PBN Procedure Design Course 2026

ICAO APAC FPP

Beijing,China

(7-25/Sep/2026)

Database Coding

Objectives

- Know the functionalities associated with PBN application
- Know the required fields to be provided for coding instruction and associated with Path Terminator
- Know the sequencing allowed between Path Terminator and type of waypoint
- Know the different impact on path regarding the use of rather equivalent Path Terminator
- Identify the limit of application of speed constraint on arrival and departure

ARINC 424

Coding Requirement

- The procedure designer develops the routes and instrument flight procedures
- Unlike humans, avionics equipment cannot read a chart therefore the designer's intentions are translated into a code
- The code is "read" by the navigation system and processed to provide flight guidance
- ARINC424 is the "language" that area navigation systems use for such coding

ARINC 424

- ARINC - Aeronautical Radio Incorporated - a major provider of transport communication and system engineering solution for different fields including aviation.
- ARINC 424 is a standard for the preparation and transmission of data for assembly of airborne navigation system data bases
- Manufacturers design their Navigation systems to interpret ARINC 424
- ARINC 424 is NOT an ICAO Standard, it is a Commercial Standard

RNAV Procedure Description

- RNAV procedures defined by Sequence of waypoints
  - Identifier
  - Co-ordinates
- Information may not be sufficient and requires
  - Path to waypoint
  - What happens at each waypoint
- Fly-over/fly-by/fixed radius
- This is provided by a system of Path & Terminator

What Pilots Need to Know

- Turn direction
- Speed restrictions
- Altitude restrictions
- Required navaid
- Leg distance and magnetic track

Path & Terminator

- PATH

  The path defines the flight path to be flown i.e. track, course, heading etc.

- TERMINATOR

  The terminator defines what happens at the end of each segment, How to join to the next segment

- Information on altitude, VPA, speed restrictions can also be added to waypoints
- This results in a complete electronic description of the procedure

Procedure Design

- The coding of procedures is a specialised task usually done by the navigation database manufacturer
- Procedure designers are not normally trained in database coding
- BUT procedure designer need to convey their design intentions to the database coder
- Procedure designers now required to specify ARINC 424 path terminators

Example

Table III-5-1-2. Illustration of the tabular description method

Serial Number	*Path Descriptor*	*Waypoint Identifier*	*Fly-over*	*Course °M(°T)*	*Magnetic Variation*	*Distance (km)*	*Turn Direction*	*Altitude (m)*	*Speed (km/h)*	*VPA/ TCH*	*Navigation Specification*
001	IF	SUSER	—	—	+2.2	—	—	+1 550	–470	—	RNP APCH
002	TF	EF974	—	048 (045.7)	+2.2	12.0	—	+1 400	—	—	RNP APCH
003	RF Centre: EF991 r =5.240 NM	EF975	—	—	+2.2	13.7	R	—	–450	—	RNP APCH
004	TF	EF976	—	348 (345.8)	+2.2	9.6	—	@900	–270	—	RNP APCH
005	TF	RW35L	Y	348 (345.8)	+2.2	9.3	—	@150	—	–3.0/50	RNP APCH
006	FA	RW35L	—	348 (345.8)	+2.2	—	—	+250	—	—	RNP APCH
007	DF	SUSER	Y		+2.2	—	L	+1 550	—	—	RNP APCH
008	HM	SUSER	—	048 (045.7)	+2.2	7.4	R	+1 550	–450	—	RNP APCH

Example

Table III-5-1-2. Illustration of the tabular description method

Serial Number	*Path Descriptor*	*Waypoint Identifier*	*Fly-over*	*Course/Track °M(°T)*	*Magnetic Variation*	*Distance (km)*	*Turn Direction*	*Altitude (m)*	*Speed (km/h)*	*VPA/ TCH*	*Navigation Specification*
001	CA	—	—	221 (223.5)	–2.3	—	—	@150	—	—	B-RNP 1
002	DF	FOKSI	—	—	–2.3	—	R	—	—	—	B-RNP 1
003	TF	EF974	—	043 (045.7)	–2.3	12.0	—	+1 400	—	—	B-RNP 1
004	RF Centre: EF991 r =5.240 NM	EF975	—	—	–2.3	13.7	R	—	–450	—	B-RNP 1
005	TF	EF976	Y	145 (147.3)	–2.3	9.6	—	+1 550	—	—	B-RNP 1
006	TF	TARTO	—	110 (112.3)	–2.3	28.2	—	—	—	—	B-RNP 1

Navigation Data Production Process

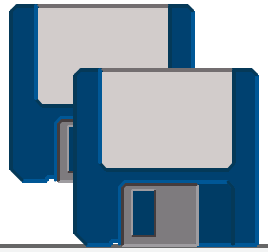
Procedure design
by Civil Aviation Authorities

AIP

Data Supplier → ARINC 424 “master” file

Operator responsibility

FMS Database Processing → Packed Data

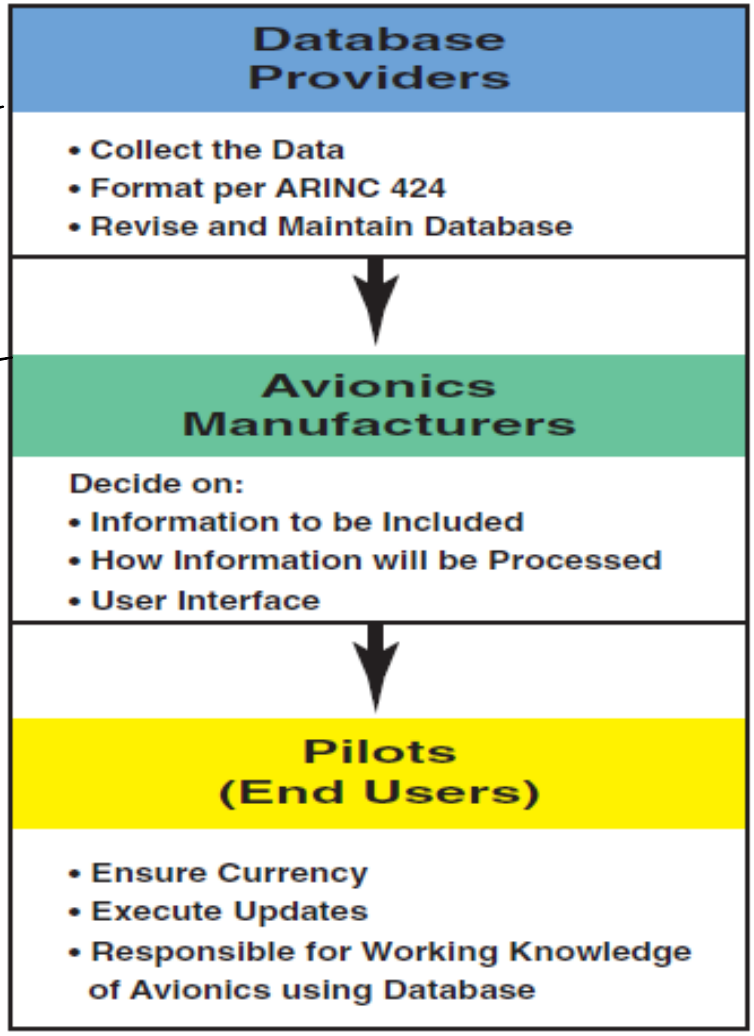


FMS

Data Chain

Jeppesen/
Lufthansa/Aerodata/Navbule

Honeywell/GE/Universal



Aeronautical Data Processing STEPS

1. Assemble a data bank.
2. Produce electronic media meeting the operational requirements of the next link in the data chain (avionics manufacturers, airlines, ATC).
3. Merge the data with the operational software of airborne navigation computers.
4. Produce electronic media containing the merged data for use on individual aircraft.

Participants in the data processing chain are public organisations, States, avionics manufacturers, datahouses and various end-users. Any participant in the data chain may originate, transmit, assemble, prepare or integrate aeronautical data.

ARINC 424

- Each navigation element in the database is uniquely defined and stored in the master user file which can be accessed for any intended navigation purpose.
- ARINC 424 was initially developed to support conventional navigation
- ARINC 424 is continually being updated, therefore all aircraft are not capable of all, or the latest ARINC 424 functions
- Although not developed for design of flight procedures, sufficient background information about ARINC 424 will enable procedure designers to perform their tasks so that misinterpretations and errors are significantly reduced.

Differences in Avionics Systems

- Individual navigation systems require different formats for navigation reference data.
- The available storage in many avionics systems prevents all procedures or data elements from being loaded into the airborne database.
- Airlines are cost driven and hence do not upgrade equipment unless there is a clear benefit.

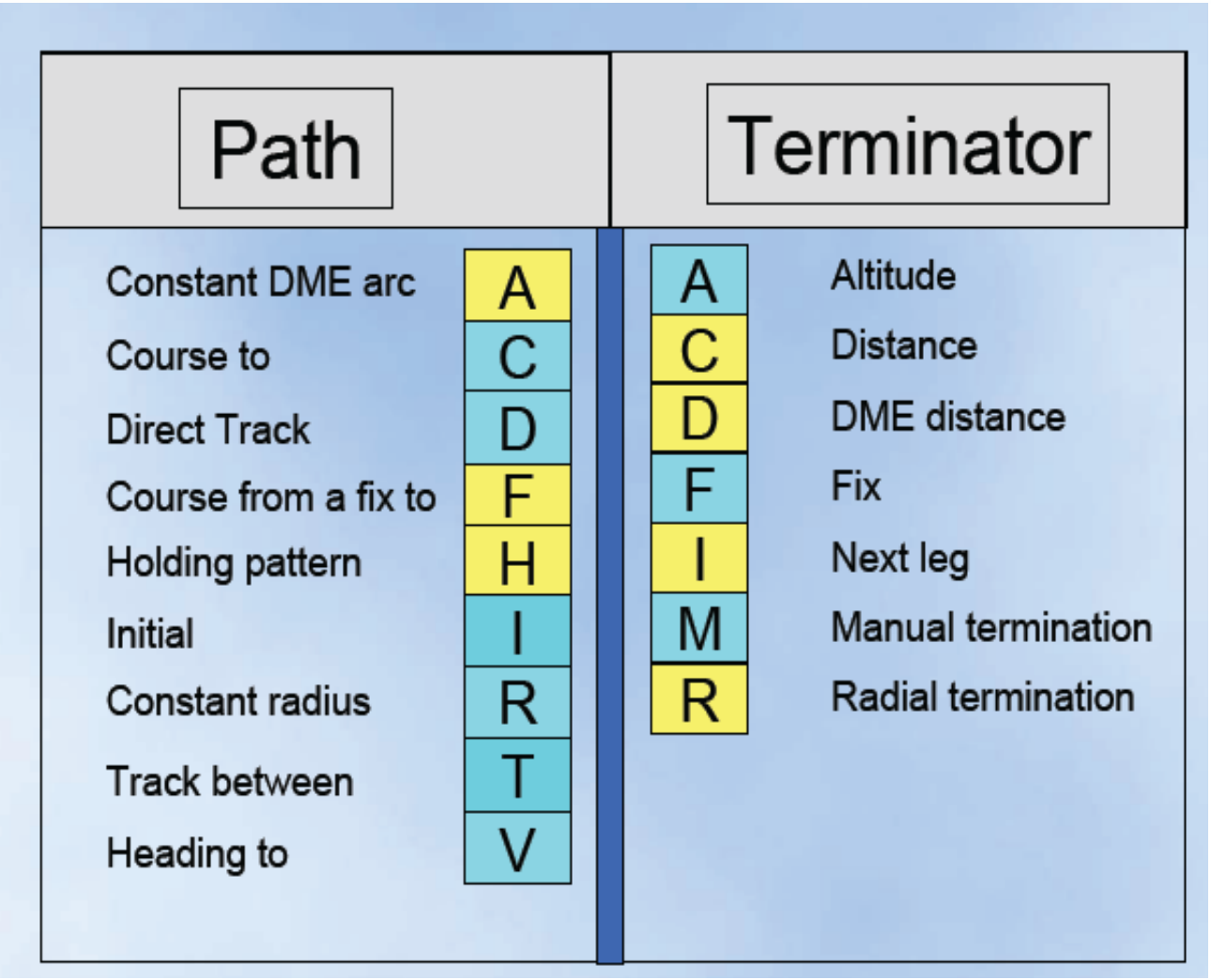
Differences in Avionics Systems

- The system life cycle of most avionics equipment is 15 to 20 years.

- Over the years, different earth models, geodesic calculations and uses of variables such as magnetic variation have been used.

  Differences in avionics systems need to be considered during the processing of aeronautical data. As a result, databases from different datahouses may not always be consistent.

Path Terminators


Path
Terminator
Constant DME arc
A
Course to
C
Direct Track
D
Course from a fix to
F
Holding pattern
H
Initial
I
Constant radius
R
Track between
T
Heading to
V
A
Altitude
C
Distance
D
DME distance
F
Fix
I
Next leg
M
Manual termination
R
Radial termination

Path Terminators

- Arc to a Fix -AF
- Course to an Altitude -CA
- Course to a DME Distance -CD
- Course to a Fix -CF
- Course to an Intercept -CI
- Course to a Radial Termination -CR
- Direct to a Fix -DF
- Fix to an Altitude -FA
- From a Fix for a Distance -FC
- From a Fix to a DME Distance -FD
- From Fix to Manual Termination -FM
- Racetrack (Alt Term) -HA
- Racetrack (Single Circuit) -HF
- Racetrack (Manual Termination) -HM
- Initial Fix -IF
- Track to a Fix -TF
- Procedure Turn -PI
- Constant Radius Arc -RF
- Heading to an Altitude -VA
- Heading to a DME Distance- -VD
- Heading to an Intercept -VI
- Heading to a Manual Termination -VM
- Heading to a Radial Termination -VR

RNAV Path Terminators

• Initial Fix	-IF	- RNP 1- RNAV1/2 - RNP APCH - RNPAR		
• Track to a Fix	-TF	- RNP4	- RNP 1- RNAV1/2 – RNPAPCH - RNPAR	
• Course to a Fix	-CF	- RNP4	- RNP 1- RNAV1/2 - RNP APCH - RNPAR	
• Direct to a Fix	-DF	- RNP4	- RNP 1- RNAV1/2 - RNP APCH - RNPAR	
• Fix to an Altitude	-FA	- RNP 1- RNAV1/2	- RNPAR	
• Course to an Altitude	-CA	- RNP 1- RNAV1/2	- RNPAR	
• Fix to a Manual Termination	-FM	- RNP 1- RNAV1/2	- RNPAR	
• Racetrack Course Reversal	-HA			
• Racetrack (Single Circuit)	- HF			
• Racetrack (Manual Termination)	-HM			
• Constant Radius Arc	-RF	A-RNP	- RNPAR (O)	
• Heading to an Altitude	- VA	- RNP 1- RNAV1/2	- RNPAR	
• Heading to a Manual Termination	- VI	- RNP 1- RNAV1/2	- RNPAR	
	-VM	- RNP 1- RNAV1/2	- RNPAR	

IF Leg Type

- The **Initial Fix or IF** Leg defines a database fix as a point in space
- It is only required to define the beginning of a route or procedure

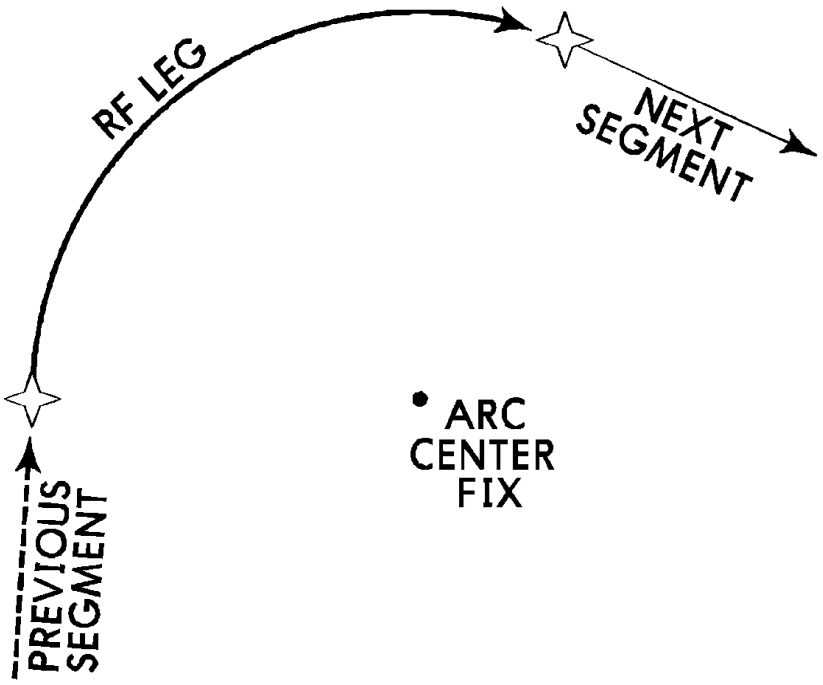
IF in coding ≠ Intermediate Fix in procedure

TF Leg Type

- **Track to a Fix** or **TF** Leg defines a great circle track over ground between two known databases fixes
- Preferred method for specification of straight legs (course or heading can be mentioned on charts, but designer should ensure TF leg is used for coding)

RF Leg Type

- **Constant Radius Arc** or RF Leg defines a constant radius turn between two database fixes, lines tangent to the arc and a center fix



Only required for A-RNP and can be used in RNP AR.

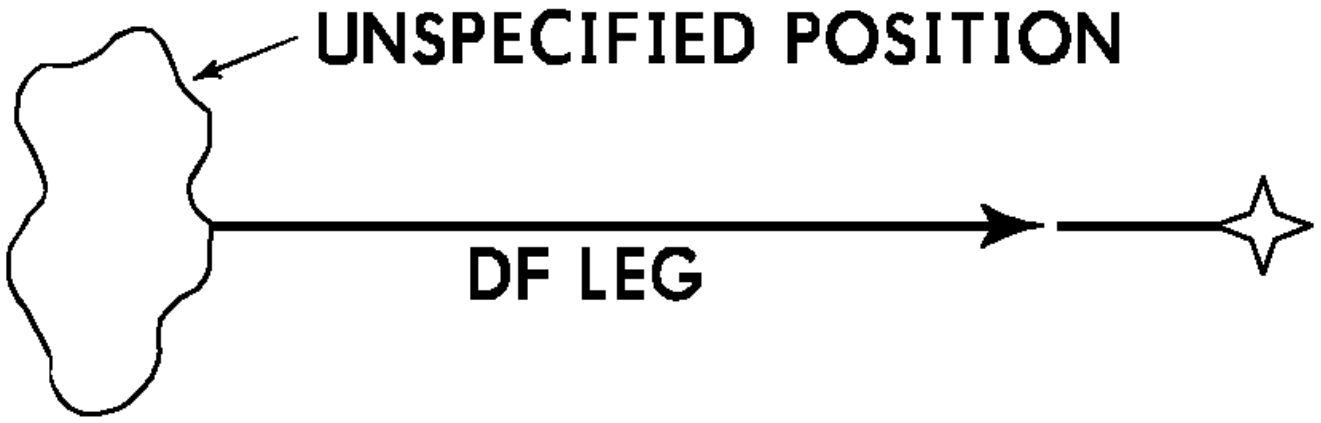
For other application, it can be addressed in national standard and can be used if a note is added on chart

CF Leg Type

- **Course to a Fix** or CF Leg defines a specified course to a specific database fix
- TF legs should be used instead of CF whenever possible to avoid **magnetic variation issues**

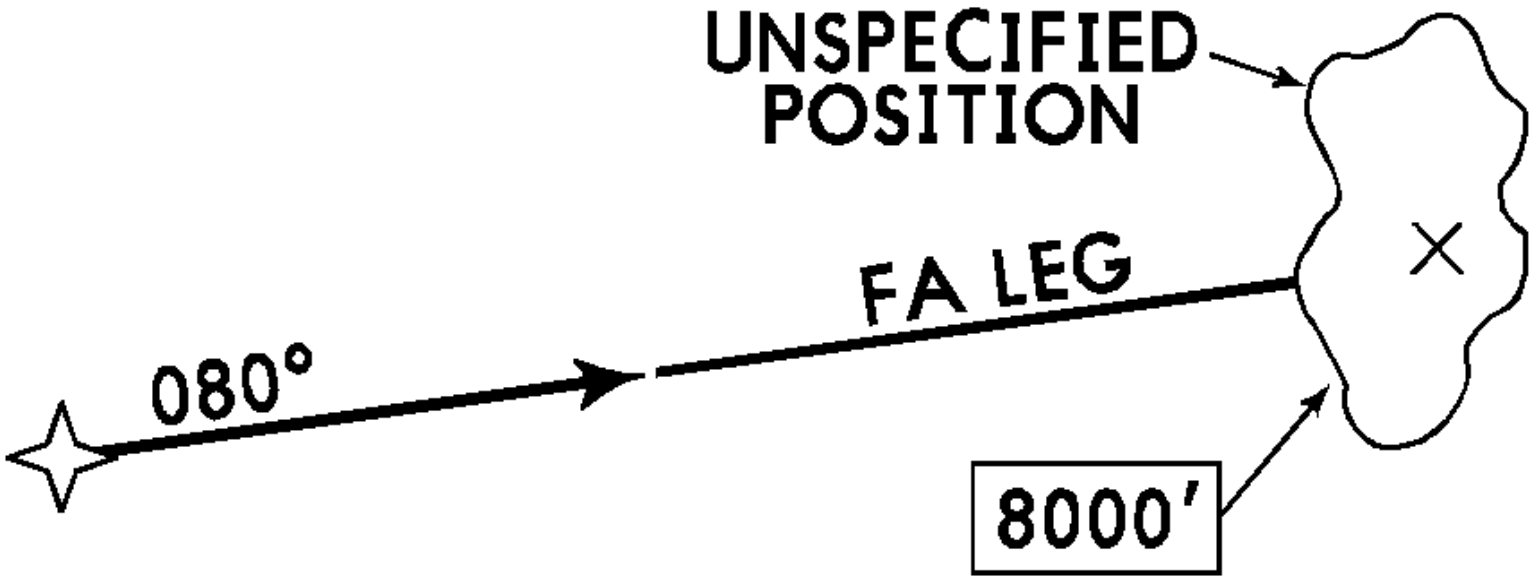
DF Leg Type

- **Direct to a Fix** or **DF** Leg defines an unspecified track starting from an undefined position to a specified fix
- Procedure designers should take into account the FMS flight path depends on initial aircraft heading as well



FA Leg Type

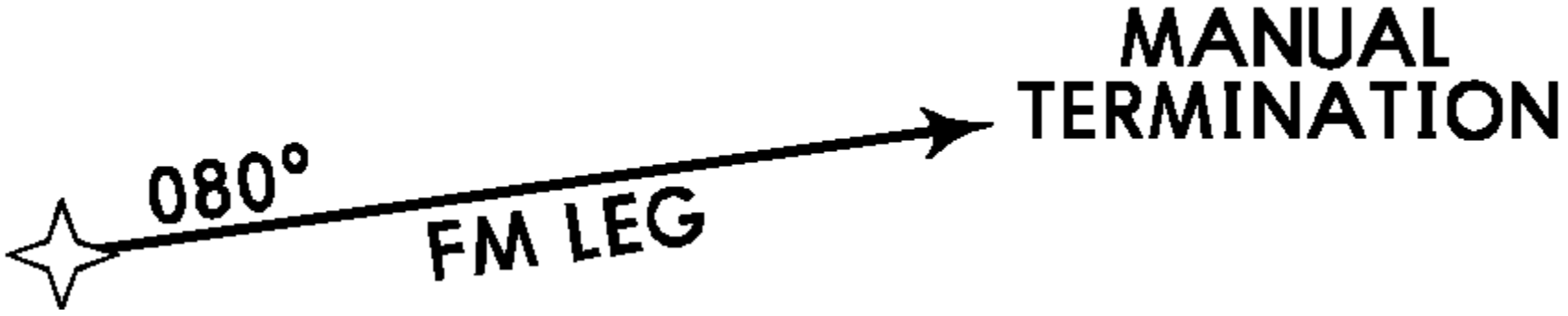
- **Fix to an Altitude** or **FA Leg** defines a specified track over ground from a database fix to a specified altitude at an unspecified position



FA leg is flown making adjustment for wind.

FM Leg Type

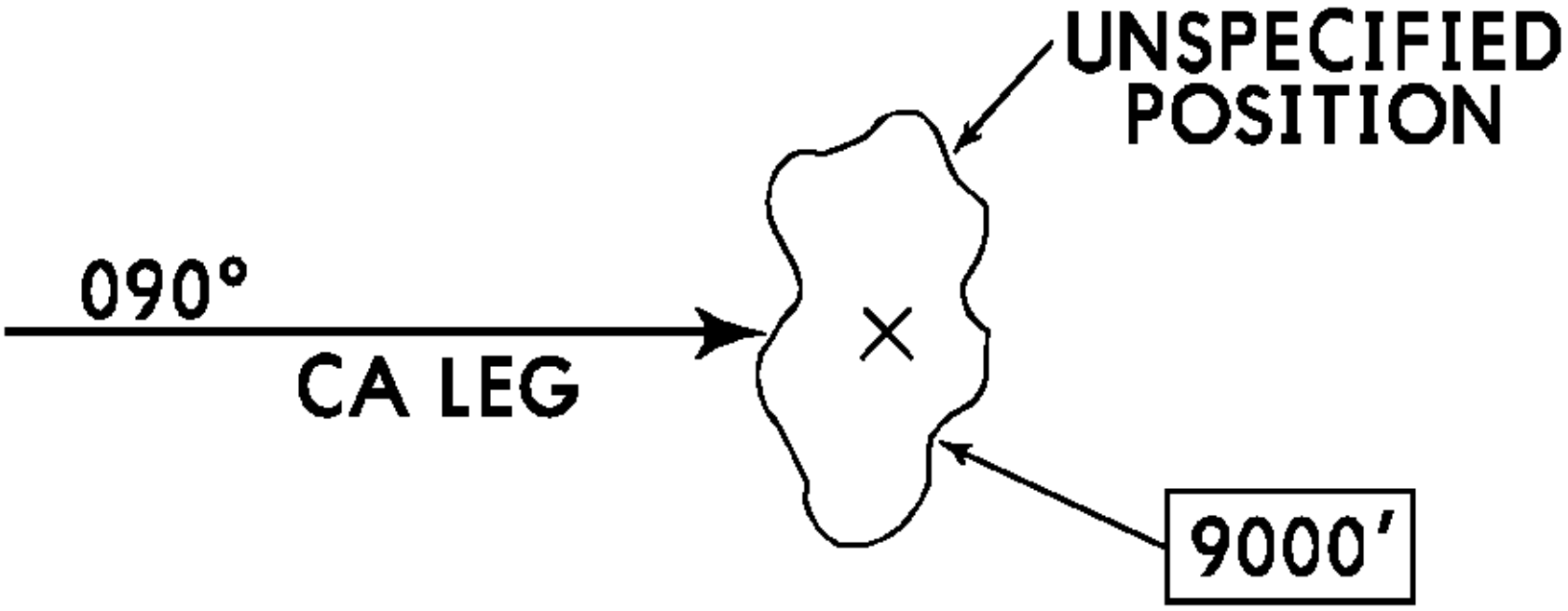
- **From a Fix to a Manual termination** or FM Leg defines a specified track over ground from a database fix until Manual termination of the leg



FM leg is flown making adjustment for wind.

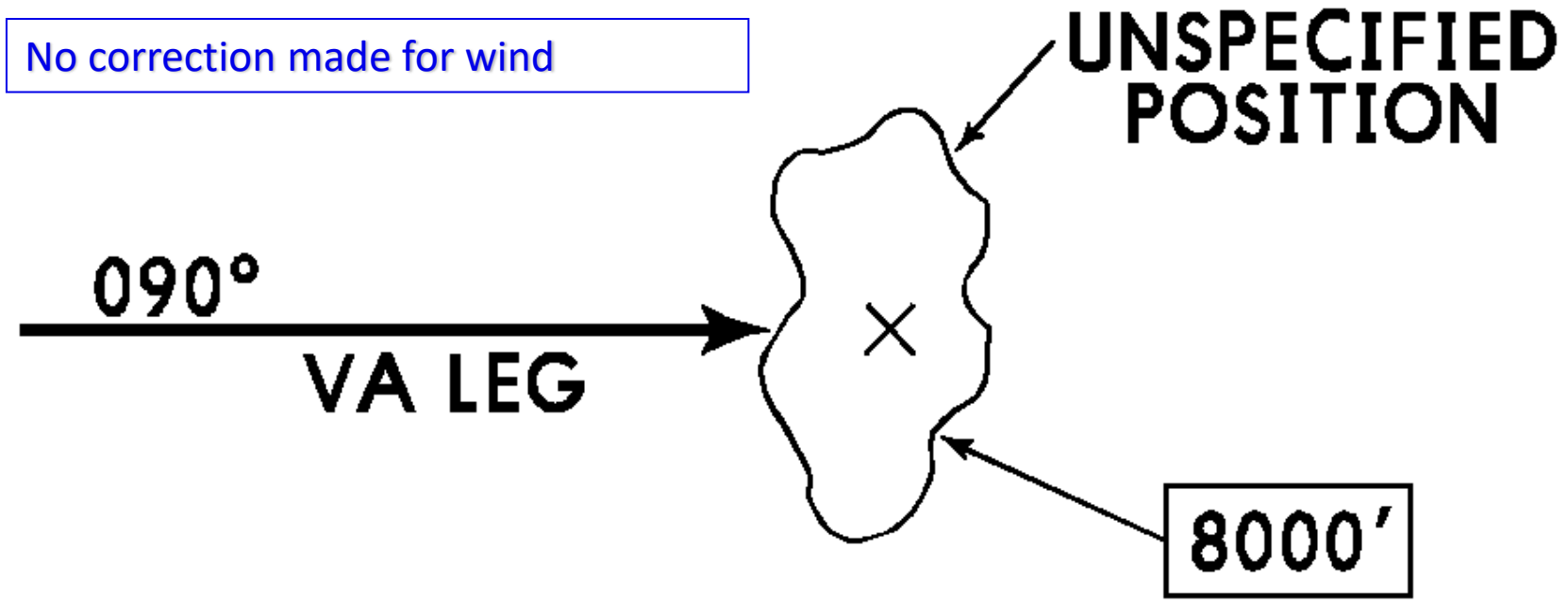
CA Leg Type

- **Course to an Altitude** or CA Leg defines a specified course to a specific altitude at an unspecified position



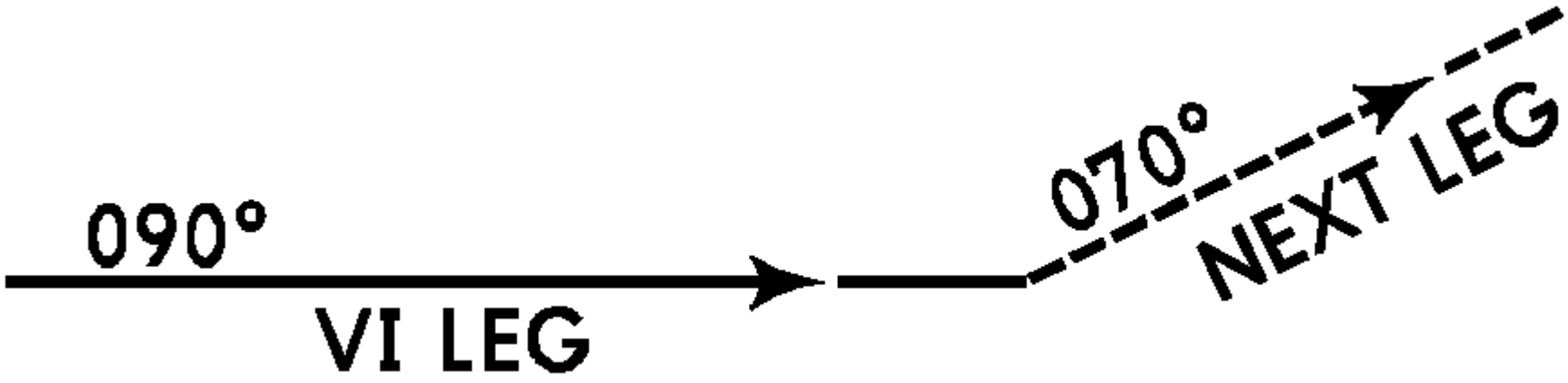
VA Leg Type

- **Heading to an Altitude termination** or VA Leg defines a specified heading to a specific Altitude termination at an unspecified position



VI Leg Type

- **Heading to an Intercept** or VI Leg defines a specified heading to intercept the subsequent leg at an unspecified position



No correction made for wind

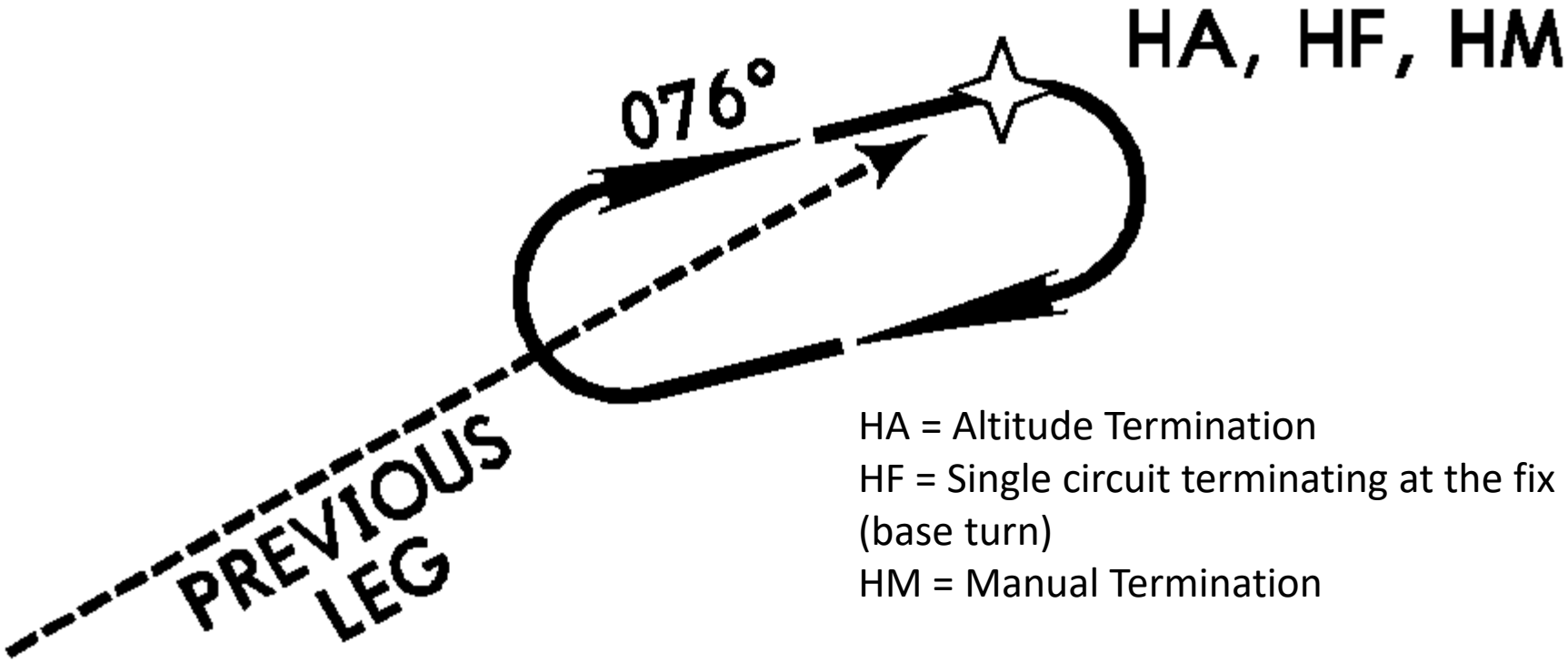
VM Leg Type

- **Heading to a Manual termination** or VM Leg defines a specified heading until a Manual termination

No correction made for wind

HA, HF, HM Leg Types

- **Racetrack Course Reversal or HA, HF and HM** Leg Types define racetrack pattern or course reversals at a specified database fix



HA = Altitude Termination
HF = Single circuit terminating at the fix (base turn)
HM = Manual Termination

Different FMS Functionality Compatibility

FMS	MAINLINE: GE FMS			REGIONAL: Universal FMS			
S/W version	U5.0	U7.5	U10.7	SCN 15/16 101-320	SCN 405/505 600/700	SCN 601+/701+	SCN 801+/901+
Year	1990	1997	2007				2001
Take-off update	yes	yes	yes	yes	yes	yes	yes
GPS	no	yes	yes	no	yes	yes	yes
DME/DME	yes	yes	yes	yes	yes	yes	yes
Intertial	yes	yes	yes	yes	yes	yes	yes
IF	yes	yes	yes	yes	yes	yes	yes
TF	yes	yes	yes	yes	yes	yes	yes
CF	yes	yes	yes	yes	yes	yes	yes
DF	yes	yes	yes	yes	yes	yes	yes
FA	yes	yes	yes	no	yes	yes	yes
FC	yes	yes	yes	no	yes	yes	yes
FD	yes	yes	yes	no	yes	yes	yes
FM	yes	yes	yes	no	yes	yes	yes
CA	yes	yes	yes	no	yes	yes	yes
CD	yes	yes	yes	no	yes	yes	yes
CI	yes	yes	yes	no	yes	yes	yes
CR	yes	yes	yes	no	yes	yes	yes
RF	no	no	yes	no	no	no	yes
AF	no	no	yes	no	yes	yes	yes
VA	yes	yes	yes	no	yes	yes	yes
VD	yes	yes	yes	no	yes	yes	yes
VI	yes	yes	yes	yes	yes	yes	yes
VM	yes	yes	yes	yes	yes	yes	yes
VR	yes	yes	yes	no	yes	yes	yes
PI	no	yes	yes	no	yes	yes	yes
HA, HF, HM (holding)	HM only	HM, HF	HM, HF	no	no	yes	yes
FRT	no	no	yes	no	no	no	no

Path Terminators Data Requirement

Recommended Navaid

- There are different ways to get magnetic variation in a TMA
  - individual navaid station declination
  - variation at ARP
  - magvar model etc
- and not all systems use the station declination.
- The **Recommended Navaid** is required for certain procedure **legs** to enable the RNAV system to use the **Station Declination** value for **Magnetic Variation**.

For CF FA FM leg, a recommended navaid is required

Required Data – CA, CF & DF

Path Terrminator	Waypoint Identifier	Flyover	Turn Direction	Recommended Navaid	Distance from Navaid	Bearing from Navaiid	Magnetic Course	Path Length	Altitude Restriction 1	Altitude Restriction 2	Speed Limit	Vertical Angle	Arc Centre
CA			O				✓		6		O		
CF	✓	1	O	✓	✓	✓	✓		O	O	O	O	
DF	✓	1	O	O	O	O			O	O	O		

✓ - Required

O – Optional

1 - Required for CF/DF and DF/DF combinations only.

6 - Altitude 'at or above

Shaded spaces represent data that are not applicable to that path terminator

Required Data – FA, FM & HM

Path Terrminator	Waypoint Identifier	Flyover	Turn Direction	Recommended Navaid	Distance from Navaid	Bearing from Navaid	Magnetic Course	Path Length	Altitude Restriction 1	Altitude Restriction 2	Speed Limit	Vertical Angle	Arc Centre
FA	✓		O	✓	✓	✓	✓		6		O		
FM	✓		O	✓	✓	✓	✓		O		O		
HM	✓		O	O	O	O	✓	✓	O		O		

✓ - Required

O – Optional

6 - Altitude 'at or above

Shaded spaces represent data that are not applicable to that path terminator

Required Data– IF, RF & TF

Path Terrminator	Waypoint Identifier	Flyover	Turn Direction	Recommended Navaid	Distance from Navaid	Bearing from Navaid	Magnetic Course	Path Length	Altitude Restriction 1	Altitude Restriction 2	Speed Limit	Vertical Angle	Arc Centre
IF	✓			O	O	O			O	O	O		
RF	✓	O	✓	O		2	3	5	O	O	O	O	✓
TF	✓	O	O	O	O	O	O	O	O	O	O	O	

✓ - Required

O – Optional

2 – Inbound tangential track

3 – outbound tangential track

5 – Along Track Distance

Shaded spaces represent data that are not applicable to that path terminator

Required Data – VA, VI & VM

Path Terrminator	Waypoint Identifier	Flyover	Turn Direction	Recommended Navaid	Distance from Navaid	Bearing from Navaid	Magnetic Course	Path Length	Altitude Restriction 1	Altitude Restriction 2	Speed Limit	Vertical Angle	Arc Centre
VA			O				4		6		O		
VI		O	O	O			4		O	O	O		
VM	O		O				4		O		O		

✓ - Required

O – Optional

4 – Heading not course

6 – Altitude at or above

Shaded spaces represent data that are not applicable to that path terminator

Path Terminator Coding Rules

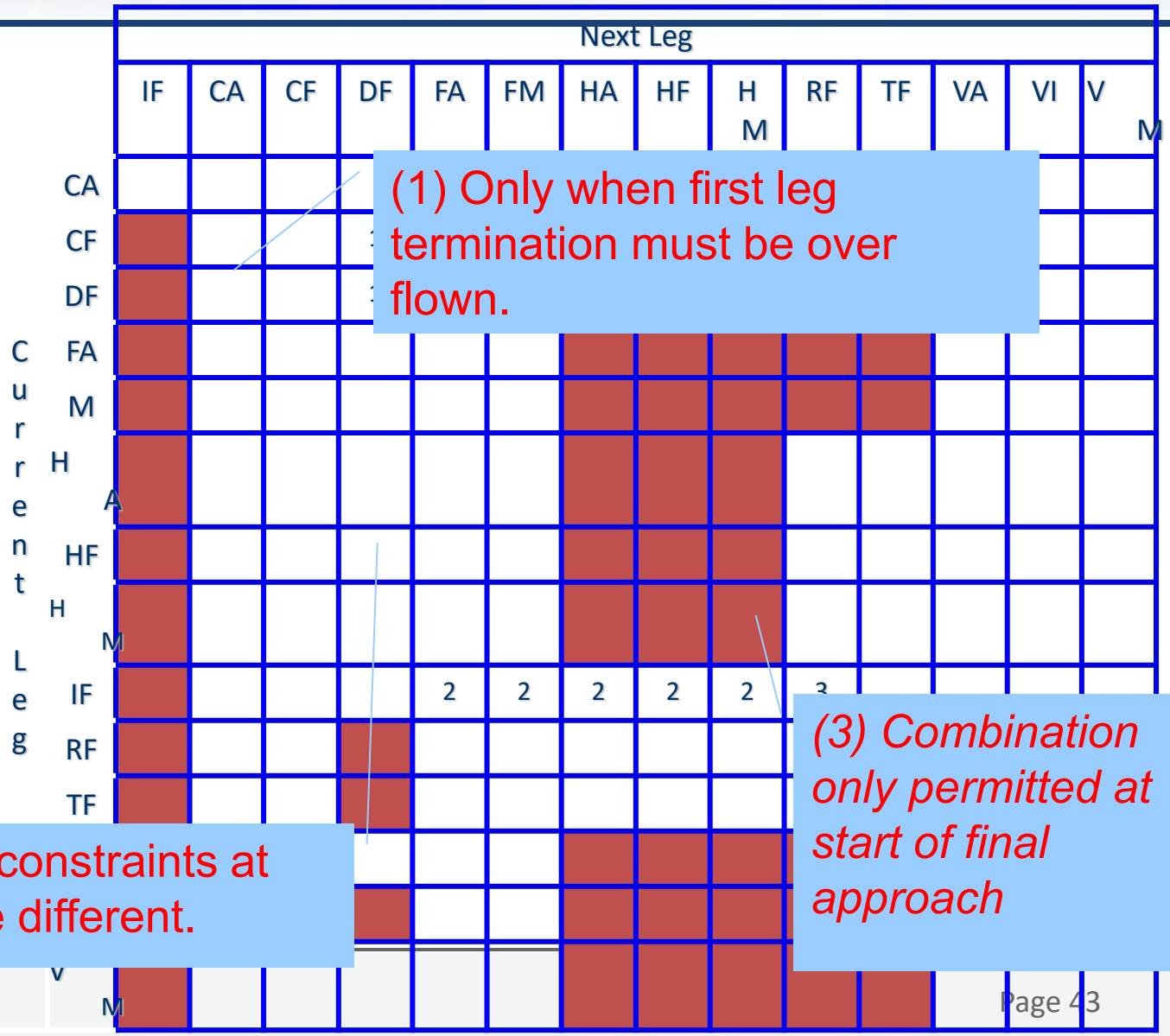
Table III-2-5-App-1. Initial and final path terminators

RNAV Procedure	Initial Leg	Final Leg
SID	CA, CF, FA, VA, VI	CF, DF, FM, HA, RF, TF, VM
STAR	IF	CF, DF, FM, HM, RF, TF, VM
Approach	IF	CF, TF, RF
Missed Approach	CA, CF, DF, FA, HA, HM, RF, VI, VM	CF, DF, FM, HM, RF, TF, VM

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

Path Terminator Sequences

Table III-2-5-App-2, "Path terminator sequences" defines the permitted leg sequences. A shaded space indicates that the "current leg/next leg" sequence is not permitted.



Path Terminator Sequences

Table III-2-5-App-2, "Path terminator sequences" defines the permitted leg sequences. A shaded space indicates that the "current leg/next leg" sequence is not permitted.

	IF	CA	CF	DF	FA	FM	HM	RF	TF	VA	VI	VM
CA												
CF			1									
DF			1									
FA												
FM												
HM												
IF					2	2	2	3				
RF												
TF												
VA												
VI												
VM												

(1) Only when first leg termination must be over flown.

(3) Combination only permitted at start of final approach

(2) Only when altitude constraints at each end of the leg are different.

Path terminator Sequences Rules

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

Path Terminator Departure notes

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.

Speed & Altitude Restrictions

- All **Speed** and **Altitude** restrictions in **RNAV** procedures should be applied at **Specific Waypoints**.
- Speed and altitude restrictions that are only applied during specific time periods are **NOT CODED** in database.
- Some legacy systems can only process speed restrictions in combination with an altitude restriction.

Speed Restrictions

- On **SIDs,** the speed limit applies to all legs **up to** and including **THE TERMINATOR** of the leg on which the limit is encoded. If a second speed limit is coded on a subsequent leg, the limit will be applied from that leg backwards to the previous terminator which contained a speed limit.

- On **STARS**, the speed limit is applied **Forward** to **The End** of arrival unless a second speed limit is encoded.

Description of Altitude in Coding

- At or above : **+ altitude**
- At or below : **- altitude**
- At : **@**
- At or above
  to at or below : B altitude1 altitude2

Naming Convention

- Do NOT deviate from the ICAO naming convention. Deviations create additional workload, cause misinterpretations and errors.
- When waypoints/fixes are not named in the AIP, they are identified in the RNAV database as Computer Navigation Fixes (CNFs), created by the datahouses. ATC is unaware that these fixes exist.
- Keep identifiers unique as applicable for 5LNC and alphanumeric.

Initial Departure Tracks

- As there is not a WP ar the DER first leg cannot be a TF
- Remaining Path terminator associated to first WP/ altitude on the first leg are CF, DF, FA,VA CA IF.
- Experience shows that CA better than FA on initial SID leg.
- VA are often used for departure with parallel runways
  - As aircraft shall deviate from the track on the same direction and remain //

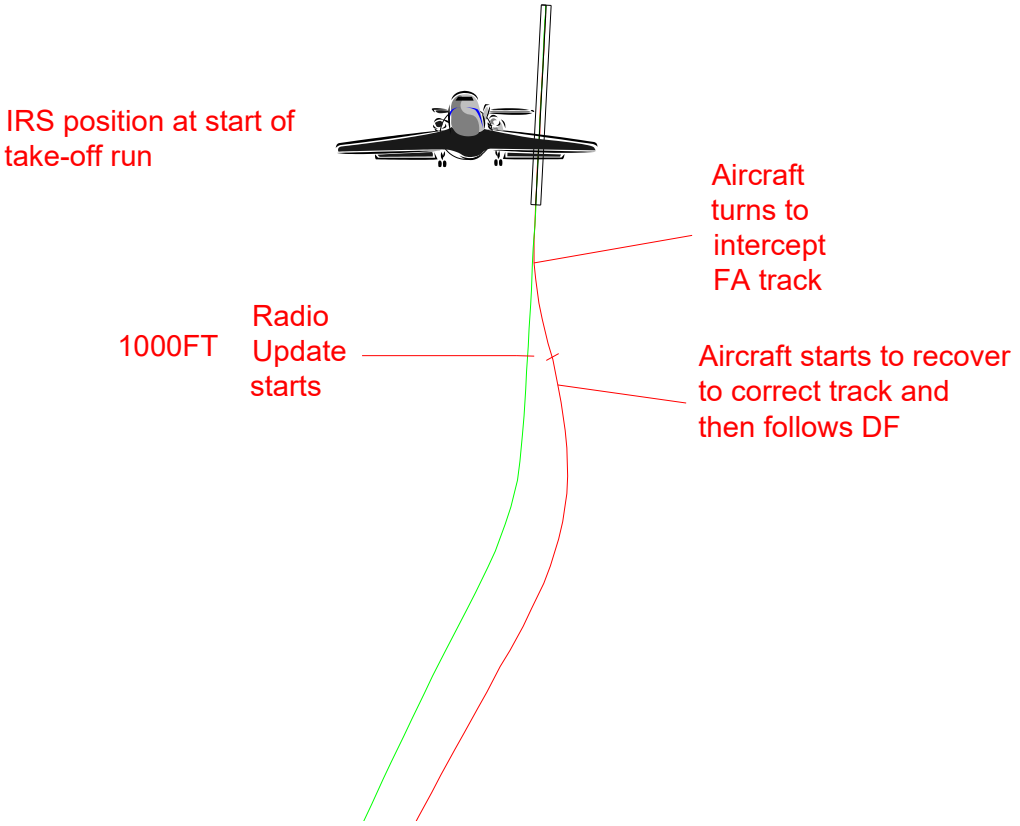
Coding the First 500ft

- RNAV has little influence on aircraft track-keeping during take-off phase:
  - Autopilots do not engage before 500ft AGL.
  - RNAV 1 requires LNAV no later than 500ft AGL.
  - Manual flight may be considered the norm, at present, up to at least 500ft AGL.
- The procedure definition, in path terminator context, must always start from the runway.

WHY NOT FA ?

FA(184°;2000ft)/DF

CA(184°;2000ft)/DF



WHY NOT CF ?

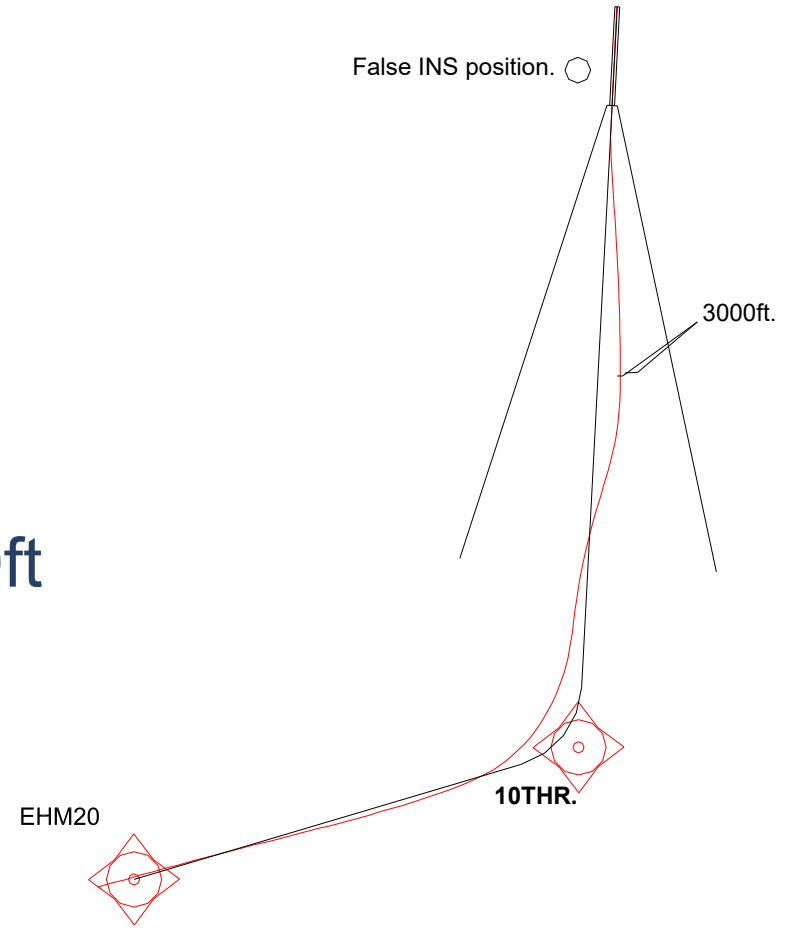
CF 183º to 10NM

CF 270º to EHM20

IRS error of 1’ lat and long

No wind

No radio updating before 3000ft



CA vs VA

After 500ft AGL, when AP engages, CA recovers to 184 track while VA remains on 184 heading until 2000ft AGL.

VA(184°;2000ft AGL)/DF

Initial Departure Conclusions

- CA controls drift in cross-wind conditions and is not affected by IRS errors.
- CA/CF, VA/CF and VI/CF are all effective solutions for early turns in departure procedures where IRS updating may be used by some aircraft.

Note: These limitations may not be necessary for procedures used by operators with modern GNSS equipped aircraft

Coding for Track-Keeping

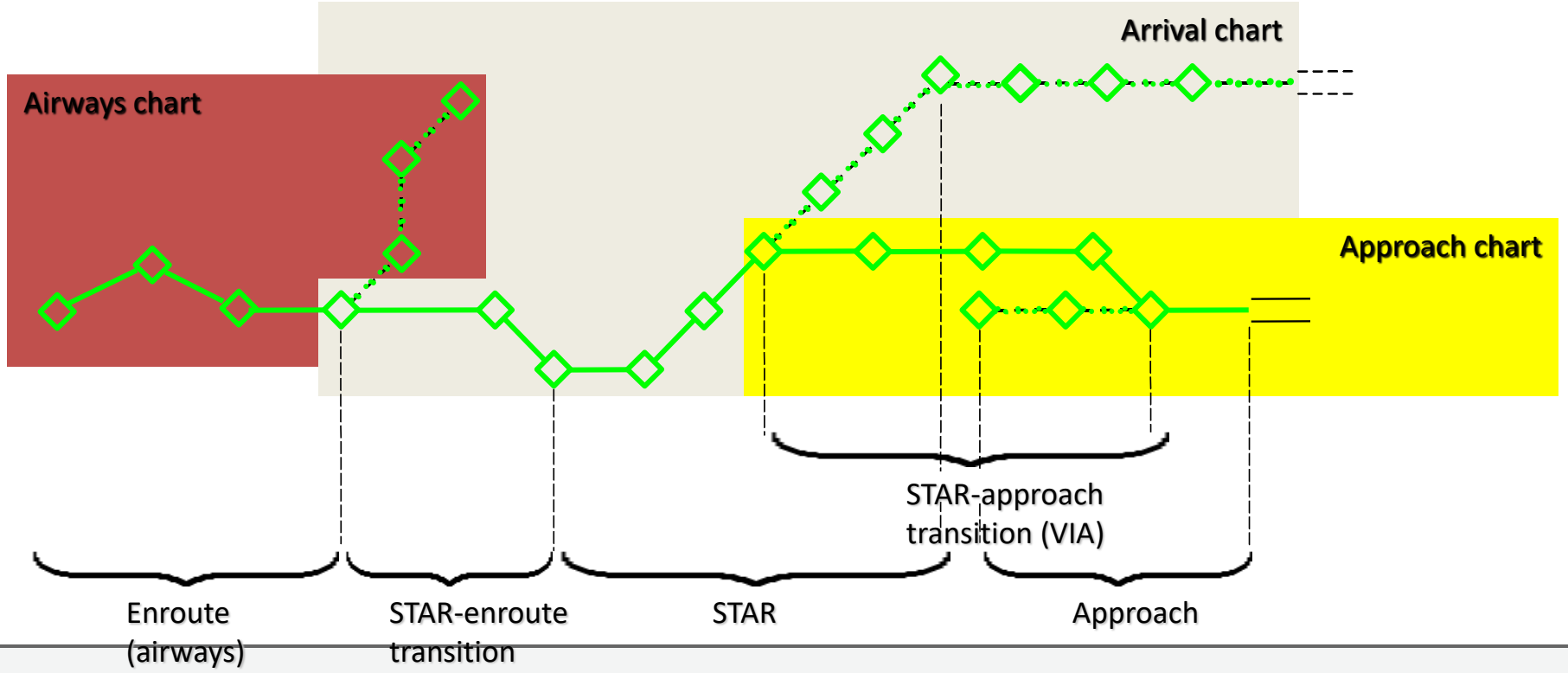
- Noise abatement procedures require track-keeping to be as accurate as possible.
- In RNAV 1 applications, judicious use of CF can limit the track-spread after conditional and fly-over turns.

Conclusion

- Designer should work with the smallest possible sub-set of path terminators:
  - Headings use VA or VM – **for departures use VA**
  - Tracks use FA, CA, CF, DF, FM, RF or TF – **for departures use DF or CF**
- Industry can get approval to alter coding where this can be shown to be a better solution for a particular aircraft system.
- Check flyability before implementation.

Example : F-PLN Procedure Melding

- Procedures are chained together to form the FMS flight plan. Example :



Q&A?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Thank You