraer 190 (Kostyuk A., 2016)	20 kg

Figure 3 Aircraft type related savings

4.5 Air Traffic Control objectives

Efthymiou M. (2019, 2) stated in his thesis, that the main function of ATC would be to guarantee safe passage for air traffic by providing separation between aircrafts. ICAO Document 9931 (2010, 11) defines another function, which would be to facilitate use of CDO as much possible.

As described in the ICAO document 9426 (p. 41 – 43), the airspace has been divided between several air traffic controllers which constitute the infrastructure of air traffic control system and their responsibilities. Since this thesis focuses on the approach segment of a flight, Tower Control is out of the scope of this paper. The infrastructure is shown in Figure 4.

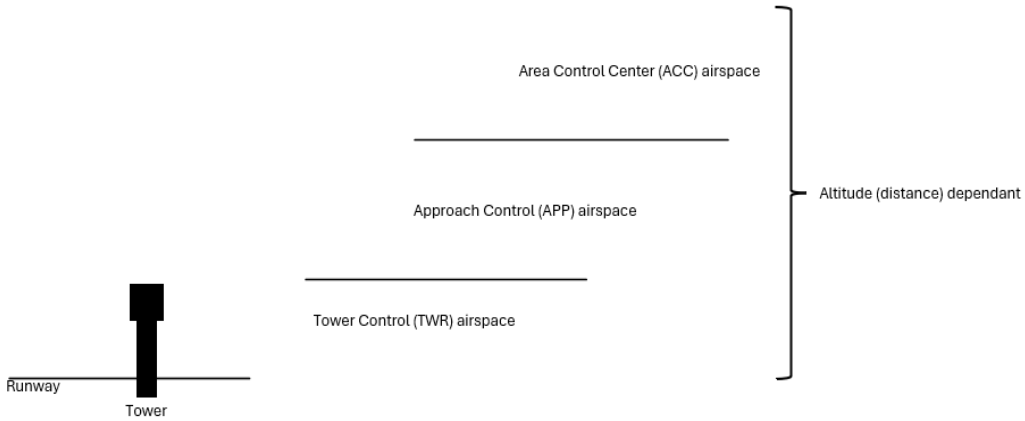


Figure 4 ATC infrastructure

4.6 Flight Crew objectives

The aim for the flight crew is to fly a constant descent without level segments which would increase the fuel flow, emissions, and disrupt the success of CDO. Brain D. and Bastin M. (2019, 151) has stated that according to the European CDO Task Force survey, less than 50 % of the aircraft operators, that participated on the survey, has offered simulator recurrence training for the flight crew on the execution of CDO and one third had their procedure attached to the Standard Operating Procedures (SOP)

Planning and execution of an optimized descent relies on crew competency received by training, the level of experience and deep understanding of the reasons behind the procedure. Therefore, The Task Force have encouraged aircraft operators to create SOP’s (Brain & al. 2019, 151), since adherence to SOP’s will help the crew to create a working environment within the flight deck to perform and monitor the idle descent successfully.

5 Theory

Brain & al (2019, 146) has stated, that CDO has been perceived as an effective way to reduce the environmental emissions which are presented to society by the aviation community today. The use of CDO is not mandatory by law, but since several research has pointed to a fact, that aviation have had its part in a climate change, it is a concerning factor to the global population (Lee & al 2021; Sáez & al 2023).

5.1 Stakeholders and corporate culture

When the author studied the practical part of CDO, important stakeholders were identified to be ATC and the aircraft operators with their flight crew (ICAO Doc 9931 2010, 11). Efthymiou (2019, 18) recognized the importance of ATC as an enabler for the flight crew to perform a continuous descent by providing DTG information on regular bases even though it might increase the workload.

According to Eurocontrol (2020 Appendix L, 1), aircraft operators could benefit from measuring their own CDO performance by using technologies such as Flight Data Monitoring or Quick Access Recorder and should bring the data to flight crews' attention by implementing it to training. This could strengthen the company culture on using CDO. Also, by acquiring an Automatic Dependent Surveillance Broadcast (ADS-B) equipment, operator could share automatically flight information about aircraft location, altitude, and speed with ATC (xamk read 2022).

5.2 Standard Arrival Route (STAR)

Closed STAR, as depicted in Figure 5, is a procedure that will join the instrument approach procedure (IAP) at a predefined point, which in turn includes the Final Approach fix (FAF) / or point (FAP) (ICAO Doc 9931, 26-27). As Efthymiou (2019, 6-7) stated in his study, closed STAR would enable the flight crew to calculate their DTG from the runway threshold accurately and according to Yandong L., Bo J., Weilong L., Chenglong L. and Yunfan Z. (2024), provide predictability to both the flight crew and ATC. However, ICAO Document 9931 (p. 24) stated, that closed method might result for ATC not to be able to sequence air traffic in an efficient manner and it may result in reduced capacity and efficiency. Sáez & al (2023), on the other hand, brought forward their concern, that due to vectoring the aircraft might end up in too high or too low energy state which could impose an interruption to the CDO with use of thrust for compensation.

Sáez & al (2020, 1) also studied the use of Required Times of Arrival (RTA) by the ATC and has come up with a conclusion that their use has proven to be beneficial for the environmental goals in the airport's Terminal Maneuvering Areas (TMA) and have enhanced the predictability of the procedure even more. During further studies they also concluded that by assigning RTA to a fix along

a STAR, ATC could separate the air traffic flow without compromising the capacity of the airport at the destination.

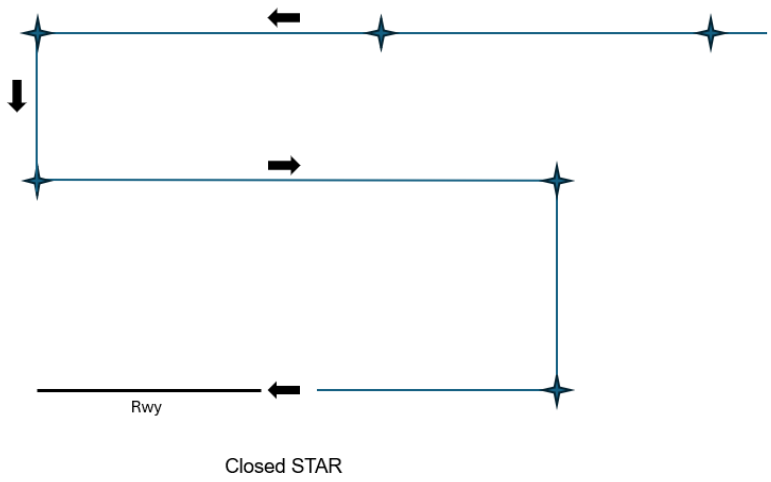


Figure 5 Closed STAR

Figure 6 depicts other method called open – ended STAR, also called open STAR. In relation to closed STAR, procedure does not include FAF/FAP, and it is discontinued at some point of the procedure by ATC with vectoring or giving clearance to proceed to identifiable fix (ICAO Doc 9931, 27). According to same page on ICAO document two types of open STARs exists, where one ends in a downwind leg followed by vectors and in the other type, the aircraft is brought to the operational environment where sequencing is done by holding patterns and vectoring.

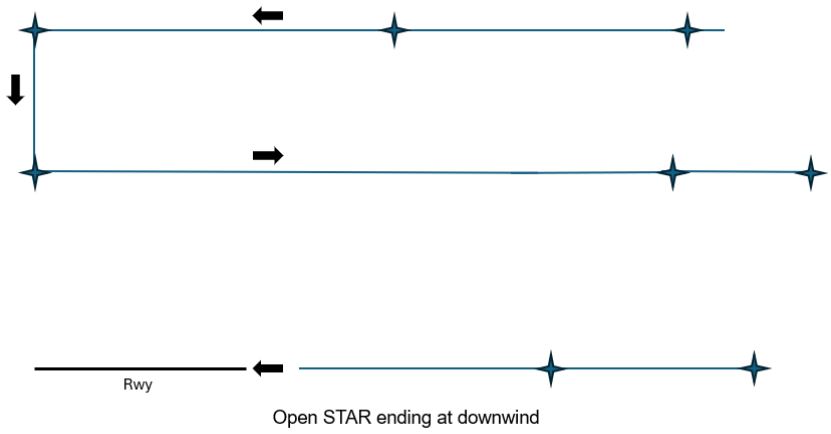
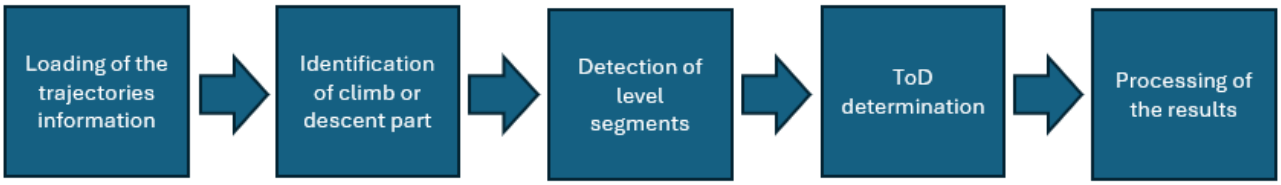


Figure 6 Open STAR

5.3 Eurocontrol harmonised parameters for measuring success of CDO and Network Manager data management

European CDO Task Force released measurement parameters in 2016 with an aim to have common rules to measure the efficiency of CDO (Eurocontrol 2020, 1). These parameters would take in consideration the average time in seconds what an aircraft spends in level flight, noise CDO measures the vertical flight efficiency below 7500 feet and fuel CDO measures vertical flight efficiency from the top of descent throughout the whole descent with fuel / CO_2 efficiency.

According to Peeters S. and Guastalla G. (2017, 7) the analysis is done by adhering to the schema shown in Figure 7. The first phase would be to load the aircraft trajectory into analysis software and in second phase descent would be identified. After level segments have been detected, the data would be saved, and additional filters would be added. Top of Descent would be determined, which after the results could processed.



Source: Peeters S. & al 2017

Figure 7 Analysis schema

Following the Eurocontrol procedure (Eurocontrol 2024) the position data of an aircraft would be gathered with ATC surveillance system and transmitted to Eurocontrol Network Manager (NM) for further analysis. Data would then be mixed with more individualised pertinent flight data received by Secondary Surveillance Radar (SSR). This data would be identified by a unique four-letter code assigned for every flight (xamk read 2022). All this data is called Correlated Position Report (CPR), and it would be sent to Eurocontrol NM every 30 second interval.

Fintraffic ANS is currently developing their own measuring system based on Eurocontrol parameters. The procedure will be presented in the Analysis section with an example.

Brain & al (2019, 150) showed in their research that based on this data Eurocontrol would create performance tables on CDO to be delivered monthly for all airlines and airports operating in Europe with support of analysing data. From the tables an airline could single out their performance on different airports or compare their performance towards all airlines. All IFR (Instrument Flight Rules) flights are processed in the NM database, excluding military or other sensitive flights.

5.4 Level segment in CDO

Huynh T., Thomas A., and Bronsvoort J. (2021, 1) found out in their research that out of pre-described Eurocontrol parameters, the measurement of level segment is perceived to be an attribute for success of CDO. According to Peeters & al study (2017), when measuring level segments, the two variables taken into consideration are Altitude and Time. Figure 8 show the formula used, where Y is Altitude and X is Time in minutes.

$$\frac{Y}{X} = 300\ feet\ per\ minute$$

Source: Peeters S. & al 2017

Figure 8 Formula for calculating level segments

Peeters & al further explains how Eurocontrol CDO Task Force has chosen 300 feet per minute descent rate to be the dividing limit between descent and level flight segment. This would mean that every passing 10 seconds of measurement the allowed descent rate would be 50 feet per minute for the CDO to be successful (2017, 7). However, Huynh & al (2021, 1) stated in their research that from the aircraft operator's point of view this methodology would not capture all the flight inefficiencies. These factors will be discussed further in the Analysis chapter.

5.5 Finavia's monitoring of noise and CDO

As an airport operator Finavia is responsible for the noise management of their airports within Finnish boarders. According to their yearly release (2024) they have the only 24-hour surveillance system in Finland called Airport Noise & Operations Monitoring System (ANOMS) (p.36), which is located at Helsinki – Vantaa airport. This system will combine the source data with local present weather information to the measured noise level and then link this information to the active flight plans to identify the correct source. Average noise level could be then calculated based on one year data

ANOMS has 10 strategically located fixed positions around the airport, where the measuring devices are located (p. 37). System has a feature to analyse CDO performance, where it acknowledges tracks below 6000 ft and allows 2 NM level segment for successful CDO. Based on analysis of the results the approach will then be categorised to be either CDO or non-CDO approach. The environmental permit for Helsinki-Vantaa airport requires 70 % CDO success rate during a day and 80 % during the night operations. Figure 9 shows that the success rates in the beginning of year 2024 were achieved (Finavia 2024, 19).

Week number	CDO % 07 – 22	CDO % 22 - 07
1	75	83
2	75	84
3	75	83
4	76	88

Figure 9 Measured CDO percentages for Helsinki – Vantaa airport

When compared to Eurocontrol Dashboard percentage from the same period (Figure 10), there are difference between the success rates on CDO. This could be explained with the parameters used by Finavia and Eurocontrol. Eurocontrol measures CDO below FL 75 whereas Finavia uses 6000 ft limit and 2 NM level segment.

Source: Finavia 2024

Airport label	Descents	Tot. level time (min)	FUEL – Avg. level time ToD (sec.)	CDO – ToD %	Noise – Avg. level time < FL 75 (sec.)	% CDO FL 75
Helsinki – Vantaa (EFHK)	5642	4395	46,7	58,6	34,4	62,4

Source: Eurocontrol Dashboard 2024

Figure 10 Eurocontrol percentages for the same period

6 Analysis

6.1 The challenges of CDO and what the results reflect?

Measuring the results of CDO should be perceived as an indirect measure, when the real aim should focus on controlling the energy levels of the aircraft performing CDO. According to research, it would appear, that in Europe the CDO itself is the focus point driven by such things as, for example, Environmental Permit. To be able to get accurate results, every CDO trajectory should be analysed as an individual flight, one at the time. Successful CDO trajectory will not always necessarily mean accomplishment as itself. Currently there are no measures to conclude whether the flight crew used air brakes, or the engines were actually on flight idle.

There are three types of measurement parameters on measuring CDO, where one is Eurocontrol parameters concentrating on trajectory from ToD to final approach track and the other two are for noise. The Eurocontrol noise measurement starts at FL 75 (7500 feet, dependant on the atmospheric conditions) where in Finland the measurement starts at 6000 feet. These two noise parameters would render in different results and could be a problem when assessing development of future airspace.

Airspace structure will bring challenges on the success of CDO. State borders are restrictive factors at some airports by their location. Air traffic service agreements between states might bring challenges to CDO operations and airspace divided to controlled and uncontrolled airspace would dictate the trajectory of an aircraft, since the flight crew would not want to descent to uncontrolled airspace for safety reasons. From the flight procedure design point of view, crossing departure and arrival routes should be avoided, since they would put pressure on ATC to orchestrate altitude restrictions on conflicting traffic.

6.2 Effects of weather and holding procedure on CDO

As far as to author's knowledge the weather conditions have been acknowledged but not considered, when evaluating a single flight level segment. European CDO Action Plan (Appendix A, p. 25 – 26) stated, that there have been some scientific studies made about the effects of weather to level segments during CDO, but it has mainly taken into consideration precipitation, visibility, humidity, and wind. As rare as a phenomenon like thunderstorm is, they have not been accounted for. Avoidance action and convective updrafts or turbulence associated with thunderstorms could result on level segment which would be received as a prolonged primary radar echo with less than 300 feet per minute continuous descent, hence non - CDO.

During the harmonisation of measuring parameters, Eurocontrol CDO Task Force has not mentioned the effects of holding procedure on CDO or how this procedure should be considered. Weather conditions, airport capacity restrictions, ATC sequencing, aircraft malfunctions or inadequate onboard equipment needed to perform approach and landing (CAT II / III) could be reasons why an aircraft would enter holding. Also, when simultaneous approaches are made to two adjacent runways with vertical separation of 1000 ft, the low side approach is more likely to be non-CDO since the aircraft must maintain constant altitude for a long period of time. This procedure is called Simultaneous Operations on parallel or near-parallel Instrument Runways (SOIR). Maybe in the future, when technology advances, all these factors mentioned in this paragraph could be taken into consideration when assessing a CDO percentage for an airport or aircraft operator in question.

For future reference it would be beneficiary to build a system that would mix more detailed weather information with the flight trajectory data and focus more on the speed of the aircraft. The speed is an indication of the intentions of the flight crew whether the aircraft is indeed descending or reducing speed on a flat intermediate segment. Maybe it could also be considered that the level segment time frame for successful CDO could be extended or allowed to have longer level flight for the aircraft to decelerate in a calculated manner and still could achieve the parameters set for a successful CDO.

6.3 Effects of company culture

The possibilities presented by the CDO to the company should be studied and understood by the shareholders, management and middle management of the company. By creating procedures to acquire data from aircraft operators own performance in relation to use of CDO and implementing it to the pilot training could make all the difference in making profit at the same time while saving fuel and environment. Sharing the results of CDO performance with pilots could create an atmosphere of curiosity and result on individual growth on the subject. This would also send a positive message to the pilots about companies' environmental values and appreciation towards CDO as a procedure.

Flight crew's knowledge on CDO have an influence on the attitude towards the procedure. If the crew could not connect the environmental or financial background with the importance of CDO procedure and the operator would not enhance the company culture on the subject, on the worse case the flight crew would perceive the procedure as non-important and put minimum effort on pursuing it.

6.4 STAR as a tool for arriving traffic flow management

As pointed out in the Theory section the closed STAR should produce constant quality CDO because of its predictability. Therefore, the use and construction of STAR should get undivided attention from the stakeholders. The structure of the corridor acting as the space, where STAR is located, could be designed so that there would be room enough for the ATC to provide sequencing between aircraft within the corridor. This would mean, that there should not be adjacent STAR procedures too close to each other to block the airspace. The result could prevent the aircraft from exiting the corridor further than necessary from the original planned path and the corrections to the trajectory could be minimal. If a situation should occur, where the aircraft is guided far away from the original trajectory, it could end up in a high energy situation (high altitude), where the use of speed brakes, flaps or gear would create noise to environment or in a low energy situation (low altitude), where it could result in use of thrust for compensation creating unnecessary emissions to the atmosphere.

When providing DTG to the flight crew, especially during the peak hours, it could result in more workload for the ATC. Nevertheless, it should be kept in mind, that the flight crew is the operative stakeholder to perform the CDO itself and therefore serves as a critical component on the success of CDO and reducing the environmental emissions. The effectiveness of the actions of the flight crew could not be verified at this moment to the extent necessary, but maybe someday the advancement of technology will make the data transfer automatic, and the resulting factors could be analysed in more detail.

An open STAR includes tactical intervention of ATC to the flight crew execution of the CDO procedure. This is examined in more detail in paragraph 6.5.

6.5 Effects of RTA and tactical intervention on CDO

Several studies have concluded that the problem of the use of closed STAR lies in the ATC ability to sequence air traffic within that confined space. As suggested by Sáez R. & al (2020) the implementation of RTAs more efficiently as a working tool could be a part of the solution to lighten the workload of ATC and enhance the willingness to use CDO more effectively. More structured use of RTAs could improve the use of available airport runway capacity which in return could be beneficial to airport, aircraft operator and advance the environmental goals.

Flight crew could participate on improving the predictability of CDO by sending their Estimated Time of Arrival (ETA) by datalink or automatically via ADS-B system in collaboration with ATC. This kind of versatility in a process would benefit both sides and might lessen the use of holding patterns as a tool for sequencing and therefore enhance the success of CDO.

According to Huynh & al (2021, 1), tactical intervention (vectoring) by ATC, for example during an open STAR method, could lead in decoupling of automation on the aircraft rendering the flight to use manual modes, which could result in use of thrust as a mean to overcome level segments and inadvertently release more emissions to the atmosphere. Every time an aircraft is pulled from the calculated flight idle descent using tactical intervention it will jeopardize the continuance of CDO. However, as Figure 11 shows, the success rate of CDO at Helsinki – Vantaa airport compared to other Nordic states is at a good level in Avg. level time ToD (sec), CDO – ToD percentage and noise CDO below 7500 feet even though all STARs are constructed with open – ended method.

Airport label	Descents	Tot. level time (min)	FUEL – Avg. level time ToD (sec.)	CDO – ToD %	Noise – Avg. level time < FL 75 (sec.)	% CDO FL 75
Copenhagen / Kastrup (EKCH)	67 742	65 097	57,7	48,1	43,8	54,1
Helsinki – Vantaa (EFHK)	42 508	28 996	40,9	62,0	29,1	67,4
Oslo / Gardermoen (ENGM)	61 096	38 082	37,4	58,8	21,2	67,5
Stockholm / Arlanda (ESSA)	53 175	44 413	50,1	48,3	36,8	54,5
Total	**224 521**	**176 588**	**47,2**	**53,7**	**33,2**	**60,3**

Source: Eurcontrol Dashboard 2024

Figure 11 Comparison between Nordic states

This could be an indication that both methods would be beneficiary if the procedure would include comprehensive communication between ATC and flight crew and more precise procedure would be constructed to be used as standard operating procedure to enforce the predictability.

6.6 Finnish network airports

There are 21 airports in Finland managed by Finavia that has adapted CDO as a method for approach and the results would be measured with radar tracking. They are relatively small airports which have moderate air traffic per day. Therefore, compared to Helsinki-Vantaa airport the CDO results should be nearing 100 % success rate, but as Figure 12 shows, this is not the case for the most airports.

Airport label	Descents	Tot. level time (min)	FUEL – Avg. level time ToD (sec.)	CDO – ToD %	Noise – Avg. level time < FL 75 (sec.)	% CDO FL 75
Ivalo (EFIV)	647	514	47,7	44,4	45,1	45,4
Kuopio (EFKU)	710	172	14,6	88,5	9,2	90,4
Rovaniemi (EFRO)	1870	1512	48,5	58,0	32,8	63,6
Tampere / Pirkkala (EFTP)	756	688	54,6	49,3	45,5	54,9
Total	**3983**	**2887**	**43,5**	**59,6**	**33,0**	**63,8**

Source: Eurocontrol Dashboard 2024

Figure 12 Comparison between Finnish airports

After research it was evident that these figures could be problematic, because there is no knowledge of the type of air traffic the measured trajectories project; commercial, training or business flights. Under Eurocontrol parameters all the processed air traffic is operated under Instrument Flight Rules (IFR). Amongst the air traffic there could be measuring flights at the airport airspace evaluating the instrument landing systems functionality and this type of operation would have significant amount of level segments during each flight. All these air traffic types could have different objectives where CDO would not necessarily be the main priority. Therefore, these values could be inconclusive if used as a general guideline for aircraft operator operations or airspace development when considering the replacement of current procedures.

6.7 Primary Eurocontrol databases used on measuring the effectiveness of CDO

Eurocontrol has provided two databases available for the consumer to extract flight information from, Dashboard and an Excel file. Dashboard includes information about all IFR flights within Europe when the Excel file excludes helicopter flights, flights with same departure and arrival aerodrome and diverted flights. Both databases exclude military and police operations and other sensitive flights occurring within the state. In Figure 13 there are statistics from the Excel database about Finnish airports.

	EFHK	EFOU	EFTU	EFTP	EFRO	EFVA	EFKU	EFKT	EFMA	EFKK	EFJY	EFJO	EFPO	EFIV	EFKI	EFKE	EFKS	EFSA	EFLP	EFSI	EFHA	EFET	EFUT	EFMI	Grand Tot
NBR_FLIGHTS_DESCENT	661836	36094	30117	25029	23789	19281	16494	13589	12751	11063	10659	9074	8810	8636	7386	6361	5826	3193	1567	1098	738	737	424	152	914704
2024	11177	558	364	485	1002	255	312	629	175	166	244	92	120	330	93	113	273	47	21	22	12	28	9	1	16528
2023	70665	3191	2525	3011	3653	1514	1905	1729	1196	1087	1474	574	918	1025	546	683	791	242	201	186	151	101	76	32	97476
2022	66030	3289	2149	2919	3106	1107	1712	1617	1090	1088	1302	574	1236	964	500	613	781	366	235	187	143	103	75	13	91199
2021	35215	2221	1426	1407	1771	381	967	1037	852	842	1111	504	1303	699	402	555	568	109	122	193	163	67	80	30	52025
2020	35507	2137	2157	1273	1599	818	922	1070	1150	271	490	384	1069	659	289	236	482	114	134	134	123	22	57	4	51101
2019	95905	4673	5066	3249	2831	3214	2301	1695	1683	1094	1347	1461	1038	1161	1143	931	762	472	330	55	45	92	32	12	130592
2018	94900	5103	4525	3342	2919	3082	2142	1728	1624	1456	1318	1316	988	1175	1093	946	727	468	169	64	75	92	33	25	129310
2017	87262	4708	4155	2912	2445	3040	1938	1629	1529	1623	1068	1385	1157	990	1094	965	537	464	104	72	8	81	15	10	119191
2016	82520	5144	3897	2990	2182	2980	2143	1296	1547	1635	1067	1370	388	862	1066	619	455	452	76	83	11	78	20	9	112890
2015	82655	5070	3853	3441	2281	2890	2152	1159	1905	1801	1238	1414	593	771	1160	700	450	459	175	102	7	73	27	16	114392
CDO % all descents	64 %	64 %	66 %	65 %	60 %	74 %	76 %	47 %	71 %	82 %	75 %	83 %	57 %	45 %	89 %	86 %	84 %	55 %	72 %	70 %	46 %	63 %	56 %	61 %	65 %
2024	59 %	56 %	48 %	49 %	48 %	71 %	84 %	44 %	49 %	93 %	71 %	85 %	37 %	44 %	83 %	94 %	76 %	26 %	71 %	73 %	17 %	82 %	67 %	0 %	59 %
2023	63 %	62 %	56 %	50 %	61 %	79 %	83 %	45 %	62 %	87 %	74 %	90 %	51 %	48 %	91 %	96 %	80 %	67 %	63 %	72 %	35 %	68 %	59 %	69 %	64 %
2022	63 %	63 %	52 %	53 %	61 %	83 %	81 %	41 %	74 %	78 %	67 %	55 %	60 %	46 %	84 %	82 %	75 %	55 %	67 %	79 %	43 %	61 %	56 %	54 %	63 %
2021	64 %	72 %	50 %	46 %	65 %	77 %	73 %	43 %	72 %	73 %	59 %	44 %	57 %	44 %	83 %	75 %	83 %	29 %	71 %	70 %	49 %	60 %	63 %	53 %	63 %
2020	60 %	66 %	53 %	48 %	66 %	68 %	75 %	52 %	68 %	81 %	67 %	85 %	52 %	41 %	87 %	86 %	89 %	46 %	84 %	66 %	34 %	73 %	53 %	75 %	61 %
2019	59 %	60 %	67 %	71 %	55 %	71 %	75 %	45 %	67 %	84 %	73 %	82 %	56 %	42 %	88 %	87 %	89 %	45 %	77 %	55 %	38 %	57 %	69 %	50 %	61 %
2018	62 %	57 %	70 %	70 %	57 %	72 %	72 %	44 %	72 %	84 %	75 %	89 %	55 %	36 %	88 %	88 %	88 %	55 %	64 %	55 %	40 %	66 %	42 %	68 %	63 %
2017	57 %	55 %	68 %	72 %	49 %	70 %	66 %	43 %	72 %	79 %	77 %	87 %	63 %	38 %	89 %	80 %	85 %	60 %	77 %	67 %	38 %	59 %	67 %	60 %	60 %
2016	61 %	61 %	68 %	69 %	53 %	73 %	72 %	52 %	76 %	82 %	82 %	87 %	38 %	41 %	88 %	87 %	90 %	61 %	82 %	66 %	45 %	60 %	50 %	67 %	63 %
2015	85 %	88 %	85 %	85 %	81 %	81 %	84 %	70 %	78 %	81 %	95 %	95 %	81 %	80 %	95 %	95 %	91 %	57 %	74 %	82 %	57 %	63 %	37 %	56 %	84 %
AVG time level all s	42	42	82	103	64	52	50	74	63	45	73	38	172	56	41	34	35	60	48	76	367	99	214	119	49
2024	44	41	145	108	88	45	32	86	114	4	71	79	281	61	61	15	27	109	32	55	630	11	156	460	56
2023	40	51	116	120	68	38	36	63	62	28	83	23	210	45	37	6	31	41	52	61	431	114	162	85	49
2022	39	44	125	145	66	33	45	68	55	34	73	78	162	51	51	28	55	63	58	77	350	131	135	86	50
2021	38	57	166	222	72	56	103	64	64	52	102	81	202	67	41	50	29	165	54	109	213	44	164	174	59
2020	48	47	142	209	59	83	102	70	97	72	104	67	253	67	79	61	32	80	31	92	394	54	193	15	66
2019	50	46	79	95	73	63	58	71	76	39	83	37	162	64	44	35	16	84	49	133	568	207	164	97	55
2018	44	47	69	96	59	66	54	76	73	40	99	30	186	64	40	32	31	60	65	59	441	102	305	144	50
2017	50	50	61	61	67	50	44	87	42	48	54	34	99	61	38	42	51	41	40	58	310	107	108	42	52
2016	47	37	64	86	67	44	42	96	52	49	54	33	146	57	41	42	34	40	20	33	287	39	560	64	50
2015	18	16	28	30	29	35	21	65	47	57	20	19	57	22	31	36	42	45	34	45	69	49	543	173	22

Figure 13 Statistics from Eurocontrol Excel database

In Figure 14 the same information for the year 2023 is extracted from the Eurocontrol Dashboard limited only to two airports as a base work for following case study.

Airport label	Descents	Tot. level time (min)	FUEL – Avg. level time ToD (sec.)	CDO – ToD %	Noise – Avg. level time < FL 75 (sec.)	% CDO FL 75
Pori (EFPO)	472	344	43,7	60,6	41,4	62,3
Kajaani (EFKI)	524	300	34,4	92,2	5,3	95,6

Source: Eurocontrol Dashboard 2024

Figure 14 Statistics from Eurocontrol Dashboard

As seen in Figure 14, the FUEL – Avg. level time ToD in seconds for EFPO was 43,7 seconds during descent whereas for EFKI it was 34,4 seconds. Even though these numbers are rather good, from the environmental point of view these numbers could be lower. What is not known is how high in the airspace these values were measured, although it could be concluded that most significant portion of level flight was above FL 75. This is shown especially in EFKI as a difference in values between 34,4 and 5,3 seconds, where the latter is below FL 75.

Noise CDO figures are shown in column Noise – Avg. level time < FL 75 (sec.). EFPO was 41,4 seconds whereas for EFKI it was 5,3 seconds. This would mean that the success rate for noise CDO was much higher for EFKI than for EFPO. That is clearly shown in the column CDO – ToD % where success rate for EFPO was 60,6 % where EFKI results in 92,2 %.

The parameters for Fuel and Noise CDO differ in terms of altitude window. Values in the Figure 14 are according to the European CDO Task Force recommendations. Finavia, however, measures the noise levels below 6000 feet with allowance for 2 NM level segment. Therefore, the numbers are not very comparable since the baseline is not the same.

6.8 Case study Pori (EFPO) vs. Kajaani (EFKI)

In the light of this comparison there is a conclusion, that these two databases produce different results when comparing number of flights, CDO % on all descents and average time spent on level segment in seconds. Figure 15 will show statistics for EFPO and EFKI based on the numbers in Figure 13. Focus is in the year 2023.

	EFPO	EFKI
Number of flights and descents	8810	7386
2024	120	93
2023	918	546
2022	1236	500
CDO % all descents	57 %	89 %
2024	37 %	83 %
2023	51 %	91 %
2022	60 %	84 %
Average time level all (sec)	172	41
2024	281	61
2023	210	37
2022	162	51

Source: Eurocontrol Dashboard 2024

Figure 15 2023 numbers for EFPO and EFKI

As shown in this Figure 16 there are significant informative differences between these two databases. Data is extracted from Figures 13 and 14.

2023	Excel database		Dashboard database	
	EFPO	EFKI	EFPO	EFKI
Flights / year	918	546	472	524
CDO % all descents	51	91	60,6	92,2
Average level flight in seconds	210	37	43,7	34,4

Figure 16 Database differences

The difference in numbers for flights per year could be partially explained by the type of aviation that is dominant for these airports. According to research, EFPO air traffic was consisted of training flights due to Suomen Ilmailuopisto, the largest aviation school in Finland and from scheduled airlink to Helsinki – Vantaa airport. At EFKI most of the air traffic was based on commuter operations to Helsinki-Vantaa airport. Still, these activities could not explain why these numbers from two different databases differ this way.

The CDO percentage at EFPO airport suggests that the procedure was not the focus on the flight operations whereas at EFKI airport the percentage was consistent according to both databases. This could be explained with the type of air traffic, where today's commercial aircraft operators

have understood the importance of CDO as an environmentally beneficiary and a source for fuel savings. The fact that only one domestic operator was flying most commercial flights to EFKI could imply that the company culture emphasizes CDO as a preferable procedure.

As the level segment is the most followed criteria set forth by Eurocontrol CDO Task Force on measuring the success of CDO, the difference on the results between these two databases was noticeable as shown in Figure 16, especially at EFPO airport. Considering the parameters explained in the Theory section, according to these findings, these discrepancies between two databases could bring more uncertainty for the measurement procedures of CDO.

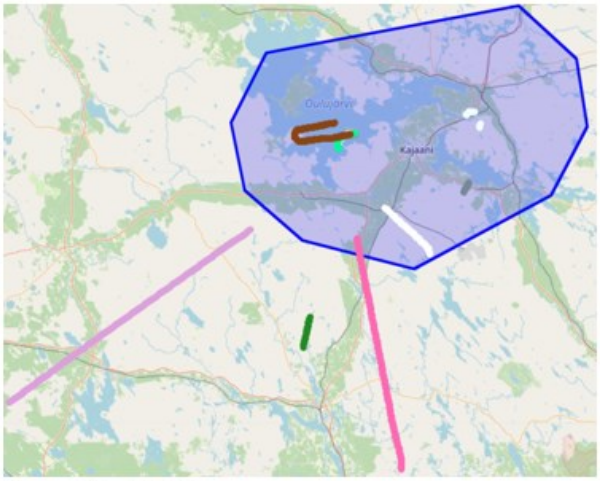
These discrepancies should be solved so that Fintraffic ANS among other instances would have a thorough understanding on the phenomenon behind the numbers and realisation if the data is useful in the reconstruction of airspace. Uniformity and transparency on databases should be formed for them to be easily understood and used as a guidance to future measurements. Furthermore, it should be considered if the CDO percentage is the right metering tool for measuring successful environmentally sustainable descending approach and can the suggested parameters by Eurocontrol CDO Task Force used for measurement. This factor could be researched in the future in more detailed fashion.

Since noise abatement and environmental questions are strong contributors for Fintraffic ANS today and in future planning of flight procedures, a solid base would be needed from the authorities so that the aviation infrastructure could be set in the right direction permanently.

6.9 Fintraffic ANS as a data provider

Fintraffic ANS is currently developing their own procedure for more detailed analyses of CDO in Finnish airspace which will follow the parameters given by Eurocontrol CDO Task Force. Figure 17 offers an example of the graphical content manufactured from the data. Since the system is under construction, following data is incomplete and holds no official status.

Figure 17 presents Fintraffic ANS data and Figure 18 is the same data from Eurocontrol Dashboard. Both represent timeframe 01.01.2024 – 30.06.2024 for Kajaani (EFKI) airport.



Source: Fintraffic 2024

Figure 17 Data from Fintraffic

Airport label	Descents	Tot. level time (min)	FUEL – Avg. level time ToD (sec.)	CDO – ToD %	Noise – Avg. level time < FL 75 (sec.)	% CDO FL 75
Kajaani (EFKI)	255	136	32,1	89,4	16,5	92,9

Source: Eurocontrol Dashboard 2024

Figure 18 Data from Eurocontrol

In Figure 17 different colours represent level segments with different time values which then are calculated into percentage. Radar tracking has begun 100 NM before the airport and measuring scope was from ToD to 3000 ft. Total flights tracked was 182.

Fintraffic ANS uses in house developed software to create images on the map shown in Figure 17. This kind of visual presentation aids on perceiving the situation better. The aim is to focus on the phenomenon behind the data. As mentioned before, Fintraffic ANS data is incomplete regarding the number of Descents by few operations, so the content is not fully comparable with Eurocontrol Dashboard data shown in Figure 18. However, the result for CDO – ToD % for this timeframe according to Fintraffic ANS data was 87 % where Eurocontrol Dashboard offers 89,4 % for the same period.

7 Conclusion

Continuous Descent Operation is a procedure which is a tool that help solving environmental issues to satisfy aviation needs and transition to sustainability. It is also a measure of success when fulfilling the parameters set by Eurocontrol CDO Task Force. However, the announced CDO percentage should not be an intrinsic value especially when there are different parameters between states on measuring the success of CDO. Further consideration should be done on the CDO parameter values to compensate for level segments which would be induced by weather phenomenon, airspace structure, flight crew, holding procedure, and flight technical reasons.

This research has considered the Finnish network airports, where the average air traffic flow was considered compared to Helsinki-Vantaa airport. Therefore, the CDO success rate should have been higher, which it was not since a single flight could affect the CDO success figures substantially. From these numbers one should be careful when interpreting them and not to make fast conclusions without understanding all the phenomenon behind the data. The parameters measuring success of CDO should be reconsidered and made more transparent for the stakeholders to understand.

Fintraffic ANS among other European ANS's gather information processed by NM on calculating the success of CDO. However, this information is one-sided, therefore aircraft operators should engage on study on their own CDO performance and make sure their ADS-B information is accessible for ATC through modern equipment to improve the quality of data. Data gathered by surveillance system is valid, but ADS-B data consists of less background noise, raising the quality of data higher.

The results of this research will be used as a tool for improving the services delivered by Fintraffic ANS. The reasons for incapacitation of CDO described in chapter 6.1 cannot be corrected by actions performed by Fintraffic ANS, they can only improve the airspace as an environment that will enable the use of CDO effectively. According to Fintraffic ANS values, they want to create the most environmentally friendly environment in the world which would enhance the possibilities for CDO performance to be better.

Level segment parameters could be researched more to see, if there would be reasons to widen the variety of resulting factors as a critical factor to CDO measurements and implement their effects into results so that they could be analysed more comprehensively.

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