



Procedure Design Considerations



Learning Objectives



✈ By the end of this presentation you should understand:

✈ Procedure design considerations including:

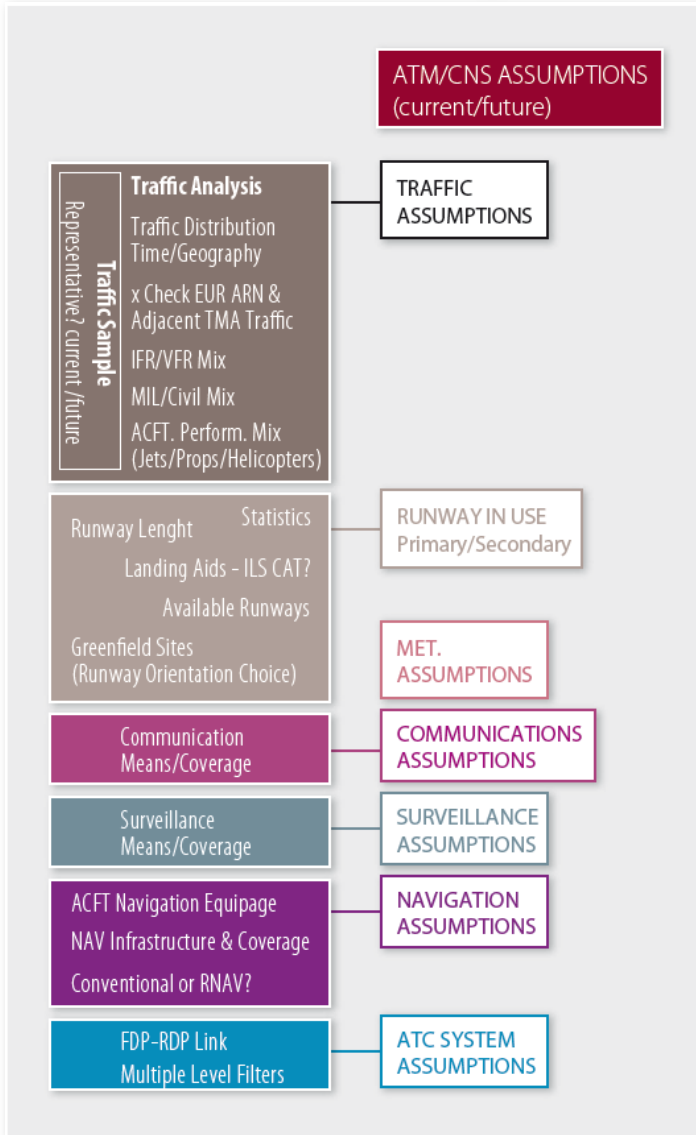
✈ Path Terminators

✈ Waypoint Types

✈ Factors affecting turn radius



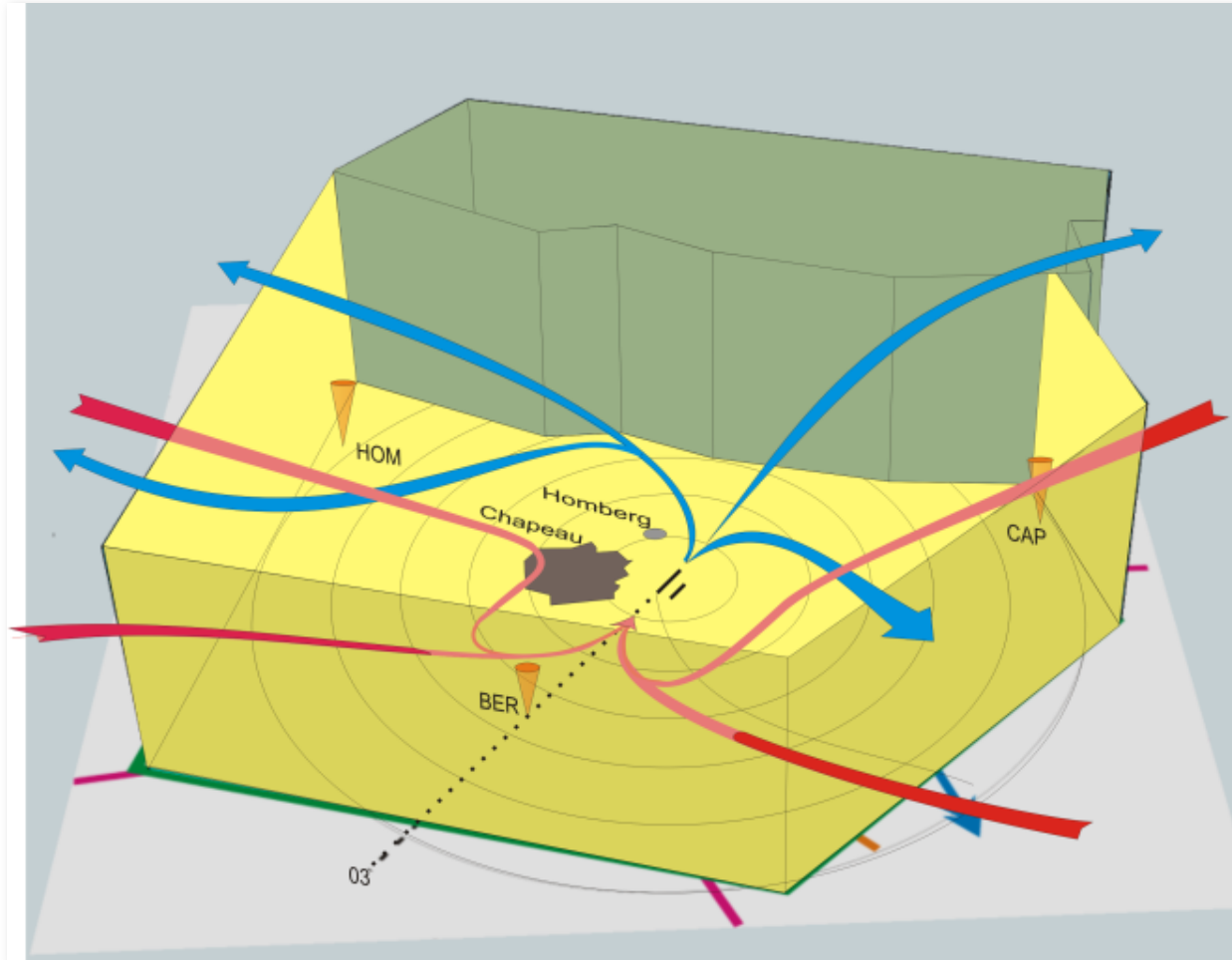
Assumptions >> Design



- * When agreeing on assumptions, Airspace Design Team determines what's available in terms of ..
 - Air Traffic
 - Runways
 - C
 - N
 - S
 - ATM System
- * The Airspace Design Team should design its airspace based on *realistic* assumptions i.e. by relying on what does exist or what will exist at implementation date (rather than on what one would wish to exist).



Conceptual Design: What Next?





Procedure Design Considerations RNAV Path Types

Why PBN

Conventional Routes



Limited Design Flexibility

RNAV



Increased Airspace Efficiency

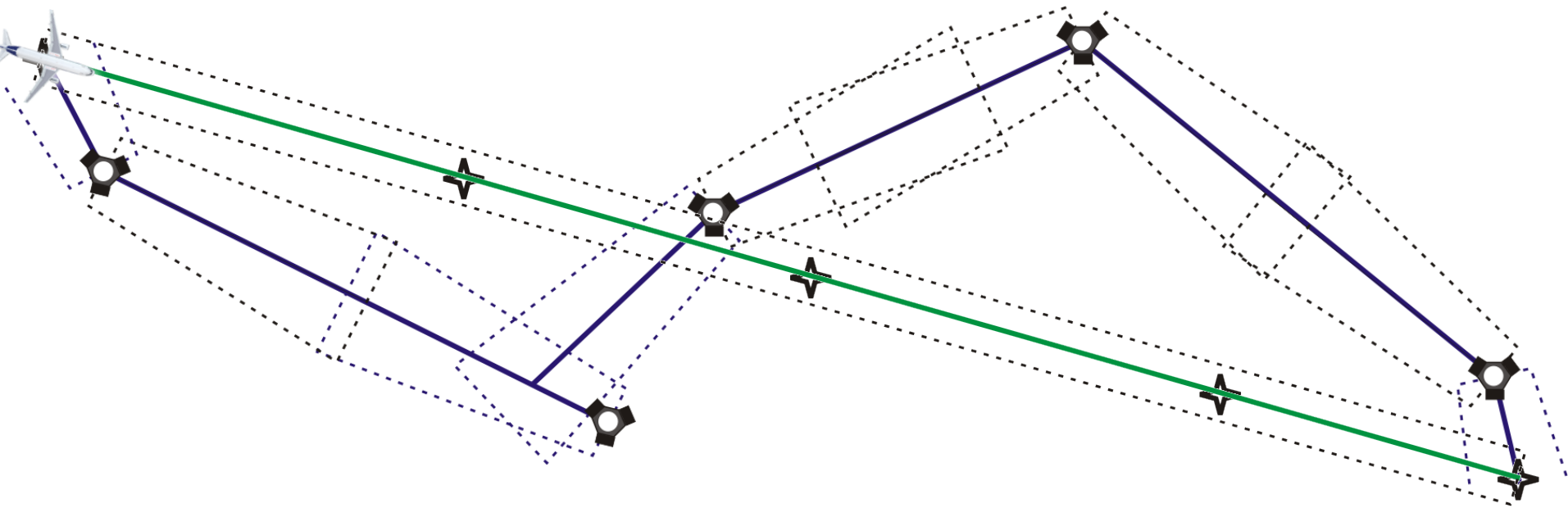
RNP



Optimize Use of Airspace



Waypoints



PBN Route Using Waypoints



Path Terminators



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



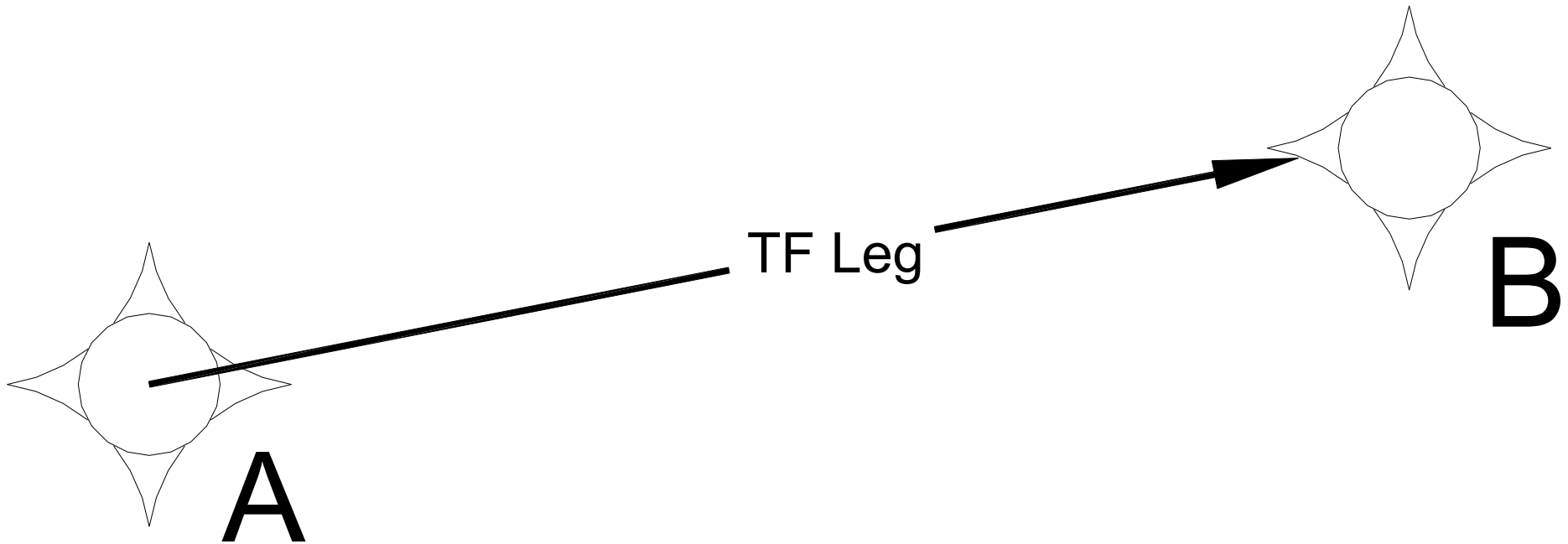
Path Terminators



- ✈ Track to Fix - TF
- ✈ Direct to Fix - DF
- ✈ Course to Fix - CF
- ✈ Fix to Altitude - FA
- ✈ Course to Altitude - CA
- ✈ Heading to Altitude - VA
- ✈ Radius to Fix - RF
- ✈ Fix to Manual Termination – FM/VM

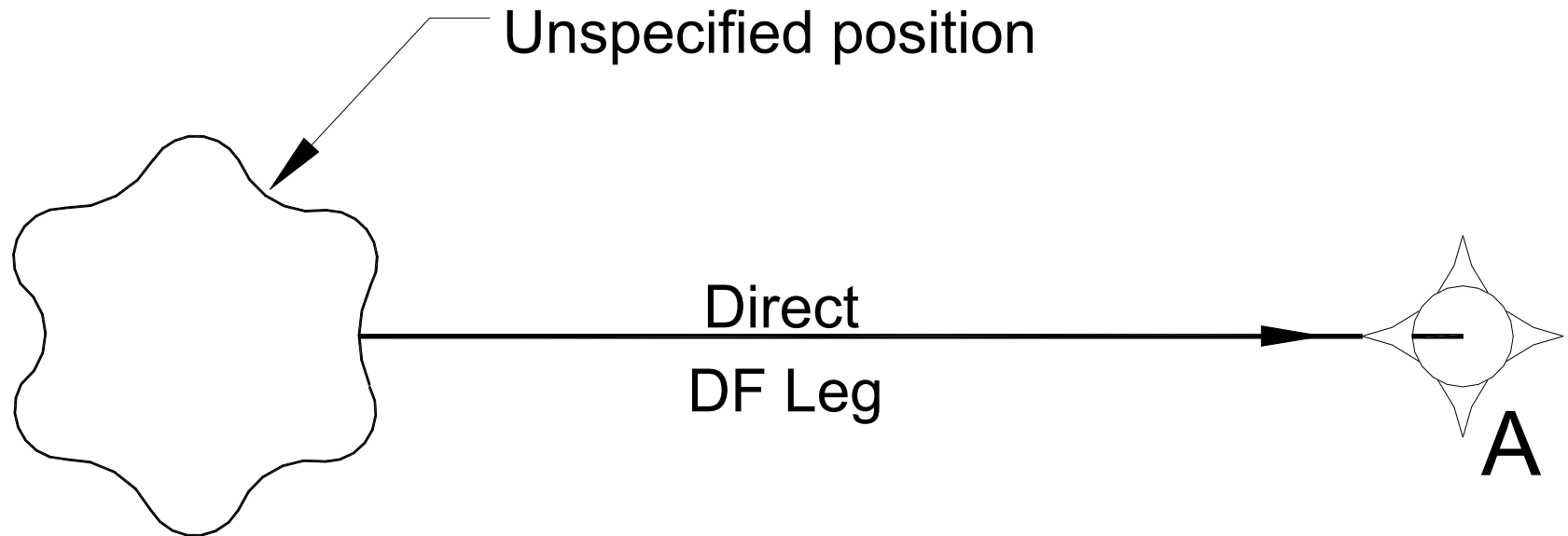


Track to Fix



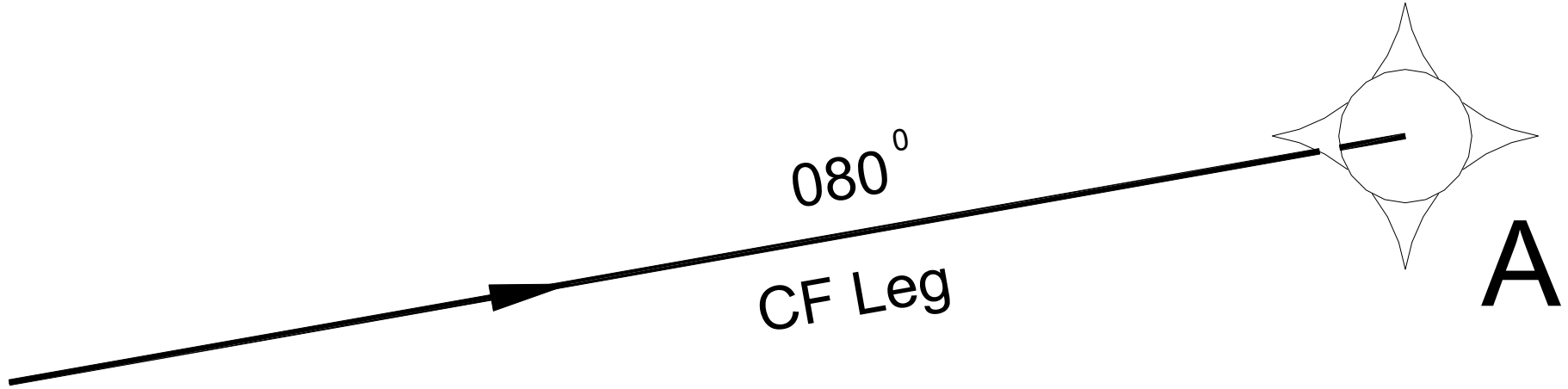


Direct to Fix



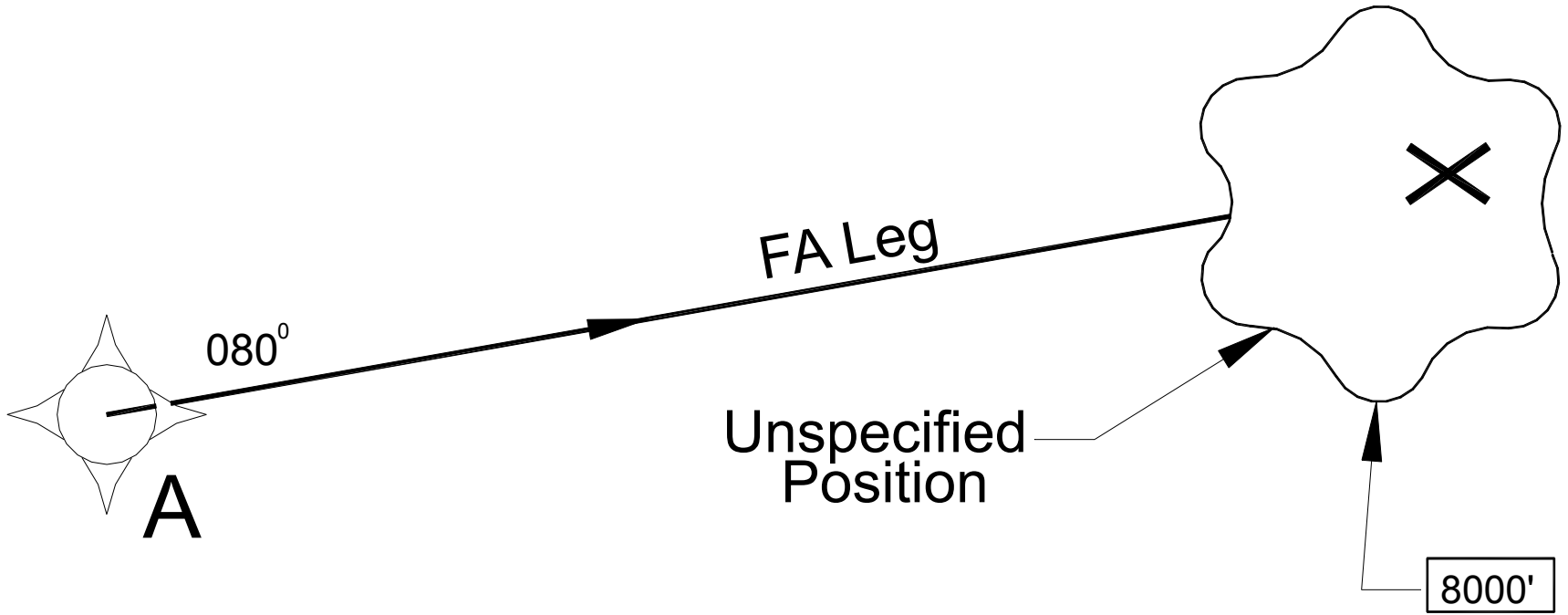


Course to Fix



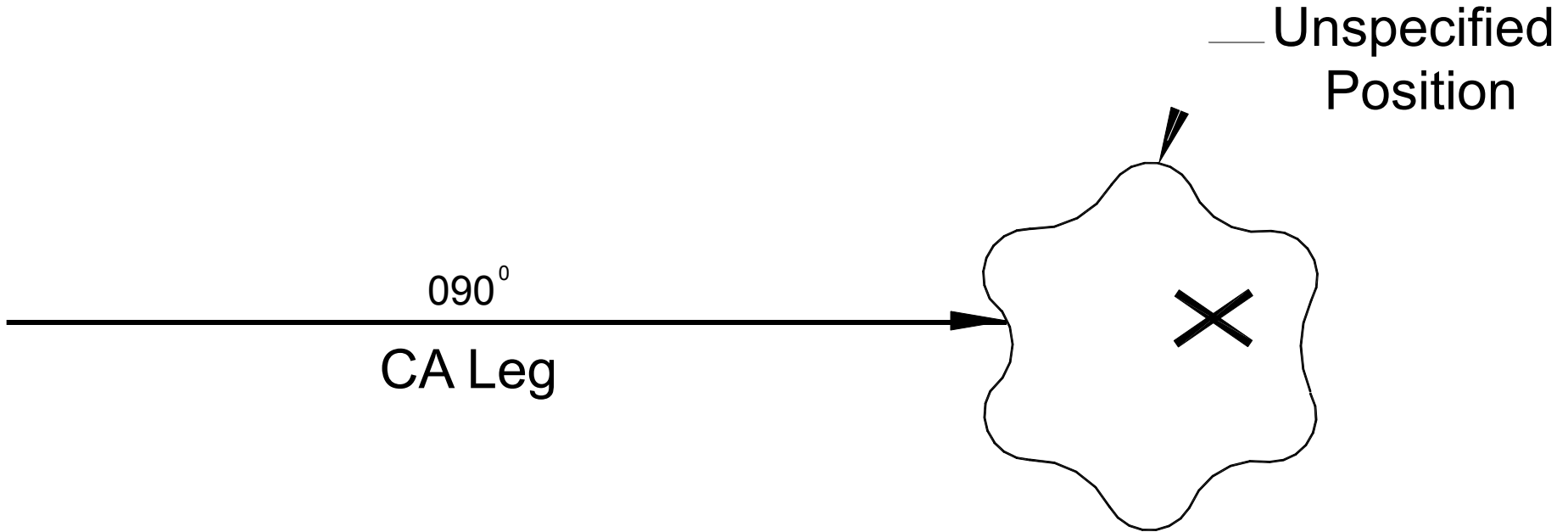


Fix to Altitude



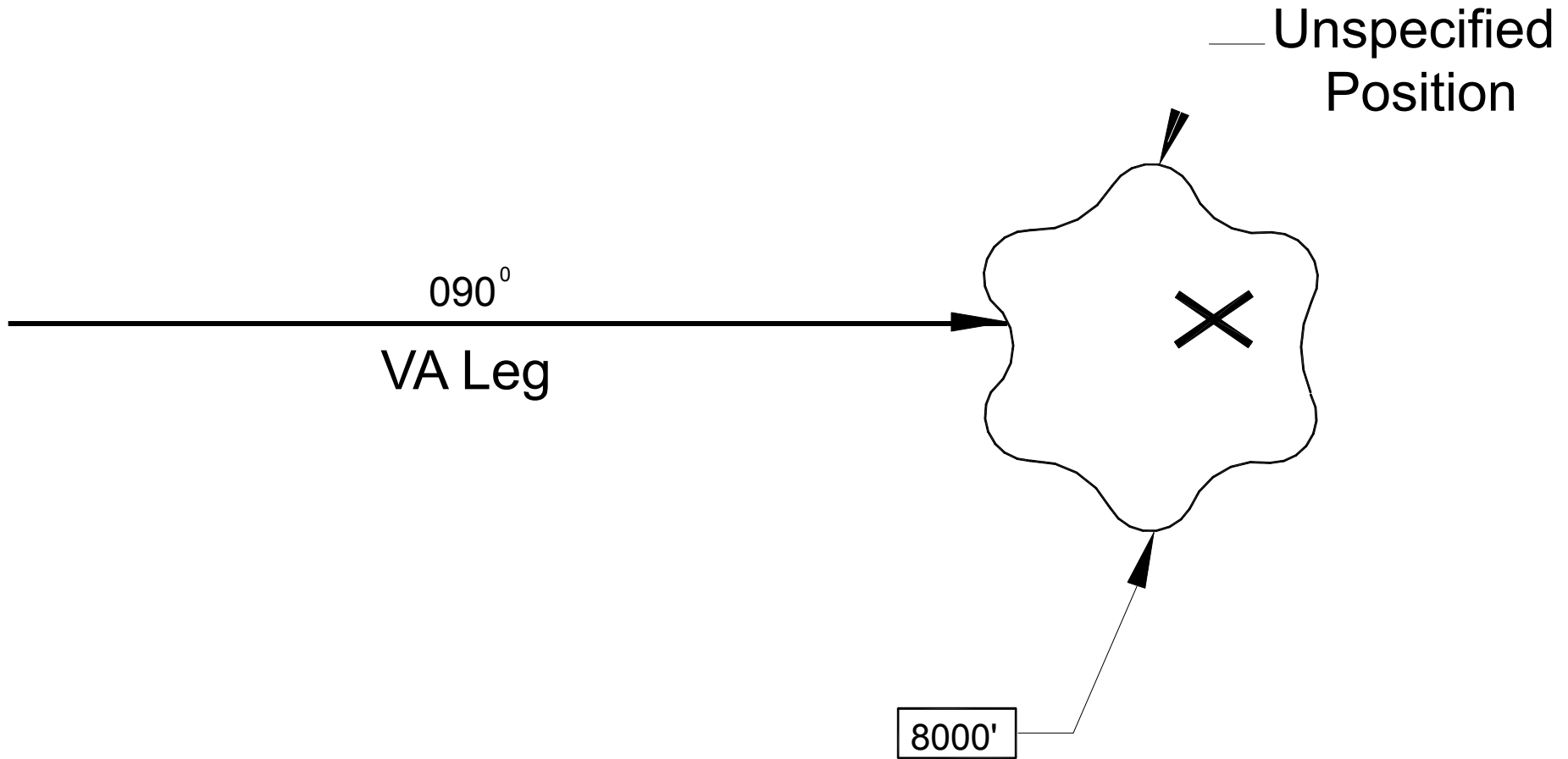


Course to Altitude



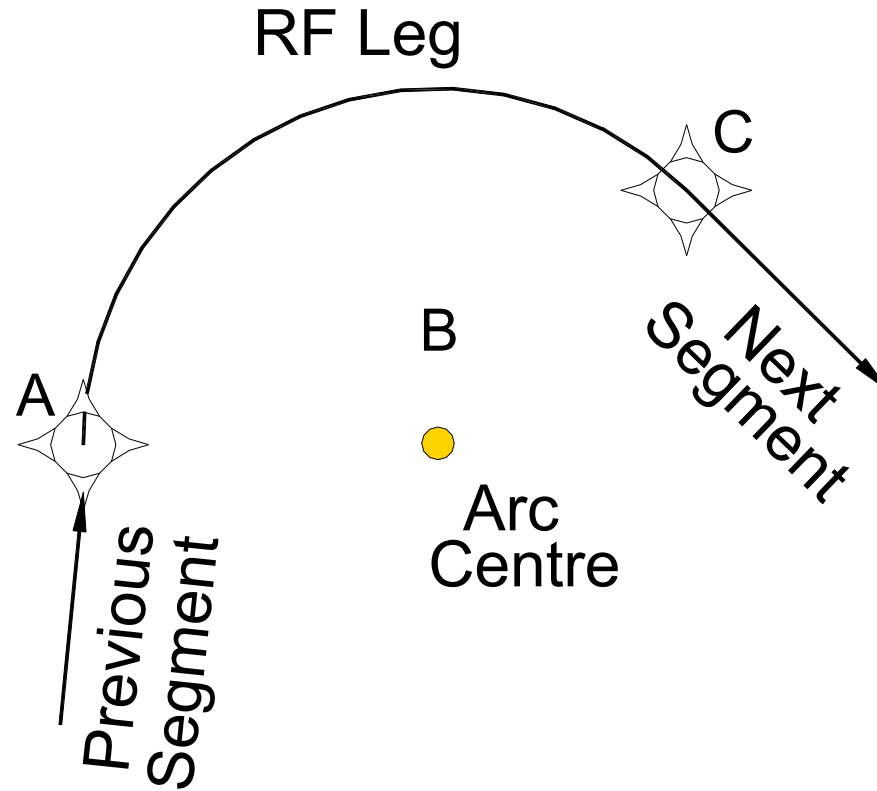


Heading to Altitude



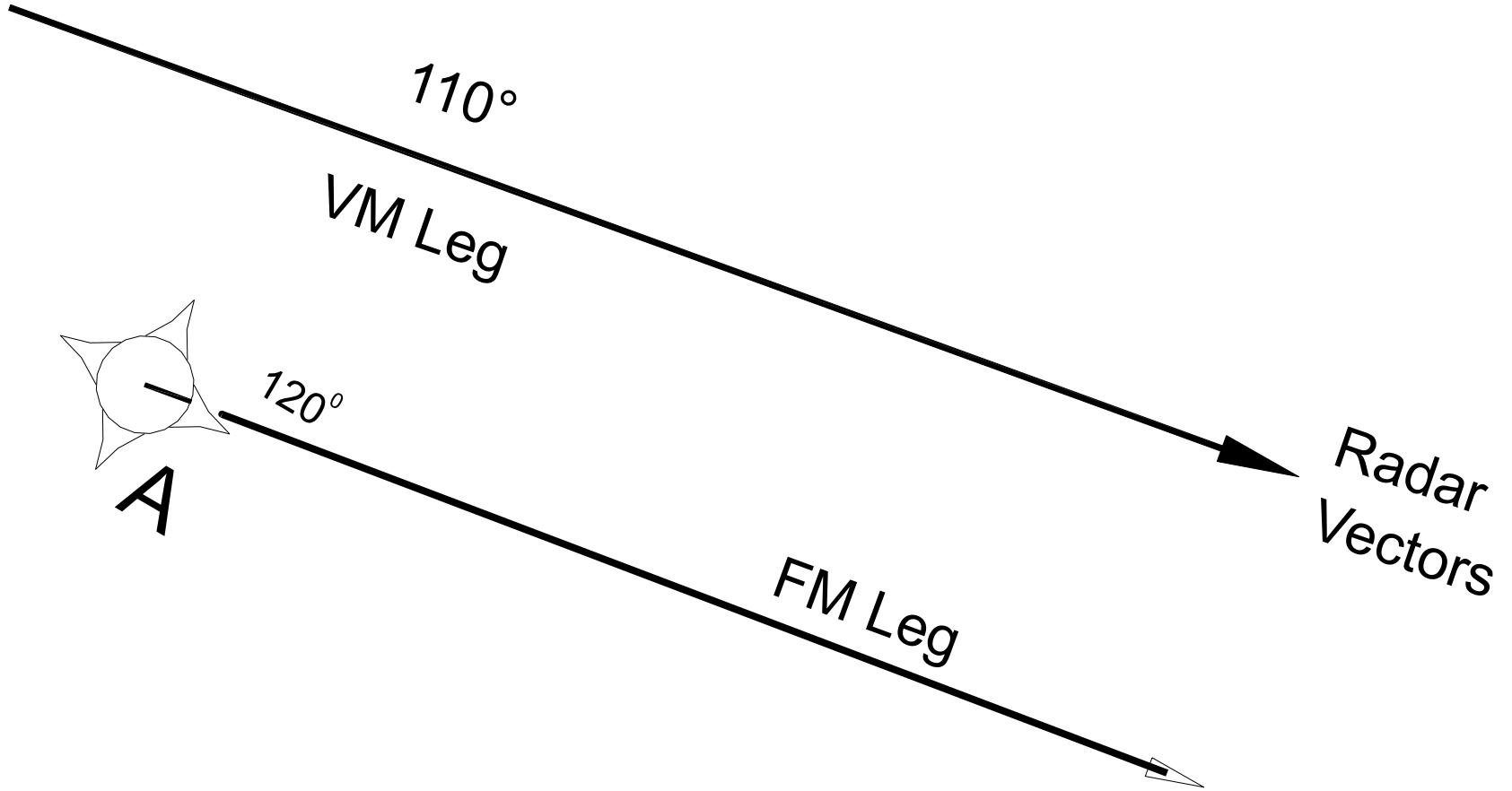


Radius to Fix

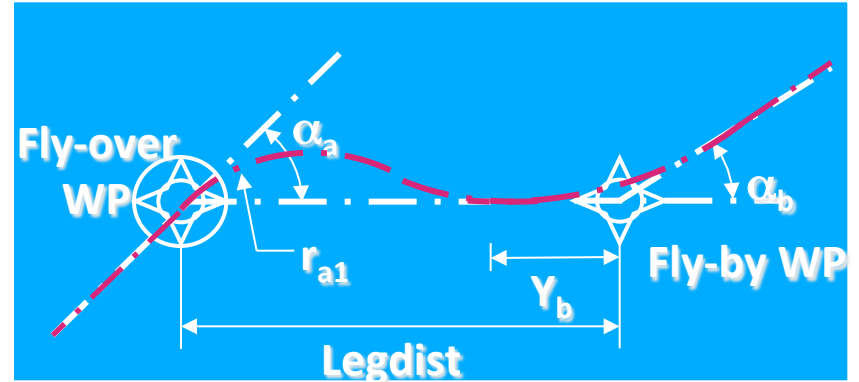
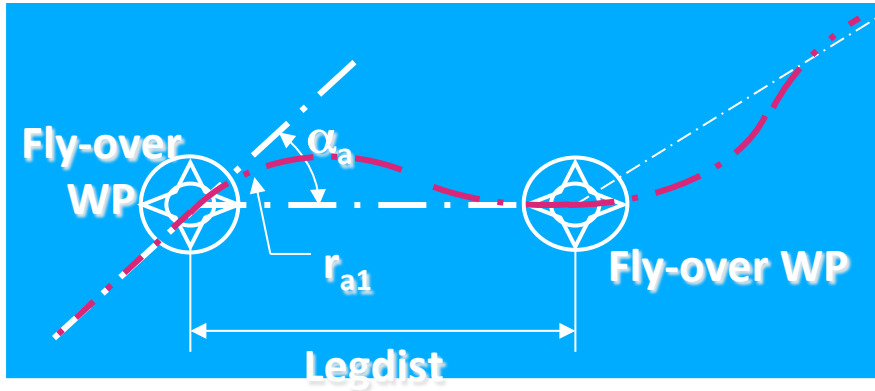
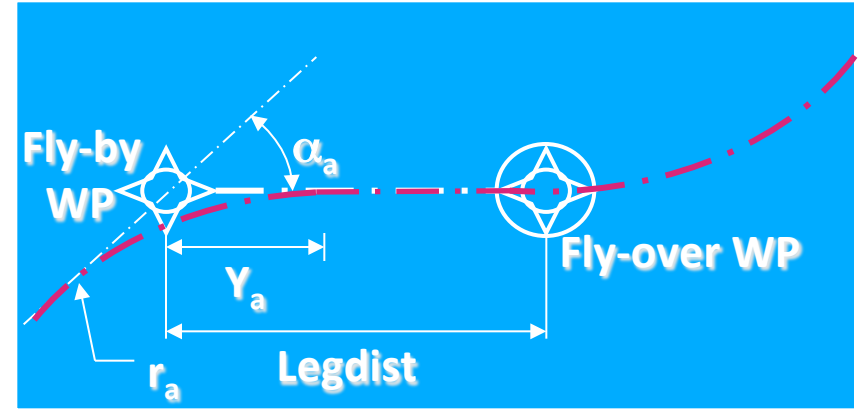
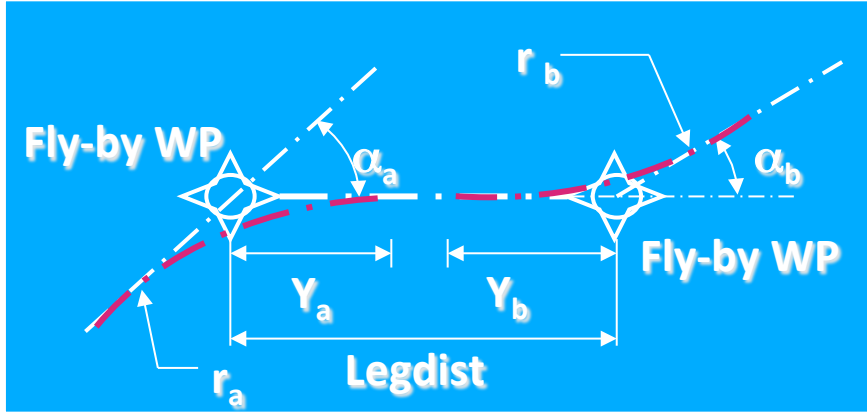




Fix to Manual Termination



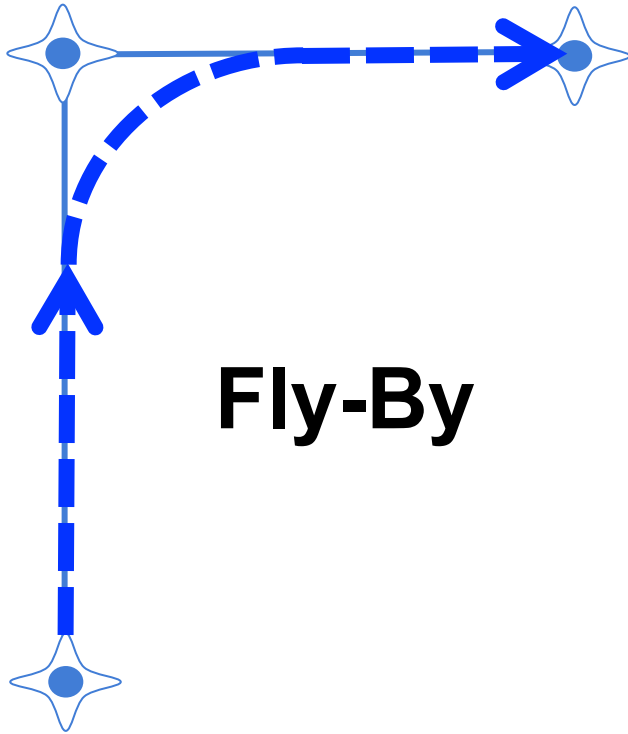
Track Distances Between Turns



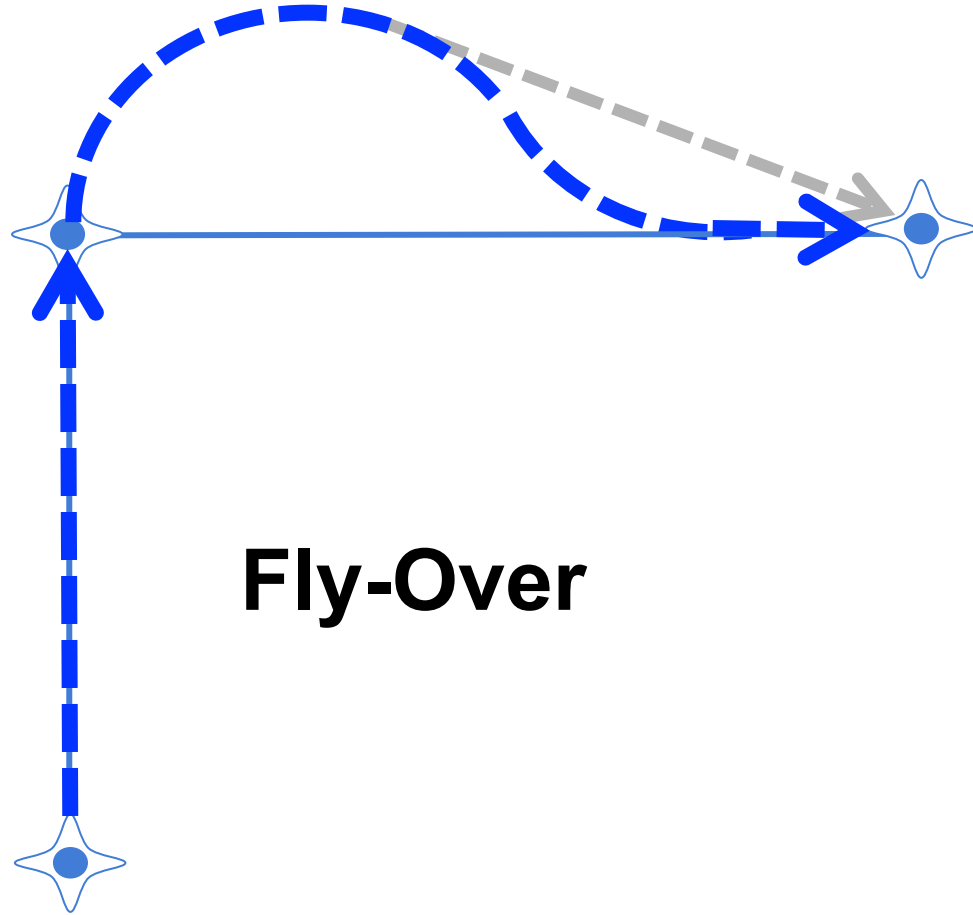


Impact of Turn Performance

Fly-By vs Fly-Over

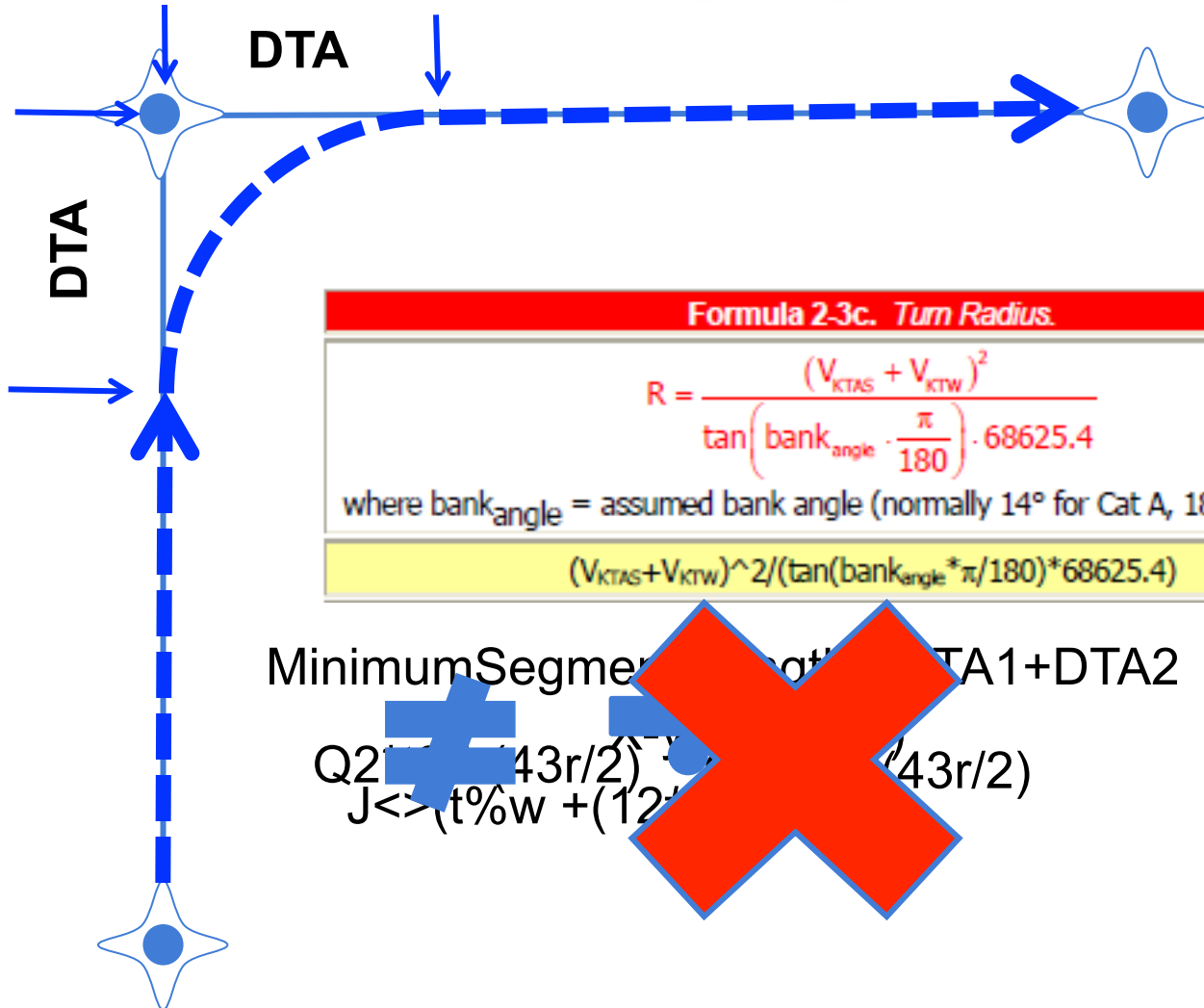


Fly-By



Fly-Over

Impact of Turn Performance Fly-By



Formula 2-3c. Turn Radius.

$$R = \frac{(V_{KTAS} + V_{KTW})^2}{\tan\left(\text{bank}_{\text{angle}} \cdot \frac{\pi}{180}\right) \cdot 68625.4}$$

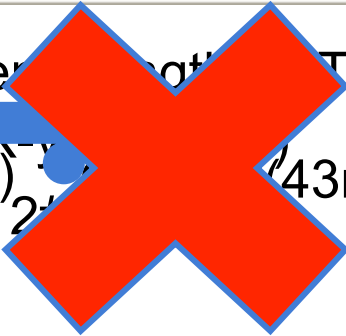
where $\text{bank}_{\text{angle}}$ = assumed bank angle (normally 14° for Cat A, 18° for Cats B-D)

$$(V_{KTAS} + V_{KTW})^2 / (\tan(\text{bank}_{\text{angle}} \cdot \pi / 180) \cdot 68625.4)$$

Minimum Segment Length $\geq \text{DTA1} + \text{DTA2}$

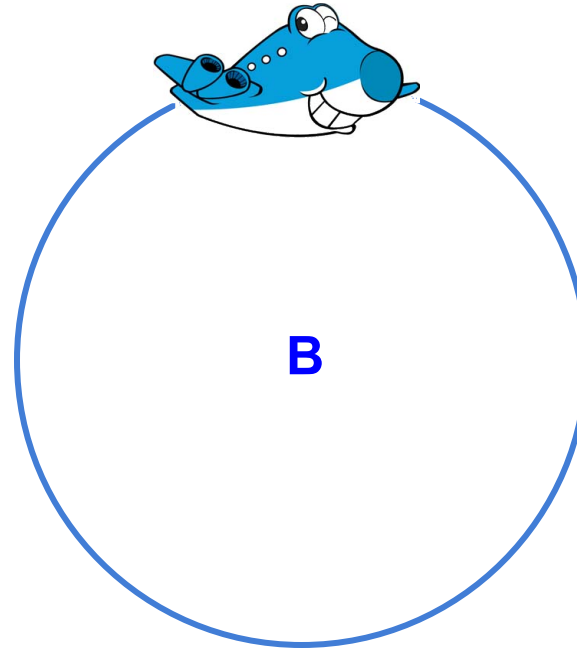
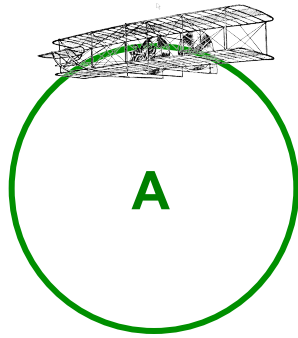
~~$Q2 = (43r/2) \cdot \dots$~~

~~$J < (t\%w + (12 \dots (43r/2))$~~





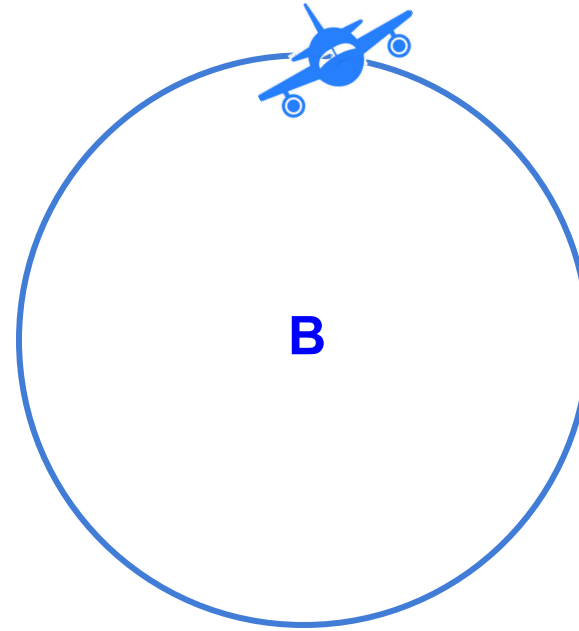
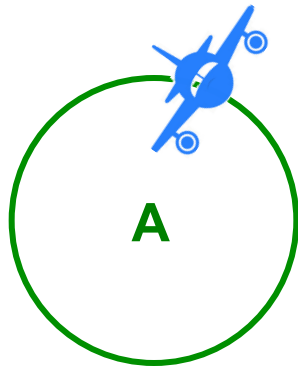
Impact of Turn Performance Speed Affects Turn Radius





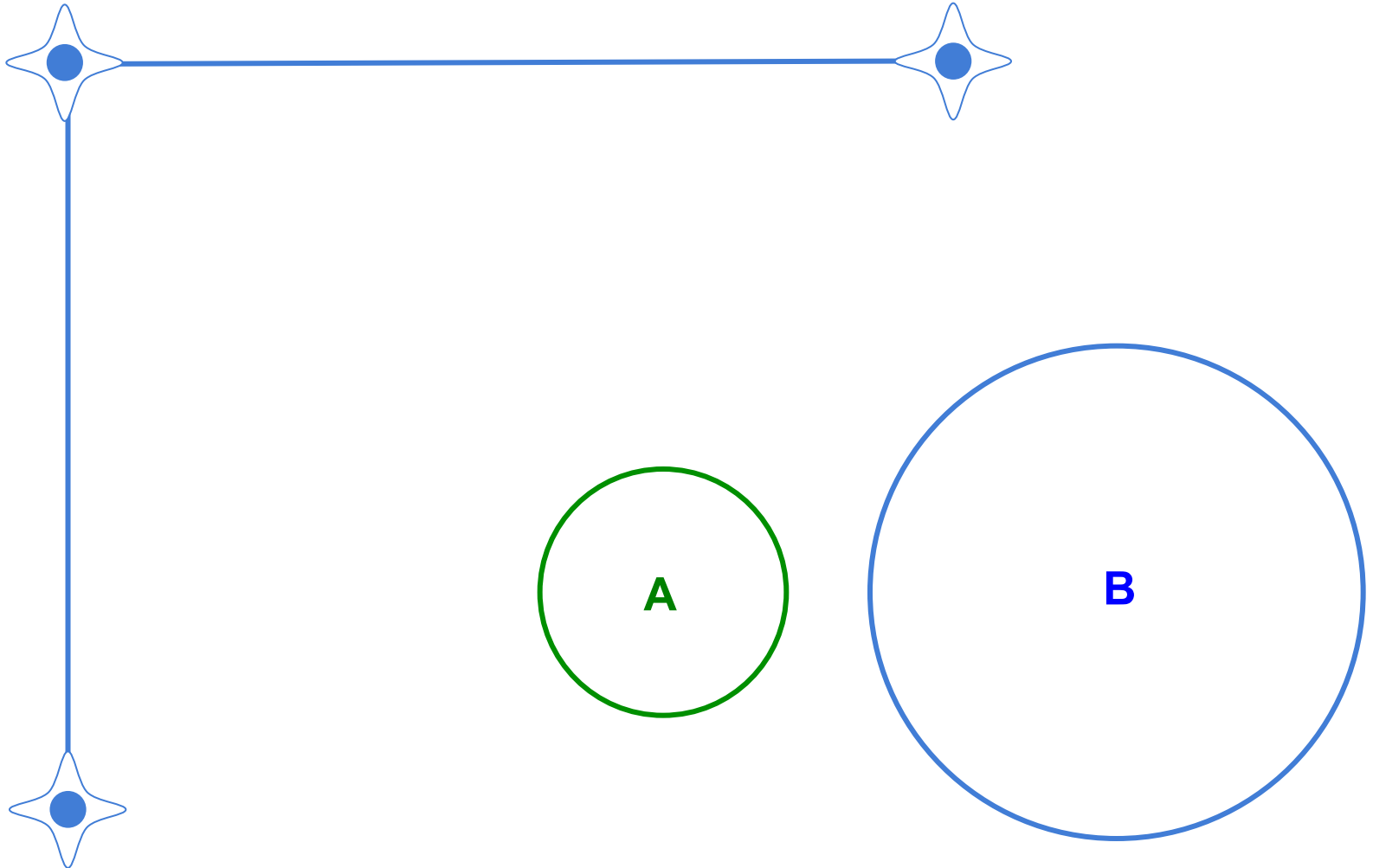
Impact of Turn Performance

Bank Angle Affects Turn Radius

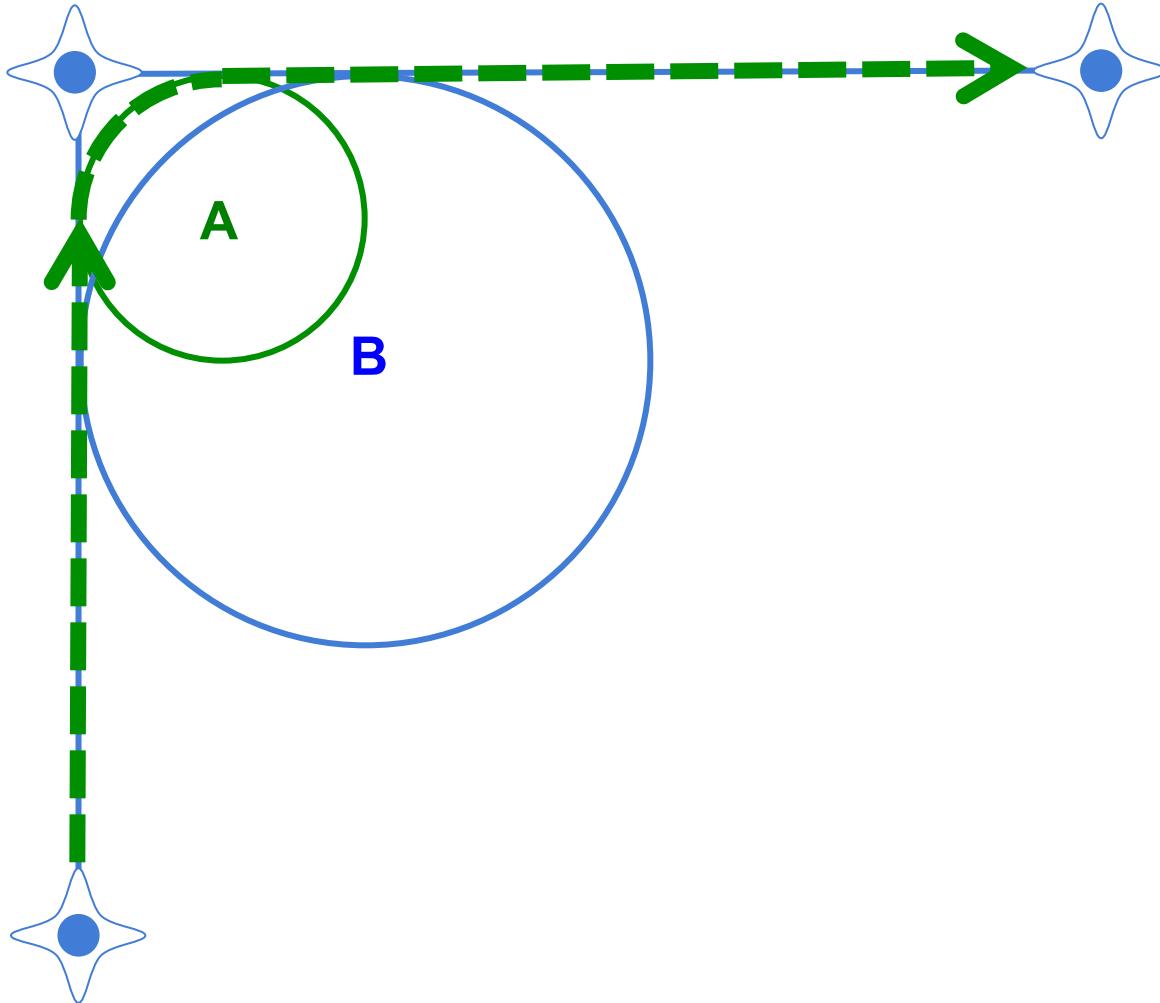




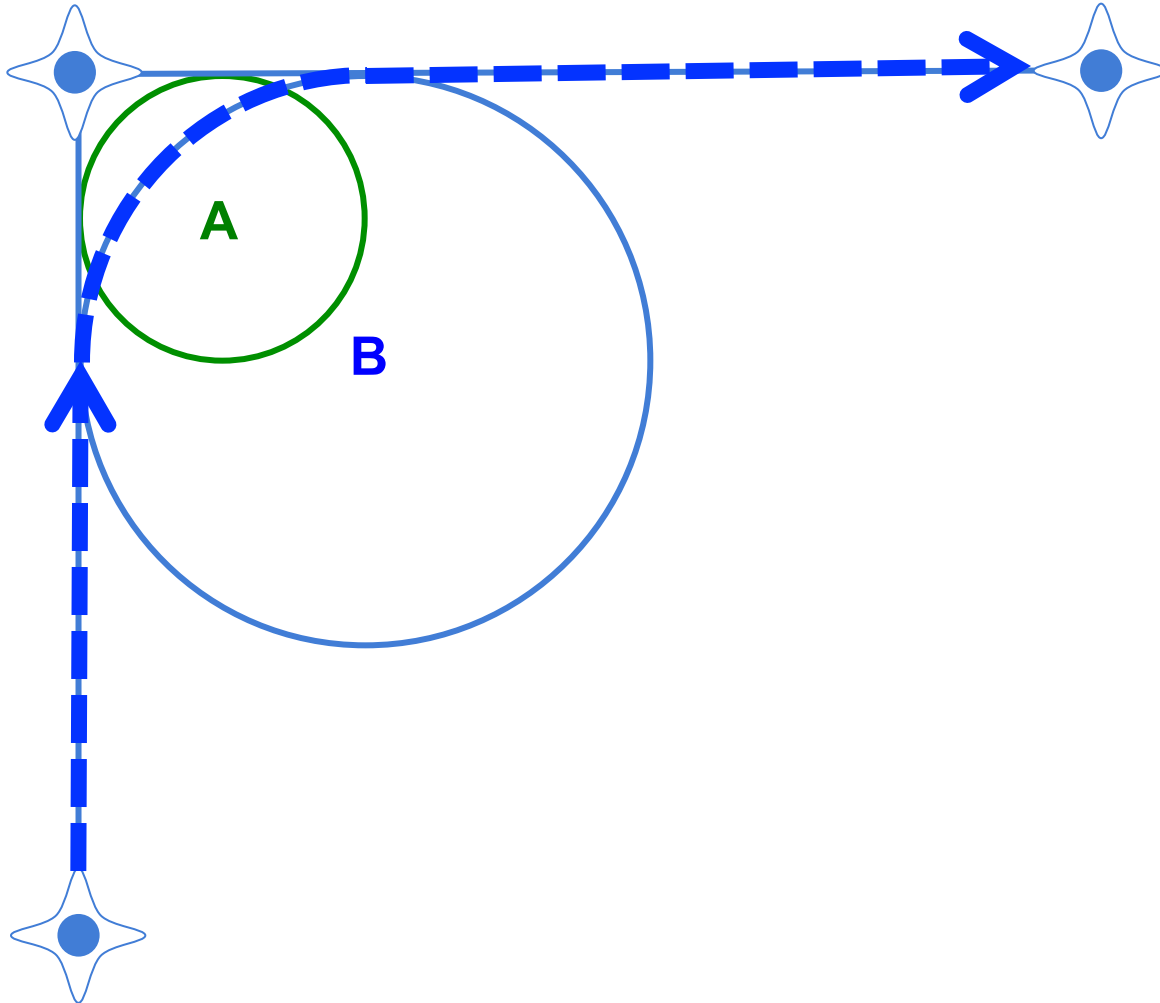
Impact of Turn Performance Fly-By



Impact of Turn Performance

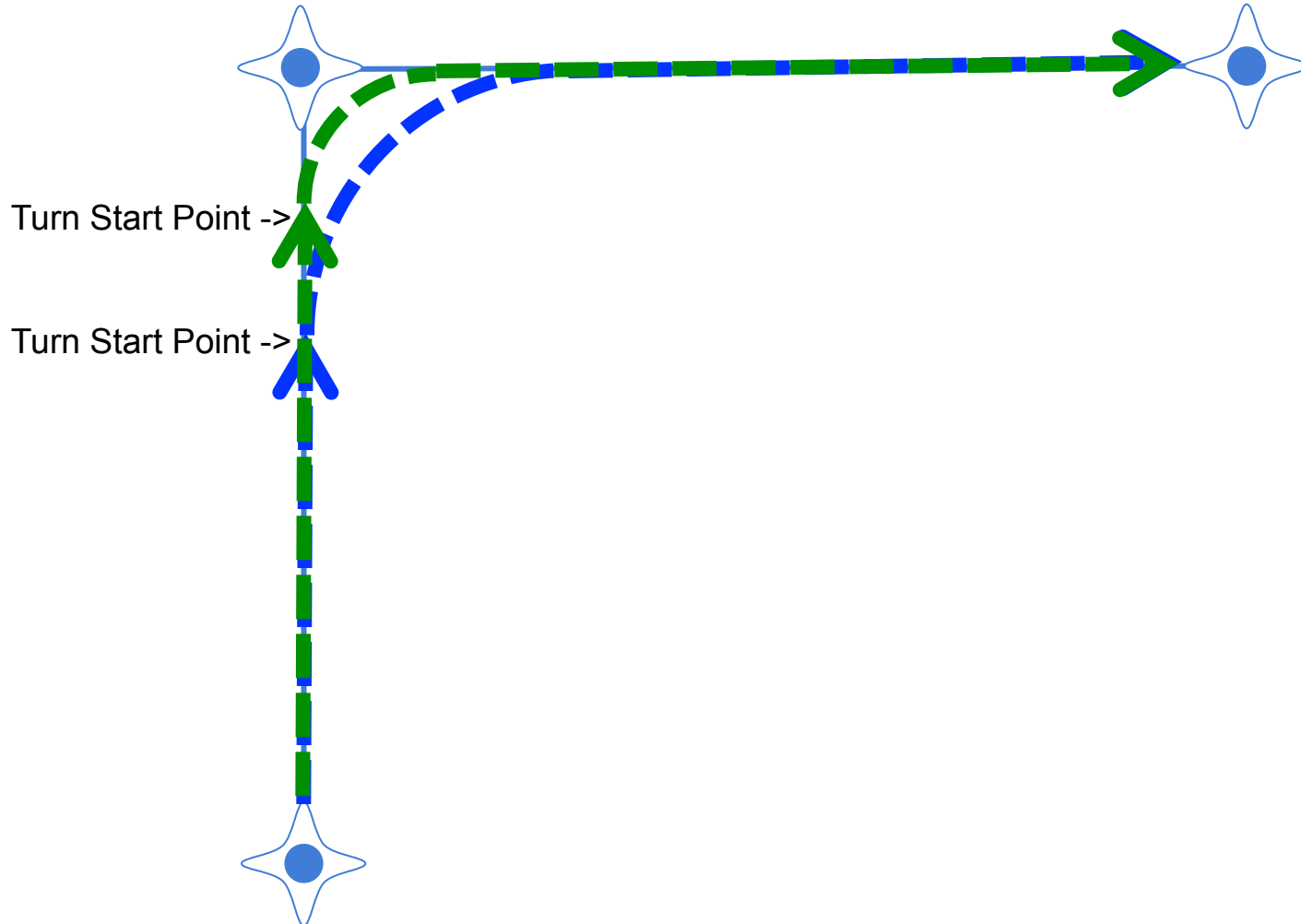


Impact of Turn Performance



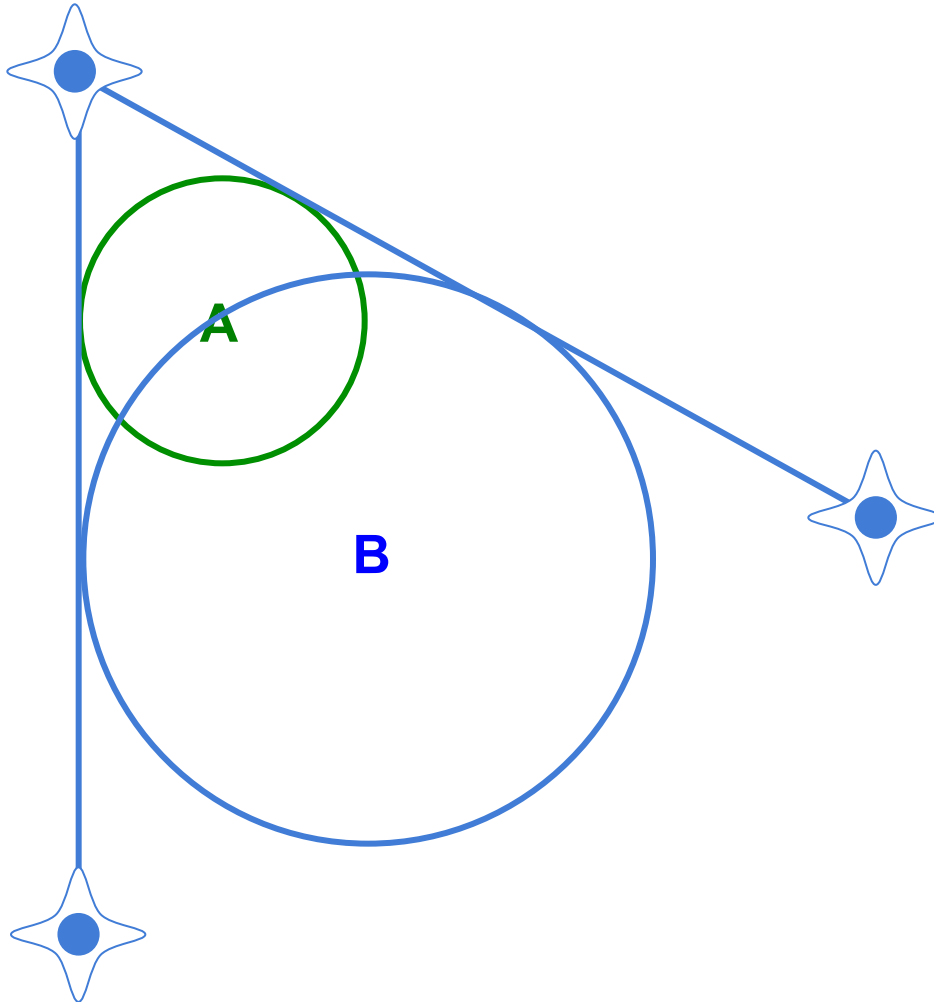


Impact of Turn Performance



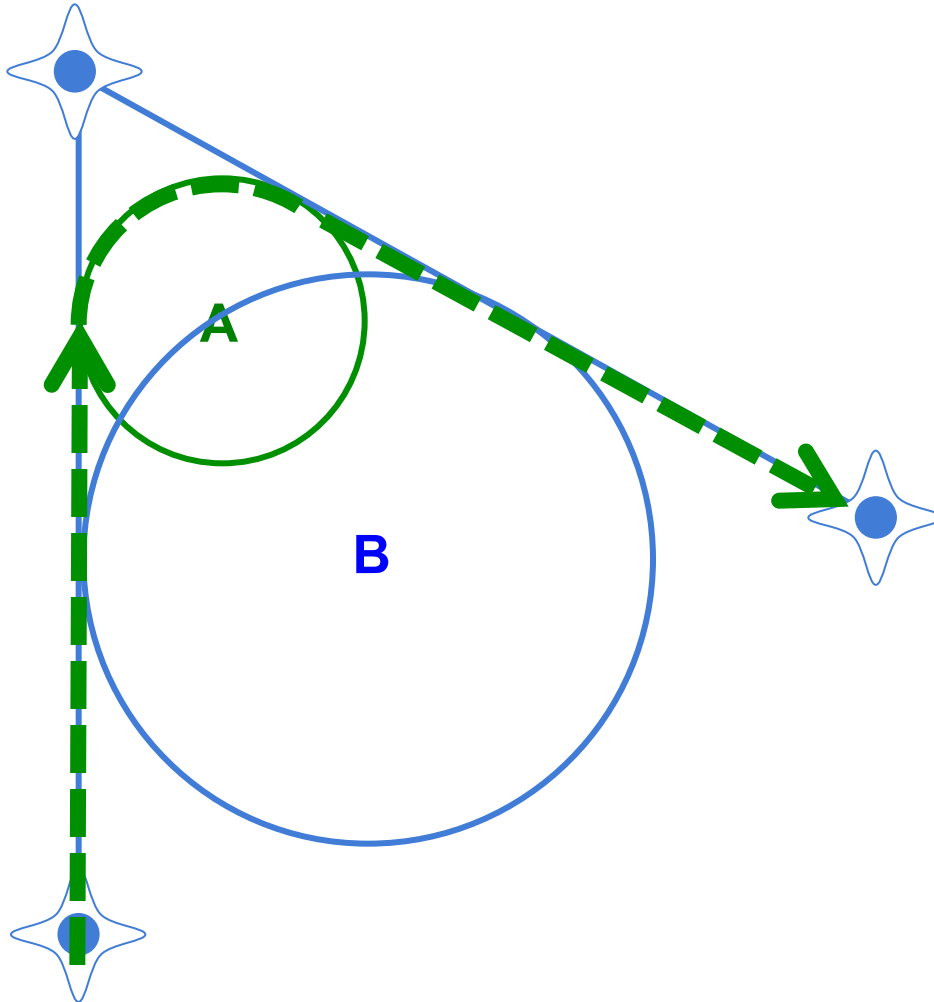


Impact of Turn Performance

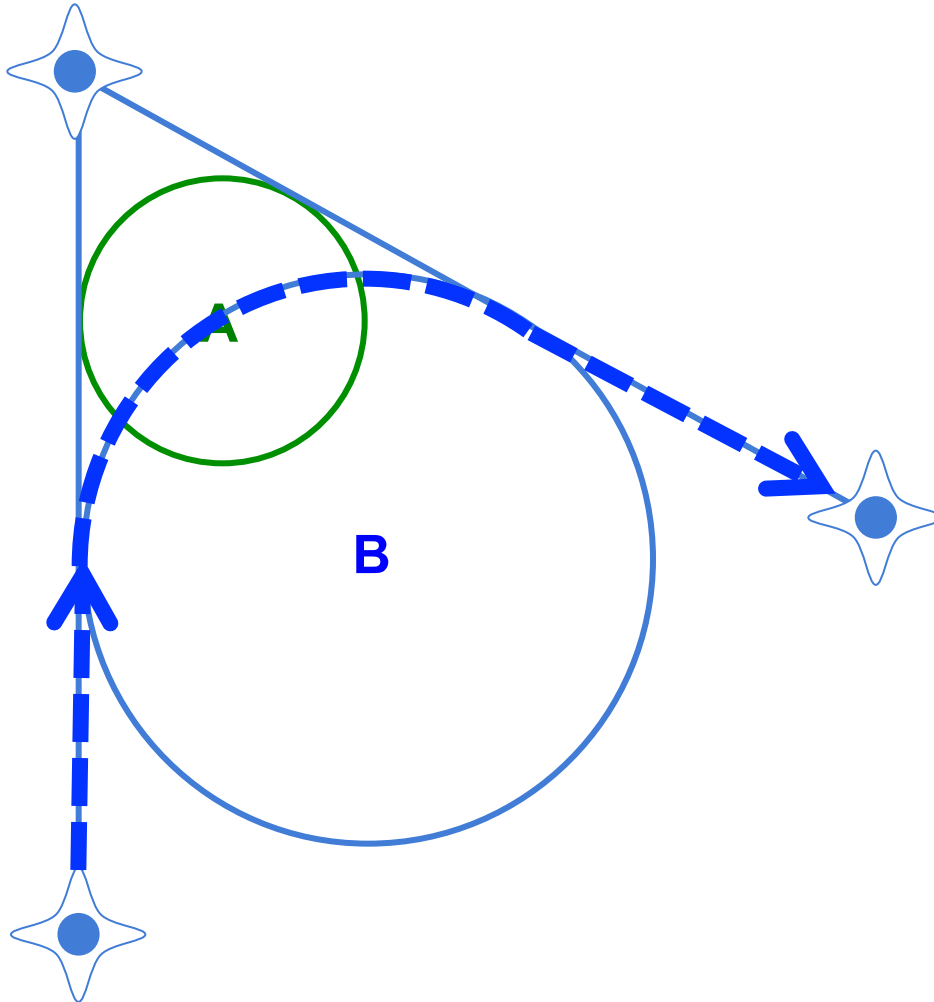




Impact of Turn Performance

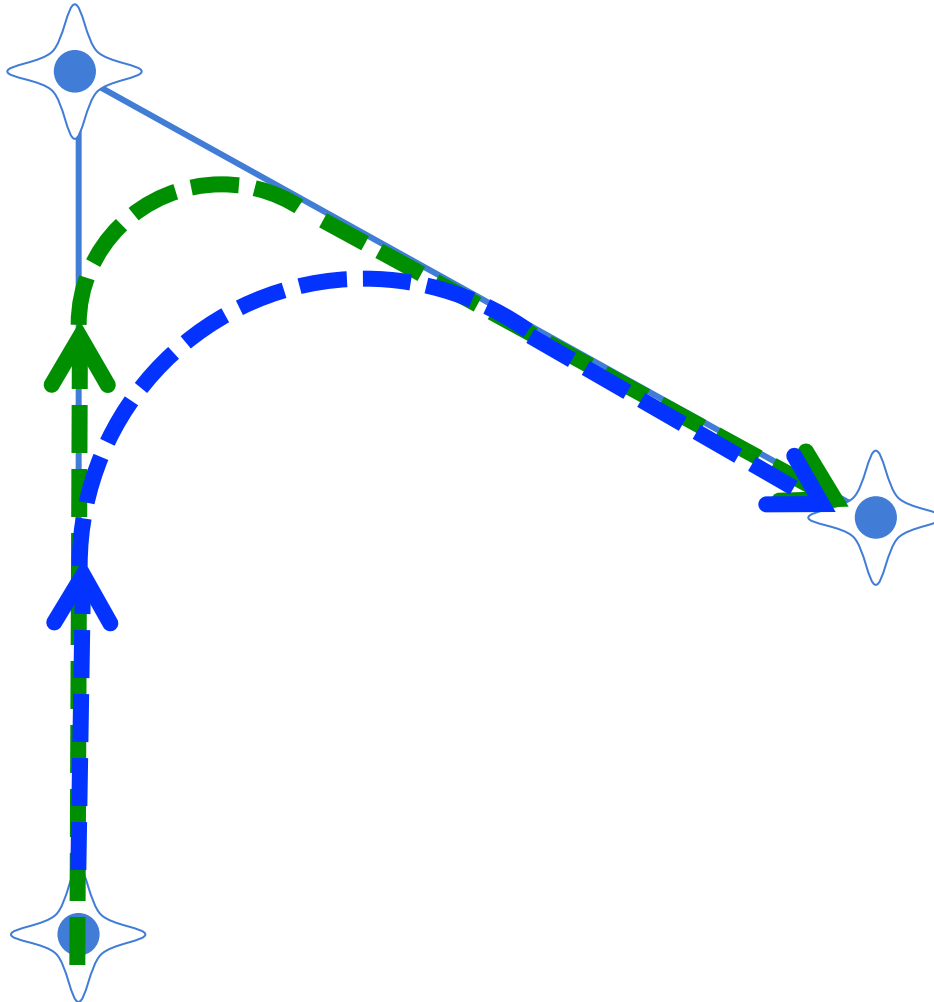


Impact of Turn Performance



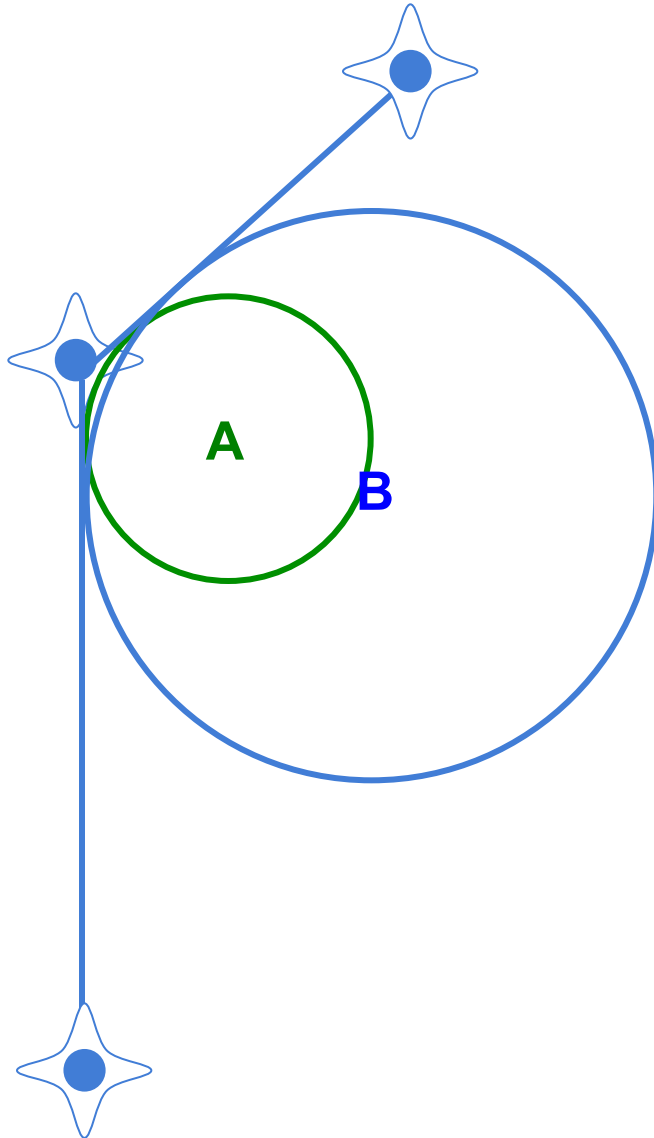


Impact of Turn Angle

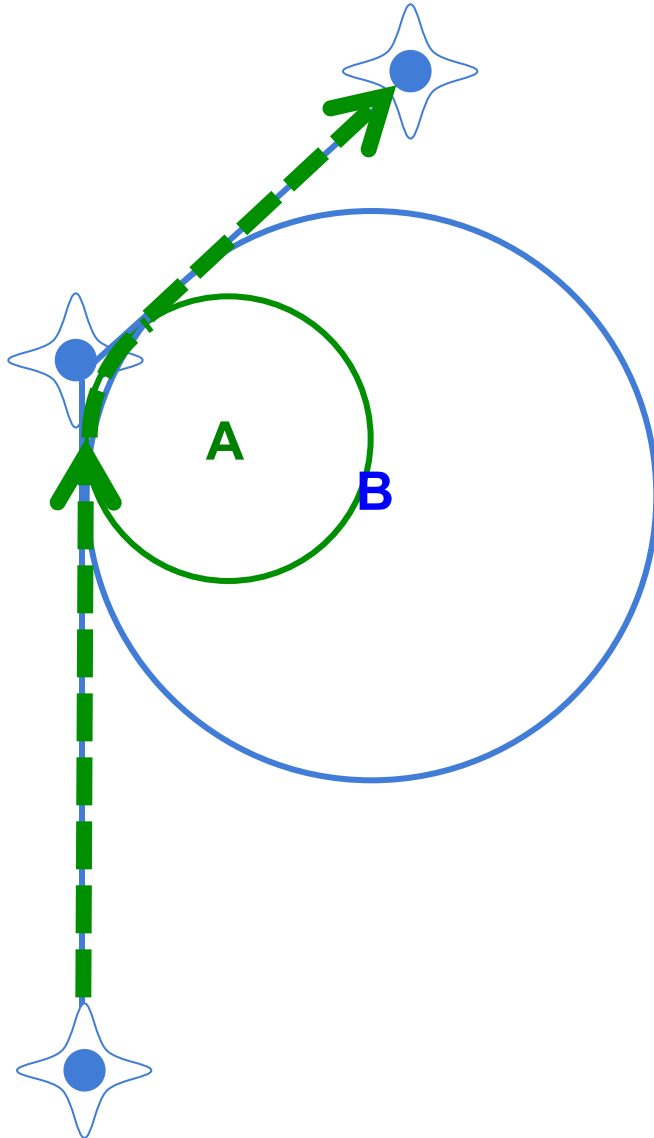




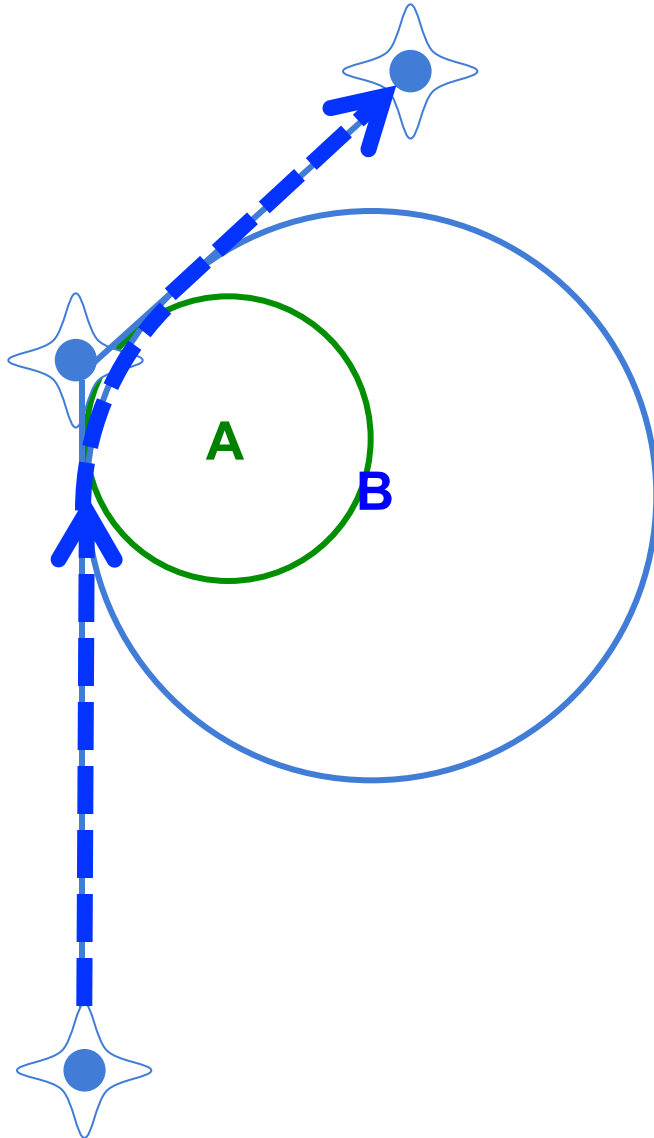
Impact of Turn Angle



Impact of Turn Angle

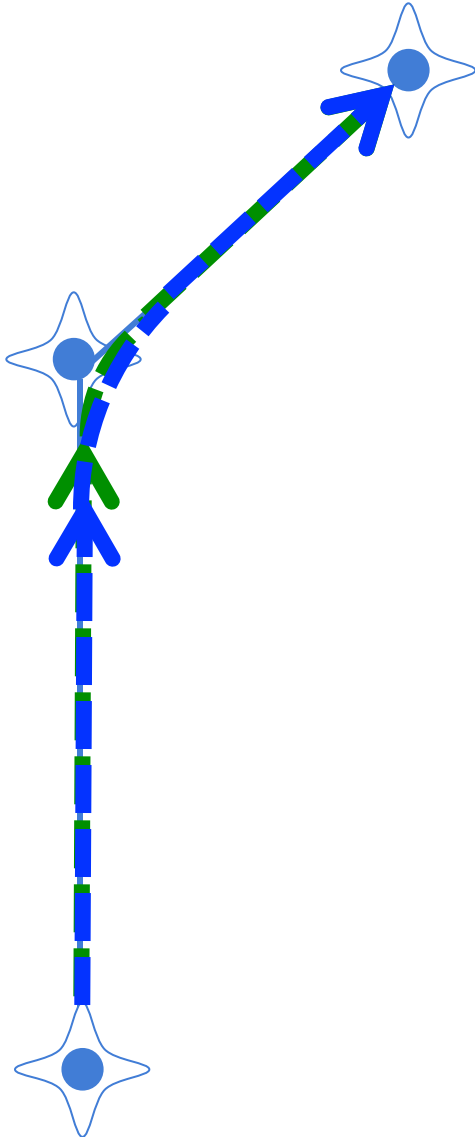


Impact of Turn Angle

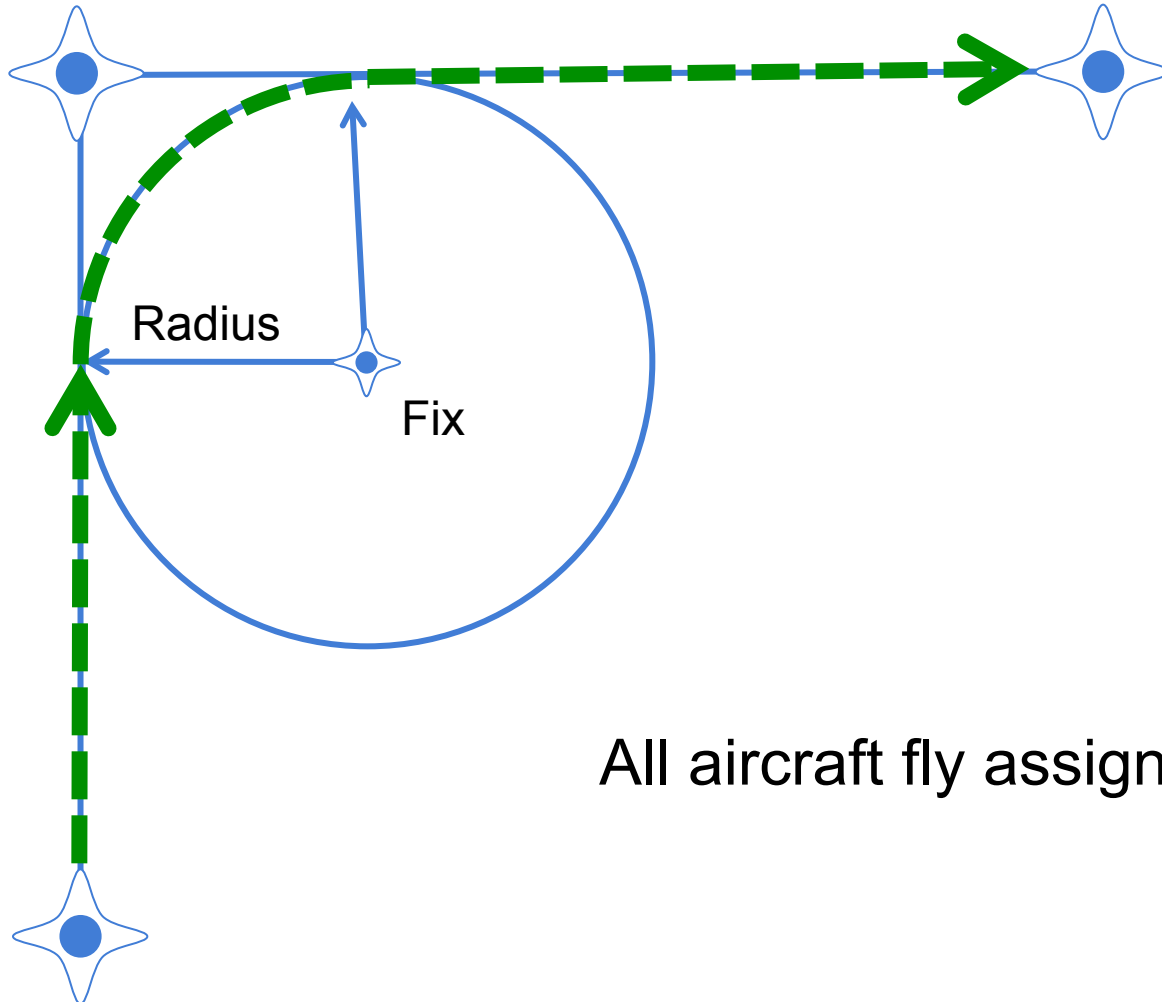




Impact of Turn Angle



Impact of Turn Performance RF Turns



All aircraft fly assigned radius



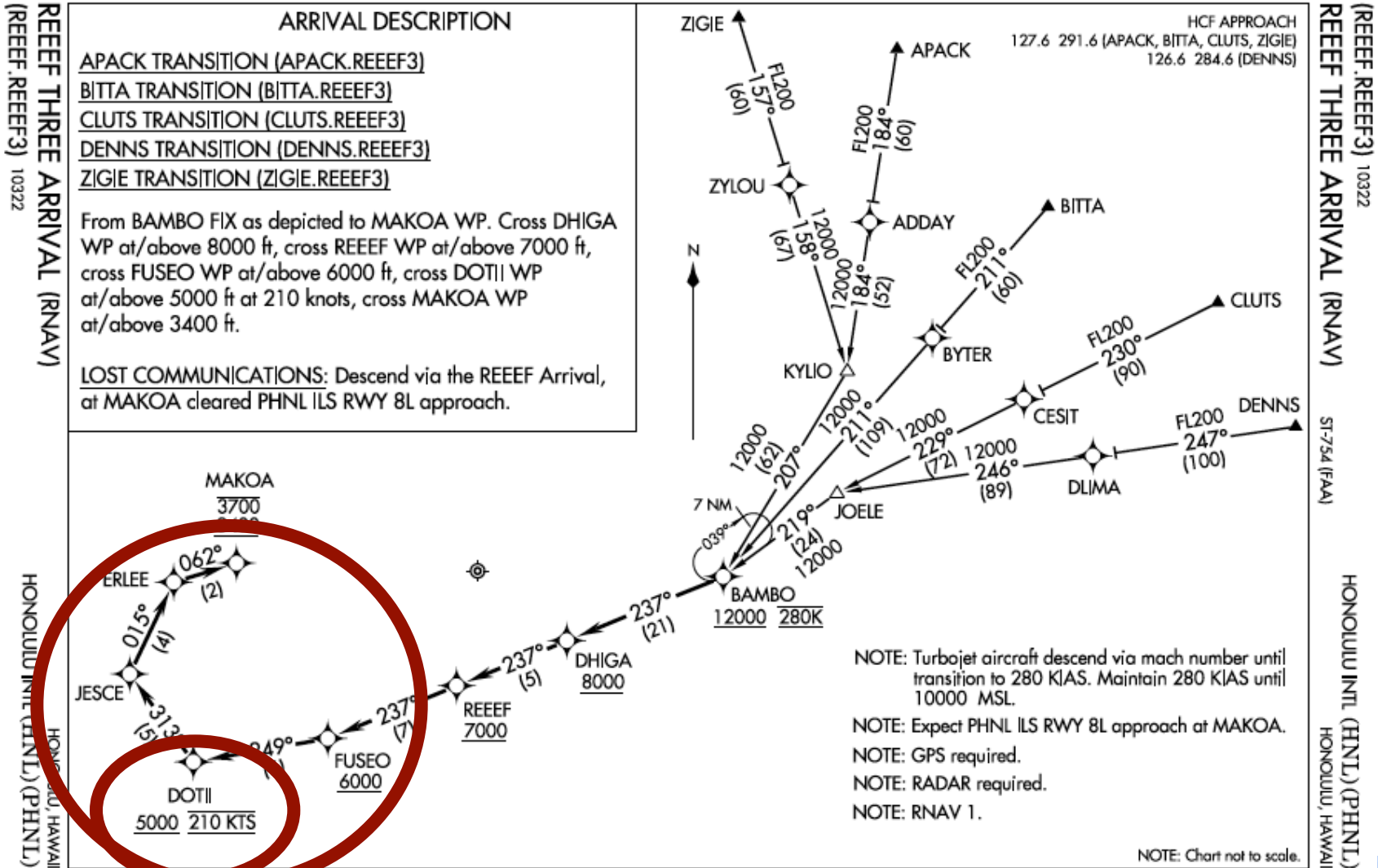
ATC Design Considerations



- ✈ Turns of more than 90 degrees may result in significant track variation.
- ✈ Turns of 60 to 90 degrees create more manageable track variations.
- ✈ Turns of 60 or less result in little track variation.
- ✈ RF turns result in little track variation.



Impact of Turn Performance Controlling Angles & Speed





Speed and Altitude Constraints



- ✈ Speed constraints allow tighter turns and can assist ATC function.
- ✈ Altitude constraints can provide separation from obstacles and other aircraft.



Procedure Design Considerations RNAV Approach Types

{ RNAV (GNSS) vs RNAV(RNP) }



PBN




ICAO State Letter SP 65/4-13/24

Proposes amendments to:

- PANS-OPS, Volume I
- PAN-OPS Volume II
- Annex 4
- Annex 6, Parts I, II and III
- Annex 14, Volume II
- Annex 15
- PANS-ABC

Applicable on 13 November 2014


International
Civil Aviation
Organization Organisation
de l'Aviation
Civile
Internationale Organización
de Aviación
Civil
Internacional Международная
органация
гражданской
авиации منظمة الطيران
المدني الدولي 国际民用
航空组织

Tel.: +1 (514) 954-8219 ext. 6718

Ref: SP 65/4-13/24 14 June 2013

Subject: Proposal for the amendment of PANS-OPS, Volumes I and II regarding procedure design criteria and charting requirements to support performance-based navigation (PBN) as well as helicopter point-in-space (PinS) approach and departure operations with consequential amendments to Annexes 4; 6, Parts I, II and III; 14, Volume II; 15 and the PANS-ABC

Action required: Comments to reach Montréal by 30 September 2013

Sir/Madam,

1. I have the honour to inform you that the Air Navigation Commission, at the tenth meeting of its 192nd Session on 7 March 2013 and the twelfth meeting of its 193rd Session on 4 June 2013, considered proposals developed by the Instrument Flight Procedures Panel (IFPP) seventh, eighth, ninth, tenth and eleventh working group of the whole meetings to amend the *Procedures for Air Navigation Services — Aircraft Operations*, Volume I — *Flight Procedures and Volume II — Construction of Visual and Instrument Flight Procedures* (PANS-OPS, Doc 8168) with consequential amendments to Annex 4 — *Aeronautical Charts*; Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, Part II — *International General Aviation — Aeroplanes* and Part III — *International Operations — Helicopters*; Annex 14 — *Aerodromes*, Volume II — *Heliports*; Annex 15 — *Aeronautical Information Services; Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400) regarding flight procedure design criteria and associated charting requirements for performance-based navigation (PBN), in particular for the new navigation specifications as well as for helicopter point-in-space (PinS) approach and departure operations.
2. The proposed amendment to PANS-OPS, Volumes I and II are in Attachments B and C, respectively. Consequential amendments to Annexes 4; 6, Parts I, II and III; 14, Volume II; 15 and the PANS-ABC are in Attachments D to H, respectively.
3. The amendment proposals address specific areas as listed and explained in Attachment A.
4. To facilitate your review of the proposed amendments, the rationale for each proposal has been provided in the text boxes immediately following the proposals throughout Attachments B, C, D, E, F, G and H.

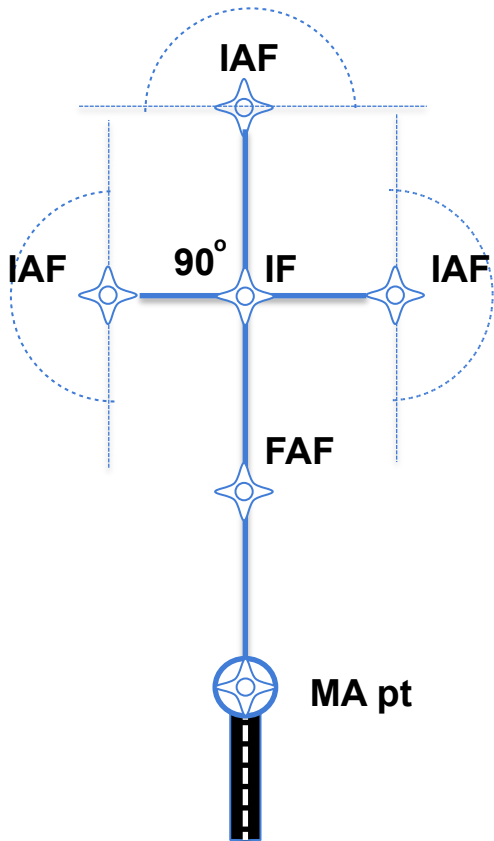
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www.icao.int



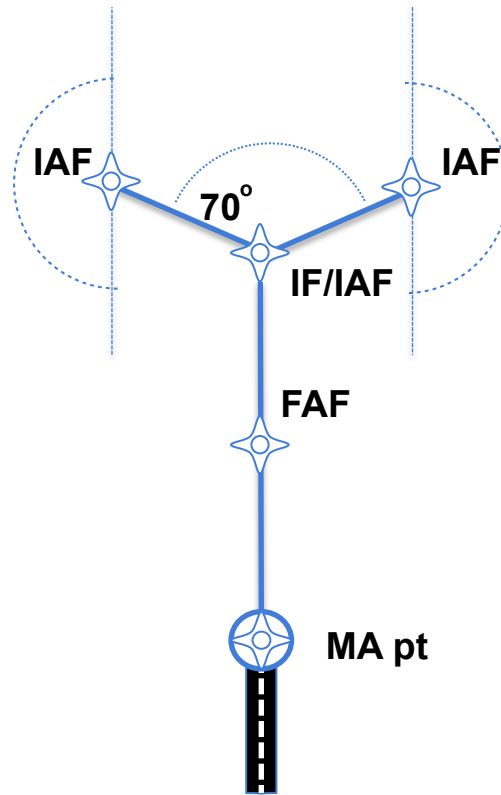
RNAV (GNSS) Approaches



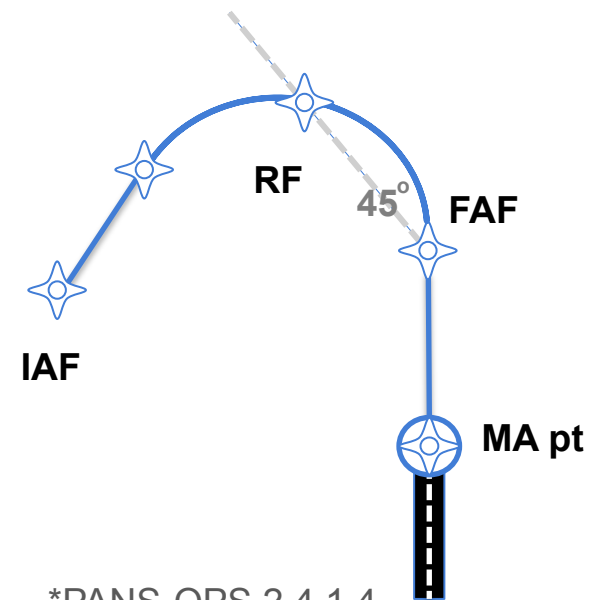
T Bar



Y Bar



With RF*



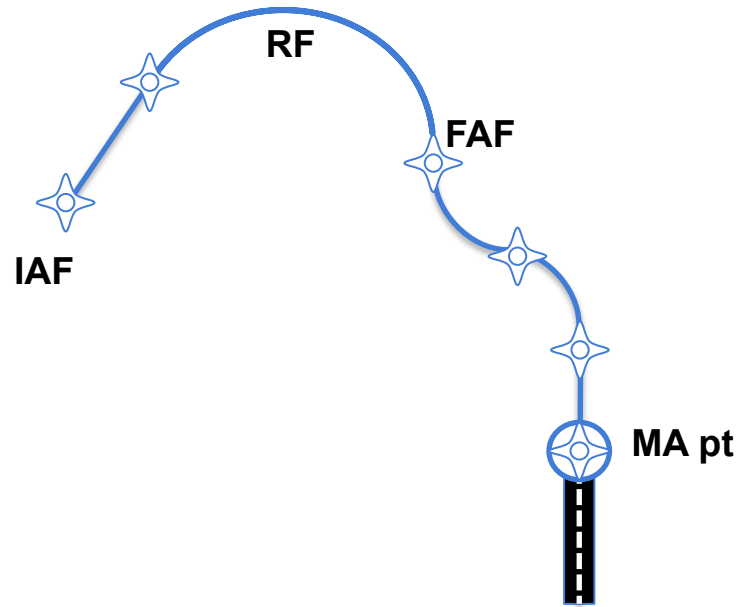
*PANS-OPS 2.4.1.4
13 NOV 2014



RNAV (RNP) Approaches



RNP-AR





RNAV (GNSS and RNP)



- ✈ RNAV(GNSS) is an RNP approach
- ✈ RNAV(RNP) is an RNP-AR approach
- ✈ Letters in parenthesis are not said in clearance
- ✈ RNAV(GNSS) RWY22 and RNAV(RNP)RWY22 are both cleared as RNAV RWY22 approach.



RNAV (GNSS and RNP)



- State Letter SP 65/4-13/24 effective 13 NOV 2014
- A one-step eight-year transition period, starting 13 November 2014, is being proposed to allow States sufficient time to develop a transition plan and to convert the existing RNAV approach procedures to RNP by 2022.
- ICAO will issue a new circular (Circ 336 — Circular on Conversion of RNAV to RNP Approach Chart Depiction)
- From 1 December 2022:
 - charts depicting procedures that meet the RNP APCH navigation specification criteria shall include the term RNP in the identification (e.g. **RNP RWY 23**).
 - charts depicting procedures that meet the RNP AR APCH navigation specification shall include the term RNP in the identification with a parenthetical suffix (AR). (e.g. **RNP RWY 23 (AR)**).



Reminder

Steps so far!



- ✈ What is the Intended Purpose – *as per Airspace Concept*
- ✈ Which Operators and Aircraft Types – *as per traffic sample (assumptions)*
- ✈ What is the Navaid Coverage – *as per infrastructure assumptions*
- ✈ What are the Environment Constraints – *determined by Airspace Design Team*
- ✈ What other Constraints, incl. obstacles?
- ✈ Design the Procedure



Thank You