

Trajectory APproach AnalysiS: a post-operational aircraft approach analysis tool

9th SESAR Innovation Days



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Wednesday, December 4th, 2019

Content

1. Introduction
2. Software
3. Study
4. Conclusions

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Safety Context

- ▶ Traffic Growth (7.8 billion in 2036)
- ▶ Approach and landing accidents (47% of the total number of accident)
- ▶ Identify, detect, and manage safety event precursors



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Non Stabilized Approaches (NSA)



Figure: Stabilized vs Non Stabilized Approach

Non Compliant Approaches (NCA)

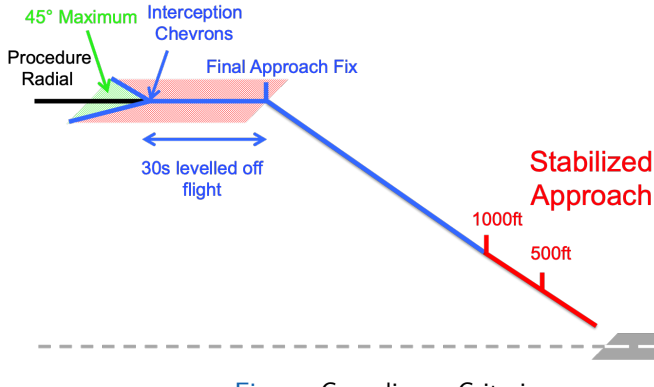


Figure: Compliance Criteria

Operational Context

French Safety State Programme (SSP) :

- ▶ NCA identified as undesirable events.
- ▶ Approach path management.

Accidents Study - DGAC 2015 :

- ▶ 57% NSA with 74% of them in NCA
- ▶ While stabilized 84% compliant
- ▶ 74% bad weather condition, 15% final approach tailwind



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Glide Interception From Above detection tool at CDG Airport

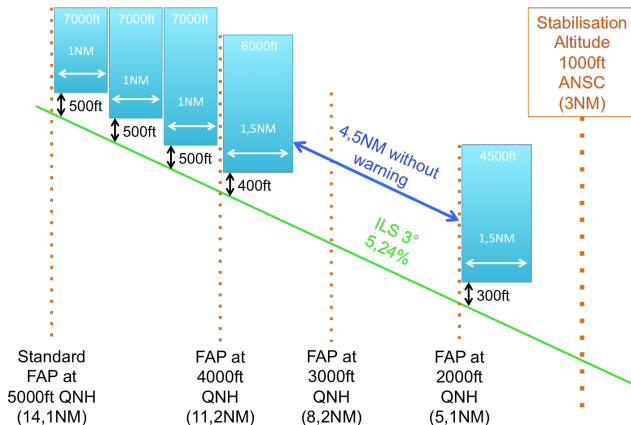


Figure: GIFA detection tool using the APW at CDG Airport

Ideas

- ▶ No or few speed monitoring from ground side
- ▶ Airline safety offices focus on the last 5NM
- ▶ Approach path management, atypical total energy detection



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Our Methodology

- ▶ Functional Principal Component Analysis

$$\gamma(t) = \sum_0^K \alpha_k \cdot \phi_k(t), \text{ (K min)}$$

- ▶ Sliding Window

- ▶ Total Specific Energy (from radar equivalent parameters):

$$E_t = E_c + E_p = \frac{1}{2} \cdot V^2 + g \cdot h \text{ (J/kg)}$$

- ▶ Localization of atypical energy behaviors, categorization with threshold (typical, atypical)

Algorithm

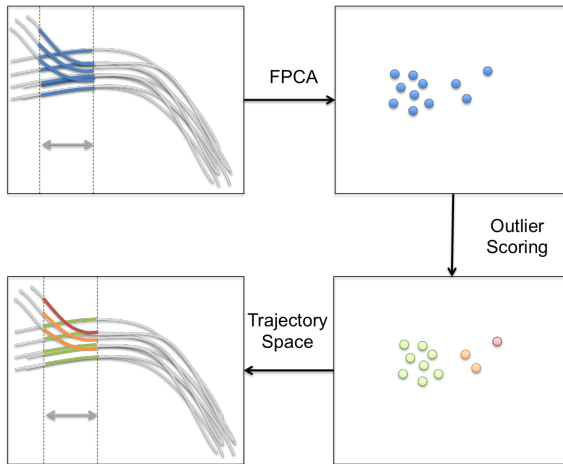


Figure: Atypical Scoring Algorithm

Objectives

- ▶ Trajectory APproach AnalysiS (TAPAS) a post-operational approach analysis software
- ▶ Validation with FDM data and safety office analysis
- ▶ Providing non-monitored flights, potential safety precursors, can help enhancing safety



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Data Section

TAPAS - Trajectory Approach Analysis

Data Statistics Events Flight Study

All Compliant Non Compliant Nominal Warning Critical Atypical Typical

Phase :

25NM-THR

Airport :

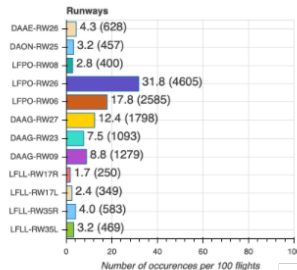
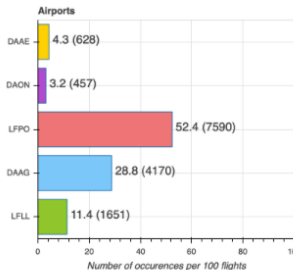
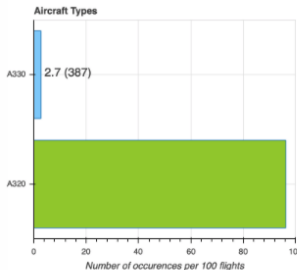
All

Runway :

All

Aircraft :

All



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TAPAS - Trajectory Approach Analysis

Data **Statistics** Events Flight Study

All Compliant Non Compliant Nominal Warning Critical Atypical Typical

Phase :

2SNM-THR

Airport :

All

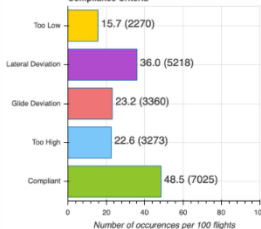
Runway :

All

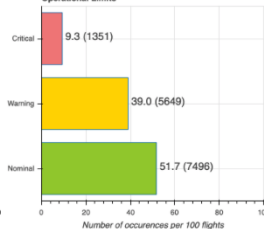
Aircraft :

All

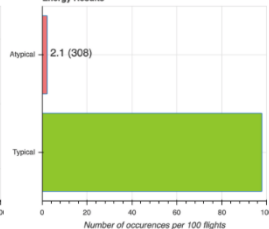
Compliance Criteria



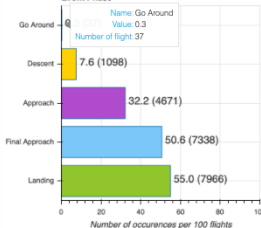
Operational Limits



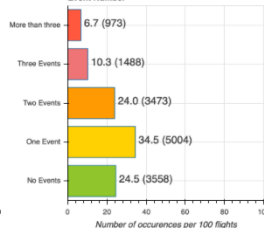
Energy Results



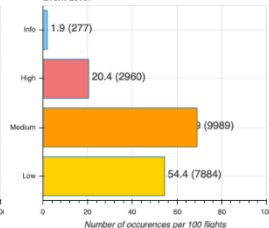
Event Phase



Event Number



Event Level



Event Section

TAPAS - Trajectory Approach Analysis

Data Statistics **Events** Flight Study

Phase :

25NM-THR

Airport :

All

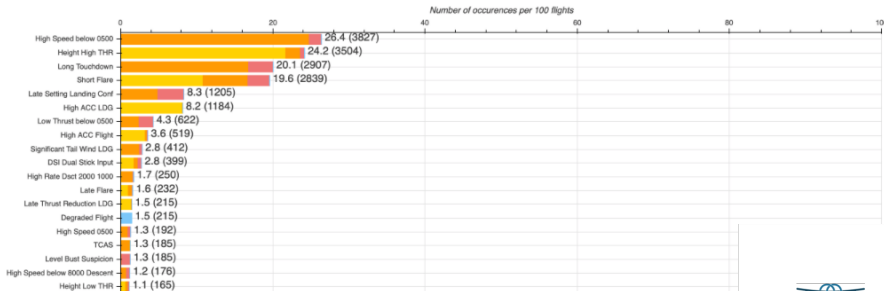
Runway :

All

Aircraft :

All

Event List



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Flight Study Section

TAPAS - Trajectory Approach Analysis

Data Statistics Events **Flight Study**

Phase :
25NM-THRAirport :
LFPORunway :
AllAircraft :
All

Limits:

Traj ID :

12891

Traj ID :

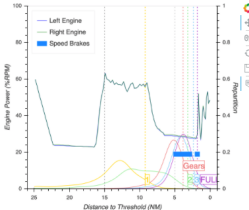
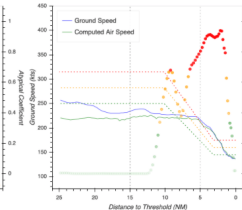
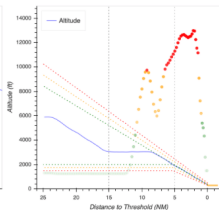
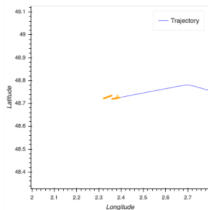
12891

Traj # (over 123): 30

Origin Airport	Destination Airport	Destination Runway	Registration	Type
LPPI	LFPO	RW26		A320-200

Compliance	Atypical	Operational
1	1	2

Too High	Glide Deviation	Too Low	Lateral Deviation
0	0	0	0



#	Event	Event Flight Phase	Event Level	Event STD Altitude (ft)	Event Airspeed (kts)
0	High Speed below 0500	FIN_APPROACH	High	1038	151
1	Late Setting Landing Conf	APPROACH	High	1135	153.4
2	Low Thrust below 0500	FIN_APPROACH	High	1022	150.1

Parameters	25NM - 15NM	15NM - 5NM	5NM - THR
Atypical	0	2	2
Operational	0	2	2
GS	0	2	2
CAS	0	1	2
Alt	0	0	0



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Case Study

- ▶ 16471 flights approach at LFPO, LFLL, LFML, DAON, DAAE and DAAG
- ▶ A320
- ▶ 25NM to runway threshold (25NM-15NM-5NM-THR)
- ▶ FDM events (low, medium, high)



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Safety Event Analysis

Strong correlation between atypical flights and safety events number/intensity

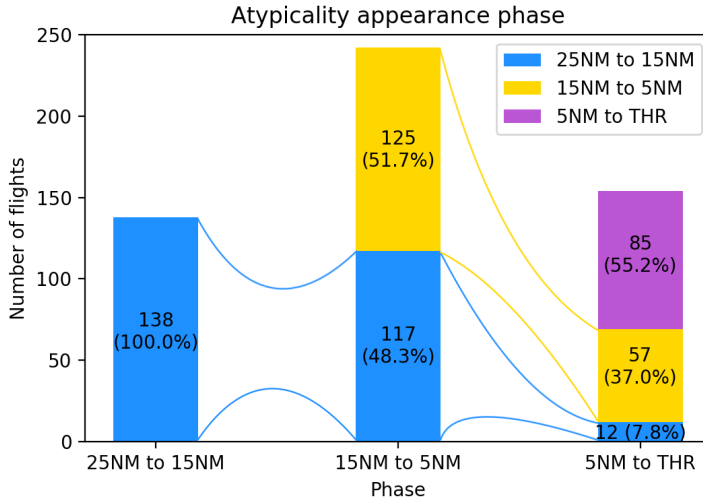
- ▶ No safety event ratio: 27.8% -> 9.7%
- ▶ More than 3 safety events ratio: 5.4% -> 30.6%
- ▶ high-intensity events per 100 flights: 18.5 -> 92.7
- ▶ Long Touchdown ratio: 4.3% -> 7.5%
- ▶ Unstabilized Approach Low: 2.9% -> 18.6%
- ▶ Unstabilized Approach High: 0.3% -> 2.7%



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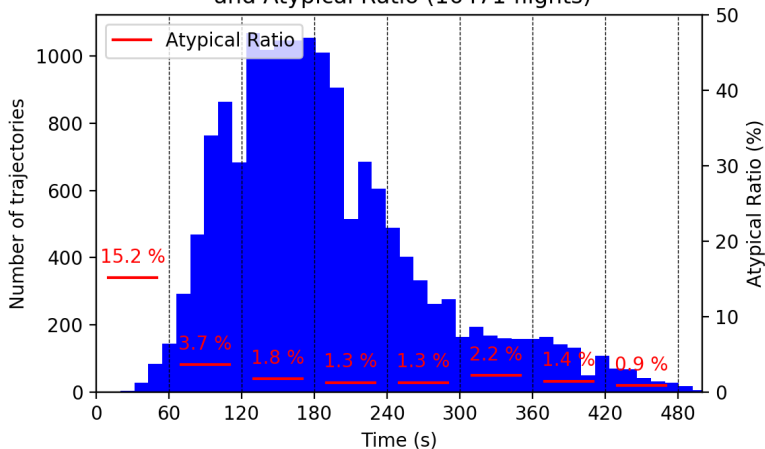


Atypicality Appearance Phase Analysis



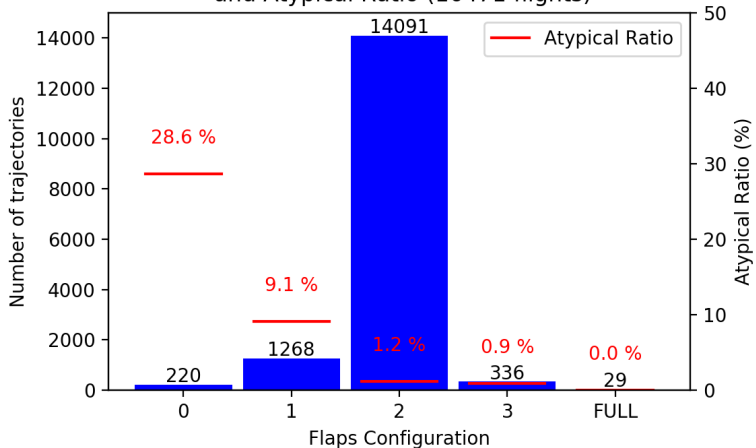
Innapropriate Control Inputs

A320 - Flaps Configuration Time Distribution and Atypical Ratio (16471 flights)



Innapropriate Control Inputs

A320 - Gear Down Configuration
and Atypical Ratio (16471 flights)



Example 1

TAPAS - Trajectory APProach Analysis



Example 2

TAPAS - Trajectory Approach Analysis



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Conclusions

- ▶ Relevant atypical energy behaviours detection based on ground data available parameters and confirmed by FDM data
- ▶ Pedagogical tool highlighting non monitored behaviors and potential threats
- ▶ Off-line analysis software, complementary to FDM monitoring analysis



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Perspectives and future works

- ▶ Other aircraft types (B737)
- ▶ Real time extension to ground and on-board tools (research)
- ▶ Aircraft landing configuration detection
- ▶ Discussions with FDM analysis software providers



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Questions

Thank you for your attention, any questions ?