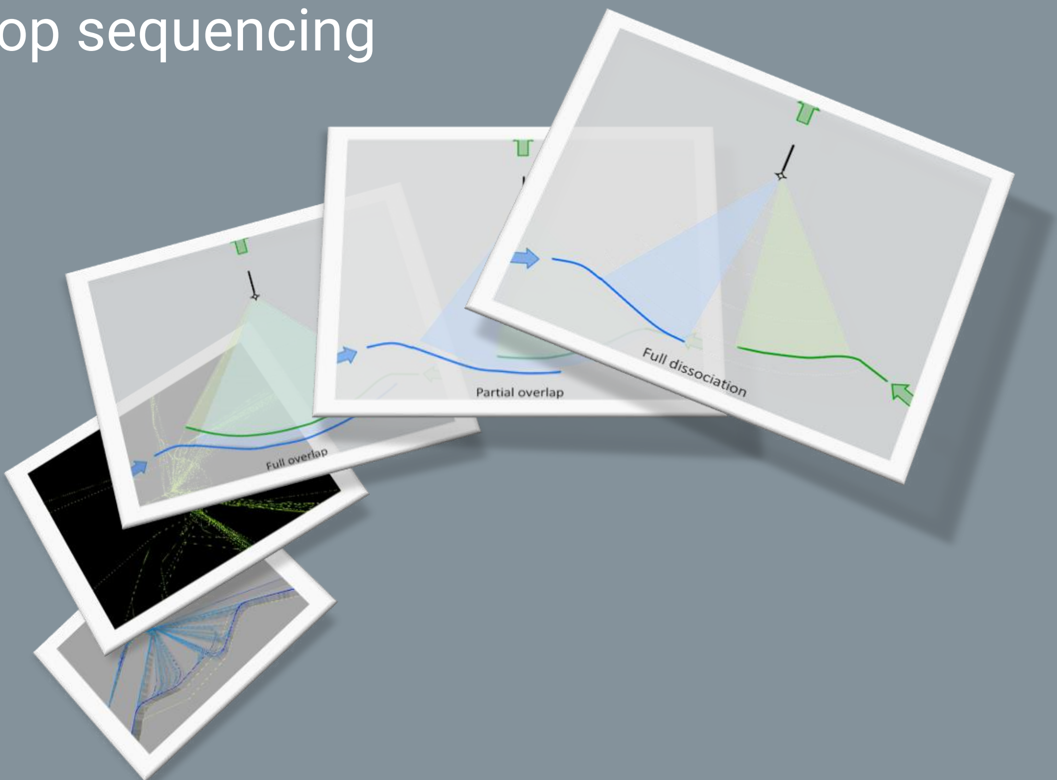
Point Merge implementation

A quick guide

Simplifying and enhancing arrival operations with closed loop sequencing



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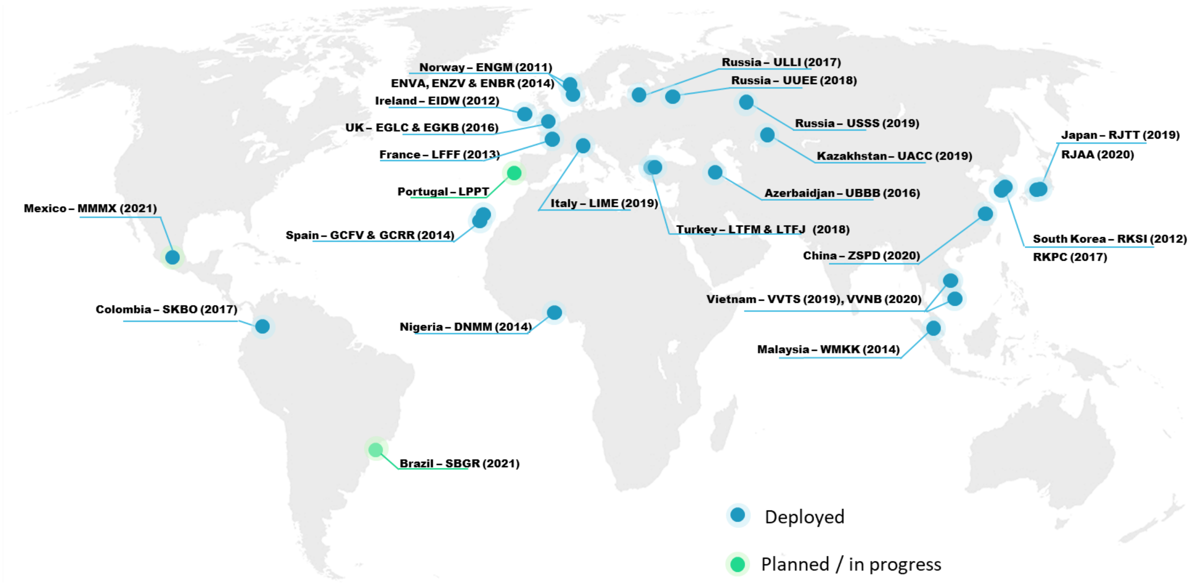
Foreword

The present document is intended as an introduction to Point Merge, providing an overview of the technique, its main principles, benefits/constraints and most salient implementation guidelines. It does however not replace EUROCONTROL’s Point Merge reference document [1], which the reader is referred to for more details.

What is Point Merge?

In 2006, as an outcome of its R&D activities, the EUROCONTROL Experimental Centre developed Point Merge, an innovative sequencing technique to simplify and enhance arrival operations. This technique allows controllers to sequence and merge arrivals without vectoring, while enabling continuous descent operations and maintaining runway throughput, even under high traffic. Unlike previous Performance Based Navigation (PBN) procedures in terminal areas, Point Merge has been conceived from a 'blank sheet', relying on modern navigation capabilities but also rethinking the nature of arrival sequencing.

After the first implementations in Oslo (2011) and Dublin (2012), the new method spread not only within the ECAC area, but also far beyond its borders. **As of May 2021, the procedure has been deployed in terminal areas around 30 airports across four continents**, including for instance: Istanbul, Tokyo, Mexico, Seoul, Moscow, Kuala Lumpur, Bogota, and London City. There are also plans for São Paulo and Lisbon. **Point Merge is now referenced by ICAO both as part of an aviation system block upgrade [2] and as a technique supporting Continuous Descent Operations [3].**



Why a new procedure?

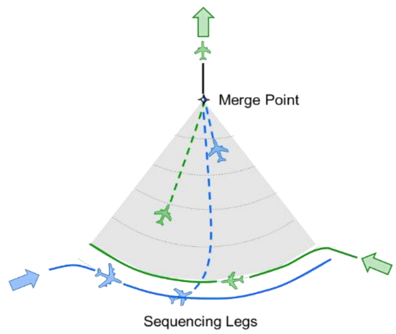
From the 1990s, Performance Based Navigation (PBN) procedures have been gradually introduced in some terminal areas to replace vectors prior to final approach. In medium to high-density airspace, where path stretching is required during traffic peaks for arrivals sequencing [4], the designs generally mimicked traditional vectoring patterns – typically trombone-shaped routes including a series of tactical waypoints. Such designs aim at providing high capacity and acceptability for controllers. However, experience has shown that when traffic rises, controllers tend to revert to tactical vectoring to join the final due to lack of flexibility. PBN arrival routes in terminal areas have therefore not brought in the past the full range of expected benefits especially in terms of predictability, flight efficiency and environmental impact.

How does it work?

The specific design uses a single point to merge arrivals. This differs from current techniques where traffic merges to the extended runway centreline. From the merge point, aircraft join the final approach via a fixed path. Before merging, a portion of the procedure (sequencing legs) is devoted to path stretching/delay absorption when necessary. Those legs are designed in the form of segments forming "quasi arcs" with equidistance from the merge point. Sequencing is achieved through a single *direct to* instruction issued to each aircraft along the legs, as soon as the required spacing with the preceding aircraft is obtained. When traffic permits, aircraft are cleared to the merge point without using the legs.

The determination of the sequence order and the appropriate times to issue the "direct to" instructions are extremely intuitive thanks to the predictable (monotonous) variation of inter-aircraft spacing. Simple distance markings on the controller's display (range rings centered on the merge point) are sufficient to support the operating method.

Pilots fly the procedure with lateral navigation engaged at all times (nominal conditions). Once on course to the merge point, the distance to go is known by on-board systems.



Design example with two parallel, vertically separated sequencing legs of opposite directions.

Aircraft can then achieve continuous descents from the legs level/altitude, only subject to speed adjustments to maintain spacing while on course to the merge point, and past it when joining final.

What are the main benefits?

Point Merge increases the general benefits brought by PBN in terminal areas, since it ensures continued adherence to the procedure, extensive use of lateral navigation, and support of continuous descent operations, even during peaks of traffic. Point Merge is also scalable: trade-offs between improvements in terms of capacity/throughput, safety, flight efficiency, and environmental impact can be adjusted through design options according to local requirements. In addition, the standardised nature of the technique benefits to controller training and staffing.

Workload, capacity and safety

From a controller's perspective, the structured method provides a clear air traffic picture. There is also a natural mapping with air traffic control tasks for arrivals, and in particular a dissociation between sequence building, sequence maintenance and interception of the final approach. As any PBN to xLS procedure, it also results in a standard intercept. Along with its simplicity and intuitiveness for controllers, Point Merge enables a **significant reduction in ATC tactical interventions, hence in controller's workload, R/T occupancy and communications task load.** Thanks to standardised and streamlined working methods, Point Merge also addresses controllers staffing and qualification, with a straightforward initial training.

From a pilot's perspective, Point Merge provides an improved situational awareness and reduced communications task load.

All of these features globally result in a safety increase.

In approach airspace, the procedure allows to maintain the runway throughput during longer periods and with high accuracy – with the potential to match future runway capacity increases. It also maintains, and possibly increases terminal airspace capacity (thanks to the reduction in controller's workload and R/T occupancy). Upstream, in en-route terminal sectors, it has the potential to increase capacity.

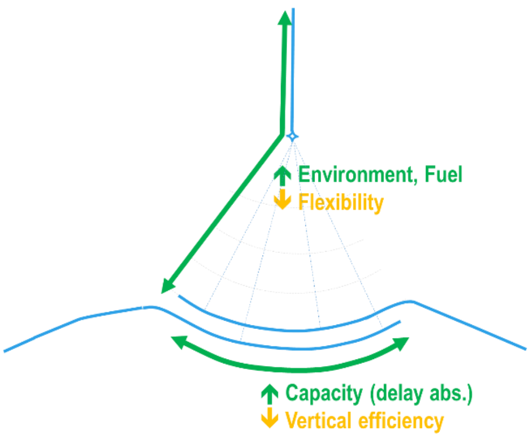
Environmental impact and flight efficiency

Point Merge offers both the path stretching capability required to build the sequence in dense terminal areas, and, once aircraft are directed to the merge point, the necessary predictability to support continuous descent operations [2] [3], resulting in a reduced environmental impact and improved flight efficiency.

In terminal areas, the **containment of arrival trajectories especially at low altitudes** allows controlling the 2D footprint and optimising it with respect to noise impact in densely populated areas. It also enables a **better flow segregation** – including departures, which may in turn facilitate Continuous Climb Operations (CCOs), and/or be adapted to complex terminal areas with multiple airports.

Trade-offs

While a single procedure cannot provide simultaneously maximum benefits in all performance areas, **Point Merge offers a scalable design with a clear trade-off between key performance areas, allowing procedure designers to reflect local needs**. For instance, increasing the distance between the sequencing legs and the merge point (and further down to final) results in a longer portion of the trajectory flyable as a continuous descent, with environmental and fuel efficiency benefits. On the other hand, this also reduces the flexibility to cope with gaps in the runway sequence and maintain the runway throughput in case of e.g. go-arounds. Increasing the length of the sequencing legs provides a larger capacity (delay absorption) – but results in longer restrictions in the vertical profiles – although still enabling continuous descents in high traffic conditions - once on course to the merge point. Design variants (see below) such as parallel legs with overlap or dissociated legs also provide different trade-offs between capacity and environmental impact/fuel efficiency.



Is any new equipment required?

Point Merge usually relies on existing technology on-board aircraft such as RNAV1 navigation specification. More stringent navigation specifications (RNP x) may be used if deemed necessary depending on local/specific requirements (e.g. airspace complexity, terrain clearance, runway spacing in case of independent parallel approaches, etc...).

Similarly no new specific ground tool nor system is required. Simple visual markings on the controllers display (e.g. range rings centered on the merge point) adequately support the operating method.

Where is it applicable?

Point Merge was initially thought as a sequencing and merging arrival procedure in approach sectors, feeding a single runway. Since its inception, studies and implementation experience

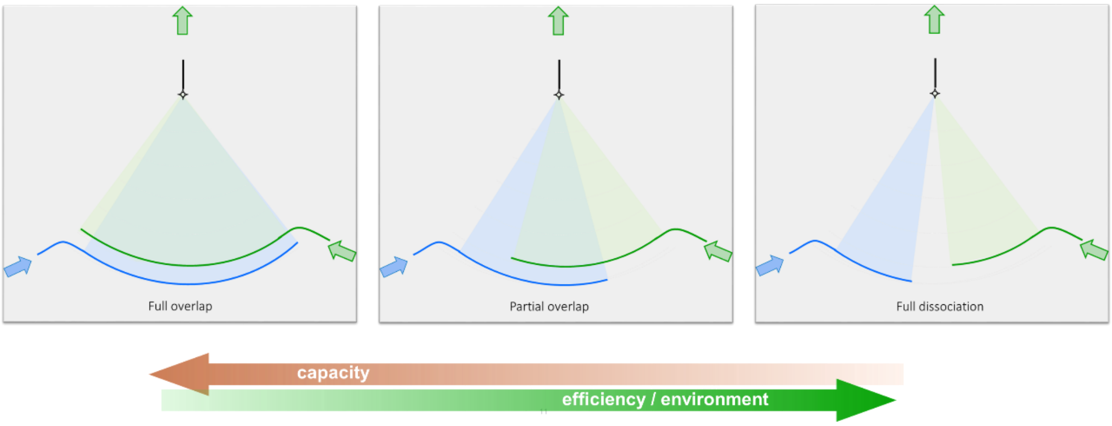
have expanded its usage to a broad variety of environments in and around terminal areas with medium-to-high density/complexity:

- terminal area, sequencing and merging arrivals towards a single runway in segregated or mixed mode operations [5] [6] [7],
- terminal area, sequencing and merging arrivals towards parallel runways [8] [10],
- terminal sectors in an En-Route control centre, pre-sequencing of arrivals towards TMA entry points supported by an arrival manager (AMAN) [11].

A Point Merge procedure in the initial/intermediate approach can be followed by a precision approach procedure (e.g. ILS), or an RNAV approach. In addition, Point Merge can be considered/combined with other concepts and improvements such as RECAT (wake turbulence re-categorisations), or TBS (time-based separation).

Main variants and options

Relative positioning of sequencing legs: subject to capacity requirements and/or specific constraints, sequencing legs may be parallel (fully overlapping), fully dissociated or with a partial overlap. This is the most important option impacting vertical performances. Fully or partially overlapping legs are generally associated with larger delay absorption capacity but require level-off segments to be vertically separated. Dissociated sequencing legs typically either use more airspace horizontally or provide less path stretching capacity, but allow for less vertical constraints hence improved vertical profiles. **Ultimately, shorter and dissociated legs, whenever possible and supported in particular by an adequate upstream metering, pave the way towards the application of full CDOs.**

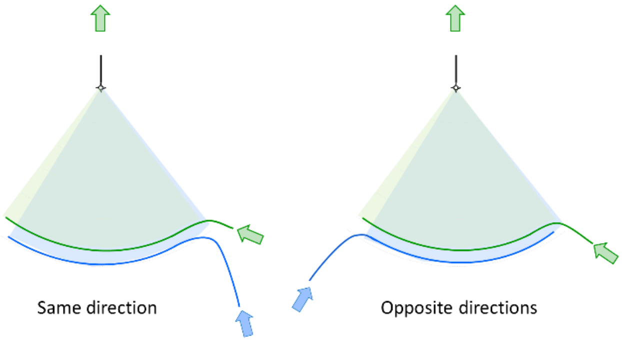


On the other hand, **the case of parallel, vertically separated sequencing legs generally imposes levelling off along the legs. It also generates specific safety requirements** in terms of design, operating method and controllers training, in particular:

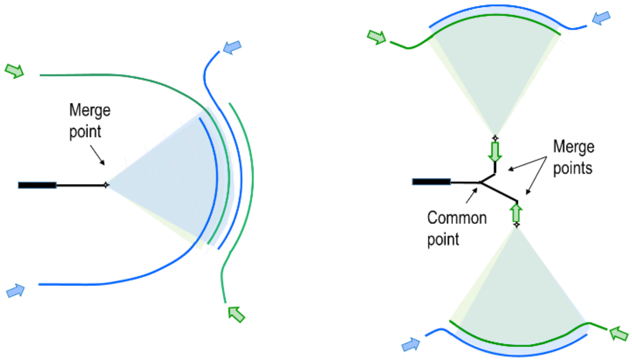
- published vertical restrictions upstream of sequencing legs entry points,
- specific monitoring of adherence to vertical clearances,
- inner leg designed higher than outer leg and systematic dissociation of direct to and descent clearances (to avoid losses of separation in specific instances),
- provision for a spare level if/as necessary,
- a minimum lateral distance between parallel legs to avoid cluttering the radar display and mitigate the risks in case of vertical deviation.

Importantly, the relative positioning (and size) of sequencing legs can also be envisaged from the perspective of **dynamic deployment of arrival route structures**, rather than static designs. Capacity (with continuous descents from the sequencing legs altitude) may be provided with parallel and overlapping sequencing legs during traffic peaks - while continuous descents from higher FL/altitudes would be enabled outside peak hours thanks to shorter, dissociated legs.

Sequencing legs may be of opposite or same direction subject to airspace geometry - especially the respective locations of TMA entry points. Using sequencing legs of same direction may result in better acceptability by controllers, reflecting a more familiar shape of traffic patterns that are used under vectoring.



With more than two main inbound flows, a Point Merge procedure may need to incorporate **multiple sequencing legs**. However, designs with e.g. three or four parallel legs may have significant drawbacks. They could induce too large level/altitude differences or lateral distance between parallel sequencing legs; result in high concentration of traffic and clutter the controller's display - or add extra track miles. Another option, where airspace constraints permit, is to **split the Point Merge procedure into two parts** with a common point after their respective merge points, and ensure an equidistance property from the sequencing legs of each system to this common point. In such configurations feeding a single runway however, cross winds may affect differently the two parts of the procedure in particular once traffic is directed to the merge points.



Options: 4 entry points, 1 runway

Open or closed procedure: Even though it is theoretically possible to publish a Point Merge procedure as open, by default it should be published as a closed procedure - in particular where there is a need to contain arrival trajectories (e.g. complex airspaces with strategic separation of flows and/or in the case of parallel approaches).

Key design guidelines

General – PBN level

Standard/general PBN design requirements obviously apply to any Point Merge design such as minimum procedure segments' length, turn angles/maximum track angle changes especially at the merge point [12] [13] [14] [15]. Equally important, the design process shall involve all relevant stakeholders as early as possible [16]. In addition, some specific guidelines applicable to Point Merge are summarised here below.

Waypoint types: in a Point Merge design, waypoints should generally be defined with turn anticipation (flyby). This is intended to guarantee trajectory containment and facilitate in-trail spacing management. There may nevertheless be exceptions, requiring that a particular point is overflown (e.g. the last point of the sequencing leg in a closed Point Merge procedure where the design does not require containment for separation from other flows or areas).

Waypoint naming: tactical waypoints, and in particular the merge point, shall bear a five letters pronounceable name since it is used on a systematic basis.

Geometry

Other flows: the need for procedural segregation from other flows (departures, and in the case of complex airspace, arrivals/departures from other close airports) will influence the 3D positioning, and dimensions, of the various procedure segments.

Sequencing legs: in so far as possible, it is advisable to design Point Merge structures so that their main symmetry axis is aligned with predominant wind directions / runway orientation (i.e. sequencing legs perpendicular to that direction) in order to minimise the occurrence of adverse effects of strong wind along sequencing legs. This may be particularly true in places with common occurrences of strong headwind.

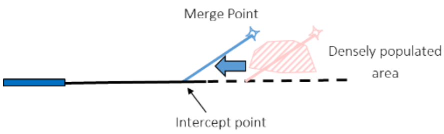
'Invariant' Point Merge designs (i.e. a same set of sequencing legs and merge point including, after the merge point, possible transitions towards either ends of the concerned runway), when they can be considered, may support smooth runway changes with smaller response times, and be worth considering e.g. in places with frequent changes in wind direction. On the other hand such designs may result in increased track miles.

Note: sequencing legs are usually designed in the form of a succession of segments tangent to an arc centered on the merge point. Individual segments are subject to minimum length requirements to accommodate flyby turn anticipation.

Horizontal dimensions: as highlighted above, the length of sequencing legs, and the distance between sequencing legs and merge point, shall be guided by a trade-off between capacity, fuel efficiency/environmental impact. Additionally some specific considerations may also impact the dimensioning. For instance, in places subject to frequent changes in wind direction affecting the runway in use, the horizontal dimensions of a Point Merge procedure, and in general the distance (track miles) from the sequencing legs to the runway may influence the response times to a change of runway in use. Smaller distances result in a potentially smaller number of aircraft flying on course to the merge point, or along the subsequent transition to final, when such a change is occurring.

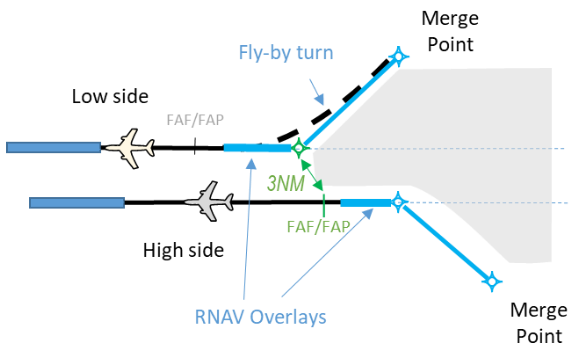
Vertical dimensions: while the sequencing legs altitude is, among others, depending from the distance to final and the need to accommodate continuous descents, additional local considerations may need to be factored in, like possible interference with the transition altitude. Parallel sequencing legs will also require vertical separation, levelling offs, and designing the inner leg higher due to safety considerations. In any case, a large altitude difference between sequencing legs should be avoided as it may lead to difficulties such as heterogeneous speeds or wind effect.

Merge point and joining final approach: in approach sectors, close to the runway and especially after the merge point, the procedure design may be subject to strong environmental constraints. The existence of densely populated areas may influence the vertical/horizontal merge point location, the geometry of the segment(s) joining the final approach, the location of the intersection point with the final approach, and also relate to e.g. ILS glideslope intercept altitude.



Where noise considerations prevail, the merge point itself shall be positioned at a sufficiently high FL/altitude (typically at, or higher than, 6500ft above ground level). For this purpose, a vertical restriction may be published at the merge point e.g. in the form of an FL/altitude window.

In this respect, while dispersion of trajectories at low altitudes is generally considered an issue, a debate has emerged in some places as to whether concentrating approach trajectories close to the runway axis would not also raise significant, albeit different, noise exposure concerns. As for any PBN implementation in terminal areas, care should be taken to account for such trade-offs when designing the low altitude portions of the procedure. For Point Merge in approach sectors, this affects in particular the common portion of the procedure after the merge point.



In case of independent parallel approach operations, additional design constraints arise such as for a precision approach the need for a high and a low ILS and a 3NM/1000ft radar separation between aircraft prior to being established on final [8].

Moreover in that particular case, the transition from lateral navigation to e.g. a localizer (LOC) mode is essential to ensure separation/segregation between flows to adjacent runways [9]. This may trigger specific requirements in terms of operations (ensure flight crews activate LOC mode at an appropriate time to avoid overshooting the last segment) and /or in terms of design (include an RNAV overlay on the extended runway centreline [17]).

Specific parts of the procedure

Holding: Point Merge provides a form of linear path elongation, but does not remove the need for holdings, which shall continue to be used as a minimum as contingency, should unpredictable events reduce the capacity of the runway or of the terminal airspace. Such patterns should be defined at a sufficient distance from the sequencing legs entry points to ensure a seamless flow of traffic is entering each leg, and minimise nuisance TCAS RAs (see also below). It may also be envisaged to include a hold on the merge point.

End of sequencing leg: even though appropriate metering is expected to be put in place upstream of the Point Merge procedure, there will remain circumstances in which, due to an unexpected runway or airspace capacity limitation, aircraft that are already flying the procedure may reach the end of a sequencing leg. In order to provide procedural containment/separation from other flows, it is recommended that the procedure be published in the form of a closed procedure, with a route segment joining the merge point at the end of each sequencing leg. If/as necessary a holding capability may be provided (e.g. at the merge point) so as to absorb a temporary under-capacity/over-demand situation.

Missed approach / communications failure: the definition of these parts of the procedure should obviously account for any local/specific constraints. A missed approach procedure may either re-join a sequencing leg – or, in case this would involve unnecessary long trajectories, provide a means to re-join the merge point or a common point, including a holding pattern as necessary to be re-inserted in the sequence. Communications failure procedures may be based on a short route, involving for instance a direct track to the merge point from the sequencing legs entry points. Emergencies may be managed through a short route or vectoring.

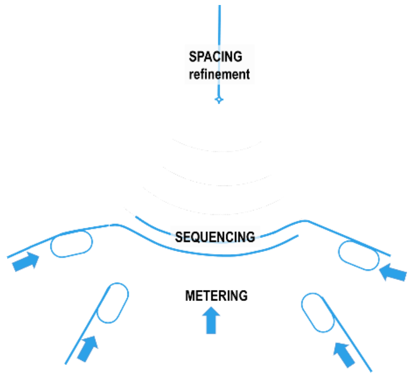
Non-nominal conditions: more generally non-nominal conditions (emergencies, weather phenomena, loss of PBN capability…) should be addressed by a reversion to vectors for one or more aircraft, and if needed, a temporary, coordinated decrease in airspace capacity. In circumstances when it remains possible to use the merge point, a specific constraint of compatibility with normal Point Merge operations can be considered, e.g. by vectoring aircraft to mimic sequencing legs.

What are the main constraints?

Traffic presentation

Point Merge implementations in terminal airspace should be considered within the greater context of arrival management. **As for any closed PBN procedure in terminal areas, an**

adequate metering is assumed to take place prior to the Point Merge entry points, relying as a minimum on holding stacks, or on arrival management measures supported by an adequate tool (AMAN). This metering shall account for the overall capacity of the procedure and ensure that, under nominal conditions, traffic does not reach the end of the sequencing legs prior to being directed towards the merge point. Care shall also be taken that traffic is properly streamed into the sequencing legs at their entry points, including appropriate de-confliction where a same sequencing leg can be fed by two or more arrival flows.



Fuel planning

With Point Merge, similarly to any arrival procedure that incorporates a path extension (e.g. trombones), the published route to be loaded in the FMS and used by default is the extended one which includes the full length of sequencing legs. This induces a change of reference for fuel planning. Indeed, applying the pre-existing standard rules and considering the full extent of the embedded path extension, actually rarely flown, as a basis for the trip fuel, would introduce an unjustified penalty. Legacy procedures such as vectoring, in contrast, do not include the tactical path stretching as part of the trip fuel but as contingency or extra fuel. Early Point Merge implementations have considered different ways to address this issue: using a short route for fuel planning purposes, and/or relying on statistics on the expected arrival delays depending on the time of the day.

Further to these, ICAO allowed explicitly in doc 9976 [18], for a Point Merge procedure, the practice of using a short STAR for fuel planning purposes and accounting for linear holding along sequencing legs as part of contingency or extra fuel, rather than as part of trip fuel. This is based either on the availability of sufficient historical data at the aircraft operator's and use of statistical contingency fuel (SCF), or on ANSP's published statistics on the anticipated amount of sequencing legs usage according to e.g. time of the day. Some states have already provided guidance at the national level for Point Merge fuel planning, providing similar mitigations [19].

Service providers and aircraft operators should therefore address fuel planning aspects for Point Merge based on such guidance, and any additional guidance issued by national authorities.

*Note: in Europe, EASA has published in 2016 a Notice for Proposed Amendment [20] introducing a notion of fuel schemes, and among others addressing the issue of fuel planning with Point Merge and trombones based on the same principles*1*. Although the amendment process is not completed yet, a subsequent 'EASA opinion' document has been published in 2020 [21].*

Training

From a controller's perspective, one important constraint lies in the risk of loss of controller's vectoring skills, which shall then be mitigated through recurrent training. The risk of a decrease in air traffic controllers' vigilance for the monitoring task shall also be highlighted during training.

From a pilots' perspective, Point Merge is using standard FMS functions (Direct To) and does not induce a need for significant change management processes, nor specific

[1] This NPA states that "*Point Merge' is a form of holding over destination which, in essence, is not different from other forms of holding like racetracks holding patterns or linear holding (e.g. trombone pattern). The condition for using contingency fuel for such calculations is the availability of relevant data, related to the average part of the Point Merge to be flown, and obtained either from internal or external sources (operator and/or ATS unit)*".

training/briefing requirements other than the standard ones applicable to the deployment of PBN procedures[2].

What are the most common misbeliefs?

Since the procedure is providing path stretching and delaying aircraft "by default", it may create the impression that track miles are increased. This is not the case: **all other things being equal, it is not expected that Point Merge would result in longer distances or larger time flown than with current procedures.**

Along similar lines, **the particular geometry of Point Merge may give the false impression that a large horizontal area is required** to accommodate the procedure. In reality the required amount of available airspace is not larger than with any other procedure providing the same path extension capacity. The driving factor here is actually **the shape of available airspace in the horizontal dimension to accommodate the design, rather than a larger amount of available airspace**.

What are the most common mistakes?

Feasibility studies, real-time simulations and implementations have provided useful lessons learned regarding choices or options to be carefully evaluated, or even avoided. The key ones are detailed here below.

Too large dimensions

In environments where airspace availability would allow for it, it may be tempting to envisage a Point Merge design of large horizontal dimensions and large path stretching capability. However, **it is recommended to avoid too long sequencing legs**, as they may generate large track angle change differences at the merge point or heterogeneous wind effect. Long sequencing legs also result in a large angular spread of tracks converging towards the merge point, which over 90° may induce face to face convergence cases. In addition, such designs increase vertical constraints and impact fuel planning.

Again, the driver shall be the required delay absorption capacity accounting for the expected traffic demand and traffic presentation at entry points. An adequate metering prior to the Point Merge procedure, and de-confliction capacities towards sequencing legs entry points provide a means to keep the length of sequencing legs within reasonable limits.

A long distance between the sequencing legs and merge point and/or final should also be avoided as it results in less flexibility for sequence management.

No provision for short routes

It would also be a mistake to design a highly capacitive procedure without considering flight efficiency during periods of low traffic. Any procedure design in approach airspace shall not only provide a sufficient path-stretching capacity to absorb peaks of traffic, but also the same reduced track miles as vectoring would achieve outside peak hours. With Point Merge, an adequate short route shall be made available, which may be a direct route from the first point of the sequencing leg, or even earlier shortcuts/directs when practicable, using specific tactical points if needed. As an example, the Dublin design for Point Merge (runway 28) incorporates a tactical waypoint aligned with the runway axis to enable early shortcuts from the downwind

[2] E.g. [22] – note however that no worldwide standardization exists on PBN pilots training (see https://www.skybrary.aero/index.php/Performance_Based_Navigation_(PBN))

segments, with acceptable track angle changes. Any unnecessary vertical restriction shall also be removed in that case.

Underestimating controllers acceptability aspects

Human factors, and especially acceptability, shall be factored in all along the implementation process. Although the operating method is simple and highly intuitive, implementing Point Merge in terminal areas where vectoring to final has been the norm for decades is a significant change. Its impact from the controller’s standpoint should be acknowledged. Traffic patterns induced by the procedure may differ significantly from vectoring patterns previously in place. Sequencing is achieved on a point, rather than an axis. It may also initially seem uncommon for controllers to delay/path stretch aircraft “by default”, or to use parallel segments of opposite directions (even though these are vertically separated). **Familiarisation/information sessions and early involvement of a core panel of controllers in the project, ahead of large-scale training, are key to a broad adoption and seamless implementation.**

Underestimating the impact on Airspace Users operations

As per a standard PBN design/implementation guideline, **all relevant stakeholders shall be involved as early as possible in the process**. In particular the main aircraft operators serving the concerned airport shall be consulted and in the case of Point Merge, specific constraints such as e.g. fuel planning shall be anticipated.

Additional recommendations

Publication

As any terminal airspace procedure, Point Merge procedures are expected to be published in the form of a PBN STAR or transition, and detailed in an official aeronautical publication (AIP) or a supporting information circular (AIC) by the concerned air navigation service provider. It is recommended to include among others an **explicit mention that pilots shall expect to be directed to the merge point at any time while flying along a sequencing leg.**

Operating method and training

In addition to the risk of loss of vectoring skills or loss of vigilance, controllers training shall highlight a few other aspects. Among these, in the case of parallel, vertically separated sequencing legs, the need to **dissociate direct to and descent instructions** so as to avoid losing vertical separation and possibly triggering TCAS RAs and associated vertical manoeuvres.

Maintaining in-trail spacing for aircraft on course towards the merge point, and after the merge point, solely based on speed control may appear as a loss of flexibility for controllers. The operating method shall include, and the training shall also highlight, the notion of a **buffer in inter-aircraft spacing** when issuing the ‘Direct To’ instruction to the merge point, in order to anticipate on this loss of flexibility and on the compression effect due to gradual speed decrease.

Strong wind conditions may result in heterogeneous ground speeds between aircraft flying on different sequencing legs. Studies and implementation experience have shown that controllers are able to adapt to a strong wind condition, as they do with e.g. vectors, also supported by FMS turn anticipation with PBN. The differential effect of strong wind conditions should nevertheless be highlighted during training.

Finally, **controllers’ training should also highlight the fact that Point Merge supports CDOs, along with an explicit phraseology** (e.g. ‘descend when ready’).

Training/briefing requirements for pilots are mainly driven by standard PBN implementation considerations. However, a few specific aspects may need to be addressed in certain cases. For instance, when a PBN arrival procedure followed by a precision approach (typically ILS) is interrupted with ATC vectors, pilots used to a vectoring environment may tend to remove the remaining points in the procedure until the runway threshold from the active flight plan in their Flight Management System. This may be done routinely in order to prepare for ILS capture and/or clean the flight plan should a missed approach need to be initiated. However, such waypoint deletion shall be avoided if the intent is to resume the PBN procedure. This may also have further safety implications in case of parallel approaches. Pilot's briefing and/or procedure publication shall highlight this constraint.

Combined Point Merge procedures

When **combining Point Merge procedures**, either ending up on a common point feeding a single runway, or leading to parallel approaches with geographical runway allocation, care should be taken to introduce a **lateral offset** between the segments leading to the common point (respectively the runways extended centrelines) to avoid face to face situations of a systematic nature close to final.

Minimising nuisance ACAS/TCAS RAs

Any terminal airspace design shall avoid creating TCAS "hotspots". Regarding Point Merge, especially in the case of parallel, vertically separated sequencing legs, nuisance TCAS RAs may occur due to configurations involving 1000ft level-offs, around the first and/or last points of sequencing legs, in the case when aircraft would be stable too late at the leg's defined FL/altitude. Consequently, in such configurations, **vertical restrictions may have to be defined at a sufficient distance upstream of sequencing legs entry points**.

Terrain/obstacle clearance

While pilots are responsible to ensure that any clearances are safe in respect to terrain clearance, ATC shall ensure assigned levels/altitudes are at or above established minimum flight altitudes. **In the case when an IFR flight following a PBN procedure is vectored off its route (be it through a Direct To instruction), the responsibility for terrain/obstacle clearance remains primarily on ATC**. This should be highlighted during controller's training, especially in environments where minimum safe altitudes may prevent continuous descents from the sequencing legs. Vertical clearance(s) should then be issued to (an) intermediate level(s)/altitude(s).

Descent performance in specific environments

In terminal areas subject to low temperatures, the prevalence of **icing conditions** may influence the descent performance and needs to be accounted for in the design of a Point Merge procedure.

Traffic mix

In environments where the mix of traffic involves a significant **heterogeneity in performances** (including purely aerodynamic aspects and/or navigation/equipment), specific/separate procedures for low performance aircraft may need to be established.

References

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