Why aircraft fly more fuel-efficiently on FRIDAY

The FRIDAY route charges method René Verbeek MSc, June 22, 2016
Ticket tax

Eurocontrol route charges system

FRIDAY route charges method

Single unit rate
FRIDAY route charges method

Two step approach:
1. Charges are calculated along the great circle line from airport to airport
2. Collected charges are distributed to servicing ANSPs according to CRCO route
Problems with Eurocontrol common route charges system

Differences in unit rates result in detours

FPL avoiding a congested area may result in higher charges

Filing indirect, and asking direct
**Underlying mechanism**

**Flight plan**

<table>
<thead>
<tr>
<th>Flight</th>
<th>Min Fuel</th>
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<tbody>
<tr>
<td>Time (h:mm)</td>
<td>3:00</td>
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<tr>
<td>Total Cost (€)</td>
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### Eurocontrol Route Charges System

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The FRIDAY route charges method, 21-6-2016
### Eurocontrol Route Charges System

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Extreme scenario: no route charge

**Airlines**
- Route charges
- **Fuel/Time** ↓
- Complexity of FPL optimization is reduced

**ANSPs**
- Cost recovery
- Traffic concentrations ↓
- SESAR: Increased benefits of 4D ops and free routing
- Less need for asking for directs → **Predictability** ↑

**Society**
- Emissions/CO₂ ↓
- No need for incentive schemes for fuel efficient trajectories
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# Eurocontrol Route Charges System

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The FRIDAY route charges method, 21-6-2016
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**Desired outcome**

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*for illustrative purposes
Alternative route charges systems

WIN-LOSE-SOLUTIONS

Single unit rate
• Has desired outcome, but
  – Some airlines will pay higher charges
  – Revenues have to be redistributed
  – ANSPs need to agree on the single unit rate
  – ANSPs need to agree on what to do with deviations from expected revenues
  – Considered for single FAB, but not for multiple FABs.

Ticket tax
• Has desired outcome, but
  – Revenues have to be redistributed
  – ANSPs need to agree on the tax rate
  – ANSPs need to agree on what to do with deviations from expected revenues
  – How to handle flights that end or start outside European airspace?
FRIDAY route charges method

Two step approach:
1. Charges are calculated along the great circle line from airport to airport
2. Collected charges are distributed to servicing ANSPs according to CRCO route
Mathematics behind FRIDAY
Eurocontrol Route Charges System

Route charge = $R_{CRCO} = \sum_{i} d_i \times p \times t_i$

Route charge = $f($airspace, distance, weight factor, unit rate$)$
1. What the airline pays:

\[ R_{\text{great circle}} = \sum_j D_j \times p \times t_j \]

Route Charge = \( f(\text{airspace, great circle dist., weight factor, unit rate}) \)

2. What the airline would pay according to CRCO:

\[ R_{\text{CRCO}} = \sum_i d_i \times p \times t_i \]

Route charge = \( f(\text{airspace, distance, weight factor, unit rate}) \)

3. What the ANSP gets paid:

\[ r_i = \frac{R_{\text{great circle}}}{R_{\text{CRCO}}} d_i \times p \times t_i \]
Influence of route charges on Flight Planning

Objective function for flight planning:

\[ J_a = \int_{t_{0a}}^{t_{1a}} \left[ C_{ta} + C_{fa} g(h, m, v) \right] dt + \sum_i d_{ia} p_{ia} u_i \]
Setting unit rates (Eurocontrol Route Charges System)

\[ c_i = u_i \sum_a d_{ia} p_a \]

- Expected service units
- \( c_i \): Cost of providing services
- \( u_i \): Unit rate
- \( d_{ia} \): Distance factor
- \( p_a \): Weight factor

The FRIDAY route charges method, 20-4-2016
Setting unit rates (Eurocontrol Route Charges System)

\[ c_i = u_i \sum_a d_{ia}(u_1, ..., u_n) p_a \]

- Cost of providing services
- Expected service units
- Unit rate?
- Distance factor
- Weight factor

The FRIDAY route charges method, 20-4-2016
Setting unit rates (FRIDAY)

\[ c_i = U_i \sum_a \frac{\sum_k D_{ka} U_k}{\sum_j d_{ja} U_j} d_{ia} p_a \]
Setting unit rates (FRIDAY)

System of non-linear equations:

\[ c_i = f_i(U_1, ..., U_n) \]

• Solve this using a generic numerical method for systems of nonlinear equations
• Routes need to be calculated only once
**FRIDAY route charges method**

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Expected impact

**Airlines**
- Cost/Fuel/Time ↓
- Route Charges the same on average
- Route Charges stay close to current
- Complexity of FPL optimization is reduced
- No Δroute charges when evading restriction/congestion

**ANSPs**
- **Cost recovery**
- **Traffic risks ↓**
- Unit rates need to be tuned
- Less need for asking for directs → **Predictability ↑**
- Traffic concentrations ↓
- SESAR: Increased benefits of 4D ops and free routing

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- ANSPs can attract more traffic when they provide more efficient routes
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The FRIDAY route charges method, 21-6-2016
Next steps?

Research questions

- What is the difference in performance between FRIDAY/ERCS/Single Unit Rate?
- What is the effect of uncertainties (weather/traffic numbers/...)?
- Is unit rate estimation method giving correct results?

Feasibility study applied to European airspace case

- Proof of concept
- Major questions:
  - Fuel/time performance
  - Traffic risks
  - Cost recovery
  - Route charge effects on individual airspace users
  - Unit rates
  - Traffic concentrations
- Unidentified issues
FRIDAY route charges method

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Fully engaged
Netherlands Aerospace Centre

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