Target:

Learn basic concept on path terminator and Database coding.
Path terminator

- **Part 1**: General
- **Part 2**: Path terminator Types
- **Part 3**: Procedure design application
- **Part 4**: Path terminator coding rules
PAN OPS Reference

PAN OPS Vol II Sixt Edition

- Part III – Section 2 – Chapter 5
- Part III – Section 2 – Appendix to Chapter 5
General Concept

- All the procedures (conventional and non-conventional) are always coded into the Airborne Navigation Database to be flown with the autopilot or by hand.

- To fly conventional procedure, the AND is not a requirement;
- To fly non-conventional procedure, the AND is a requirement;

- The A/C doesn’t fly by signal but fly by waypoint;

- FMS manages the Flight path;

- Necessity to permit the FMS to follow the procedure path as studied by the procedure designer;

- In order to translate the textual description of a procedure and the routes depicted on charts into a code suitable for navigation systems, the aviation industry has developed the PATH TERMINATOR concept;
DEFINITION

• A two-letter code, which defines a specific type of flight path along a segment of a procedure and a specific type of termination of that flight path.

• Path terminators are assigned to all RNAV, SID, STAR and approach procedure segments in an airborne navigation database.
ARINC 424

- Navigation data used by RNAV system that is certified for terminal operations are held in a navigation database, those data area code in accordance with aviation industry standard "ARINC 424 Navigation System Database Specification".

- Path terminators should be used to define each leg of an RNAV from takeoff to enroute to landing.

- Many aircraft are equipped with RNAV system only capable of using a sub-set of the ARINC 424 path terminators.

- 23 Path terminators are defined but just 11 accommodate the majority of aircraft that are expected to be approved to fly RNAV SID, STAR and Approaches.
Path Terminators

- RNAV 11 of 23
- RNP 5 of 23
- **IF (Initial Fix):**
  - The coding of RNAV procedures starts with a IF.
  - Doesn’t define a desired track, but is used in conjunction with another leg types in order to define the desired path.
  - Not used in the design process and need not to be published with the procedure description.
TF (Track to a Fix)

- TF route is defined by the geodesic path between two waypoints.
- The terminator is a waypoint
- The first waypoint is the termination waypoint of the previous leg or the IF
- Should always be used for the intermediate and the final approach segment
- In case where the FMS requires a CF for the final approach segment the database coder may use CF
- Provide a predictable, repeatable flight path
DF (Direct to a Fix)

• Used to define a route segment from an unspecified position on the aircraft present track to a specified fix or waypoint.

• Doesn’t provide a predictable, repeatable flight path

• Combination CA/DF can be used to spread environmental impact on initial departures.

• Ensure that the shortest track distance is flown from the turning point or from a turn altitude to the next waypoint
CF (Course To a Fix)

- Is a course that terminates at fix/waypoint followed by a specific route segment
- Normal use is after a FA or CA in a departure or missed approach where is effective to constraints track dispersion.
- CA/CF combination can be effective in reducing environmental impact on initial departures.
- Was originally the only path terminator permitted to define the final segment of an approach and is currently used by many RNAV System for this purpose.
CA (Course to an Altitude)

• Used to define the course of an outbound route segment that terminates at an altitude with an unspecified position.

• Used as initial path terminator of a SID in preference of a FA
FA (course from Fix to an Altitude)

• Used to define a route segment that begins at a fix/waypoint and terminates at an altitude with an unspecified position.
• Not provide a predictable, repeatable flight path (due to the unknown termination point)
• Useful path terminator in missed approach procedures.
Procedure design application

- Procedure designer must strictly adhere to path terminator coding rules
- Procedure designer should consider:
  - dual–conditional transitions, such as ‘climb to XXXX feet by waypoint NNNNN’ or ‘at waypoint ZZZZZ but not below XXXX feet, turn right direct to...’ cannot be used
  - Altitude and speed restriction shall only be applied at a waypoint
  - All details of any specific restrictions applied to a procedure shall be published
Path Terminator Coding Rules

Following tables defines the path terminators that can support the initial and final legs of an RNAV procedure (SID, STAR, approach and missed approach).

<table>
<thead>
<tr>
<th><strong>RNAV procedure</strong></th>
<th><strong>Initial leg</strong></th>
<th><strong>Final leg</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>SID</td>
<td>CA, CF, VA, VI</td>
<td>CF, DF, FM, RF, TF, VM</td>
</tr>
<tr>
<td>STAR</td>
<td>IF</td>
<td>CF, DF, FM, HM, RF, TF, VM</td>
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<tr>
<td>Approach</td>
<td>IF</td>
<td>CF, TF, RF</td>
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<tr>
<td>Missed approach</td>
<td>CA, CF, DF, FA, HM, RF, VI, VM</td>
<td>CF, DF, FM, HM, RF, TF, VM</td>
</tr>
</tbody>
</table>
Path Terminator notes

Note 1.— The ‘Final Leg’ for an approach is the final approach segment.

Note 2.— The only valid starting path terminators for the SID, from a procedure design perspective, are CA or CF. Although, according to ARINC 424, FA is allowed as an initial SID leg, it generates the same ground track as CA but is not appropriate for some operations with aircraft that rely solely on IRU inputs in the initial departure phases. In such cases an IRU with a degraded position can result in the aircraft making unexpected turns shortly after lift-off. In this context, CA generates the same ground track as FA. Furthermore, an FA path terminator on parallel departures can cause significant track deviations due to inertial drift prior to take-off. VA may be used for parallel departures where aircraft are required to follow a heading rather than a track after take-off. Database suppliers may also use VA in place of FA when coding equivalent SIDs from adjacent parallel runways in order to minimize duplicate coding (many databases in older RNAV systems have storage capacities of less than 200 kilobytes).

Note 3.— FM or VM may be used to terminate ‘Open STARs’ when radar vectoring is provided to final approach. The choice of track (FM) or heading (VM) depends upon ATC requirements.

Note 4.— RF may only be used for RNP procedures flown by aircraft equipped with systems that are compatible with ARINC 424-17, or later.
Path Terminator Sequence

Following tables defines the permitted leg sequences:

<table>
<thead>
<tr>
<th>Current Leg</th>
<th>IF</th>
<th>CA</th>
<th>CF</th>
<th>DF</th>
<th>FA</th>
<th>FM</th>
<th>HM</th>
<th>RF</th>
<th>TF</th>
<th>VA</th>
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Table III-2-5-App-2. Path terminator sequences

Note 1.— A CF/DF, or DF/DF sequence can only be used when the termination of the first leg is intended to be overflown, otherwise alternative coding needs to be used.

Note 2.— The IF leg is coded only when the altitude constraints at each end of the FA or HM leg are different.

Note 3.— The IF/RF combination is only permitted at the start of the final approach.
Path Terminator sequence Basic Rules

a) FA, CA and VA should be followed by DF or CF (DF is recommended)
b) TF to flyover shall be followed by TF or CF
c) If a procedure requires a DF after a flyover the previous leg shall be coded CF or DF
d) DF cannot follow a fly-by waypoint, and
e) The waypoint at the start and end of an RF leg is not coded as flyover

Note 1.— While most straight departures should start with a CA/DF sequence for the initial straight segment, if the first fly-by waypoint is less than 3 NM from the DER, experience has shown that it is preferable to start with a CF.

Note 2. — Where an initial departure turn is constrained by a distance from the DER and a minimum altitude, the application of an altitude constraint at the turning waypoint will not ensure that both constraints are met. A better method is to code the first leg as a CA and the second as a CF with the second leg course arranged to ensure that the earliest turn to intercept occurs at or after the required turning point.
# Path Terminator Required Data

Depending on path and terminator, some data shall be indicated in the coding table.

## Table III-2-5-App-3. Path terminators (Required data)

<table>
<thead>
<tr>
<th>Path terminator</th>
<th>Waypoint identifier</th>
<th>Flyover</th>
<th>Turn direction</th>
<th>Recommended Navaid</th>
<th>Distance from Navaid</th>
<th>Bearing from Navaid</th>
<th>Magnetic course</th>
<th>Path length</th>
<th>Altitude restriction 1</th>
<th>Altitude restriction 2</th>
<th>Speed limit</th>
<th>Vertical angle</th>
<th>Arc centre</th>
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</tbody>
</table>

- ✓ — Required
- O — Optional
- 1 — Required for CF/DF and DF/DF combinations only.
- 2 — Inbound tangential track
- 3 — Outbound tangential track
- 4 — Heading not course
- 5 — Along track distance
- 6 — Altitude at or above

Shaded spaces represent data that are not available or not part of the path.
Path Terminators example

Venezia

RNAV (GNSS) RWY22L

Waypoints Table formatted according ARINC 424 standards

<table>
<thead>
<tr>
<th>Waypoint</th>
<th>Latitude</th>
<th>Longitude</th>
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Wrap-up

- Definition of *Path and Terminator*
- Coding Rules
- Required Data
Grazie