Independent curved approach procedures – safe and feasible?*

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*Supported by UNH, FRAPORT, DFS
How to design Noise Abatement Approach Procedures?

Optimize approach profiles:

1. Clean and idle as long as possible
2. Increase distance between a/c and population
   1. Higher approach profiles
   2. Lateral avoidance of populated areas
Segmented RNAV GPS Approach

But:
- No independent parallel approaches to RWY system
- Only applicable today between 23:00 and 05:00
Independent Approaches to Parallel Runways

- Straight approaches
- Runway spacing at least 3400 ft (1036 m)
- Precision approaches (ILS or MLS)
- Implementation of a ground-based runway monitoring system, classically: Radar Surveillance
Where do the Minimum RWY Spacing Requirements Come From?
ICAO’s Safety Case

Safety concept based on a worst-case “blunder” scenario

- Miss Distance
- Navigation Buffer
- Evader
- NTZ boundary
- NOZ B (half-width)
- Blunderer

Size of Detection Buffer:

Radar Accuracy

e.g. 0.06°

→ 20 m

ICAO Standard: 10 NM

+ Radar Update Rate (2.5s)

\[ d = t \times v \times \sin(30°) \]

\( t: \) Update Rate
\( v: 150 \text{ kt} \)

→ 100 m

→ 3400 ft (1036 m) Minimum RWY Spacing
Independent curved approach procedures – safe?

Approach:
- RNAV Segmented $\rightarrow$ Advanced RNP
- Redimensioning of Normal Operating Zones (NOZ) and No Transgression Zone (NTZ) based on modified worst-case blunder scenarios
- Assumption: Worst-case blunder angle still 30° w.r.t. current approach track
Independent curved approach procedures – safe?

Assumption:
- Curved approach: RNP AR 0.3 ≈ Advanced RNP
- Blunder from curved approach
- Assumption: Worst-case blunder angle still 30° w.r.t. current approach track

Minimum RWY spacing required: 1750 m
A320 ATRA Flight trials to validate assumptions at Braunschweig Airport
A320 ATRA Flight trials: Results
Independent curved approach procedures – operationally feasible?

Requirements

- High density traffic situations (ensure spacing)
- Handling of mixed equipage
New Route Structure
Real Time Simulation to assess Operational Feasibility

- Two weeks of simulation with 6 Controllers from DFS

- Focus on approach to RWY 25L (curved approach or ILS-approach)
  - No analysis of blunder scenarios, missed approach procedures

- Per simulation run:
  - 2 controller workstations (Feeder und Pickup)
  - Curved approach: all aircraft with RNP-capability
  - ILS-approach: all aircraft without RNP-capability
  - Controller knows which aircraft are certified for RNP-approach

- Variation of Traffic and RNP-capability (segmented approach vs. ILS-approach) \(\rightarrow\) six scenarios
- Every controller did every scenario on every position
Real Time Simulation – Setup

• Flight plan 2014: busy summer day
  (core time 07:30 – 08:30 / RWY 25L: 28 approaches per hour)

  • Variation of RNP-capability
    • 50 % segmented approach / 50 % ILS approach
    • 80 % segmented approach / 20 % ILS approach
    • 100 % segmented approach / 0 % ILS approach

• Flight plan 2022: forecast Fraport
  (core time 10:30 – 11:30 / RWY 25L: 32 approaches per hour)

  • Variation of RNP-capability
    • 50 % segmented approach / 50 % ILS approach
    • 80 % segmented approach / 20 % ILS approach
    • 100 % segmented approach / 0 % ILS approach
Real Time Simulation Results – Flightpath

Scenario 1 – 2014 (50% RNP – 50% ILS) – 07:30 - 08:30
Real Time Simulation Results – Flightpath

Scenario 4 – 2022 (50% RNP – 50% ILS) – 10:30 - 11:30
Real Time Simulation Results – Flightpath

Scenario 6 – 2022 (100% RNP – 0% ILS) – 10:30 - 11:30
Real Time Simulation Results – Performance

**Average Controlled Aircraft**

- Flight Plan 2014 Scenario 1-3: 27.33
- Flight Plan 2014 Scenario 4-6: 27.89
- Flight Plan 2022 Scenario 1-3: 27.06
- Flight Plan 2022 Scenario 4-6: 26.39

**Pseudo Pilot Accuracy**

- Pickup: 98.79% (Correct), 1.21% (Incorrect)
- Feeder: 98.90% (Correct), 1.10% (Incorrect)

**Simultaneously Controlled Aircraft - Feeder**

- Flight Plan 2014 Scenario 1-3: 5.89
- Flight Plan 2014 Scenario 4-6: 6.11
- Flight Plan 2022 Scenario 1-3: 2.11
- Flight Plan 2022 Scenario 4-6: 1.89

**Simultaneously Controlled Aircraft - Pickup**

- Flight Plan 2014 Scenario 1-3: 8.72
- Flight Plan 2014 Scenario 4-6: 5.00
- Flight Plan 2022 Scenario 1-3: 3.22
- Flight Plan 2022 Scenario 4-6: 5.00
Real Time Simulation Results – Mental Workload (AIM)

### AIM-Feeder

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### AIM-Pickup

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Real Time Simulation Results – Situation Awareness (SASHA)

**SASHA-Feeder**

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**SASHA-Pickup**

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Real Time Simulation Results - ISA

Scenario 1 (2014 - 50% / 50%)

Scenario 2 (2014 - 80% / 20%)

Scenario 3 (2014 - 100% / 0%)

Scenario 4 (2022 - 50% / 50%)

Scenario 5 (2022 - 80% / 20%)

Scenario 6 (2022 - 100% / 0%)
Conclusion from Real Time Simulations

• Procedure is suitable for EDDF
  • Route distance between the waypoints is enough
  • Feeder could handle max. 5 – 6 a/c simultaneously
  • p.r.n. Changes in airspace C
  • p.r.n. reintroduction of holdings

• Subjective measurements could not detect an effect of the percentage of aircraft with RNP capabilities
• Low level of workload and high level of situation awareness in all scenarios
• All controllers can imagine working with the system themselves

→ More studies necessary
  → Real Time Simulation with independent parallel approaches and departures
  → Wind effects
  → Blunder scenarios / Go Around Procedures
  → Speed reduction on the divergent route → aircraft separation
Overall Conclusions

- Independent ILS – Advanced RNP / RNP AR approaches seemed to be possible at Frankfurt
  → has to be established at ICAO level
  → option: effect of RNP-to-xLS to be investigated

- First results from Real Time Simulations
  - New route structure enables handling of mixed equipage
  - Envisaged traffic demand should be manageable