A Framework for Assessing and Managing the Impact of ANSP Actions on Flight Efficiency

FAA/EUROCONTROL ATM R&D Seminar
Lisbon, Portugal, June 2015

Jesper Bronsvoort, Paul Zissermann, Steven Barry & Greg McDonald
Airservices Australia
How much did your ticket cost?

- Average airline profit per passenger over 2012:

  $2.56 of an average $228 revenue per passenger*

Overview

1. Introduction
2. Proposed Framework
3. Application
4. Conclusion/Discussion
Australian Flight Information Regions

Brisbane (YBBB)

Melbourne (YMMM)
Flight Efficiency Assessment

- FAA & EUROCONTROL Comparison of Air Traffic Management-Related Operational Performance:
  - Actual versus great circle.
  - Flight plan versus great circle.

- UK NATS 3Di Score:
  - Actual against basic definition of user preferred trajectory.

- ....

- Often different references to assess performance against.
Proposed Framework

- The main philosophy is to quantify the quality of the service delivered by an Air Navigation Service Provider (ANSP) to an airline in terms of meeting commonly agreed objectives – Trajectory Based Operations.

- A staged approach for flight efficiency assessment to quantify the quality of an ANSP’s service in terms of both “facilitating what has been agreed” and “improving what can be agreed”.

- Structure of defined levels between Actual Flown Trajectory and ultimate (utopian) goal of User Preferred Trajectory.
User Preferred Trajectory

- The trajectory without any third party constraints (other than legal) that minimises the cost of the operation or network.

- Minimal terminal tracking and great circle or wind-optimised lateral path, e.g. take-off, at 500ft set course to intercept 2NM final at destination.

- Utopian trajectory, i.e. only aircraft in the skies. Maybe even unknown!
Procedure Optimal Trajectory

- The trajectory corresponding to the filed flight plan and contains all procedural constraints. Uses fixed airways system supplemented with departure and arrival procedures.

- The trajectory flown if aircraft was able to conduct the flight free of tactical ATC intervention – ‘Reference Business Trajectory’ in today’s paradigm.
Network-Optimised Trajectory

- The Procedure-Optimal Trajectory, accounting for capacity/demand balancing actions by an ANSP. The Network Optimised Trajectory could also account for pre-tactical agreed weather diversions.

- Could simply be time-shifted Procedure-Optimal Trajectory by a Ground Delay Program (GDP).
Actual Flown Trajectory

- The true trajectory flown to the objectives specified in the filed flight plan, while taking into account ground delays, tactical ATC intervention and weather diversions.
Efficiency Levels

- **Procedural Efficiency:** Procedure-Optimal Trajectory vs. User Preferred Trajectory

- **Pre-tactical Efficiency:** Network-Optimised Trajectory vs. Procedure-Optimal Trajectory

- **Tactical Efficiency:** Actual Flown Trajectory vs. Network-Optimised Trajectory
Efficiency Levels (simplified)

- **Procedural Efficiency**: Procedure-Optimal Trajectory vs. User Preferred Trajectory
- **Tactical Efficiency**: Actual Flown Trajectory vs. Procedure-Optimal Trajectory
How to compute different trajectories?

- Dalí Trajectory Modeller
  - Originally developed by Airservices to demonstrate improved ground-based trajectory prediction based on data-link for arrival metering.
  - Developed in collaboration with Boeing Research & Technology Europe (Madrid, Spain).
  - Based on the Aircraft Intent Description Language framework.
Applications

Dalí acts as FMS or Flight Planning System Model

Objectives (e.g. Flight Plan) → Dalí Prediction Mode → Nominal Trajectory (e.g. Flight Plan Optimum)

Emissions Efficiency → Dalí Inferring Mode → Flown Trajectory (e.g. ‘Track Data’)

Dalí acts as Flight Emissions/Efficiency Reporter
How accurate is Dalí?

- Originally developed to support arrival metering
- Enhanced for all phases of flight and turboprops
- Validated against FMS down-linked trajectories
  - $\pm 2.2\%$ (95%) ETA accuracy (30% improvement over FMS)\(^1\)
  - $\pm 3.3\text{NM}$ (95%) top of descent accuracy\(^1\)

How accurate is Dalí?

- Work ongoing to validate with aircraft recorded data.
- Initial results indicate error <5% for 90% of investigated flights (>50).
Error Sources

- Irregularities in input surveillance data:
  - Noise in data.
  - Limited data points in oceanic airspace.

- Errors in wind and temperature forecast.

- Estimated take-off mass errors:
  - Strong correlation of fuel burn error with mass error.
Error Mitigation

- Effect of mass and forecast errors can be mitigated by comparing estimated fuel burn against a reference fuel burn based on the same mass and forecast – Procedure Optimal Trajectory.

- By providing a relative comparison, biases and constant components of the error cancel each other.
Example MEL → SYD

- User Preferred Trajectory

<table>
<thead>
<tr>
<th>Efficiency metric</th>
<th>User Preferred Trajectory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>390 NM</td>
</tr>
<tr>
<td>Flight time</td>
<td>00:59:20</td>
</tr>
<tr>
<td>Fuel burn</td>
<td>5470 kg</td>
</tr>
</tbody>
</table>
Example MEL → SYD

- User Preferred Trajectory
- Procedure Optimal Trajectory

<table>
<thead>
<tr>
<th>Efficiency metric</th>
<th>User Preferred Trajectory</th>
<th>Procedure-Optimal Trajectory</th>
<th>Proc. Ineff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>390 NM</td>
<td>424 NM</td>
<td>+8%</td>
</tr>
<tr>
<td>Flight time</td>
<td>00:59:20</td>
<td>01:04:45</td>
<td>+9%</td>
</tr>
<tr>
<td>Fuel burn</td>
<td>5470 kg</td>
<td>5850 kg</td>
<td>+7%</td>
</tr>
</tbody>
</table>

Total Ineff.:
- Distance: +24%
- Flight time: +27%
- Fuel burn: +19%
Example MEL → SYD

- **User Preferred Trajectory**
- **Procedure Optimal Trajectory**
- **Actual Flown Trajectory**

<table>
<thead>
<tr>
<th>Efficiency metric</th>
<th>User Preferred Trajectory</th>
<th>Procedure-Optimal Trajectory</th>
<th>Actual Flown Trajectory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>390 NM</td>
<td>424 NM</td>
<td>484 NM</td>
</tr>
<tr>
<td>Flight time</td>
<td>00:59:20</td>
<td>01:04:45</td>
<td>01:22:33</td>
</tr>
<tr>
<td>Fuel burn</td>
<td>5470 kg</td>
<td>5850 kg</td>
<td>6520 kg</td>
</tr>
</tbody>
</table>

Distance: +8% → +15% → +24%
Flight time: +9% → +27% → +39%
Fuel burn: +7% → +11% → +19%

**Efficiency metric**

- Distance: +8% → +15% → +24%
- Flight time: +9% → +27% → +39%
- Fuel burn: +7% → +11% → +19%
## Example MEL → SYD (3)

Metrics evaluated within 250NM of destination

<table>
<thead>
<tr>
<th>Efficiency metric</th>
<th>User Preferred Trajectory</th>
<th>Procedure-Optimal Trajectory</th>
<th>Actual Flown Trajectory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>255 NM</td>
<td>273 NM</td>
<td>335 NM</td>
</tr>
<tr>
<td>Flight time</td>
<td>00:39:00</td>
<td>00:42:50</td>
<td>00:58:45</td>
</tr>
<tr>
<td>Fuel burn</td>
<td>1635 kg</td>
<td>1840 kg</td>
<td>3020 kg</td>
</tr>
</tbody>
</table>

[Map of Sydney with flight paths]
Procedural Efficiency Gains

“Improve what can be agreed”

• True UPT often unknown, but each procedural improvement a step towards the UPT.
• Examples:
  • Flexible Tracks / User Preferred Routes.
  • RNP Approaches.
Tactical Efficiency

“Facilitate what has been agreed”

One month of Melbourne (YMML) ↔ Sydney (YSSY) traffic.
Tactical Efficiency

“Facilitate what has been agreed”

One month of Melbourne (YMML) ↔ Sydney (YSSY) traffic.

April 2014 had many severe weather days at Melbourne.
Applicability

“The flight plan might be an appropriate reference in Australia, but…”

EUROCONTROL’s Performance Review Report 2013²:

- procedural efficiency for Europe 4.86% (flight plan over great circle).
- tactical efficiency 3.14% (actual over great circle).
- tactical service more efficient than the filed flight plan (-1.72%).

Applicability (2)

• ...however, the practice of consistently offering track shortening leads to a penalty to industry: airlines are required to plan via the airways structure, and carry the associated fuel.

• It costs fuel to carry fuel!
Applicability (3)

• While at first thought, delivering a consistent saving over flight plan appears positive, it is not in line with the concept of TBO and performance based flight planning.

• A negative tactical efficiency can therefore be seen as an indicator of an area in which a procedural improvement can be made such that full benefit can be realised by allowing operators to plan the way they tactically fly.
Ultimate Goal

ATM Planning ➔ Initiative Delivery

Operational Deployment ➔ Measure & Monitor

Accurate Data + Improved Analysis ➔ Better Informed Decisions

“Facilitate what has been agreed”

“Improve what can be agreed”
Conclusion

• The main philosophy of proposed framework is to quantify the quality of the service delivered by an Air Navigation Service Provider (ANSP) to an airline in terms of meeting commonly agreed objectives – focusing at Trajectory Based Operations paradigm.

• A staged approach for flight efficiency assessment to quantify the quality of an ANSP’s service in terms of both “facilitating what has been agreed” and “improving what can be agreed”.
Thank you

Flying has torn apart the relationship of space and time: it uses our old clock but with new yardsticks.

— Charles A. Lindbergh.