Vertical efficiency in descent compared to best local practices

Pierrick Pasutto, Eric Hoffman and Karim Zeghal

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What is the problem?

- How to take into consideration the airspace constraints, imposed by other flows and other airports?
- How to focus on a delimited area (e.g., terminal) and eliminate the effect of the entry conditions?
- How to assess (or isolate) the effect of the path stretching and more generally of the congestion level?
- How to measure vertical efficiency? What indicator to use?
State of the art

- Many contributions from FAA, NASA, MITRE, EUROCONTROL, …
- Measure and compare vertical performance of current operations
- Estimate efficiency pools and benefits brought by new concepts
- Effect of level of congestion (low, medium, high)
- Focus on continuous descend and level segments

- e.g. median continuous descent altitude
- e.g. distance and time flown level
Motivation and approach

• Approach
  • Complement absolute assessment of vertical efficiency, focus on terminal area
  • Develop a relative assessment based on local best performers for each airport and flow*
  • Assess the potential for short term improvements through increased adherence to best local practices
  • Expected benefits in terms of fuel consumption or noise reduction

*Similar to the method developed by the PRU to assess vertical enroute efficiency per city pairs

• Indicators
  • Level-offs and continuous descent related indicators may be used for relative assessment
  • Use of altitude deviation to a reference profile
    • to avoid any issue with detection of level-offs
    • to combine two dimensions of altitude and duration into a single indicator

Conducted as part of SESAR2020 (PJ01-02)
Reference profile

- For each arrival flow (same runway, same entry and altitude at 50NM)

- Reference profile at time to final $t = 90^{th}$ percentile of altitude of flown profiles at time $t$ (or closer time to final)

- A succession of portions of flow profiles, generally in non congested condition
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Vertical deviation

Indicator of vertical deviation = surface, normalized 10 minutes flight time
Data

- Four major European airports, different types of operations, 50NM area
- Position reports (update rate 30s, 1min for LFPG)
- Daytime operations, most representative runways, flows and flight levels (> 15%)
- Six months from 2018, +200 000 arrival flights in total
Vertical profiles
Vertical profiles

Similar highest altitude curves
Vertical profiles

Significant differences on lowest curves
Vertical deviations

Different shapes and maximum (95th percentile)
On average, for 10 minutes flight time, aircraft fly 2300 feet below best profile.
Vertical deviations split at FL70

Significant differences of ratio above/below
Below FL70, limited variability for EGLL (systematic procedure), large for EHAM
Additional time

• Extra time generated by the arrival management during congested periods (Performance Review Unit of EUROCONTROL)
• Difference between actual transit time and unimpeded time for a considered flow (entry point to landing runway)
Additional time

Transit time, minute

Additional time, minute

EDDF
EGLL
EHAM
LFPG
Trajectories with additional time
Vertical profiles with additional time
Vertical deviations with additional time
Vertical deviations with additional time

Increase of vertical deviation with additional time
Vertical deviations and additional time

Vertical deviation in common range 0-5min: 1760, 1860, 2150, 1580
Vertical deviations and additional time

Increase of vertical deviation with additional time (800ft x 10min per 1min add time)
Effect of sequencing with current techniques
Vertical deviations and additional time

Variability of vertical deviation for a same additional time (span +2000ft x 10min)
Causes unclear
Vertical deviations and additional time (split FL70)

Increase and variability, above and below FL70
In particular EHAM below, but except EGLL below
Relative vs. absolute

Best performer

Ideal profile (continuous descent 2.5 deg)
Relative vs. absolute

Relative assessment (best performer) = indication of performance considering constraints

Absolute assessment (ideal profile) = indication of performance regardless of constraints
Conclusion, key results

- Descent profiles significantly lower than best practices
  - median deviation exceeds 2300 feet

- Degradation of descent profiles with the level of congestion
  - median deviation increases by 800 feet per 1 minute additional time

- Variability of descent profiles for a same level of congestion
  - deviation spread (90% containment) is +2000 feet for a same additional time

- Significant differences among the four airports
  - deviation between 1600 feet and 2100 feet for common range of additional time
  - deviation ratio above/below FL70 between 1.2 and 5.8
Conclusion, in perspective

• Method
  • Relative and absolute assessments depending on reference profiles
  • Focus on an area of interest eliminating the effect of the entry conditions
  • Integration of the level of congestion through additional time
  • Altitude and duration combined into a single indicator

• Next steps
  • Identify the causes of large vertical deviations
  • Investigate possible ways to reinforce adherence to best profiles