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Investigation of Point Merge Utilization Worldwide Using Opensky Network Data

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Abstract

Point Merge (PM) arrival procedure is implemented at multiple airports around the World. There are different PM design variants: with overlapping, partially overlapping or separated sequencing legs, a position of the sequencing legs inside or outside the TMA, different geometry of the flows to PM or merging to a point; each coming with a different impact on the trade-offs associated with the structure. In this work, we investigate the usage of PM procedures in several airports around the globe using open-access ADS-B-based data provided by the OpenSky Network. We analyse arrival flows at the airports with PM, and propose a catchment algorithm to see which flights from the blend are actually adherent to the procedure. Then quantify the PM utilization by applying the performance indicators specifically designed for this purpose.

Keywords: Arrival procedures, Key Performance Indicators; Point Merge; TMA

Abbreviations: ATM: Air Traffic Management, CDOs: Continuous Descent Operations, EGLC: London City Airport, EIDW: Dublin Airport, ENBR: Bergen Airport, ENGM: Oslo Gardermoen Airport, KPIs: Key Performance Indicators, PM: Point Merge, RKSI: South Korea Seoul Incheon Airport, SKBO: Bogotá El Dorado Airport, TMA: Terminal Maneuvering Area, ULLI: St. Petersburg Pulkovo Airport

1. Introduction

The Point Merge procedure was developed in 2006 by the EUROCONTROL Experimental Centre (EEC). The main goal of PM development was to facilitate more environmentally efficient arrivals, including Continuous Descent Operations (CDOs) and noise reduction [1, 2, 3]. Since the development of the PM procedure, many airports implemented and started using it. There are a number of variants of the PM system implementation such as overlapping, partially overlapping, or separated sequencing legs. The positioning of the PM system and different geometry of the flows to PM or merging to a point also differs among airports based on their design goals. The authors of [4] proposed a data-driven computer vision approach for identification of the PM structures in the large datasets containing historical flight tracks. In [5] the authors analyzed arrival trajectories of five major European airports to assess the inefficiencies associated with holding patterns, PM, and CDOs. To detect the trajectories adhering to PM systems at different airports, the authors relied on the method implemented in the *traffic* library [6]. In our previous work [7], we investigated PM usage and utilization at Oslo Gardermoen airport, and we concluded that the PM systems are significantly underutilized. In this work, we enhance our PM catchment algorithm, applying it to analyse the PMs at other airports worldwide, and evaluate the overall usage and utilization of the PM systems.

2. Methodology

In this section, we present the methodology used for our investigation. We describe the airports chosen for the studies, the data, the catching algorithm and then the KPIs used for PM evaluation.

2.1 Airports

We investigate the PM procedure usage and utilization at several airports. According to Eurocontrol [8], Point Merge is now operational for 38 airports through 19 countries and 4 continents. In this work, we consider the following airports: London-City Airport (United Kingdom, Europe), Dublin (Ireland, Europe), Bergen (Norway, Europe), Oslo Gardermoen (Norway, Europe), Bogotá El Dorado (Colombia, South America), Seoul-Incheon airport (South Korea, Asia), and Pulkovo Airport St. Petersburg (Russia, Euro-Asia). Figure 1 shows example PM charts for the seven airports (please, note that the figure displays one example PM system per airport, not all the PM systems).

London City handled 49.000 movements in 2022 and has operated with PM since 2016. The PM procedures consist of two overlapping arcs, used for both directions of the airport's single runway.

Dublin is currently the only Irish airport operating with PM. The procedures were introduced in 2012 to its 10/28 runway, with fully overlapping legs to runway 28 and fully dissociated legs to runway 10. Since August 2022, the airport has operated with a second parallel runway. In 2022 the airport facilitated 242.000 movements.

Bergen airport has operated with PM to its single runway since 2014, and had 82.000 movements in 2022. There are two fully dissociated arcs for each runway direction.

Oslo-Gardermoen implemented PM in 2011 to both of its parallel runways, and it is the busiest airport in Norway, handling 163.000 movements in 2022. The PM procedures are of the overlapping type, where aircraft may be vertically separated on the arcs.

The first South American airport to implement PM (since 2017) is Bogotá El Dorado airport, which features three fully dissociated systems serving the two parallel runways. In 2022, the airport handled 297.000 movements.

Seoul Incheon Airport in South Korea has operated with PM since 2012. It handled 94.000 movements in 2022. The arrival procedures consist of a mix of PM and trombone structures.

The Russian airport of Pulkovo operates with four dissociated PM systems connected to its two parallel runways. At the airport, which handled 41.000 arrivals in 2022, PM has been used since 2017.

Table 1. Investigated Airports

ICAO	Airport name	# of PM systems	Point Merge types	Runways	Movements 2022
EGLC	London City	One	Overlapping arcs	Single runway	49.000
EIDW	Dublin airport	Two	Both types	Two runways	242.000
ENBR	Bergen airport	Two	Dissociated arcs	Single runway	82.000
ENGM	Oslo Gardermoen	Four	Overlapping arcs	Two parallel	163.000
RKSI	Seoul Incheon	One	Overlapping arcs	Four runways	94.000
SKBO	Bogotá El Dorado	One	Overlapping arcs	Two runways	297.000
ULLI	St. Petersburg Pulkovo	Two	Overlapping arcs	Two parallel	41.000

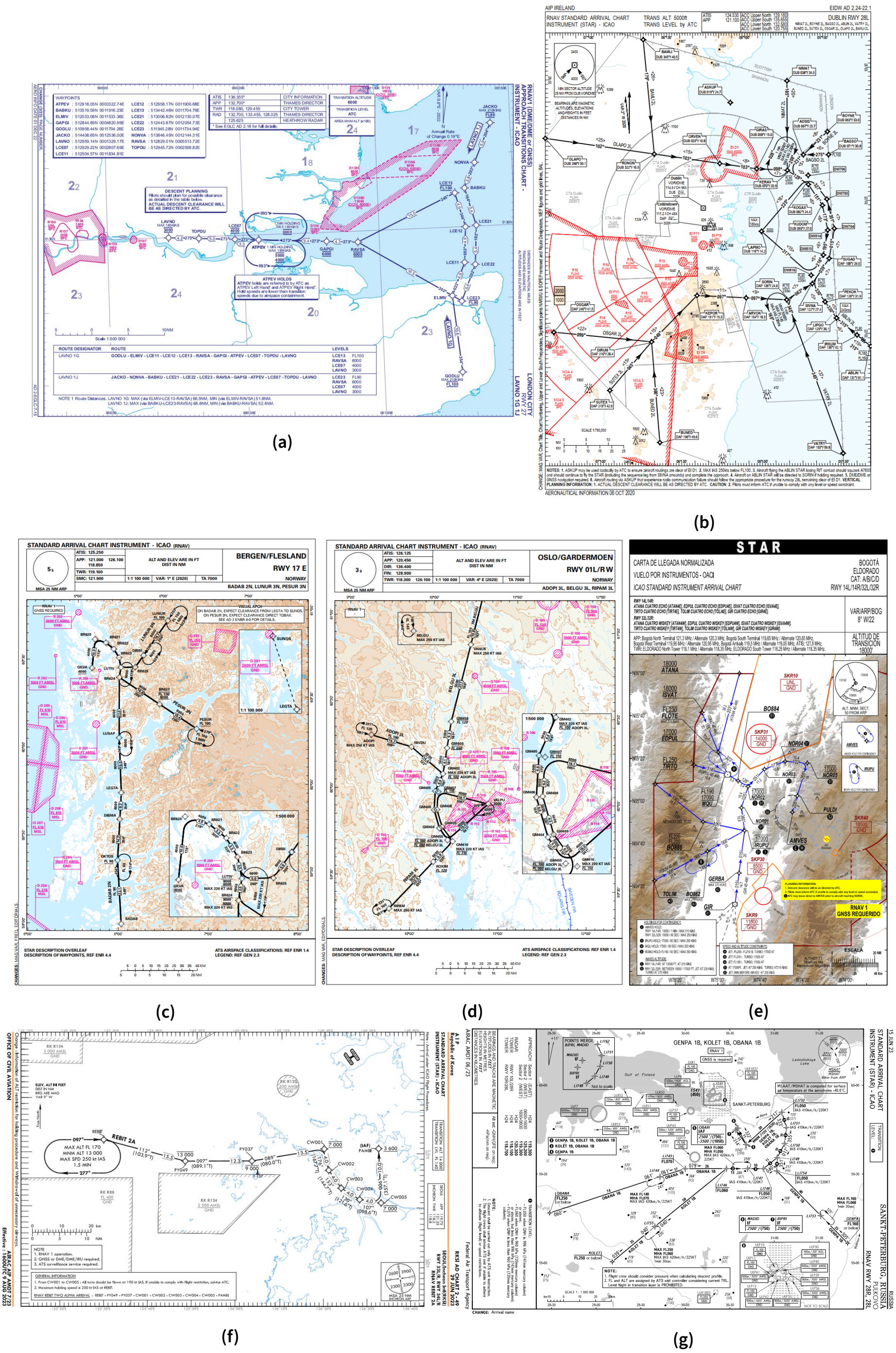


Figure 1. Example PM charts for the airports of London-City (a), Dublin (b), Bergen (c), Oslo-Gardermoen (d), Bogotá El Dorado (e), Seoul-Incheon (f) and St. Petersburg-Pulkovo (g).
Sources: State AIPs of the respective countries [9] [10] [11] [12] [13] [14].

2.2 Data

The historical flight data is provided by the Opensky Network [15]. The database contains geographical flight trajectory data granulated by one second in the form of state vectors. The data is transmitted by the Automatic Dependent Surveillance-Broadcast (ADS-B) aircraft transponders, and collected via sensors on the ground, supported by volunteers, industrial supporters, and academic or governmental organizations. Due to the non-reliable nature of the data transmission technology and collection technique, the raw data may be incomplete and contain erroneous records.

We apply multiple cleaning procedures to each dataset. First, we detect inconsistencies in the latitudes and longitudes and remove the fluctuations. Then, we apply the Gaussian filter to smooth altitude fluctuations and remove all incomplete or damaged trajectories including outliers such as go-arounds, flights which do not land on the runway, flights with departure and arrival at the same airports (mostly helicopters), most non-commercial flights. For the airports where it was needed, we divided the flight trajectories into smaller data subsets according to which runway they landed on. To achieve that, we detected the last 30 seconds before reaching zero altitude for each flight, calculated the azimuth of the trajectory and assigned the flight to the corresponding runway based on the azimuth of the runway and heading of the flight in the last 30 seconds before landing.

For each airport, we study one month of data for the year 2022, which was the year when the air traffic started recovering from the COVID-19 pandemic levels at most airports. We chose the busiest month of the year 2022 for each of the airports (see Table 2).

Table 2. Investigated Busiest Months in 2022

Airport ICAO	Country	City	Month	Arrivals (Opensky)
EGLC	United Kingdom	London City	June	2030 flights
EIDW	Ireland	Dublin	July	8648 flights
ENBR	Norway	Bergen	October	3464 flights
ENGM	Norway	Oslo Gardermoen	October	7788 flights
RKSI	South Korea	Seoul Incheon	December	1419 flights
SKBO	Colombia	Bogotá El Dorado	December	8989 flights
ULLI	Russia	St. Petersburg Pulkovo	August	6761 flights

2.3 KPIs

In this subsection, we present the PM utilization and PM usage performance indicators. They were designed specifically for this kind of study and first described in [7].

2.3.1 PM Usage

We define the **PM usage** by identifying the flights which adhere to the PM procedures, and calculating the proportion of these flights in the given dataset. The PM usage indicates how often is the PM procedure used during the period of consideration.

2.3.2 PM Utilization

We define **PM Utilization** to evaluate what part of the PM sequencing legs is utilized by the flights. The PM Utilization metric indicates the proportion of the length of the PM sequencing leg flown by the arriving aircraft to the full length of the corresponding PM sequencing leg, in percent. To estimate this, we measure the distance along the sequencing leg from the starting point to the point, when the aircraft was directed to turn towards the merge point and proceeded to the final approach. We apply small circles of ≈3 NM around each waypoint on the sequencing legs of each PM system to capture that (red and green circles in Figure 2). We chose the **PM Utilization** metric to capture the proportion of the arc utilized regardless of the actual distance flown along the sequencing leg as the distances between the waypoints differ among airports, and also among different PM systems in the same airport.

2.4 Catchment Algorithm

The Point Merge systems can have different configurations, and hence, the catchment algorithm which we use for identifying the flights adherent to the PM structures, has to be modified and fine-tuned for each airport individually. The idea is to consider a set of circular areas with a radius of about 3 NM around the starting points of the PM sequencing legs and filter out all aircraft which did not pass through these areas. Figure 2 illustrates the technique applied to the North-Eastern part of the PM system at Oslo Gardermoen airport. The red circles representing the catchment areas are positioned around *GM*418 and *GM*423 waypoints which are the beginnings of PM legs. Colored curves in the figure illustrate the example flight trajectories performing the PM procedure captured by the proposed technique. We choose the smallest radius of the circle which enables identification of all the PM flights.

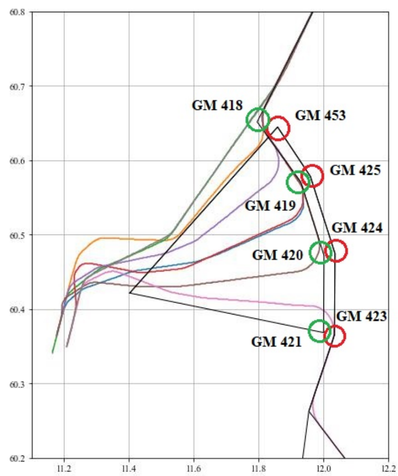


Figure 2. Example PM system at Oslo Gardermoen airport - North-Eastern part, with red and green circles around the waypoints along the sequencing legs, used for the calculation of the PM utilization KPI.

Since the airports in our selection implemented various configurations of the Point Merge system into their arrival routes, we have to identify the catching areas for each airport separately.

Figures 3 - (a-h) show trajectories of the flights adherent to the example PM system for each of the studied airports. The trajectories not identified as adherent to the PM system are analyzed separately and are not reflected in these figures.

The arrival flights to London City Airport (EGLC) often cross the PM system arcs, even when they don't perform the PM procedure itself. Because of that, we aim to detect the flights already in STARs preceding the actual start of the sequencing legs. This way we consider only the flights which passed both the waypoint in the STAR: *NONVA* and *GODLU* waypoints marked with blue circles in Figure 3-(a) and the one at the start of the corresponding PM sequencing leg *BABKU* and *ELMIV* marked with red circle in Figure 3-(a).

Dublin Airport (EIDW) operates two different PM systems. We detect flights performing the Eastern PM procedure by allocating catchment circle areas around the first waypoints *SIVNA and KOGAX*,

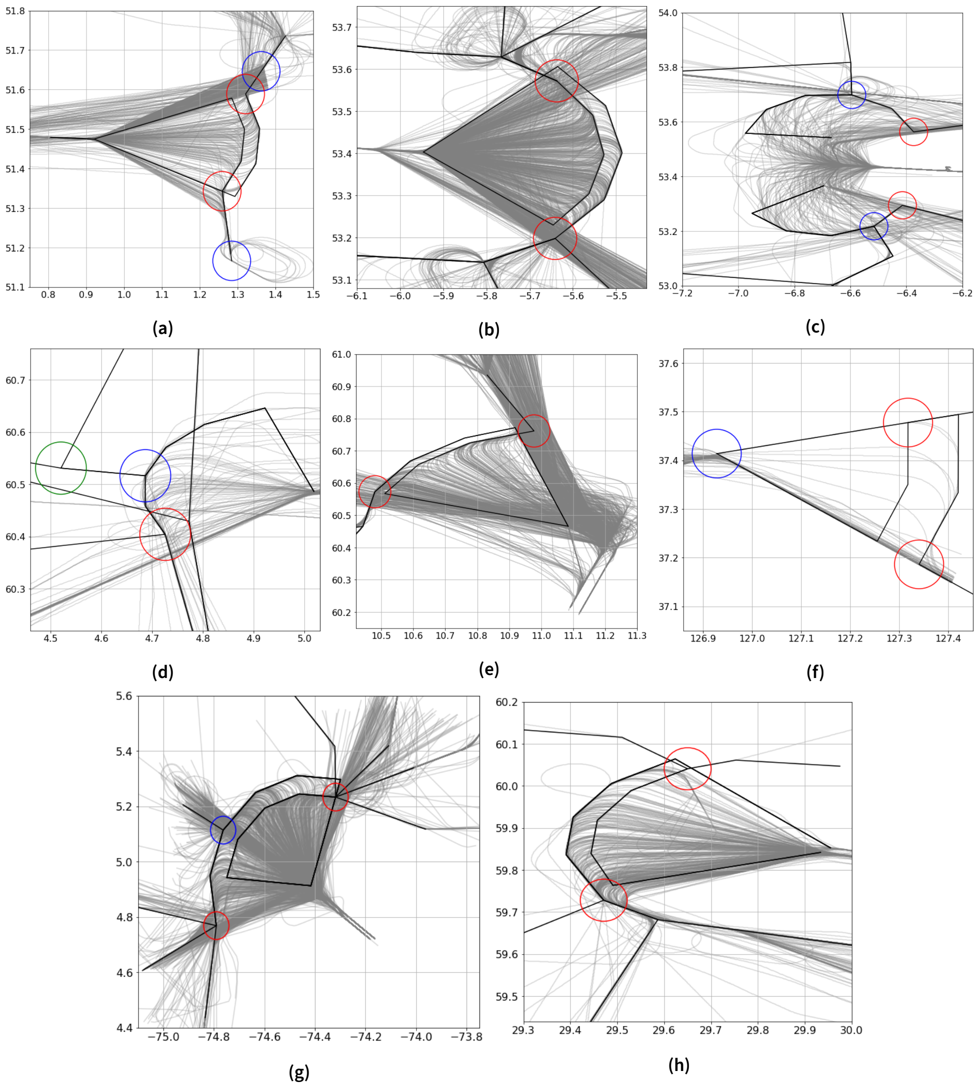


Figure 3. Point Merge flights captured by the catchment algorithm for: a) London-City (June), b) Dublin East (second week of July), C) Dublin West (fourth week of July), d) Bergen North-West (October), e) Oslo-Gardermoen North-West (October), f) Seoul-Incheon (December), g) Bogotá El Dorado (second week of December), h) St. Petersburg-Pulkovo South-East (August).

marked with a red circle, on the sequencing legs from each direction. We apply the same technique to the Western PM system, using the *ASDER* and *BERMO* waypoints, also marked with red circles. To accommodate the inbound traffic inside the arcs, we also consider flights joining the sequencing legs in *BABON* and *ADNAL* waypoints, marked with blue circles (Figures 3 - b, c).

Bergen Airport (ENBR) implemented two PM systems with fully dissociated sequencing legs. For each of the four PM parts, we assign a catchment circle area around the first waypoint on the PM arc (*BR634, BR624, BR724, BR734*, marked with red color,) for NW, NE, SW, SE Point Merge part respectively. Each of them allows for inbound traffic to one of the waypoints on the sequencing leg. To catch only the flights performing PM and not the ones which just pass the waypoint on their way directly to the runway, we assign circular catchment areas to both, the waypoint receiving the inbound traffic and the preceding one along the route: *BR*635 and *IRLOB* for NW, *BR*625 and *LUTIV* for NE, *BR*725 and *IBLIR* for SW, and *BR*735 and *RATUG* for SE Point Merge system (Figure 3 - d). The *IRLOB*, *LUTIV*, *IBLIR*, and *RATUG* waypoints are marked with blue circles and the waypoints *BR*635, *BR*625, *BR*725, and *BR*735 are marked with green circles.

In Oslo Gardermoen airport (ENGM), we consider the following waypoints of the North-Western to South-Eastern PM systems: *GM429, GM432, GM418, GM423, GM405, GM410, GM416, and GM411*, marked with red circles. Figure 3 - (e) illustrates the results of the PM catchment algorithm for the North-Western PM system.

South Korean Incheon Airport (RKSI) implemented Eastern and Western parts of the PM systems. In this work, we investigate only the Eastern PM part of the system for RKSI, as for the other (Western PM) the utilization of the Western part is negligibly low. The first waypoints of each sequencing leg with the catchment area around them are *NODUN* and *UPSOM*, marked with red circle, for Southern and Northern parts respectively, we consider also *ANYANG*, marked with blue circle, to filter out arrival flights which pass *NODUN* or *UPSOM* but then turn directly towards the runway and miss the merge point (Figure 3 - f).

Colombian airport (SKBO) operates one PM system with overlapping sequencing legs. To identify the flights performing the PM procedures, we allocate catchment area circles around *PAPET and IRUPU* waypoints, marked with red circles. We also add traffic incoming to the Point Merge in *NOR*02 waypoint, marked with a blue circle. The result of the PM identification is illustrated in Figure 3 - (g).

For the two PM systems at St. Petersburg airport (ULLI), we use the waypoints *LI739, LI760, LI725, and LI748*, marked with red circles, for NW, NE, SW, and SE PM parts respectively. The additional inbound traffic to Eastern parts of PM is also covered by *LI*761 for NE and *LI*749 for SE which are marked with blue circles, as shown in Figure 3 - (h).

2.4.1 Correctness Check

We check the correctness of the proposed algorithm by visual observation. For that, we plot non-PM trajectories (the ones which are left in the full dataset after we remove the PM flights) together with the procedures for the corresponding airport, and check how many flights performing the PM were not identified as such. Figure 4 illustrates several examples of the non-PM figures used for the correctness check. We also calculate the false-positive flights, the ones which were identified as PM flights by the catchment algorithm, but in fact, did not perform the PM procedures. False-positive flights are often the ones which fly directly to the merge point without contributing to the traffic on the arcs but close enough to the catchment areas to be included in the PM datasets. Table 3 provides information about the quantity of the false-positive flights caught by the algorithm.

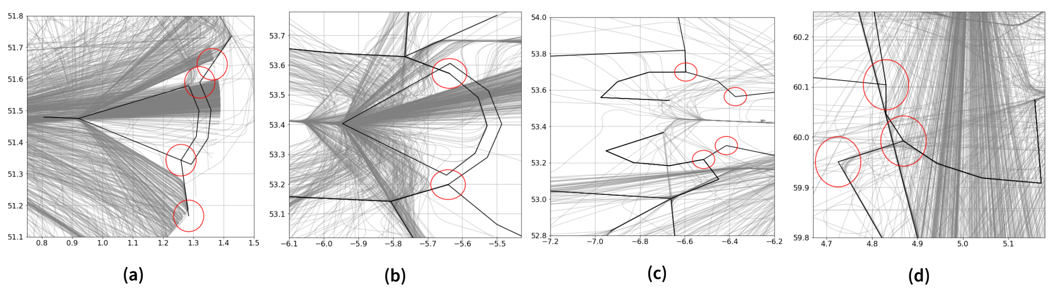


Figure 4. Example of the correctness check for: a) London-City (June), b) Dublin Eastern PM (second week of July), c) Dublin Western PM (fourth week of July), d) Bergen South-Western PM (October).

3. Experimental Results

In this section, we present the results of our investigations, i.e. calculate and compare the usage and utilization of the PM systems at seven airports around the globe.

3.1 PM Usage

We evaluate the PM usage for each airport and present the results in Table 4. We conclude that the PM systems are used by about 34% of the flights in average over the airports in the study, with the maximum observed at Bogotá El Dorado (67%), and also high in Dublin (51%). The PM systems are not used that often in RKSI (9%) and ENBR (16%). Additionally, we discovered that most of the airports do not use the PM sequencing legs evenly, some sequencing legs are used with higher frequency. In Table 5 we display the percentage of usage of the different sequencing legs from the PM datasets for each airport.

Table 3. Number of PM and False-Positive Flights Classified as PM by the Catchment Algorithm

Airport ICAO	Number of all flights	Number of PM flights	Number of false-positive flights
EGLC	2030	476	2
EIDW	8648	4685	108
ENBR	3464	556	71
ENGM	7788	1900	15
RKSI	1419	137	16
SKBO	8989	6051	262
ULLI	6462	1960	39

Table 4. PM Usage

Airport ICAO	Number of PM flights	Number of all flights	PM usage
EGLC	476	2030	23.6%
EIDW	4685	8648	51.2%
ENBR	556	3464	16.1%
ENGM	1900	7788	24.4%
RKSI	137	1419	9.65%
SKBO	6051	8989	67.3%
ULLI	1960	6462	30.3%

Table 5. PM Usage Based on Sequencing Legs (in % of PM Flights)

Airport	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5	Leg 6	Leg 7	Leg 8
EGLC	North (80%)	South (20%)						
EIDW	NW (12%)	SW (8%)	NE(38%)	SE (42%)				
ENBR	NW (69%)	SW (2%)	NE (22%)	SE (7%)				
ENGM	NW1 (27%)	NW2 (8%)	SW1 (8%)	SW2 (24%)	NE1 (5%)	NE2 (4%)	SE1 (3%)	SE2 (21%)
RKSI	North (0%)	South (100%)						
SKBO	West (70%)	East (30%)						
ULLI	NW (38%)	SW (30%)	NE (17%)	SE (15%)				

Table 6. PM Utilization EGLC

Airport ICAO	PM system	Only start	One-third	Two-thirds	Full arc
EGLC	North	76.3%	14.2%	6.4%	3.2%
EGLC	South	61.5%	25%	9.4%	4.2%
EGLC	All PM	73.3%	16.4%	6.9%	3.4%

Table 7. PM Utilization EIDW

Airport ICAO	PM system	Only start	One-quarter	Half	Three-quarters	Full arc	
EIDW	South-West	38.6%	28.2%	14%	15.4%	3.9%	
EIDW	East	57.4%	18.9%	13.8%	7.7%	2.3%	
EIDW	SW and E	55.8%	19.7%	13.8%	8.3%	2.5%	
Airport ICAO	PM system	Only start	20%	40%	60%	80%	Full arc
EIDW	North-West	34.9%	44%	7.7%	5.6%	6.2%	1.8%

Table 8. PM Utilization ENBR

Airport ICAO	PM system	Only start	20%	40%	60%	80%	Full arc
ENBR	North-West	22%	23%	45.5%	5.2%	1.3%	3.1%
ENBR	North-East	16.1%	24.2%	25.8%	14.5%	9.7%	9.7%
ENBR	South-West	55.6%	22.2%	22.2%	0%	0%	0%
ENBR	South-East	68.3%	9.8%	12.2%	2.4%	7.3%	0%
ENBR	All PM	24.6%	22.3%	38.3%	7%	3.6%	4.3%

Table 9. PM Utilization ENGM

Radius 0.05 (3 NM)					
Airport ICAO	PM system	Only start	One-third	Two-thirds	Full arc
ENGM	North-West	72.1%	13.8%	1.8%	12.3%
ENGM	North-East	69.7%	26.9%	2.3%	1.1%
ENGM	South-West	88.7%	8.7%	1.8%	0.8%
ENGM	south-East	90.3%	5.4%	1.6%	2.7%
ENGM	All PM	81.4%	11.4%	1.8%	5.4%
Radius 0.03 (1.8 NM)					
ENGM	North-West	71.7%	12.2%	1.8%	14.3%
ENGM	North-East	69.5%	26.7%	3.8%	0%
ENGM	South-West	87.2%	10.3%	2.3%	0.2%
ENGM	South-East	91.4%	4.2%	1.8%	2.7%
ENGM	All PM	81.5%	10.1%	2.1%	5.4%

Table 10. PM Utilization RKSI

Airport ICAO	PM system	Only start	Half	Full arc
RKSI	North	0%	0%	0%
RKSI	South	96.4%	2.9%	0.7%

3.2 PM Utilization

We summarize the results obtained for PM utilization in Tables 6, 7, 8, 9, 10, 11, 12 for EGLC, EIDW, ENBR, ENGM, RKSI, SKBO, and ULLI airports, respectively. EIDW, RKSI, and SKBO airports tables contain two different granulation of the results which is caused by the fact that the PM systems at these airports are not unified and each PM system, or even each sequencing leg of one PM system (EIDW and SKBO), operates with different number of waypoints along the sequencing leg. And since we apply the catchment areas around the waypoints, the way how the sequencing legs are partitioned differ between the PMs. We include a summarizing row *All PM*, to the tables where it is suitable, which gives information about the overall PM Utilization performance of that airport. In the 'all PM' row, the PM Utilization values are calculated based on the accumulated values from each of the contributing sequencing legs. The calculations are based on all the trajectories passing each segment regardless of the sequencing leg location and then we calculate the percentage from that.

We conclude that most of the airports do not utilize the full capacity of their Point Merge systems, i.e. rarely use the whole length of the sequencing legs to provide the aircraft separation and sequencing. ULLI has the highest proportion of the flights which reached to the final turning point of the corresponding sequencing leg. RKSI and ENGM are the airports with the highest proportion of the flights which turn towards the Merge Point directly after entering the PM system.

The comparative results for the PM Utilization at different airports are illustrated in Figure 5 with a cumulative function showing the percentage of flights utilizing up to a certain percent/portion of the PM arc. The utilization curves for all airports follow similar shape, i.e. very steep descent until approximately 30% of the PM arcs length, with very small utilization values for the rest. Except Bergen airport, most flights leave the PM arcs before they reach 50% of their lengths.

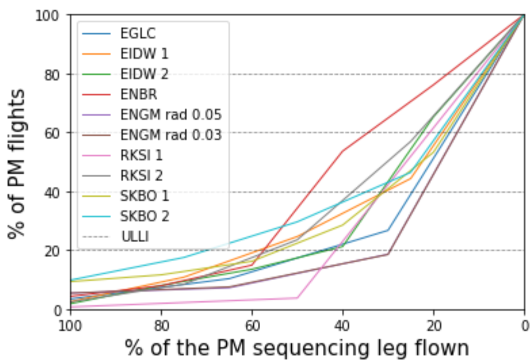


Figure 5. Cumulative PM utilization of the seven airports in the study.

3.2.1 Sensitivity Analysis

We conduct an initial analysis of the sensitivity of our algorithm to the radius of the catchment area circle. For that, we analyze the PM and non-PM flight trajectories for ENGM airport, applying

Table 11. PM Utilization SKBO

Airport ICAO	PM system	Only start	One-quarter	Half	Three-quarters	Full arc	
SKBO	East	43.1%	33.4%	15.1%	6%	2.4%	
Airport ICAO	PM system	Only start	20%	40%	60%	80%	Full arc
SKBO	West	46.8%	24.8%	12.3%	4.5%	2.4%	9.3%

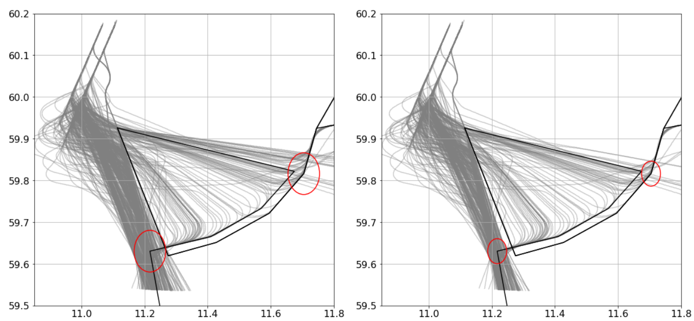
Table 12. PM Utilization ULLI

Airport ICAO	PM system	Only start	One-quarter	Half	Three-quarters	Full arc
ULLI	North-West	74.4%	9.2%	7%	4.6%	4.7%
ULLI	North-East	51.1%	16.7%	14.3%	6%	11.9%
ULLI	South-West	31.8%	24.3%	15.6%	11.4%	16.9%
ULLI	South-East	0%	39.6%	30.9%	18.1%	11.4%
ULLI	All PM	54.2%	16.5%	12%	7.5%	9.7%

the default 0.05 decimal degree (DD) radius which is around 3 NM and a smaller radius of 0.03 DD (approximately 1.8 NM). The number of flights identified as PM with a radius of 0.05 DD is 1900, while for a radius of 0.03 DD, we obtain 1355. The difference is illustrated in the example of the South-Eastern PM system in Figure 6 and the corresponding PM usage is provided in Table 13. A smaller radius of the circle enables filtering out more false-positive flights, which are the flights going directly to the merge point without entering the PM sequencing leg, but still passing near the start of it. Whether to attribute such flights to the PM system or not, is an open question, and has to be addressed in future work. The resulting PM utilization values for the two radii do not differ significantly (see Table 9). By increasing the radius, we lower the probability of missing the actual PM-adherent flights, but increasing the probability of the false positive ones. We leave the sensitivity analysis for all the airports in the study for future work as well.

Table 13. Sensitivity Analysis: PM Usage at Oslo Gardermoen Airport, South-Eastern Part

Radius	Number of PM flights	Number of all flights	PM usage
Radius 0.05 DD	1900	7788	24.4%
Radius 0.03 DD	1355	7788	17.4%



(a) (b)

Figure 6. Example of the sensitivity analysis performed for the South-Eastern PM system at Oslo-Gardermoen airport: a) Catchment area with the radius 0.05 DD b) Catchment area with radius 0.03 DD.

4. Conclusions and Future Work

In this work, we focused on the Point Merge arrival procedures implemented at seven airports around the globe. We proposed a catchment algorithm to create datasets containing the flights adherent to the PM arrival procedures for further analysis. We justified the correctness of the algorithms by analysing the flights identified as non-PM and confirmed that most of the flights were attributed correctly with minor exceptions. We tested the sensitivity of our algorithm to the changes in the radius of the catchment area circles, and concluded that this parameter should be fine-tuned for each particular airport setting. In future work we plan to enrich the algorithm by some additional criteria, such as, for example, considering the vertical profiles of the flights according to the PM flight levels.

Using the PM datasets for each airport, we calculated the PM usage and PM utilization metrics which were developed specifically for evaluation of the Point Merge procedures. The PM usage largely varies with with the average value of 34%. The PM Utilization results indicate that the capacity of the PM sequencing legs is underutilized at most of the airports in our studies, which indicates that the PM systems have a potential to accommodate higher traffic volumes in the future. The potential full utilization of the PM system arcs indicates traffic congestion. Furthermore, when the PM system arcs are utilized to the full extent frequently, it may indicate that the arrival capacity of the airport is not sufficient.

Author contributions

- Tatiana Polishchuk: Conceptualization, Methodology, Investigation, Paper Writing
- Lucie Smetanová: Data curation, Methodology, Implementation, Investigation, Paper Writing
- Henrik Hardell: Methodology, Investigation, Data curation

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Open data statement

The authors completely support the open access data initiative. The datasets created for these studies are provided in https://github.com/LucieSmetanova/Opensky_Syposium_2023.git. The provided repository contains source codes, datasets and instructions how to use them.

Reproducibility statement

Information on how to reproduce this research, including access to 1) source code related the research, 2) source code for the figures is provided in https://github.com/LucieSmetanova/Opensky_Syposium_2023.git.

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