Australian Government
Civil Aviation Safety Authority

Civil Aviation Advisory Publication

March 2006

Guidelines for the Consideration and Design of: Engine Out SID (EOSID) and Engine Out Missed Approach Procedures

This publication is advisory only and provides guidance and advice on complying with the Civil Aviation Regulations 1988 (CAR 1988).

Read this advice in conjunction with the appropriate regulations.

Contents

See Page 2

The relevant regulations and other references

See Page 3

Who this CAAP applies to

This CAAP applies to holders of AOCs and operators.

Why this publication was written

The information contained herein has been developed as guidance for the design and generation of engine out takeoff procedures and engine out missed approach procedures. Compliance with this guidance does not constitute regulatory compliance or approval. It is the Operator's responsibility to satisfy the applicable regulatory requirements.

The methods and guidelines presented in this guidance are neither mandatory nor are they the only acceptable methods. An operator, who requests to use an alternate means, should submit an application to the CASA office that provides regulatory oversight for the operator's AOC, for review and approval if appropriate.

Note: The guidance provided in the document targets both small and large aircraft operators that operate to CAO 20.7.1b. Depending upon the approved equipment fitted and the navigational capabilities of the aircraft some guidance may not be applicable. It is the responsibility of the operator to determine this.

Status of this CAAP

This is the first CAAP written on this subject.

For further information

Contact the CASA Office closest to you on 131757

Table of Contents

Regulations and References

- Civil Aviation Regulations 1988, Reg 235, Takeoff and Landing of Aircraft etc.
- Civil Aviation Order Part 20, Section 20.7.1B, Issue 5, Aeroplane Weight and Performance Limitations — Specified Aeroplanes Above 5700 kg — All Operations (Turbine and Piston and Engined)
- Civil Aviation Order Part 40, Section 40.2.1, Issue 4 Instrument Ratings.
- Getting to Grips with aircraft Performance, Airbus Publication
- Boeing Performance Training - Operations Course notes
- Boeing Jet Transport Methods, Document D61420, Seventh Edition dated May 1989
- Boeing FMS RNAV Workshop February 9,2000
- Code of Federal Regulations Title 14, Aeronautics and Space Part 25—Airworthiness Standards – Transport Category Airplanes.
- Code of Federal Regulations Title 14, Aeronautics and Space Part 77—Objects Affecting Navigable Airspace.
- Code of Federal Regulations Title 14, Aeronautics and Space Part 121—Operating Requirements, Domestic, Flag, and supplemental Operations.
- Boeing Document D6-39067-3 RNP Capability of FMC equipped 737, Generation 3
- Joint Aviation Requirements for Large Aeroplanes JAR-25
- ICAO Procedures for Air Navigation Services, DOC 8 168 Volume II, 4th Edition, Construction of Visual and instrument Flight Procedures.
- FAA Order 8260.3, United States Standard for Terminal Instrument Procedures (TERPS), current edition.
- FAA Order 8260. 48 Area Navigation (RNAV) Approach Construction Criteria
- FAA Order 8260.44A Civil Utilisation of Area Navigation (RNAV) Departure Procedures
- FAA Order 8260.40B Flight Management System (FMS) Instrument Procedures Development
- FAA Advisory Circular 120- OBS-11, Airport Obstacle Analysis, Draft Copy Issue
- RTCA DO-236A, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation, dated September 13,2000
- RTCA DO-201A Standards for Aeronautical Information, dated April 19, 2000
- ARINC Specification 424-17 Navigation System Data Base, published August 31, 2004
- Collins FMS Newsletter Business and Regional Systems July 1998 Volume 1, Issue 2
- FAA Notice N8400.80 Special Instrument approach and Engine Out Missed approach Procedures.

Definitions

Climb Gradient	The ratio, expressed as a percentage, of the change in geometric height divided by the horizontal distance travelled in a given time. Gross gradient is the actual calculated performance of the airplane under specified conditions, while Net gradient is the gross gradient reduced by an increment specified in the regulations.
Gross Height	The geometric height attained at any point in the takeoff flight path using gross climb performance. Gross height is used for calculating actual pressure altitude at which obstacle clearance procedures and wing flap retraction are initiated, and level-off height scheduled.
Net Height	The geometric height attained at any point in the takeoff flight path using net climb performance. Net height is used to determine the net flight path which must clear any obstacle by at least 35 feet to comply with the regulations.
Reference Zero	A point on the runway or clearway plane at the end of the takeoff distance and 35 feet below the flight path to which the height and distance coordinates of other points in the takeoff flight path are referred.

PART A ENGINE OUT DEPARTURES

1.0 Introduction

Engine out takeoff guidance has a number of names as adopted by industry, some of the common names include:

1. Engine Out Departure Procedures
2. Engine Out Contingency Procedures
3. Engine Out Escape Paths
4. Engine Out SIDs

The name selected is optional but it must reflect the approved kind of operation of the aircraft. Items 1, 2 and 3 can make reference to both VMC and IMC operations and must have the appropriate guidance for the operation type. Item 4, as the name suggests is based on IMC operations.

Although not a requirement of CAO 20.7.1B, the majority of the aircraft that operate to this CAO are IFR approved. For IFR approved aircraft an EOSID must cover takeoffs in both VMC and IMC. From this point forward engine out takeoff guidance will be referred to as an EOSID.

1.1 Engine out SIDs (EOSIDs)

Standard Instrument Departures (SIDs) or departure procedures (DPs) are designed in accordance with U.S. Standards for Terminal Instrument Procedures (TERPS) or ICAO Pans-Ops. These are based on normal all-engine operations and assume that the aircraft are capable of maintaining a climb profile.

These departure procedures are normally published as specific routes to be followed or as omni-directional departures, together with procedure design gradients and details of significant obstacles. They are normally established for each runway where instrument departures are expected to be used and they define a departure procedure for the various categories of aircraft used.

In the event of an engine failure, continued adherence to departure procedures may not be possible as SIDs or DPs do not necessarily assure that engine-out obstacle clearance requirements are met.

An engine failure during takeoff is a non-normal condition, and therefore, takes precedence over noise abatement, air traffic, SID's, DPs, and other normal operating considerations.

The fundamental difference between SIDs and EOSIDs is that SIDs provides the minimum performance considerations to meet the departure requirements assuming an all engine operation whereas EOSIDs are based upon engine out performance in relation to obstacle clearance. EOSIDs can be in the form of a straight departure and or a series of turns.

Note: Development of Engine Out Takeoff Procedures is the responsibility of the operator.

2.0 Regulatory Requirement for EOSIDs

For aircraft operating above 5700 kg and in accordance with CASA CAO 20.7.1B, operators must comply with paragraph 14 of the order for the development of takeoff performance data and procedures. Sub-paragraph 14.2, states:

> *" Procedures to be followed consistent with this Order, including procedures anticipating engine failure at any time between the commencement of take-off and completion of landing, must be specified in the Operator's Operation Manual. The procedures so specified must be such that they can be consistently executed in service by flight crews of average skill and they must also be such that the take-off flight path with all engines operating is above the one-engine inoperative take-off flight path."*

2.1 The EOSID Takeoff Flight path

The takeoff flight path in the context of this guidance and for the purpose of defining the path requirements for an EOSID is as noted below:

The EOSID by definition must commence from a time where engine failure has occurred and where the flight crew are committed to a continued takeoff with one engine out.

The takeoff flight path of the EOSID should be able to join a suitable en route path to the planned destination or to another suitable airport or at least have a holding pattern at the end of the EOSID. The aircraft is considered to be enroute when it is at the higher attitude of 1500 feet:

> *CAO 20.7.1b Para 12.6*
>
> *"The net flight path in the en-route configurations must have a positive slope at 1500 feet above the aerodrome where a landing is assumed to be made following engine failure. …"*

or the altitude where 1000 feet enroute obstacle occurs

> *CAO 20.7.1b Para 12.4*
>
> *"…the en-route obstacle clearance requirements are met if the en-route configuration with a critical engine inoperative the net flight path of an aircraft under V.M.C. clears by 1 000 feet vertically all obstacles within 5 nautical miles of the aeroplane's track or, under I.M.C., by such greater distance as is determined by the accuracy of the navigation aid(s) used.*

Operationally alternative options are normally considered. This may include climbing to either a minimum safe altitude (MSA), a minimum vectoring altitude (MVA), or a fix and altitude, from which an approach may be initiated to the departure airport or departure alternate.

Operators should note that the end of the takeoff flight path is determined by the aircraft's gross flight path but the obstacle analysis must use the net flight path data.

2.2 Certified Engine out Takeoff Flight Path

The takeoff path extends from a standing start to a point, at which the aircraft is at a height of 1500 ft above the takeoff surface, or at which the transition from the takeoff to the en-route configuration is completed and the final takeoff speed is reached, whichever point is higher.

> *JAR/ FAR 25.111 Takeoff path.*
>
> *"The takeoff path extends from a standing start to a point in the takeoff at which the airplane is 1,500 feet above the takeoff surface, or at which the transition from the takeoff to the en route configuration is completed and V_{FTO} is reached whichever point is higher."*

CASA accepts the certification of aircraft as detailed in the Aircraft Flight Manual (AFM), however the operational rules of CAO 20.7.1B must be considered in the analysis. If there is any conflict between the AFM data and the operating rules, then if the AFM is more restrictive, that is what must be used.

The takeoff path definition assumes that the aircraft is accelerated on the ground to VEF, at which point the critical engine is made inoperative and remains inoperative for the rest of the takeoff. Moreover, the V2 speed must be reached by 35 feet[1] above the takeoff surface (this point is also known as reference zero). The aircraft must continue at a speed not less than V2 and achieve the regulatory climb and any obstacle clearance requirements until the aircraft reaches the acceleration altitude. The minimum height is 400 feet above the takeoff surface; however operators may select a higher altitude.

This path is a certification requirement and the certification standard is accepted by CASA. The related performance data is contained in the Aircraft Flight Manual (AFM).

[1] 15 feet above the takeoff surface for aircraft with wet certification or aircraft using approved or wet runway performance from the aircraft manufacturer. Refer to Appendix 3, Wet and Contaminated runway Performance.

Note that the V2 speed is not the speed for best angle of climb. It is the minimum safe climb speed (not less than 1.2Vs) and climbing at a speed higher than V2 will improve the aircraft's climb performance. Modern aircraft flight directors will typically command a climb speed of V2 if an engine failure occurs between V1 and V2 or the speed at which the engine failure occurred (up to a limit) if the failure occurred at a speed above V2.

Note: While the AFM provides detailed instructions for determining the vertical clearance, it offers little guidance on the lateral clearance requirements. The objective of this guidance is to provide information for determining safe clearance from obstacles for the actual flight path, and to consider the factors, which may cause a divergence of the actual flight path from the intended flight path. Further this guidance provides an acceptable lateral criterion to assist an operator in developing takeoff procedures and allowable weights for operational use.

2.3 Gross and Net Takeoff Flight Paths

Most of the time, runways have surrounding obstacles which should be taken into account prior to takeoff, to ascertain that the aircraft is able to clear them. A vertical margin has to be considered between the aircraft and each obstacle in the takeoff flight path. This margin, based on a climb gradient reduction, leads to the definitions of the Gross Takeoff Flight Path and the Net takeoff flight Path.

Gross Flight Path = Takeoff flight path actually flown by the aircraft, based upon the gross height attained. The flight path commences at reference zero.

Net Flight Path = Gross takeoff flight path minus a mandatory reduction, based upon the net height attained.

The gradient reduction is considered to account for pilot technique, degraded aircraft performance, and ambient conditions.

The net takeoff flight path data must be determined so that they represent the actual (Gross) takeoff flight path reduced at each point by a gradient equal to:

0.8% for two-engine aircraft

0.9% for three-engine aircraft

1.0% for four-engine aircraft

CAO 20.7.1B Para 7.5

"In determining the net flight path of an aeroplane to show compliance with subsection 12, the gross gradients of climb achieved in paragraphs 7.2 and 7.4 must be reduced by 0.8% for twin-engined aeroplanes, 0.9% for three-engined aeroplanes and 1.0% for four-engined aeroplanes."

2.4 Vertical Clearance Requirements -Takeoff Segments

The takeoff flight path can be divided into several segments. Each segment is characteristic of a distinct change in configuration, thrust, and speed. Moreover, the configuration, weight, and thrust of the aircraft must correspond to the most critical condition prevailing in the segment. Finally, the flight path must be based on the aircraft's performance without ground effect. As a general rule, the aircraft is considered to be out of the ground effect, when it reaches a height equal to its wing span.

After an engine failure at VEF, whatever the operational conditions, the aircraft must fulfill minimum climb gradients, as required by the aircraft flight manual and the operational requirements of CAO 20.7.1B.

Figure 2.4.1, summarizes the different requirements and aircraft configuration during the four takeoff segments. This includes the minimum required climb gradient with an engine out, flaps / slats configuration, engine power rating, speed reference, and landing gear configuration.

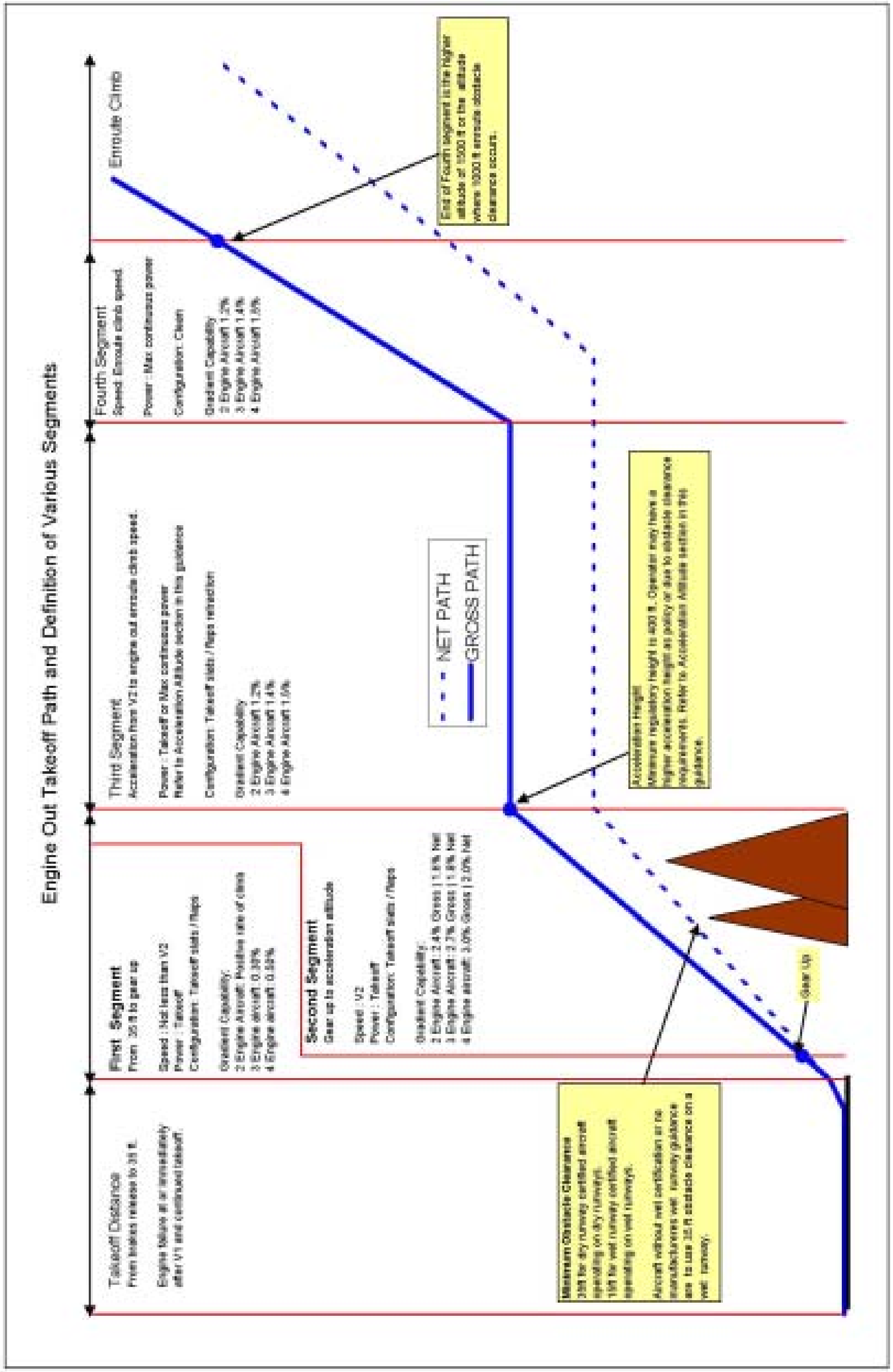


Figure 2.4.1 Vertical Flight Path Requirements

2.5 Lateral Clearance Requirements -Takeoff Obstacle Splay Information

The takeoff splay or lateral obstacle containment area represents an area surrounding the takeoff flight path, within which all obstacles must be cleared, assuming they are all projected on the intended track. The contours of this area are defined in the table below, as extracted from paragraph 12 of CAO 20.7.1B.

Some operators choose to use PANS-OPS lateral containment areas for designing EOSIDs. This is acceptable as long as the splays used are identical to or are more conservative than the CAO requirements.

Note: The use of PANS-OPS guidance for lateral guidance does not absolve the requirements to comply with the vertical clearance requirements per the CAO.

Operation	Max Takeoff weight	Heading Change	Half Splay Requirement	Max half splay width	Comments
VMC	<22 700 kg	<=15 Deg	150 ft + 0.125D*	1000 ft	
		>15 Deg	150 ft + 0.125D*	Continue half splay requirement until turn is completed.	Splay width the greater of 1000 ft or 150ft + 0.125D at the completion of turn.
	≥ 22 700 kg	Any	250 ft + 0.125D*	Intersection the area of probability of a radio navigation aid	The probability of a radio navigation aid is the rated coverage of the navigation aid. (Refer to AIP Gen 1.5, Paragraph 2.2)
IMC	ALL	Any	250 ft + 0.125D*	Intersection the area of probability of a radio navigation aid	The probability of a radio navigation aid is the rated coverage of the navigation aid. (Refer to AIP Gen 1.5, Paragraph 2.2)
VMC by Day (alternate)	ALL	Any	90 m +0.125D*	600 m	Alternative takeoff obstacle clearance requirements
VMC by Night and IMC (alternate)	ALL	≤15 Deg	90 m +0.125D*	600 m	Alternative takeoff obstacle clearance requirements
		>15 Deg	90 m +0.125D*	900 m	Alternative takeoff obstacle clearance requirements
RNP	ALL	Any	250 ft + 0.125D* or 90 m + 0.125D*	Width of RNP containment specified in the regulatory approval (equal to 2*RNP value)	The aircraft must meet the RNP capability necessary for an approved RNP operation in accordance the aircraft's flight manual.

*The distance measured horizontally along the planned flight path and commencing at the end of the takeoff distance available.

Table 2.5.1 Lateral Flight Path Requirements

3.0 EOSID Design Considerations

In order for an operator to determine that a departure maintains the necessary obstacle clearance with an engine failure, the operator should consider that an engine failure may occur at any point on the departure flight path.

The most common procedure to maximize takeoff weight when significant obstacles are present along the normal departure route is to use an EOSID in the event of an engine failure on takeoff. If the EOSID routing is different from a SID or DP, then the obstacles along this track are used to determine the maximum allowable takeoff weight for that runway. Note that often the path of the EOSID will not overfly the area where the aerodrome operator has provided an obstacle survey.

Consideration should be given to the possibility of an engine failure occurring after passing the point at which the engine-out track diverges from the normal departure track (SID or DP). A careful selection of this point will simplify the procedure and minimize the difficulty of this analysis. This is generally achieved by keeping the two tracks identical for as far as practicable.

In some cases, two or more special engine-out tracks may be required to accommodate all the potential engine failure scenarios.

In the event that the aircraft cannot return to and land at the departure airport, the takeoff flight path should join a suitable en route path to the planned destination or to another suitable airport. It may be necessary to address extended times and alternate fuel requirements when climbing in a holding pattern with reduced climb gradients associated with engine-out turns.

Analysis of an engine failure after takeoff may require the use of performance data in addition to that provided in the Aircraft Flight Manual. It is recognized that many AFM's generally contain only the engine-out performance for loss of an engine at V_1 on takeoff. All-engine performance should also be considered to determine the aircrafts flight path in the event of an engine failure at a point on the flight path after V_1. The best available all-engine data should be used consistently with best engineering practices. This data may be found in sources such as community noise documents for Boeing aircraft, performance engineer's handbook, FCOMs, flight characteristics manual, manufacturer's computer programs, etc.

3.1 Risk Management Strategy.

When designing an EOSID, it is sometimes tempting to design an elaborate procedure involving a number of turns, conditional statements, speed restrictions etc. Operationally this procedure may not be practical for the flight crew to follow. Remember that the aircraft may have suffered a catastrophic engine failure, an emergency may have been declared and the workload on the flight deck may be very high. A good EOSID is one that is simple and effective.

Perform a risk assessment. Identify and focus the high risk portion(s) of the departure. This may include relatively high terrain, relatively narrow escape pathways, aircraft performance limitations, weather phenomena etc. Properly mitigated high risk items can become low risk.

Some examples to highlight mitigators that can be used to reduce the level of risk in a proposed procedure for illustrative purposes only are:

- ✈ If an airport is near the coast, with high terrain inland, consider directing the aircraft over the coast and out to sea.
- ✈ If an airport is located in a valley and the escape paths are very narrow, consider spiral climbing out of the valley if clearance permits.

3.2 EOSID Design Method

Traditionally there has been one common method for designing an EOSID. This method consists of defining a lateral containment area consistent within the regulatory splay requirements as detailed in Table 2.5.1. All obstacles within the lateral containment area or splay must be cleared vertically as required by the regulations for that part of the takeoff. The lateral area is centered on the intended flight track usually defined by ground based navigation aids. When this method is used for straight out departures, the operator is not required to account for crosswind, instrument error or flight technical error within the lateral containment area.

3.3 EOSID Analysis Requirements

Study the terrain in the area around the airport and select a departure path, several paths may have to be analyzed and:

- Determine any critical obstacles for the chosen departure path.
- Determine the required turn radius.
- Examine other issues:
- Weather (Wind, OAT, QNH)
- Piloting considerations
- Need to calculate the "equivalent still air distance" for analysis with wind
- Turn allowed when 50 ft height reached (refer to section 5.2 Obstacle Clearance during a Turn)
- 15 degrees maximum bank, unless approval from the regulatory authority is granted
- Gross Flight Path
- Net Flight Path –regulatory requirements
- The EOSID should have sufficient guidance such that it can be followed in both IMC and VMC.
- A single intended track may be used for analysis if it is representative of operational procedures.
- For turning departures the bank angle, speed, and turn radius may be fixed and or varying to achieve the required result (refer to section 6.0 Turn Analysis).
- The distance to an obstacle within the lateral containment area should be measured along the intended track to a point abeam the obstacle.
- Obstacles prior to the end of the runway need not be accounted for, unless a turn is made prior to the end of the runway over the obstacles.
- Avoid restricted or prohibited areas, for example military airspace.

4.0 Flight Tolerances and Course Guidance

Additional consideration should be given to flight tolerance in constructing EOSID to ensure that the required flight path is able to be flown comfortably without the need of excessive precision.

Extract from CAO 40.2.1 Instrument Ratings

3.1 Flight within the tolerances specified is necessary for the applicant to be judged proficient in the required flying manoeuvres. There shall be no sustained errors in excess of the specified tolerances.

3.2 Normal flight tolerances:

(a) heading ±5° of nominated heading; and

(b) indicated ±10 knots (or ±> M.02) of nominated speed, not below minimum approach speed for the configuration; and

(c) height ±100 feet, at minimum altitudes + 100 feet - 0 feet.

3.3 Asymmetric flight tolerances (aeroplanes):

(a) heading (from datum heading) ±20° initially, then ±5°; and

(b) indicated airspeed:

(I) initial climb — nominated 1 engine inoperative climb speeds + 5, - 0 knots;

(ii) subsequent operations ±10 knots (±M.02); not below minimum approach speed for the configuration; and

(c) height ±100 feet; at minimum altitudes + 100 feet and - 0 feet.

Note These tolerances are generally not applicable to RNP EOSID departures

4.1 Course Guidance

EOSID designers should be aware of their navigation system inputs, alerts, and annunciations in order to make better-informed design decisions. In addition, the availability and suitability of particular sensors and systems should be considered.

GPS. Operators using TSO-C129 systems should ensure EOSIDs are entered to ensure proper RAIM availability and CDI sensitivity.

DME/DME. Operators should be aware that DME/DME position updating is dependent on FMS logic and DME facility proximity, availability, and signal masking. The available number and geometry of facilities influences DME/DME performance.

VOR/DME. Unique VOR characteristics may result in less accurate values from VOR/DME position updating than from GPS or DME/DME position updating.

Inertial Navigation. Inertial reference units and inertial navigation systems are often coupled with other types of navigation inputs, e.g., DME/DME or GPS, to improve overall navigation system performance.

4.2 Ground Based Navaid Tolerances

When ground based course guidance is available for flight track analysis, the following nominal allowances should be considered, unless the operator substantiates allowances for specific navigational aids at a particular airport:

Note: The data below has been extracted from ICAO Procedures for Air Navigation Services, DOC 8 168 Volume II, 4th Edition, Construction of Visual and instrument Flight Procedures, Part III Chapter 2 Terminal Area Fixes

VOR	+/-5.2° Tracking tolerance
	+/-4.5° Intersecting tolerance
NDB	+/-6.9° Tracking tolerance
	+/-6.2° Intersecting tolerance
ILS	+/-1.4° Intersecting tolerance
DME	+/-0.25 nm +1.25% of the distance to the antenna.

Note: The above splays originate from the navigation facility.

These figures reflect the following tolerances:

- Ground station tolerance
- Receive tolerance
- Flight technical tolerance
- System computation tolerance

Ground based course guidance may be used in combination with other forms of course guidance to construct a departure procedure

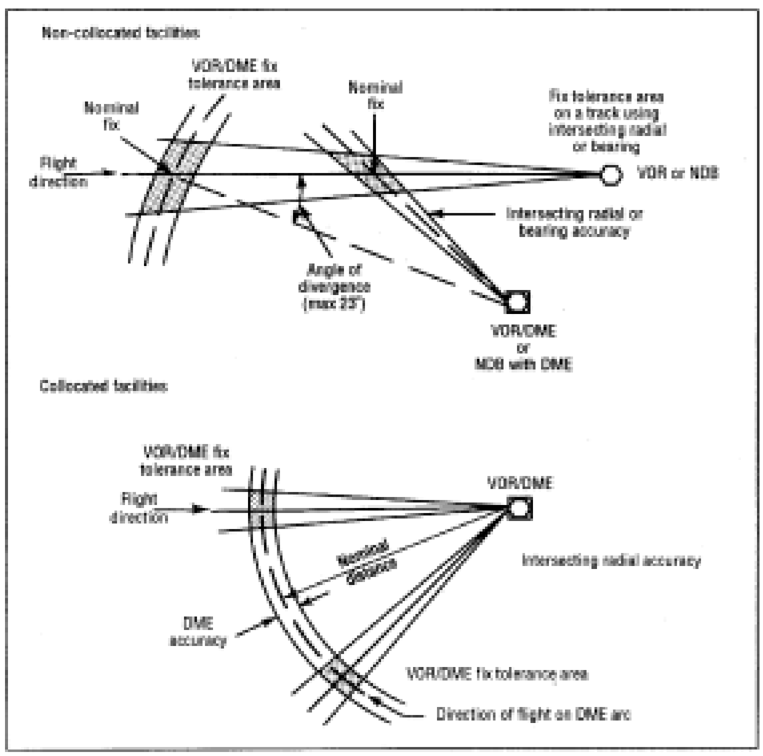


Figure 4.2.1 Fix tolerance areas

Below are two examples in Figure 4.2.2 highlighting fix tolerances for a VOR/DME facility. Example 1 highlights an along track fix from the naviad. Example 2 highlights an intersecting fix with the navaid. The grey areas in both cases indicate the fix tolerance associated with his specific navaid. The aircraft can be nominally anywhere within the grey areas at the fix, and hence the extremes (corners) of the fix area needs to be considered for lateral obstacle clearance.

Example 1 Aircraft path Track 090M inbound XY VOR and at 20 DME XY turn left heading 020M to avoid terrain

Based upon the tolerances from the previous page the aircraft can register the fix 0.5 nm before reaching the fix and can be placed approximately (20.5*tan(5.2)) 1.86 nm either side of intended track.

Worst case scenario: The aircraft begins the left turn 0.5 nm from the fix and 1.86 nm to the right of the nominal track. Depending upon the aircraft TAS and bank angle, the resultant turn radius may steer the aircraft closer to the terrain than anticipated.

Example 2 Aircraft path Intercept outbound radial 180°M XY VOR and then maintain a 20 DME to avoid terrain.

Based upon the tolerances from the previous page the aircraft can register the fix (20.5*tan(4.5)) 1.61 nm before reaching the fix and can be placed approximately 0.5 nm either side of intended track.

Worst case scenario: The aircraft begins tracking the arc 1.61 nm before the fix and 0.5 nm to the left or right. In other words the aircraft can perform a 19.5 or 20.5 DME arc.

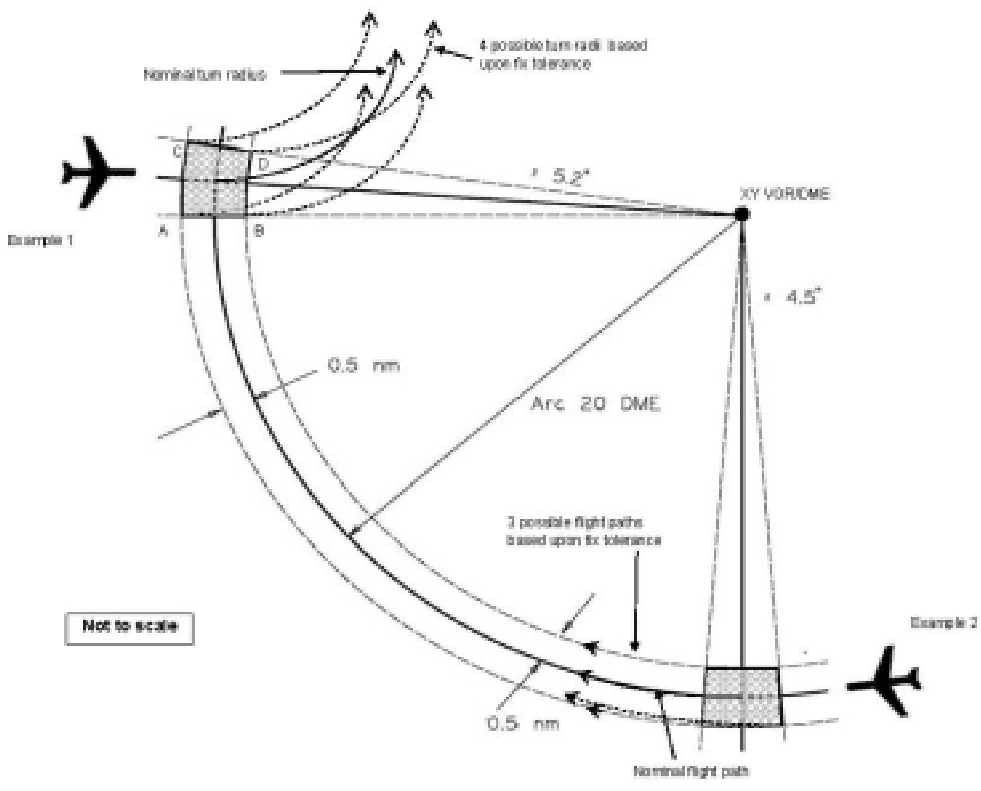


Figure 4.2.2 Fix Accuracy VOR/DME

The purpose of these examples is to highlight the relatively large fix tolerances associated with the navaids, especially when the navaid is relatively distant. When considering navaids for course guidance check the resultant tolerances associated with a fix and the worst case scenarios (corners of the fix area) to ensure that obstacle clearance is maintained.

4.3 Global Navigation Satellite Systems (GNSS)

GNSS may be used for the design and execution of EOSIDs and at this stage operational approval is limited to use of the US Government Global Positioning System (GPS). Guidance for the design requirements and consideration can be found in the CASA 'Manual of Operational Standards, Part 2 Section 10.1. Below is the referenced extract from the manual detailing the requirements.

1. *The aircraft must be fitted with an approved TSO C129, C129a, C145a or C146a receiver which has been fitted in accordance with AC21-36.*
2. *Pilots must have completed appropriate GNSS training and had their log books endorsed as required by CAO 40.2.1.*
3. *GPS must only be used to determine distance information.*
4. *The datum used to measure distances must be extracted from an approved and current database, and be selected from points associated with the departure aerodrome.*
5. *The horizontal integrity of the GPS must be confirmed immediately prior to each departure by:*
   a. *Positioning the aircraft at a pre-determined point on the aerodrome for which the distance from the selected aerodrome datum has been determined and published on the departure procedure, and*
   b. *Comparing the distance shown on the GPS receiver with the distance published on the procedure.*

   The allowable tolerance between the published distance and the GPS receiver indicated is ±0.2 nm.
6. *RAIM (Fault detection) must be available prior to the commencement of the procedure.*
7. *A tolerance of ±300 m must be applied to a turning-point position determined by the GPS.*
8. *The procedure must conform to the requirements of CAO 20.7.1B.*
9. *If the conditions contained in this procedure cannot be met, an alternative procedure must be used.*

5.0 Obstacle Considerations

- Use the latest obstacle information available from an approved source. The most common examples are surveys and ICAO Type A charts. These charts usually account for close in obstacles (normally within 10 miles of the airport) and other references such as approved topographic charts may need to be referenced for surrounding terrain. Refer to Appendix 3 for a list of obstacle information sources.
- Frangible structures fixed by function with an aeronautical purpose such as antennas, approach lights, and signs need not be considered in an obstacle analysis.
- Accountability should be made for local temporary or transient obstacles such as vehicles, ships, cranes, trains etc. FAR Part 77 contains guidance for consideration of the above. Refer to the extract attached below. If the operator has a means to ensure the absence of a movable object at the time of takeoff, then it need not be accounted for in the analysis.

Extract from FAR 77.23 Standards for determining obstructions.

Except for traverse ways on or near an airport with an operative ground traffic control service, furnished by an air traffic control tower or by the airport management and coordinated with the air traffic control service, the standards of paragraph (a) of this section apply to traverse ways used or to be used for the passage of mobile objects only after the heights of these traverse ways are increased by:

1. *Seventeen feet for an Interstate Highway that is part of the National System of Military and Interstate Highways where over crossings are designed for a minimum of 17 feet vertical distance.*
2. *Fifteen feet for any other public roadway.*
3. *Ten feet or the height of the highest mobile object that would normally traverse the road, whichever is greater, for a private road.*
4. *Twenty-three feet for a railroad, and,*
5. *For a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it.*

- Reasonable judgement should be used to account for the height of indeterminate objects (objects without recorded height) displayed on topographic maps. Indeterminate objects include such items as trees, buildings, flagpoles, chimneys, transmission lines, etc. The operator should use sound judgement in determining the best available data sources when conflicts occur between heights and locations of obstacles in the various sources.
- If adequate takeoff weights cannot be obtained through the methods of analysis an obstacle removal program if applicable and appropriate should be considered.
- Operators should establish an appropriate review cycle to periodically assure the suitability of their performance data and procedures. In addition, operators should evaluate the effect of changes that occur outside of normal information or charting cycles. These changes may occur as a result of an issuance of an operationally significant NOTAM, temporary obstacle information, new construction, navaid outages, etc. For both periodic reviews and temporary changes, the operator should consider at least the following:
  - The need for an immediate change versus a routine periodic update.
  - Use of the best available information.
  - Any significant vulnerability that may result from the continued use of data other than the most current data, until performance and/or procedures are updated through a routine revision cycle.
  - Continued suitability of estimates or assumptions used for wind, temperature, climb gradients, NAVAID performance or other such factors that may affect performance or flight paths.
  - The review cycles and response times should be keyed to the needs and characteristics of the operator's fleet, routes, airports, and operating environment. No specific time frame is established for an operator to conduct either periodic reviews or short-term temporary adjustments.

5.1 Obstacle Clearance during a Straight Takeoff

CAO 20.7.1b paragraph 12.1 states that an operator shall ensure that the net take-off flight path clears all obstacles by a vertical distance of at least 35 ft.

As an example, the minimum required climb gross gradient during the second segment must be 2.4% for a two-engine aircraft. But, as per the CAO, the net flight path must clear any obstacle by at least 35 feet. This may sometimes require the second segment gradient to be greater than 2.4% (1.6 net gradient) and, consequently, the maximum takeoff weight may have to be reduced accordingly. This is a case of obstacle limitation.

5.2 Obstacle Clearance during a Turn

For a turn, CAO 20.7.1B paragraph 12.1 requires that a heading change must not be initiated prior to a point where the net take-off flight path clears all obstacles by a clearance of at least 50 ft. This clearance must be maintained during the turn. The turn is further limited to a bank angle of 15º. The CAO is a hybrid of the JAR-OPS 1.495 and FAR 121.189 and care must be taken to ensure compliance with the CAO is maintained.

> *FAR 121.189*
>
> *"f) For the purposes of this section, it is assumed that the airplane is not banked before reaching a height of 50 feet, as shown by the takeoff path or net takeoff flight path data (as appropriate) in the Airplane Flight Manual, and thereafter that the maximum bank is not more than 15 degrees."*
>
> *JAR-OPS 1.490*
>
> *(1) Track changes shall not be allowed up to the point at which the net take-off flight path has achieved a height equal to one half the wingspan but not less than 50 ft above the elevation of the end of the take-off run available. Thereafter, up to a height of 400 ft it is assumed that the aeroplane is banked by no more than 15°. Above 400 feet height bank angles greater than 15°, but not more than 25° may be scheduled;*

In addition to the regulatory requirements, it is good practice to consider the following in designing turns.

The 50 feet clearance should be determined from the lowest part of the banked aircraft.

- ✈ Adopting the portion of JAR-OPS 1.495 stated below.

  JAR-OPS 1.495

  "Track changes shall not be allowed up to the point at which the net take-off flight path has achieved a height equal to one half the wingspan but not less than 50 ft .."

This portion is conservative when compared to the CAO and provides extremely good guidance for obstacle clearance during a turn. This is a cautious approach especially when considering aircraft with large wingspans such as the B747-400 that has a wingspan of 211 feet.

5.3 Gross Obstacles

A gross obstacle (also known as a dummy obstacle) is used to force the aircraft to be at a required gross height at a certain distance from the end of the runway. For example, if the aircraft was required to turn at the runway end with an engine out for obstacle clearance, a gross obstacle can be used. The certification and operational rules only require a 35 feet screen height at the end of the runway. Placing a 15 feet simulated obstacle at the end of the runway will force the aircraft to be at 50 feet from the takeoff performance analysis and thus enabling a turn. In this example the obstacle would be very limiting and should only be considered as a last resort due to the relatively large weight penalty.

6.0 Turn Analysis

In many cases a turn will eliminate the need to consider limiting obstacles, increasing maximum takeoff weight (increasing payload and/or range). However, a turn may introduce new obstacles in the flight path and may limit V2 to maintain a turn radius.

EOSIDs usually involve a turn during the second segment takeoff climb phase. Sometimes the turn may be continued into the third segment. A note of caution should be made when considering turns in the third segment. Third segment distance will be extended due to the reduction of the acceleration capability (gradient capability) of the aircraft from the gradient loss in the turn. This may need to be compensated with a weight reduction or by an equivalent alternative means as the regulatory gradient capability must be restored.

Turns in the third segment can be penalizing for obstacle clearance and should only be used for clearance turns to avoid obstacles rather than flying over obstacles. Refer to section 8.0 for the acceleration altitude strategies used to avoid turns in the third segment.

For the purpose of this section, it is assumed that the aircraft is not banked before reaching a height of 50 feet and thereafter that the maximum bank is not more than 15 degrees.

6.1 Turn Radius Splay

The lateral obstacle containment area or splay in a turn can be significantly effected by temperature. The turn radius is a function of true airspeed (plus wind), which varies with temperature at the same indicated airspeed.

Formula for the calculation of the radius of a turn

$$R = \frac{V^2}{g \times \tan \phi}$$

- R Radius of turn in feet
- g Is the acceleration due to gravity (standard value is 32.17405 ft/sec^2 or 9.81 m/sec^2)
- ϕ Is the bank angle (limited to 15 degrees)
- V^2 Is the true airspeed in ft/sec or m/sec, to yield a radius in feet or metres (1 knot = 1.6878 ft/sec)

Also, the engine-out indicated airspeed (V2 or V2 plus an increment) varies considerably with weight, and limit weight is strongly affected by temperature. The temperature effect on both the maximum and minimum turn radii must be taken into account. For turn radius consideration the following guidance can be applied:

- Inner radius: Minimum dispatch weight at the coldest planned departure. This will give the tightest turn radius.
- Outer radius: Maximum dispatch weight at the hottest planned departure. This will provide the largest turn radius.

However, it is acceptable to do a turn analysis based on a single critical temperature if that temperature produces results which are conservative for all other temperatures.

In a turn, the specified lateral containment half-widths (i.e., one-half of the lateral containment maximum width) should be applied to the inside of the minimum turn radius and the outside of the maximum turn radius. An average turn radius may be used to calculate distances along track. Refer to Figure 6.1.1.

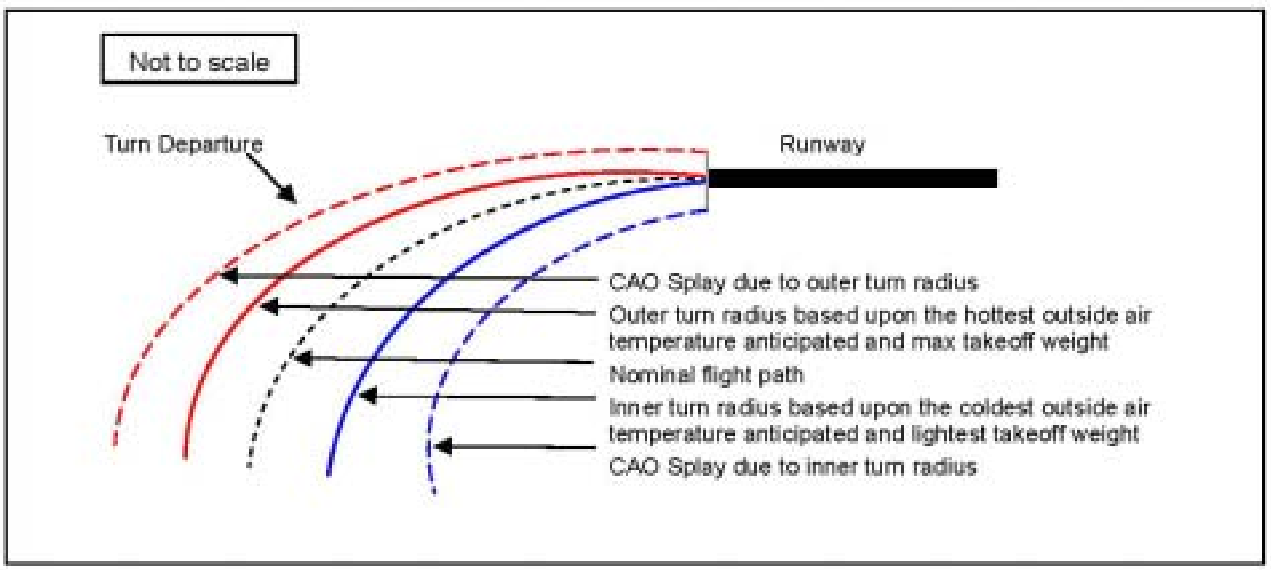


Figure 6.1.1 Splay Design in a Turn

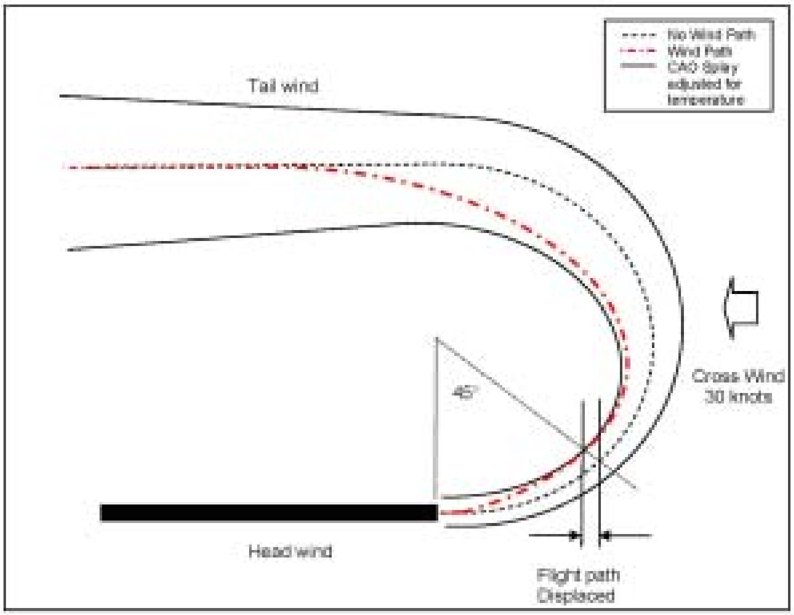
6.2 Wind Effect Upon Turns

The effect of wind on the takeoff flight path should be taken into account during a turn. This is in addition to making the headwind and tailwind component corrections to takeoff gross weight used in a straight-out departure. When assessing the effect of wind in a turn, the wind may be held constant in velocity and direction throughout the analysis unless known local weather phenomena indicate otherwise.

Once a splay is constructed as per the requirements above, wind accountability if known and constant to the departure should be superimposed on top of the turn splay and the turn splay further adjusted as required. Alternatively the turn and wind effect splays can be analysed concurrently. If wind gradient information is available near the airport and flight path (e.g., wind reports in mountainous areas adjacent to the flight path), the operator should take that information into account in development of a procedure.

The following example illustrates an acceptable method for accounting for the effect of wind in a turn.

Example 6.2.1



Radius of turn	= 2250
Wind speed m/sec	= 30 knots = 15.4
Distance to turn 180°	= p x r =3.142 x 2250 =7068 m
Aircraft speeds (V2)	=140 KTAS =72 m/sec
Time in turn (180°)	=Distance/Speed =7068/72 =98.2 sec
Heading Change	= 180°/98.2 ≈ 2°/sec

Fight Path Displacement
= Wind speed x Time

Time to turn 45°	=45/(2°/sec) ≈23 secs
Flight path displacement	=23 x 15.4 =354.m

Similarly for

Turn Angle	Time (sec)	Displacement (m)
90°	45	693
135°	68	1047
180°	90	1386

All values are to the nearest whole number.

In this example the splay would need to be re-adjusted to account for wind. As previously stated any obstacles that are considered for the takeoff analysis are required to be adjusted to set up an equivalent still air straight out flight path.

Note: the effect of wind is non-linear.

If the departure was such that the takeoff weight was based upon the crosswind component due to different splays capturing critical obstacles, then a different analysis would be required for different winds.

The takeoff information would be in a similar format to existing RTOW tables. A 10 knot headwind is representative of a 10 knot crosswind pushing the aircraft inside the nominal flight path. Similarly a 10 knot tailwind would be representative of a 10 knot crosswind pushing the aircraft outside the nominal flight path.

6.3 Obstacles in a Turn

Typical aircraft manufacturer's takeoff performance software and AFM performance data considers only straight out departures. The climb capability in a turn is decreased, and thus the obstacle height in the turn must be adjusted and projected as if it was in a straight out departure.

6.4 Loss of Climb Gradient during a Turn

During a turn, an aircraft is not only subjected to its weight, but also to a horizontal acceleration force. The resulting force is called "apparent weight", and its magnitude is equal to the load factor times the weight.

The load factor is typically expressed versus the bank angle (Φ). So, as soon as the aircraft is banked, the load factor becomes greater than one. This induces a loss of climb gradient.

The Aircraft Flight Manual generally provides a climb gradient decrement for a 15° bank turn. For bank angles of less than 15°, a proportionate amount should be applied, unless the manufacturer or Aircraft Flight Manual has provided other data.

The most common way to account for the gradient loss is by increasing the obstacle height by the gradient loss multiplied by the flight path distance in the turn, in order to arrive at an equivalent obstacle height that can be analysed as a "straight-out" obstacle in the operator's airport analysis programs or from AFM performance data. Refer to example

Example 6.4.1

EOSID Runway 34: At 1 DME TF VOR (runway head), turn right and track 050°M until clear of the coast.

An obstacle exists at an arc length 300 metres (984 feet) from the beginning of the turn, Height is 75 feet AMSL

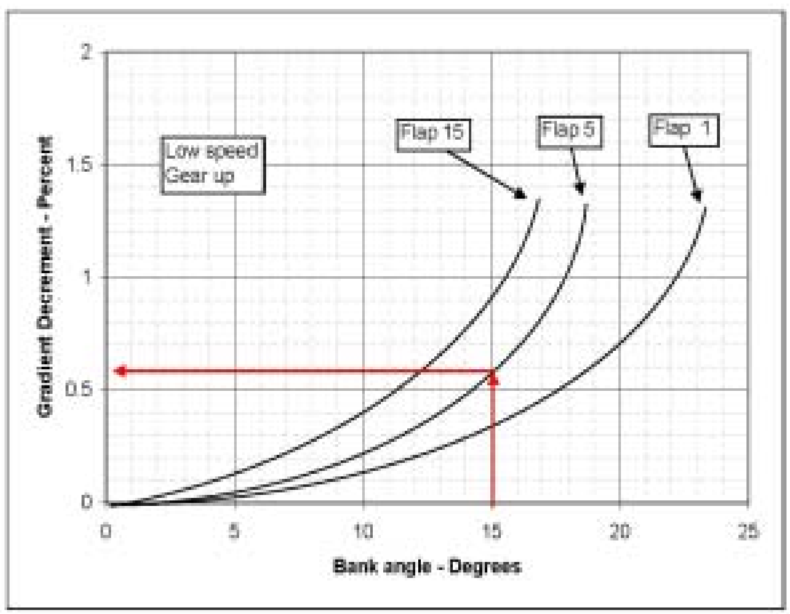
From the diagram, the gradient decrement is equal to 0.6% or 0.006 for a Flap 5 takeoff

The adjusted obstacle height can be calculated as;

0.006 x 984 + 75 = 81 feet AMSL

The regulatory requirements require are that obstacles in a turn are cleared by 50 feet. Normal obstacle clearance requirement is 35 feet. So for the obstacle in a turn an additional 15 feet needs to be added.

The straight out equivalent obstacle height thus becomes 96 feet AMSL.



Some EOSIDs require a turn to be performed with a bank angle of more than 15°. In these cases the V_2 speeds may have to be increased (Refer to Improved Climb) to provide an equivalent level of stall margin protection and adequate controllability, i.e., V_{MCA} (minimum control speed, air). Prior regulatory approval must be obtained to conduct a EOSID containing a turn with more than a 15° bank angle.

7.0 Improved Climb

Improved climb (also known as Overspeed) when certified in the AFM, is used to increase the maximum allowable takeoff weight when an aircraft is climb limited. To use improved climb, there must be excess field length, tyre speed, brake energy and obstacle performance. The improved climb procedure increases the normal V2 and because of that, increases the climb capability of the aircraft. V1 and Vr must also be increased if V2 is increased.

An increased V2 provides bank angle protection. This is accomplished by increasing the margin over the stall speed for the specific takeoff configuration of the aircraft.

8.0 Acceleration Altitude

CAO 20.7.1b Paragraph 7.3 requires that the aircraft climb at a minimum speed of V2 to a height of 400 feet above the takeoff surface or at a height that may be necessary to achieve obstacle clearance in accordance with Paragraph 12 of the same order. Once the aircraft has reached the acceleration altitude, it must have available a gradient climb equivalent of 1.2% for twin engined aircraft, 1.4% for three engined aircraft and 1.5% for four engined aircraft before the commencement of acceleration and clean up segment can begin. It is this climb capability that is used to accelerate the aircraft from a minimum of V2 to the engine out enroute climb speed while retracting the flaps. Aircraft that have a greater climb capability available during this segment may continue to climb during clean up and improve the obstacle clearance margins.

For standardization of operating procedures, operators may select a standard cleanup altitude that is higher than the 400 feet or that required for obstacle clearance at most airports. With the standard cleanup altitudes, the acceleration and cleanup must be accomplished within the takeoff thrust time limit established in the AFM. The obstacle analysis is usually based on a level off for cleanup, but, there is no operational requirement to level off, except in the rare case of a distant obstacle, which must be cleared in the final segment.

The terrain and obstacles at certain airports may require a higher than standard cleanup altitude to be used and must still allow acceleration and cleanup to be accomplished within the takeoff thrust time limit.

Note: During the acceleration segment, obstacle clearance must be ensured at all times

8.1 Acceleration Strategies

Different aircraft manufacturers permit different strategies for determining an optimum acceleration altitude for the purpose of obstacle clearance. These strategies are typically limited by the maximum takeoff thrust or power setting time limit. The maximum takeoff thrust is certified for use for a maximum time limit in the event of engine failure upon takeoff. Depending upon the aircraft manufacturer this typically is 5 or 10 minutes. Reference to the AFM must be made for guidance in relation to the strategies available. Figure 8.1.1 illustrates strategies which can be adopted. These strategies are for demonstrative purposes only, and do not represent any specific aircraft's performance. Before determining a strategy, assess the location of any obstacles and or terrain in the flight path and their location relative to the end of the runway. It may be necessary to evaluate all three strategies to determine which one will provide the required obstacle clearance and permit the higher takeoff weight. Typical considerations are:

- ✈ For distant obstacles, consider an early clean up and acceleration. You may find that a clean aircraft at max continuous thrust may climb better than an aircraft at takeoff thrust with flaps extended.
- ✈ For relatively close in limiting obstacles consider an extended second segment, especially if there are no further obstacles in the takeoff flight path

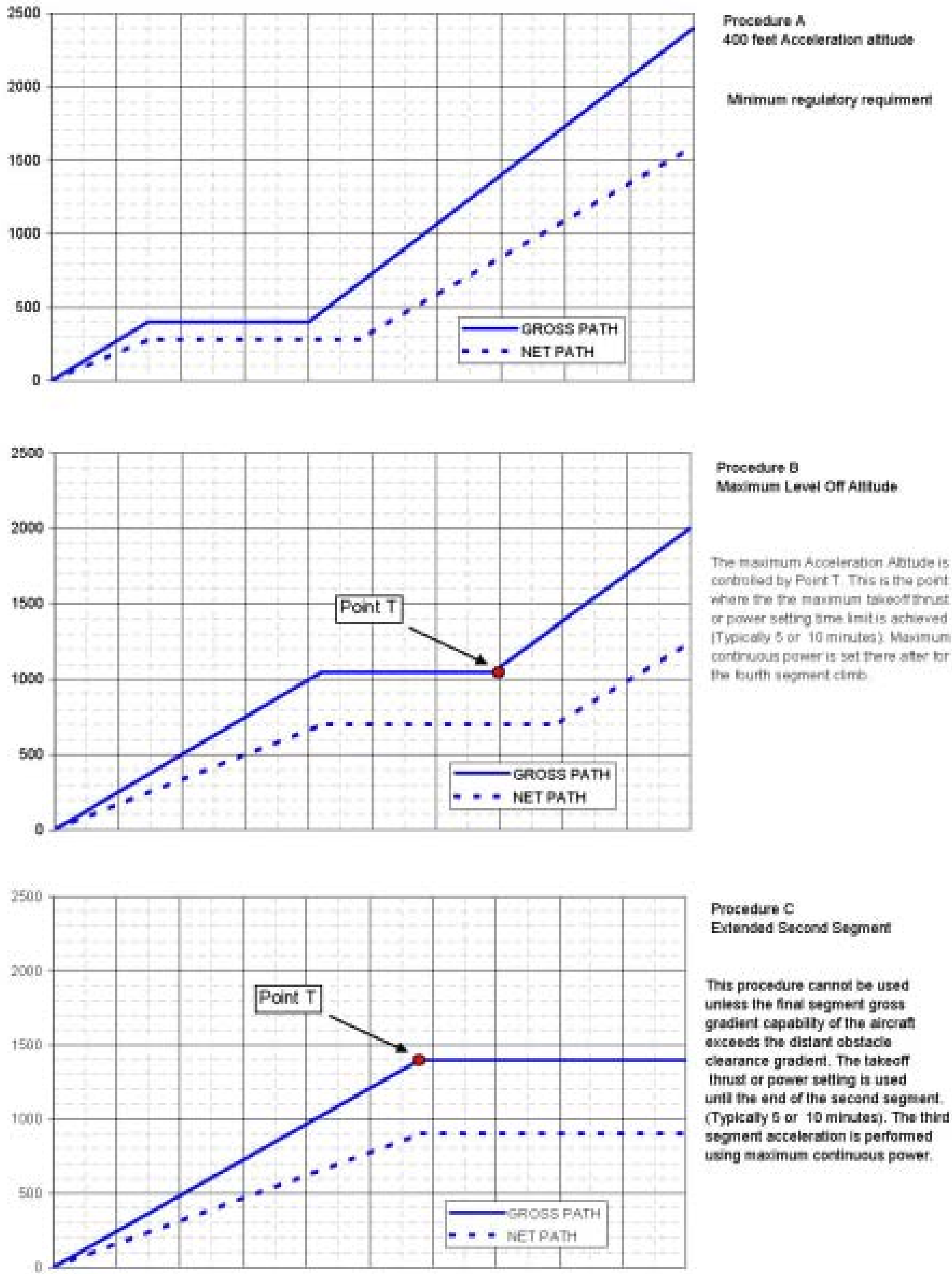


Figure 8.1.1 Second Segment Climb Strategies

9.0 EOSID Promulgation

9.1 EOSID Validation

Consideration should be given to conducting a flight or a simulator session to confirm flight crews' ability to fly the special engine-out departures. Obviously this will depend upon the complexity of the EOSID. This validation will help uncover any potential problems associated with those procedures and cockpit workload considerations, if they differ significantly from the all-engine procedures, or if terrain makes course guidance questionable at the engine-out altitudes. It should be emphasized that the purpose of such a validation is not to prove the validity of the performance data, nor to demonstrate obstacle clearance but to confirm the fly-ability of the procedure.

Acceptable techniques used for these flights include:

- ✈ Initiating the procedure from a low pass over the runway at configurations, speeds, and altitudes that represent takeoff conditions.
- ✈ Using a power setting on all engines calculated to give a thrust/weight ratio representative of engine-out conditions or setting one engine to flight idle.

A CONFIRMATION FLIGHT WITH A SIMULATED ENGINE FAILURE AT V_1 IS NOT RECOMMENDED.

9.2 Pilot Information

The development and implementation of unique departure and go around procedures should be coordinated with the Flight Operations department. Flight Crews should receive instructions, through an appropriate means, regarding these procedures. Based on complexity, this could be done through Flight Operations Bulletins, revisions to selected Flight Crew manuals, takeoff charts, Notams or special ground or simulator training.

The operator should advise flight crews of the following: (This may be accomplished as a general policy for all airports with exceptions stated as applicable, or specified for each airport).

- ✈ How to obtain V-speeds consistent with the allowable weights, with particular attention given to the effects of wind, slope, Improved Climb Performance and contaminants.
- ✈ The intended track with an engine failure. Some operators have a standard policy of flying runway heading after an engine failure; others routinely assume the all-engine ground track unless specifically stated otherwise. In any case, the intended track should be apparent to the flight crew, and the failure at any point along the track should be taken into account.
- ✈ Speeds (relative to V_2) and bank angles to be flown -- all-engines and engine-out.
- ✈ The points along the flight path at which the flap retraction sequence and thrust reduction are to be initiated.
- ✈ Initial turns should be well defined. ("Immediate" turns should be specified with a minimum altitude for initiation of the turn or a readily identifiable location relative to the runway in IMC or navigational fix).

10.0 CASA Approval

CASA does not individually approve each EOSID that an operator may have published in their manual. During scheduled audits or spot checks, CASA may request that the operator demonstrate that the procedure:

- ✈ Complies with all relevant regulatory requirements
- ✈ Complies with the AFM
- ✈ Is safe
- ✈ Provides sufficient obstacle clearance
- ✈ Can be executed by flight crews of average skill
- ✈ Contains the correct and required information

For this purpose CASA has developed a checklist as attached in Appendix 2, to provide guidance during the design and acceptance of EOSIDs.

PART B MISSED APPROACHES.

1.0 Introduction

Generally any multi-engine aircraft IFR capable, flying under IMC conditions with all engine performance can meet gradient capabilities published in missed approaches.

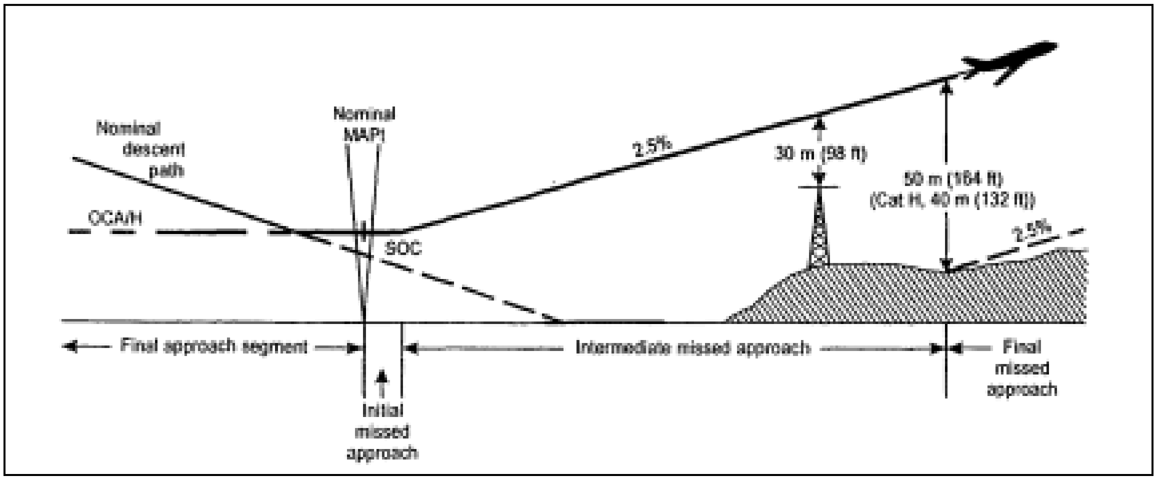


Figure 1.0 Missed Approach Phase

Source Figure 111-7-1, Chapter 7, ICAO Procedures for Air Navigation Services, DOC 8 168 Volume II, 4th Edition, Construction of Visual and instrument Flight Procedures.

Missed approach procedures are generally divided into the initial, intermediate and the final phase. Obstacle clearance requirements begin in the intermediate phase with a 30 metre (98 feet) clearance requirement. In the final phase, the obstacle clearance requirement becomes 50 metres (164 feet). The nominal climb gradient of a missed approach surface is 2.5%, however higher gradients may be required where obstacle clearance dictates.

For older aircraft, particularly piston engined, aircraft compliance with the published missed approach may not be achievable when operating at or near the maximum certificated weight, high altitudes, high temperatures and engine out conditions.

Note: *It is the responsibility of the operator to ensure that the aircraft does not conduct an approach at a weight and/or temperature that would not permit the aircraft to comply with the published missed approach procedure under normal "all engine" operational conditions. However under "engine out" emergency conditions compliance with the published missed approach procedures are not required.*

2.0 Regulatory Requirements

As stated in Section 2.0 from Part A, procedures anticipating engine failure at any time between the commencement of takeoff and completion of landing must be specified. This includes missed approaches with an engine out.

More specifically CAO 20.7.1B Paragraph 5.1(b) specifies that the landing weight of the aircraft must be reduced to meet amongst other things, the approach climb requirements in Paragraph 9. The approach climb performance requirements in Paragraph 9 stipulates that a gross gradient of 2.1% for twin-engine aircraft, 2.3% for three engine aircraft and 2.4% for four engine aircraft must be available for engine out performance. This is obviously the minimum climb certification requirement and is not related to any published missed approach procedures. Paragraph 12 makes reference to obstacle clearance however, it is limited to the context of takeoff and enroute.

3.0 Guidance

Operators should develop engine out missed approach guidance for all instrument approach procedures where the aircraft would not be able to comply with the climb gradient performance requirements of the normal published missed approach procedures with an engine out.

It is the responsibility of the operator to ensure that, for any engine out missed approach procedures developed for use within their operation, sufficient aircraft performance studies have been developed to verify that the procedure provides adequate obstacle clearance throughout the flight path. When developing engine out missed approach procedures, operators may be limited to flight paths that would only allow for obstacle avoidance until sufficient altitude is achieved to land at the airport or fly to an alternate airport as required by the type of emergency.

The intent is to identify the best option or options for a safe lateral ground track and flight path to follow in the event that a missed approach or balked landing go-around is necessary with an engine out. To accomplish this, the operator may develop the methods and criteria for the analysis of engine-out procedures which best reflect that operator's operational procedures.

Specific Engine Out Missed Approach Procedures may be designed when compliance with the published missed approach procedure cannot be achieved during engine out operations. An alternative option to designing an engine out missed approach procedure may be, to use an existing EOSID for the nominated runway.

Note: If an operator chooses to use an EOSID in lieu of a published missed approach path, they must first demonstrate that the aircraft has the navigational capability to overfly the landing threshold, track runway centreline and overfly the runway end within the initial splay tolerance as detailed in Table 2.5.1 and shown in Figure 3.1 below. Depending upon the operation type, the splay width can vary between 90 and 150 metres. Furthermore, the aircraft system and navigational capability needs to be assessed to ensure that the aircraft can be flown to the required tolerance in IMC and crew procedures must be in place to adequately address this manoeuvre.

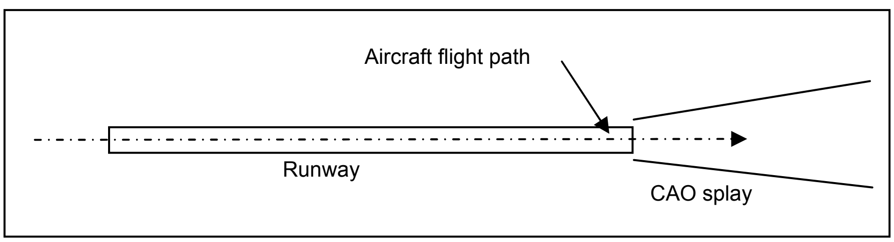


Figure 3.0.1 Runway Tracking Requirements

In the absence of an Engine Out Missed Approach Procedure, the following provides sample methods of ensuring that obstacle clearance is maintained during an engine out missed approach.

1. Limit the approach climb weight and thus the landing weight such that the aircraft can comply with the published gradient (2.5% and above) at the operating minima with an engine out.
2. Limit the operating minima to a height where the missed approach equivalent gradient capability is assured at the typical mission landing weight.

3.

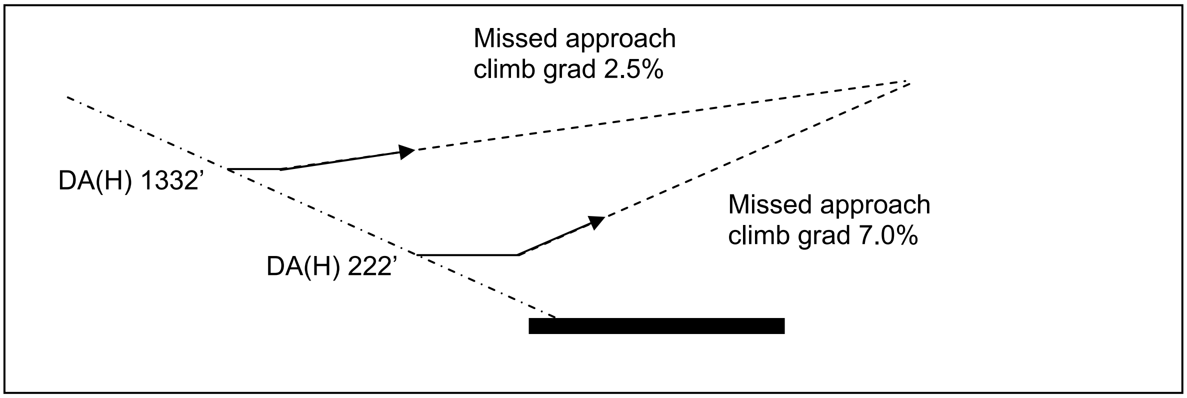


Figure 3.0.2 Multiple Minima for a Missed Approach.

In the diagram above, if the aircraft cannot comply with a 7.0% climb gradient engine out, the operator may choose a higher minima to enable a lower and compliable climb gradient. Some published procedures frequently provide alternate minima to accommodate different aircraft performance.

4.0 Missed Approach Procedure Assessment Considerations

Operators may accomplish such assessments generically for a particular runway, procedure, aircraft type, and expected performance, and need not perform this assessment for each specific flight. Operators may use simplifying assumptions to account for the transition, reconfiguration and acceleration distances following go-around (e.g., use expected landing weights, anticipated landing flap settings).

The operator should use the best available information or methods from applicable aircraft manuals or supplementary information from aircraft or engine manufacturers. If performance or flight path data are not otherwise available to support the necessary analysis from the above sources, the operator may develop, compute, demonstrate or determine such information to the extent necessary to provide for safe obstacle clearance.

The operational considerations should include:

- Go-around configuration transitions from approach to missed approach configuration including expected flap settings and flap retraction procedures.
- Expected speed changes.
- Appropriate engine failure and shutdown (feathering if applicable) provisions, if the approach was assumed to be initiated with all engines operative.
- Any lateral differences of the missed approach flight path from the corresponding takeoff flight path.
- Suitable balked landing obstacle clearance, until reaching instrument approach missed approach or enroute procedurally protected airspace.
- Any performance or gradient loss during turning flight
- Methods used for takeoff analysis, engine-out maximum angle climb, or other such techniques.
- Operators may make obstacle clearance assumptions similar to those applied to corresponding takeoff flight paths in the determination of net vertical flight path clearance or lateral track obstacle clearance.

4.1 Flight Crew Guidance

The operator should provide the following guidance to the flight crew:

- The flight path that provides the best ground track for obstacle clearance.
- The maximum weight(s) at which a safe missed approach or rejected landing can be safely accomplished under various conditions of temperature, wind and aircraft configuration.
- A "commit point" beyond which a safe rejected landing cannot be assured. This should only be used where it is not otherwise possible to identify a safe go-around procedure.

5.0 CASA Approval

CASA does not individually approve each Engine Out Missed Approach Procedure that an operator may have published in their manual. During scheduled audits or spot checks however, CASA may request that the operator demonstrate that the procedure:

- Complies with any relevant regulatory requirements
- Complies with the AFM
- Is safe
- Provides sufficient obstacle clearance
- Can be executed by flight crews of average skill
- Contains the correct and required information

Area Navigation (RNAV) RNP Appendix 1

It is assumed that the reader has a prior knowledge of the subject presented in this section. The guidance will be limited to the content of EOSID consideration and design utilising the subject topic.

RNAV is defined as a method of navigation that permits aircraft operations on any desired course. RNAV systems are known for their capability to utilize one or more navigation sensor source to determine the aircraft position. They compute flight paths referenced to navigation aids including VOR, DME, self-contained systems such as inertial reference systems or points defined by latitude and longitude (space based systems such as GNSS) and provide guidance cues or tracking of the flight path.

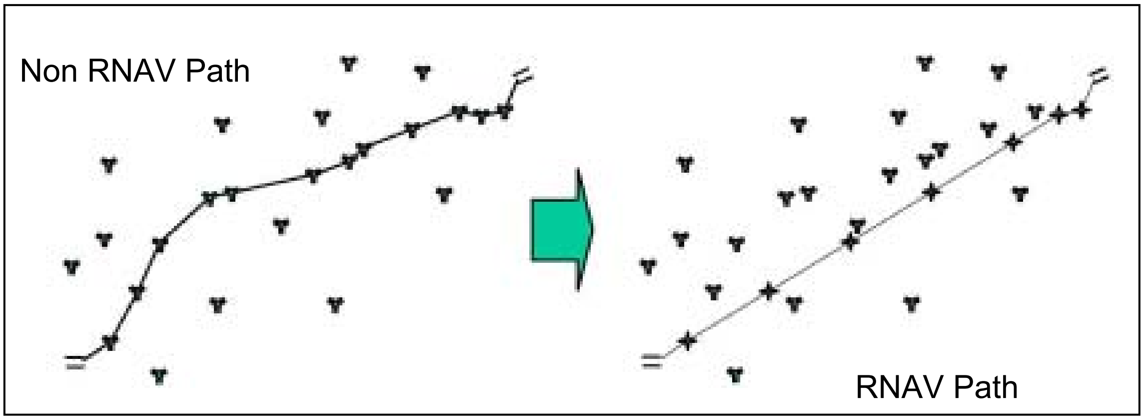


Figure A1.0.1 RNAV Path Definition

The flight paths used for RNAV have been established in a number of ways. One form has been the use of an on-board navigation database, where pre-stored information and data such as for airports, navigation aids, departure/arrival procedures, routes/airways, altitudes, speed, frequencies, elevation, distance, and magnetic variation is located.

RNAV procedures demand that designers possess a working knowledge of their aircraft navigation system to ensure RNAV procedures are flown in an appropriate manner. Additionally, procedure designers should have an understanding of the various waypoint and leg types used in RNAV procedures; these are discussed in more detail in the following sections.

Further development of navigation technology has resulted in a refinement of RNAV called Required Navigation Performance (RNP). RNP is performance based and not dependent on a specific piece of equipment. It is a statement of navigation position accuracy necessary for operation within a defined airspace. RNP is not new hardware for the cockpit or new navaids.

RNP is both a lateral and along-track specification. RNP is really a minimum performance standard which forms the basis for procedure design.

A1.1 RNP – Accuracy

The precision with which an RNP procedure is flown depends on the navigation source and on the aircraft onboard equipment and database.

Even though a standard format exists (i.e., ARINC 424), the coding of a procedure into a database (or the interpretation of that coding) may vary slightly. Differences in the databases along with variations in aircraft performance may result in slightly different tracks between RNAV RNP capable aircraft on the same procedure.

The RNP accuracy considers the following error sources:

- Position errors induced by the navigation aids or GPS satellite constellation.
- Position errors induced by the navigation sensors on the airplane.
- Position errors induced by the navigation system (FMC).
- Flight Technical Error

The RNP accuracy does not consider the following error sources:

- Software errors or hardware failures in the FMC or Sensor.
- Errors in time source used when reporting the position.
- Position errors in the navigation database data or resulting from incorrect manual waypoint entry.
- Differences in local datum other than World Geodetic System 1984 (WGS-84).
- Path definition errors (differences between the coded path in the database and the required path)

When designing RNAV RNP procedures, the above should be taken into account. The magnitude of the errors will vary with the aircraft equipment installation, information sources and design strategies.

A1.2 Aircraft Eligibility for RNP Operations.

Aircraft meeting RNP criteria will have an appropriate entry including special conditions and limitations in its Aircraft Flight Manual (AFM), or supplement. RNAV installations with AFM-RNP certification based on GPS or systems integrating GPS are considered to meet certifying authority's standard RNP levels for all phases of flight.

A1.3 RNAV RNP EOSIDs

With the advent of aircraft based area navigation capabilities, an alternative method of designing EOSIDs is becoming more widespread. This method involves analyzing the ground track of the flight path. The lateral obstacle clearance splay and subsequent area is based upon the navigational capabilities of the aircraft.

The minimum allowance is the demonstrated accuracy of the aircraft based navigation equipment. Aircraft based course guidance may be used in combination with other navigational course guidance to construct a departure procedure.

This method tends to be complicated, but may result in a smaller area for obstacle consideration. At present operational approval from CASA is required for use of this method in relation to technologies such as RNP.

A1.4 RNP Containment

The EOSID takeoff splay is currently defined by the lateral expansion as dictated by CAO 20.7.1B (12). The expansion is discontinued when the splay intersects the RNP containment area specified in the CASA approval as appropriate for the RNP type of operation and aircraft. CAO 20.7.1B provides guidance for EOSID requirements for aircraft utilizing RNP departures.

> *Extract from CAO 20.7.1B Paragraph 12.1.1(b)*
>
> *"….for an RNP-capable aeroplane engaged in an approved RNP operation, the lateral expansion of the take-off area may be discontinued when the take-off area intersects the RNP containment specified in the approval as appropriate for the RNP type that is:*
> *(i) selected in the FMS by the flight crew; and*
> *(ii) within the RNP capability specified in the flight manual for an*
> *operation of that kind.*

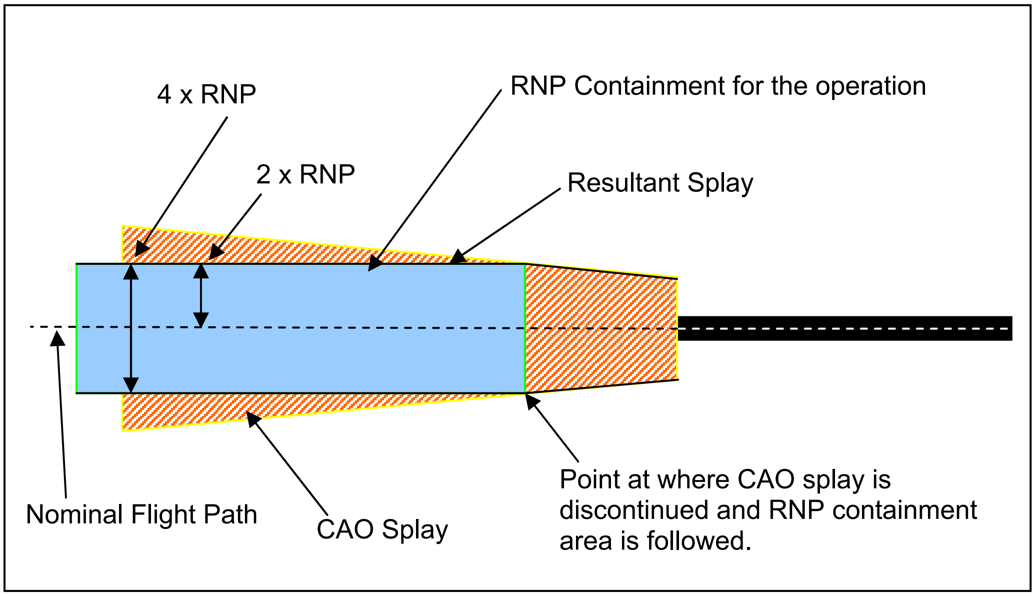


Figure A1.4.1 Path Transition from CAO 20.7.1B Splay to RNP Containment

The accuracy value ascribed to an RNP type approximates to a circle, with a radius equal to the RNP value, centred on the intended position of the aircraft. The actual position of an aircraft, which meets the RNP requirements, would be expected to be within such a circle, for 95.4% of the total flying time of that aircraft. This represents a 2*Σ (standard deviation) confidence limit

DO236A/ED75 states that 'a lateral containment limit of two times the RNP was chosen following consideration of the typical performance of existing navigation systems and evaluation of what was necessary to obtain the operational benefit. A containment of two times RNP is considered to equate to a 3*Σ or 99.7% confidence limit.

The half splay width as indicated by figure A1.4.1, above is thus equal to 2xRNP value, therefore the total RNP containment for the operation is 4xRNP.

A1.5 Waypoints

RNAV paths are defined by positive course guidance typically in the form of waypoints. A waypoint is a predetermined geographical position that is defined in terms of latitude/longitude coordinates. Waypoints may be a simple named point in space or associated with existing navaids, intersections, or fixes. A waypoint is most often used to indicate a change in direction, speed, or altitude along the desired path. Aircraft turns or transitions along a procedure make use of both fly-over and fly-by waypoints.

Fly-by waypoints. Fly-by waypoints are used when an aircraft should begin a turn to the next course prior to reaching the waypoint separating the two route segments. A change in direction at a fly-by waypoint requires the navigation system to "anticipate" the turn in order to intercept and fly the next leg. The amount of distance of turn anticipation prior to the waypoint depends primarily on the aircraft speed and the angle of bank in the turn.

Fly-over waypoints. Fly-over waypoints are used when the aircraft must fly over the point prior to starting a turn. At a fly-over waypoint, the aircraft will not turn to intercept the following leg until passing over or abeam the waypoint. Aircraft speed and angle of turn will influence the resulting flight path. Fly over waypoints result in an overshoot at the fix and a required turn back to the outbound segment.

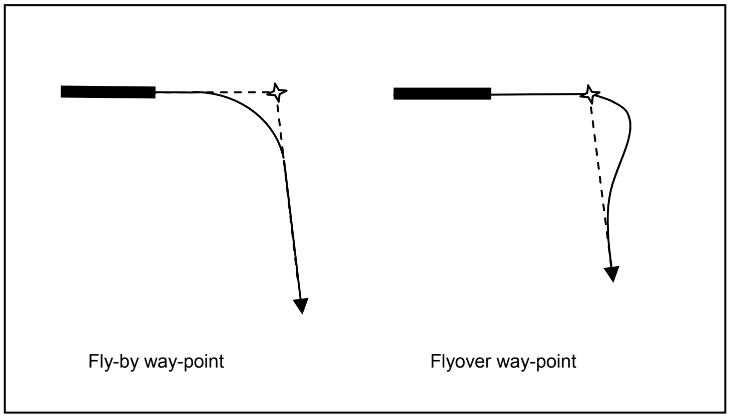


Figure A1.5.1. Waypoint Types

The choices between these various kinds of turns shall take into account obstacle clearance. In order for an aircraft to execute the turn in the designed RNP procedure properly, each specified track change should be at least 5° and, in case of a fly by turn, it is recommended that it not exceed 120°.

A1.6 Minimum Distances

To prevent turning waypoints being placed so close that RNAV systems are forced to bypass them, a minimum distance between successive turning points must be taken into account. Pans-Ops Construction of Visual and Instrument Flight Procedures, DOC 8168, Volume II, provides excellent guidance.

For each waypoint a minimum stabilisation distance between the way point and the point where the trajectory joins the tangentially the nominal track must be determined. This will enable the aircraft to stabilise after the first turn before commencing the next.

It is unwise to have consecutive legs of minimum length, as certain RNAV systems define an optimised course, which may contravene the obstacle clearance area boundaries. Moreover, the designer should note that some RNAV systems will not accept leg distances which are less than 2NM, regardless of the turn logic.

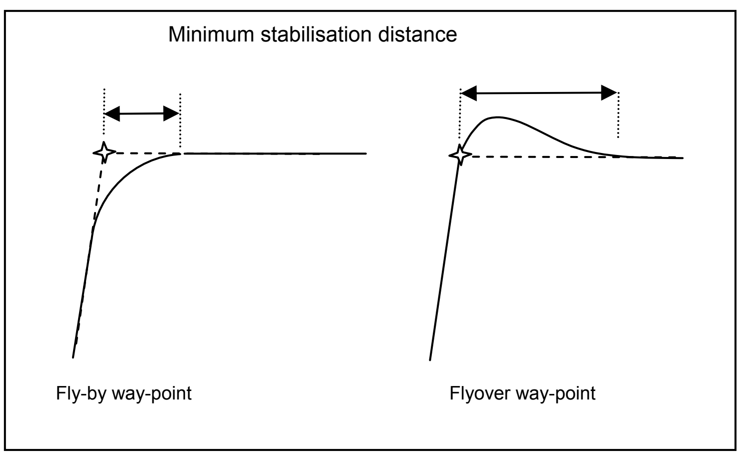


Figure A1.5.2 Minimum Stabilization Distance

A1.7 Path and Terminator Concept

The industry applies a “path and terminator concept” for transforming procedures into coded flight paths that can be interpreted and used by a computer-based navigation system. The path and terminator concept includes a set of defined codes referred to as “path terminators”. A path terminator instructs an aircraft to navigate from a starting point along a defined path to a specific point or terminating condition. A sequence of path terminators can define the intended route from take-off, through each departure segment, to a point on the enroute airway.

A leg describes the desired path proceeding, following, or between waypoints on an RNAV procedure. Leg types are identified by a code that describes the path (e.g., heading, course, track, etc.) and the termination point (e.g., the path terminates at an altitude, distance, fix, etc.). Leg types used for procedure design are included in the aircraft navigation database, but not normally provided on the procedure.

A leg consists of a set of two alphabetic characters, each of which has meaning when describing a flight manoeuvre to a computer. The first character indicates the type of flight path to be flown and the second character indicates where the route segment terminates. For example, a direct track from one explicit fix to another would be coded with a "TF" path terminator. The "T" represents the type of flight path to be flown (a track in this case) and the "F" indicates that the segment terminates at a fix.

Some of the common legs that are used for RNP procedures comprise of direct to a fix (DF), course to a fix (CF), track to a fix (TF), initial fix (IF), and Radius to Fix (RF).

Initial Fix — Initial Fix (IF) defines a database fix as a point in space. The IF normally indicates the initial sequence of the procedure. The IF leg does not define a desired track in and of itself, but is used in conjunction with another leg type in order to define the desired path.

Track to Fix. — A Track to Fix (TF) leg is intercepted and acquired as the flight track to the following waypoint based upon a magnetic course They define a great circle tack over ground between two known points. Track to a Fix legs are sometimes called point-to-point legs for this reason.

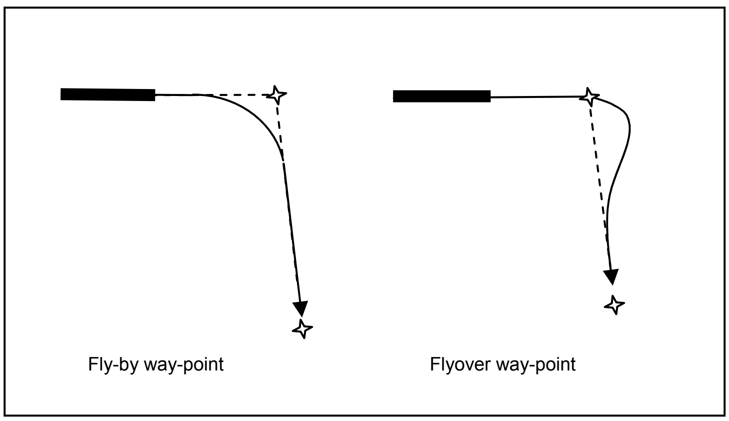


Figure A1.5.3 Track to Fix

Direct to Fix. — A Direct to Fix (DF) leg is a path described by an aircraft's track from an initial area direct to the next waypoint. A direct fix allows an immediate turn to a waypoint without requiring interception of a particular course. A DF leg is highly variable.

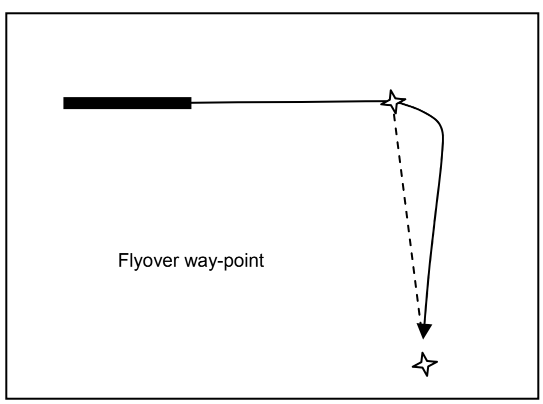


Figure A1.5.4 Direct to Fix

Course to Fix. — A Course to Fix (CF) leg is magnetic path that terminates at a fix with a course at that fix. A CF leg differs from a TF only in that it does not have a beginning waypoint.

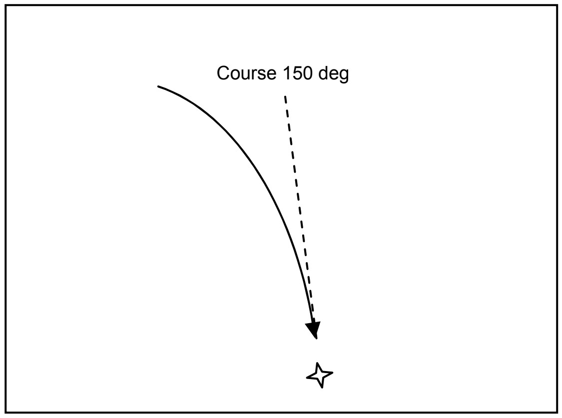


Figure A1.5.5 Course to Fix

Radius to Fix. A Radius to Fix (RF) leg is defined as a constant radius circular path around a defined turn centre that terminates at a fix. A radius turn is a constant radius circular path defined by the tangential point at the end of the turn, or the centre of the turn and the turn radius. For this kind of turn, the aircraft must be able to make variations in bank angle to compensate for wind effects and follow the pre-determined trajectory with a navigational accuracy related to the RNP.

The leg prior to a RF leg must be at a tangent to the radius. Use of an RF leg for a turn reduces the requirement to consider the effect of the wind during the turn, however this is only the case if the expected wind, ground speed and turn radius are such that the flight director (or Auto-pilot) can command the required turn radius given any bank angle limitations with one-engine out

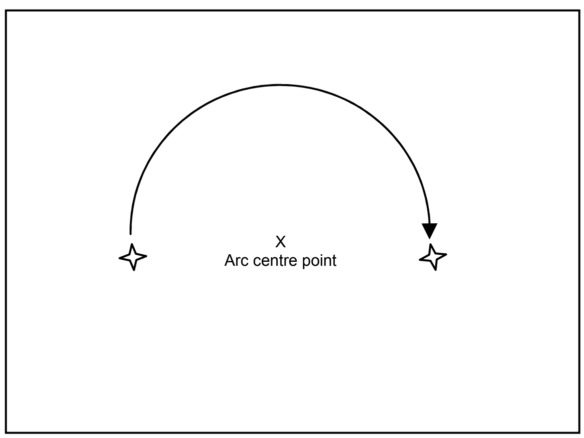


Figure A1.5.6 Radius to Fix

Putting some of the leg types together can produce a sample RNAV RNP EOSID as detailed below.

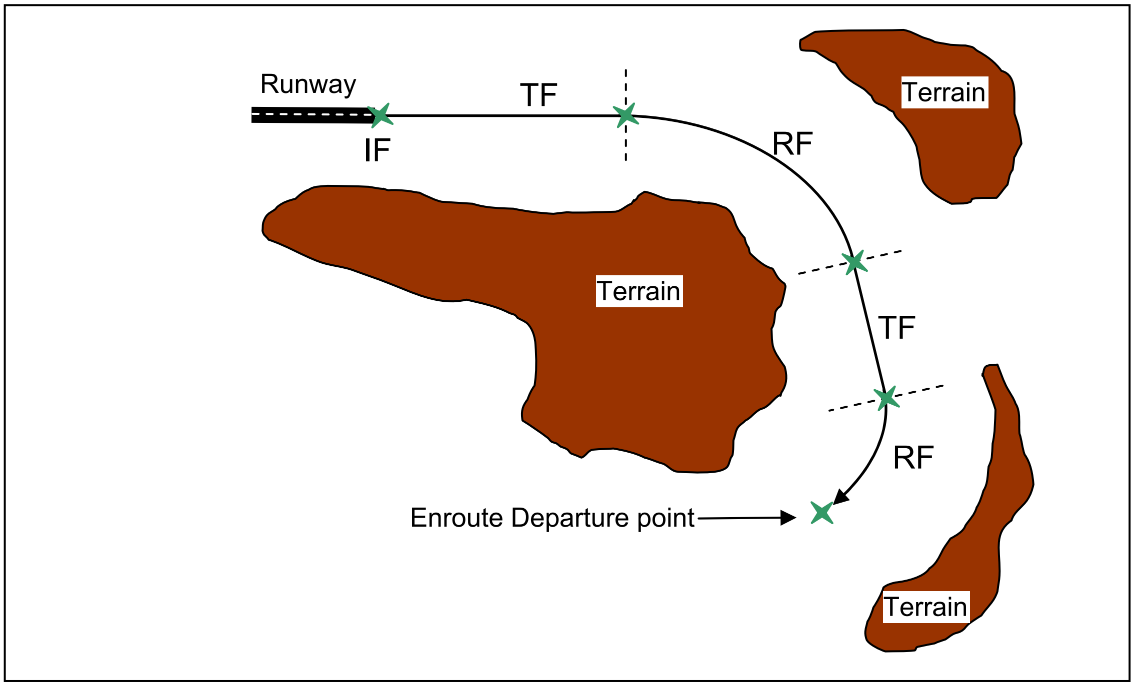


Figure A1.5.7 Sample RNAV RNP EOSID

A1.8 Path Definition Error

To reduce path definition error, uses of certain leg types are discouraged in order to achieve reliable, repeatable, and consistent system performance. Eliminated for RNP applications are flight path leg types which are inherently unstable due to factors such as magnetic variation, and dependencies on altitude and distance crossings. Retained are those flight path leg types whose reliability, repeatability and predictability as a path in space are maximized. Note, that even in the case of these permissible leg types, the path definition error contribution may need further evaluation for the planned RNP operation. This includes the earth model, fix resolution, turn radius resolution, course resolution and/or magnetic variation that apply to each leg type.

Additionally, the navigation data contained in a database used for RNP operations is now required to have the data integrity, resolution, geodetic references and procedure designs consistent with minimized variance effects on the path in space.

There are 23 different path and terminator sets used by the aviation industry to accommodate the coding of procedure route segments. The 23 different path terminator sets are shown in the Table A1.8.1. Only 9 of the 23 path terminator sets are usable in defining RNP procedures and airspace.

The leg types acceptable for RNP RNAV operations are identified as “preferred”. The leg types that are characterised by greater variability in the flight path are identified as “discouraged”. These are not desired for RNP RNAV flight paths. However, in the case where they must be used, the variability must be accounted for in the airspace criteria.

Leg Types	Description	RNAV Emulating Non-RNAV	RNAV	RNAV RNP
IF	Initial Fix	Yes	Yes (Preferred)	Yes (Preferred)
TF	Track to Fix	Yes	Yes (Preferred)	Yes (Preferred)
RF	Radius to Fix	No	No	Yes (Preferred)
DF	Direct to Fix	Yes	Yes	Yes (Discouraged)
FA	Fix to Altitude (Climb)	Yes	Yes	Yes (Discouraged)
CF	Course to Fix	Yes	Yes	Yes (To be Phased out)
HF	Hold to Fix (And Exit)	Yes	Yes	Yes (New RNP Hold Criteria)
HA	Hold to Altitude (Climb)	Yes	Yes	Yes (New RNP Hold Criteria)
HM	Hold for Clearance	Yes	Yes	Yes (New RNP Hold Criteria)
PI	Procedure Turn to Intercept	Yes	No	No
CA	Course to Altitude (Climb)	Yes	No	No
CI	Course to Intercept	Yes	No	No
CD	Course to DME Arc	Yes	No	No
CR	Course to VOR Radial	Yes	No	No
FC	Course From Fix	Yes	No	No
FD	Fix to DME Arc	Yes	No	No
FM	Vectors From Fix	Yes	No	No
AF	DME Arc to Fix	Yes	No	No
VD	Heading to DME Arc	Yes	No	No
VA	Heading to Altitude (Climb)	Yes	No	No
VM	Heading (Vectors)	Yes	No	No
VI	Heading to Intercept	Yes	No	No
VR	Heading to VOR Radial	Yes	No	No

Note: Most legs except those with an "A" as a terminator (second character) can be used for climb or descent.

Source. Table 3.1 Path and Terminator Sets -RTCA DO-201A April 19, 2000

Table A1.8.1 RNAV Legs for FMS Coding

A1.9 RNAV RNP EOSID Design Considerations

RNAV RNP procedure design requires that the procedure designer be mindful of the requirement of the aviation industry in coding procedures. The following guidelines are provided to accomplish this:

- **Positive Course Guidance.** All RNAV segments are assumed to have positive course guidance. Criteria for "climb to an altitude and turn" are not provided due to the inability to specify a positive course with an altitude.

- **Waypoints.** The following general considerations should be considered to the creation and use of waypoints for RNAV RNP EOSIDs:
  - Substitution. Existing fixes and navigational aids may be substituted for a waypoint where conveniently located.
  - Procedures must be designed, using the fewest number of waypoints possible, without any route gaps or discontinuities.
  - Fly-by waypoints should be used, wherever possible.
  - Fly-over waypoints must only be used when operationally necessary and should NOT be used for the IF.
  - RNAV waypoints must be defined as WGS 84 co-ordinates in latitude and longitude to the following accuracies:
    - Runway thresholds to 1/100 second.
    - All other waypoints to 1/10 second.

- Waypoints shall be designated where course, speed, or altitude changes occur.
- Each waypoint (WP) shall be defined by latitude and longitude in degrees, minutes, and seconds and shall be developed to the nearest hundredth of a second.
- Where appropriate, the bearing (to the nearest degree for flight crew use and to the nearest tenth of a degree for database coders) and distance (to the nearest tenth of a nautical mile) of the waypoint from the reference navaid.

✈ **World Geodetic System 1984 (WGS-84).** Since January 1998, all co-ordinates published for civil aviation navigation purposes should be based upon WGS 84. The WGS-84 co-ordinates must be expressed as latitude and longitude and the height of the specific surveyed ground points must be expressed as height above mean sea level (MSL), or another specified datum.

✈ **Aircraft Performance**. It is very important that the procedure designer be aware of the capabilities of the aircraft that are expected to use the procedure. It may be impossible for a large, long-haul jet to follow a departure procedure designed for a small, short-haul turboprop. Moreover, although more and more aircraft will have the capability to fly fixed radius turns, a significant percentage of the traffic will not have such a capability unless it is mandated. The designer must also understand the performance criteria necessary to achieve the procedure - for example, certain models may not be able to follow the procedure, if turns in excess of 120° are used.

✈ **FMS System Limitations**. Consider the system capabilities such as;

- The ability to select single or multiple branch points. When considering branch points, for the purpose of reducing the initial crew workload, consider placing the branch as far away from the runway as possible and or practical
- Can the FMS limit the turn to maximum 15° bank turn? If not limit the speed and radius to ensure that the 15° bank angle is not exceeded.
- Can multiple EOSIDs be used on the same runway? May limit payload for different ambient conditions.
- Certain systems do not recognise turns of less than 5° and do not apply turn logic in these cases.

✈ **FMS Provisions.**

- RNAV procedures must be defined in such a way that there are no ambiguities when the data is coded into a navigation database, regardless of the FMS/RNAV system that is installed. Furthermore, in general, RNAV procedure design should focus on safety, codability, flyability, repeatability, and simplicity where relevant.
- Turn Anticipation. The capability of FMS to determine the point along a course, prior to a fly-by waypoint, where a turn is initiated to provide a smooth path to intercept the succeeding course. Turn distance includes roll anticipation distance as well as the distance necessary to make the required turn.

✈ **Risk Management Strategy**.

- When converting existing conventional EOSIDs into a new RNAV RNP EOSID, the procedure may require revision or a total redesign and a new risk assessment.
- Asses the risk management strategy and maintain focus on the high risk portion of the departure. Due to FMS system limitations the RNAV RNP EOSID may not provide the optimum path for risk management, but if properly mitigated can provide an equivalent level of risk and safety.

✈ **Repeatability of flight path**. One of the main benefits of this technology is the repeatability of the flight path for a properly designed EOSID.

- For curved departures, the optimum departure requires the extensive use of fixed radius (RF) legs. For RF legs the tracking accuracy typically does not diminish as a function of distance between waypoints. In other words, no position drift occurs as a function of this distance,

- Consider using an RF leg in lieu of an inefficient number of small interval TF legs with multiple flyby waypoints to emulate an RF leg (Ferris wheel).
- The IF, TF, and RF legs are the preferred elements to define RNAV RNP procedures.
- Every leg must proceed from a waypoint to a waypoint.
- Large angle changes (>90°) should be avoided wherever possible.
- Conditional transitions should be used sparingly and with care.
- Procedures should be designed in such a way that they can be properly translated using the prescribed leg types and route types.
- The procedure designer must be aware of the impact that specific types of transition will have on the aircraft expected to use the procedure.
- All details of any specific restrictions applied to a procedure must be published.

✈ **Path transitions.** Consideration should be given to navigation system to ensure it shall provide a means to automatically transition from one leg to another. Two categories of transition between fixed path segments are fly-by transitions and fixed radius transitions. The navigation system shall be capable of accomplishing both of these transitions.

✈ **Additional Considerations.**

- Aircraft Available Technology. The basic principle is to reduce complexity by use of the proven technology available on the aircraft.
- Avoid conditional transitions, such as climb to XXXX feet by an XX DME", or "at XX DME but not below XXXX feet, turn right direct to (way-point).
- Procedures should be developed in such a way that they can easily and properly be coded into the appropriate path terminator and route type.
- Avoid the usage of the following elements:
  - Heading/vector segments
  - Track segments without a fixed termination waypoint
  - Procedure Turn segments
  - Radial or distance terminated legs

A1.10 Procedure Validation

It is imperative that adequate checks are carried out before the procedure is authorised for use. A flight check may be required to ensure that the coverage provided by the navigation infrastructure is adequate, there is no interference or multi-path effects, and none of the visible navaids cause degradation of the navigation solution.

A1.11 Database Integrity

The problem of maintaining the integrity of navigation data throughout the navigation data process, from survey/calculation to final use, is addressed in a number of ways:

✈ ICAO Annex 15 requires that a Cyclic Redundancy Check (CRC) is used to monitor the integrity of electronically stored aeronautical data. Different CRC algorithms may be used for the different data classes although it is anticipated that many States will employ the same algorithm for all navigation data.

A CRC value is generated for a group of data items, such as the name, location and elevation of a runway threshold, when that data is originated. The CRC value remains with the data group throughout the navigation data process and is used, at various stages in the process, to verify that the data group has not been corrupted. If the data group is re-formatted, a new CRC value must be generated. This CRC process already exists as a general fault detection functionality in most databases and spreadsheets however it has still to be applied in earnest to meet the specific Annex 15 requirements.

- ✈ EUROCAE 76 (RTCA DO 200) details the requirement for a suitable quality assurance system to be employed by all organisations involved in the navigation data production process. This includes all the procedures and standards necessary to ensure that the appropriate quality targets are met. One of those standards will be the application and maintenance of CRCs on all critical navigation data.
- ✈ The JAA has issued TGL 9 - Recognition of EUROCAE Document ED-76 (RTCA DO-200A): Standards for Processing Aeronautical Data. They will shortly issue additional guidance on the production approval of navigation database suppliers. TGL 10 requires that data is obtained from a suitably qualified source and that navigation accuracy checks are carried out at appropriate times during the operation. States should publish supplementary information in the form of radials/bearings and DME distances to specific waypoints in order to enable the flight crew to verify the RNAV performance during the procedure.

  The industry approach to TGL 9 and TGL 10 includes the use of a 'gold standard' database against which the production navigation database is checked every AIRAC. This serves to highlight all the changes made to the database during the cycle and provides assurance that data integrity is maintained.

The data originator/State may consider it has a 'duty of care' to obtain assurance that the data provided to the aircraft operator is an accurate reflection of the data published in the State AIP. This may be achieved through regular audit of the delivered databases or through a similar use of gold standard databases each AIRAC.

A1.12 Future RNAV RNP Standardization Issues

RNAV systems are manufactured by various companies that aim to tailor make their equipment for their customers. (Here, the customer is usually the aircraft manufacturer, such as Airbus Industrie or Boeing, which can in turn request special features to meet the needs of the end-user). Whilst some standardisation does exist in the data provided in the navigation databases used by the equipment, uniformity does not necessarily exist as to the way in which this data is interpreted.

Likewise, the computer ‘logic’ used (or algorithm) by one system does not necessarily correspond to another. Potentially, the end result is that one ‘desired’ track may be flown or navigated slightly differently by different equipment. It is appropriate to point out, however, that such differences are not always caused by the technology itself but may be influenced by the way in which it is operated.

It is worth remembering that differences in aircraft navigation performance are not simply explained by the fact that there are various RNAV systems on the market. Data-bases servicing the equipment may also differ, as may the algorithms used by the various systems. Moreover, not all flight decks represent the navigation data in the same way.

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Engine Out Departure Procedure Design Checklist Appendix 2

The following checklist provides guidance in assessing engine out departure procedures for regulatory compliance. The checklist can be used at the design stage by procedure designers and as an audit tool for CASA when assessing procedures for aircraft that are required to comply with CAO 20.7.1B.

CAO 20.7.1b	Design	Yes	No
14.2	Does the procedure cater for an engine failure at any point after V1?	☐	☐
12	Is the lateral splay in accordance with the requirements of CAO 20.7.1B? *Note: Refer to Table 2.5.1*	☐	☐
	Does the procedure provide positive course guidance?	☐	☐
	Is the course guidance based on visual reference to the ground?	☐	☐
	Is the company departure minima (ceiling and visibility) consistent with that required to fly the procedure with visual reference to the ground?	☐	☐
	Is the course guidance based on dead reckoning?	☐	☐
12.7	Does the lateral splay used adequately consider the effects of drift due to the maximum possible cross wind?	☐	☐
	Is the course guidance based on the use of navigation aids or track guidance?	☐	☐
12.1.1(b)	If applicable, does the lateral expansion of the splay consider the area of probability of the radio navigation aid?	☐	☐
14.2	Is the procedure such that it can be consistently flown on instruments with one engine inoperative by flight crews of average skill?[1]	☐	☐
	Does the procedure cater for navaid outages?	☐	☐
	Does the procedure cater for flight instrument unserviceabilities permitted by the MEL?	☐	☐
	Does the procedure include one or more turns?	☐	☐
	Are the turn points adequately defined?	☐	☐
	Is the turn direction and turn end condition specified?	☐	☐
12.1	Is the turn radius based on a maximum 15° angle of bank?	☐	☐
	Is the turn radius based on a minimum V2 speed and a maximum V2 or, if applicable, a maximum V2+ speed that may be commanded by the Flight Director?	☐	☐
12.7	Has the lateral splay been adjusted for the possible wind during the turns?	☐	☐
12.1	Are all turns initiated only once a 50ft obstacle clearance is achieved?	☐	☐
12.1	Have the height of the obstacles in the splay been properly adjusted for the additional clearance requirements and gradient decrement during the turn?	☐	☐

12.1 7.5	Have the certified net engine out takeoff flight path gradients been analysed against the procedure?	☐	☐
	Have all the takeoff segments been considered in the design of the procedure?	☐	☐
7.3.1	Does the acceleration altitude meet the minimum height requirement of 400ft AGL?	☐	☐
12.1	Does the net flight path clear all obstacle heights (adjusted accordingly) by 35ft?	☐	☐
	If applicable, is the turn completed prior to the commencement of the acceleration segment?	☐	☐
	Is the acceleration segment completed within the time limit that the engines are certified to produce take-off power?	☐	☐
	Does the procedure join onto a holding pattern or are there provisions to return to the departure airport?	☐	☐
	Does the procedure join onto an en-route flight path to another suitable airport?	☐	☐
12.4	Are the en-route obstacle clearance requirements considered?	☐	☐
	Does the procedure cater for all operational weights?	☐	☐
	Obstacle Data		
	Has the most current obstacle information been used in the procedure?	☐	☐
	Are the sources of obstacle data accurate and reliable?	☐	☐
	Do the selected obstacle heights consider map error, vegetation allowances etc?	☐	☐
	If applicable, have any transient obstacles been considered and are the height allowances appropriate?	☐	☐
4.1(ba)	Are the same obstacles reflected in the calculation of the RTOW data?	☐	☐
	Procedure Promulgation		
	Was the procedure reviewed by the Chief Pilot or his delegate prior to promulgating the procedure?	☐	☐
	Did this review consider any risk associated with the procedure, the fly-ability of the procedure and the appropriateness of the procedure given the type of aircraft and the type of operation?	☐	☐
	If applicable, did this review include an assessment in a flight simulator?[2]	☐	☐
14.2	Is the procedure published in the Operations Manual and readily available to flight crew in the cockpit?	☐	☐
	Is the procedure description concise and does it contain all the relevant data in a simple unambiguous format?	☐	☐

	Additional RNP Considerations		
	Is the procedure designer proficient with RNAV RNP procedures?	☐	☐
	Does the designer have a working knowledge of the aircraft's navigation system?	☐	☐
12.1.1(b) 12A.5	Has the CAO 20.7.1B takeoff splay been discontinued at the correct RNP containment?	☐	☐
	Has the use of fly by and fly over way points been properly considered?	☐	☐
	Does the selection of legs and fixes used ensure that the variability is reduced such that a repeatable flight path can be achieved and are only the permitted leg and terminator sets used? *Note: Refer to Table A1.8.1*	☐	☐
	Have the FMS RNP and navigation limitations been considered in the design of the procedure?	☐	☐
	Has the minimum aircraft equipment required to fly within the RNP of the procedure been analysed, identified and published with the procedure?	☐	☐
	Does the procedure description clearly identify the RNP?	☐	☐
	Have the limitations in the AFM been observed?	☐	☐
	Is there RTOW data applicable to each possible RNP for the procedure?	☐	☐
	Are there procedures in place to ensure that the aircraft's database integrity is maintained?	☐	☐

Notes:

1. *May require input from an appropriately qualified Flight Operations Engineering personnel.*
2. *This should be mandatory for an RNAV or RNP engine out procedure.*

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Wet and Contaminated Runway Performance Appendix 3

Aircraft certified post amendment 92 to FAR 25.109 or change 15 to JAR 25 have wet runway accountability. These aircraft have been certified to new requirements for takeoffs from wet runways.

Although there is no certification requirements for contaminated runways at present, the wet runway certification criteria equally applies to contaminated runways. For aircraft certified prior to this requirement or certified in the commuter category, some aircraft manufacturers have published guidance information for operations on wet and contaminated runways.

In keeping within the context of this guidance with regards to EOSIDs, the major difference between dry and wet/contaminated runway performance is the screen height. On a wet or contaminated runway, the screen height (height at the end of the takeoff distance is 15 feet. The net takeoff flight path starts at 35 feet at the end of the takeoff distance. So, the gross flight path starts at 15 feet while the net flight path starts at 35 feet at the end of the Takeoff distance

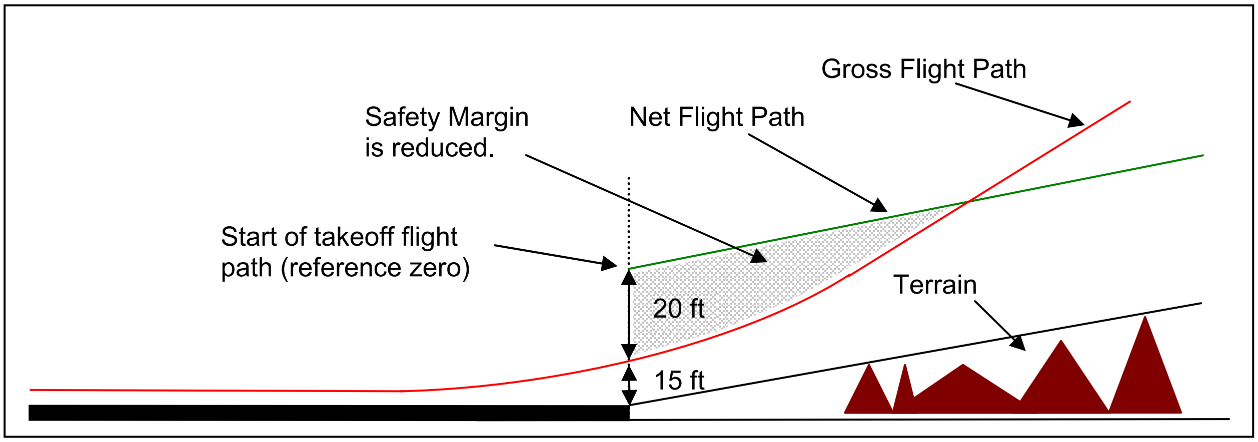

Figure A3.0.1 Wet Runway Screen Height

When taking off on a wet or a contaminated runway and an engine failure occurs at V1, this implies that the aeroplane can initially be as much as 20 ft below the net takeoff flight path, and therefore may clear close-in obstacles by only 15 feet.

This implies that while the net flight path clears the obstacles by 35 feet all along the takeoff flight path, the gross flight path can initially be at less than 35 feet above close-in obstacles.

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Airport / Obstacle Information Sources — Appendix 4

- ✈ Airport Characteristics Data Bank (ACDB)
  - o Volume 1 Summary and Explanation
  - o Volume 2 Africa - India Ocean Region
  - o Volume 3 Caribbean and South American Regions
  - o Volume 4 European Region
  - o Volume 5 Middle East and Asia Regions
  - o Volume 6 North Atlantic North American and Pacific Regions
- ✈ Aerodrome Obstruction Chart - Type A
- ✈ Aerodrome Obstruction Chart - Type B
- ✈ Geological Survey Maps
  - o Maintained by Department of the Interior Geological Survey
  - o Provide surface contour information and some obstacles
  - o Provided by airport authorities for virtually all U.S. Airports
- ✈ Aeronautical Information Publications (AIP)
  - o Published by most national governments
  - o Provide Standard Instrument Departure (SID) procedures
  - o Minimum performance requirements
  - o Climb profile (minimum gradient)
  - o Maneuvering limitations (maximum turn radius)
- ✈ Jeppesen
  - o Obstacle Database
  - o Airway Manuals
- ✈ SITA
- ✈ Topographical Maps
- ✈ Airport Authority
- ✈ Geosciences Australia
- ✈ Surveys carried out for operators, preferably by surveyors experience in aviation requirements.

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