A Flight Procedure Design Method for RNP to xLS with Shallow Segment

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Outline

1. Background
2. “RNP to xLS” Procedure Design Assumption & Method
3. Full-Flight Simulator Trials
4. Summary
1. Advantage of RNP to xLS

RNP AR
No PA

FAF
Intermediate Segment

FAF
FACF
IAF
xLS
PA

RNP to xLS

Intermediate Segment
Intermediate Segment used barometric altitude while final approach segment depends on geometric altitude.
1. Temperature Correction

International Standard Atmosphere (ISA)
Temp 15°C at Mean Sea Level, Lapse rate ~ −2°C per 1,000 ft

ΔISA = 30°C  10.2 %
ΔISA = 20°C  6.8 %
ΔISA = 10°C  3.4 %
1. Difficulty of Procedure Design

- GS should be captured after capturing LOC.
  - **For short intermediate design, GS capture may happen before LOC capture.**

![Diagram showing GS and LOC capture points with different conditions]

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1. Shallow segment

- FAA PARC reported RNP to xLS procedure design using **Shallow Intermediate Segments**
- Improving flight efficiency: Long level segment decrease it.
- Considering capture condition and guideline.

Discussing more detail, and optimum design method
2. Assumption of procedure design

1. ARINC 424 compliance

**424-19 (2008)**
- “All such approach procedures must begin at the FACF”
- “The rules of coding GLS approach procedure are understood to be identical to those of LOC coding”

**424-20 (2011)**
- “The final approach coding of GLS instrument approach procedures does not require the coding of a FACF waypoint”

ARINC **424-19** specification are supposed

All type of aircraft does not support 424-20

2. Hottest day temperature

\[ \Delta ISA = 30^\circ C \]

\[113^\circ F\] MSL
2. Assumption of procedure design

3. Glideslope & Localizer capture timing

Type A aircraft allows Glideslope capture before Localizer capture

Type B aircraft inhibits Glideslope capture before Localizer capture

Type A aircraft are supposed ← Critical

4. Glideslope pointer exceed one dot

Pilots need a buffer for pushing APP switch

5. Glideslope capture boundary ↦ a half dot
2. Procedure design

- **RW24R (90FT)**
  - GLS: GKW (FREQ: 21475)
  - GS intercept alt: 1700FT
  - GS crossing alt: 1053FT

- **WP 0**
  - FAF
- **WP 1**
  - FACF
- **WP 2**
- **WP 3**
  - At 3189FT
- **WP 4**
  - At 3189FT

- **CF LEG**
- **TF LEG**

- **MAX 180KIAS**

- **V/A 3.0**
  - 3.0 NM
  - 2.0 NM

- **ANG**
  - LEN
  - TOTAL 17.85

- **LEN**
  - A: 1.0
  - B: 1.5
  - C: 2.0

- **ANG**
  - A: 1.4
  - B: 1.5
  - C: 1.6

- **GLS: GKW (FREQ: 21475)**
- **GS intercept alt: 1700FT**
- **GS crossing alt: 1053FT**
2. Deviation & Capture points

![Graph showing deviation and capture points](image)

- **Case-B**
  - GS Capture
  - LOC Capture

- **Capture**
  - LOC Full Scale
  - GS Dev
  - Glideslope
  - VNAV

- **Delta ISA**
  - 0°C
  - 30°C

- **Distance to FAF (NM)**
  - 0 1 2 3 4 5

- **Deviation (dot)**
  - -2 -1 0 1 2

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2. Calculation of $\text{ANG}_{\text{max}}$

**Iteration Algorithm**

Given LEN, others

\[ \text{ANG} = \text{ANG} + \Delta \]

Calc

IF dist(●) < dist(●) & Max GS > 1.0 dot

Output $\text{ANG}_{\text{max}}$

**FAA ORDER 8260.58A, PANS-OPS**

dist(●) : distance along RF to ● from FAF
3. Simulator Trials

- Standard procedures based on **ARINC 424** specification were coded by NAV database provider
- FMS vendor checked the database quality, and converted to FMS loadable database
- Flight simulations with **variable temp** were conducted in ANA flight training center
3. Comparison with FFSIM

**CACLULATED**

![Diagram showing comparison between calculated and FFSIM results for horizontal distance to FAF along RF course (NM).]

**FFSIM (NO WIND CASE)**

![Diagram showing FFSIM results for horizontal distance to FAF along RF course (NM).]

**Horizontal distance to FAF along RF course (NM)**
3. Comparison with FFSIM

Horizontal distance to FAF along RF course (NM)

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Altitude Variation is affected by the Flap Extension, and not exceed +20 FT even severe turbulence condition.
4. Intermediate LEN vs. ANG

LTP 36 ft, TCH 54ft, Length of LOC to THD 4320 m, Course width 210 m

\[ \Delta ISA = 30^\circ C \]

Length of intermediate segment (NM)

- Direct Proportion

- Inverse Proportion

Additional assumption
By FFSIM experiments

+50FT (20FT + Margin)

**Direct Proportion**

**Inverse Proportion**

FAF ALT. vs. ANG

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5. Summary

- Development of **RNP to xLS procedures** with shallow intermediate segment were discussed.
- The design method of shallow intermediate segments were proposed based on the assumptions.
- **Full flight simulator trials** confirmed that the method enables to design procedure even in the high temperature condition.
- Findings also revealed altitude variations required a buffer.
- The revised algorithm will enable the development of the procedures design criteria.
Thank you for your attention!

Quoted from:
Sonosuke Fukushima, Ryota Mori, Shinji Saitoh,
“Geometric Approach for RNP Transition to xLS Procedure Design,”