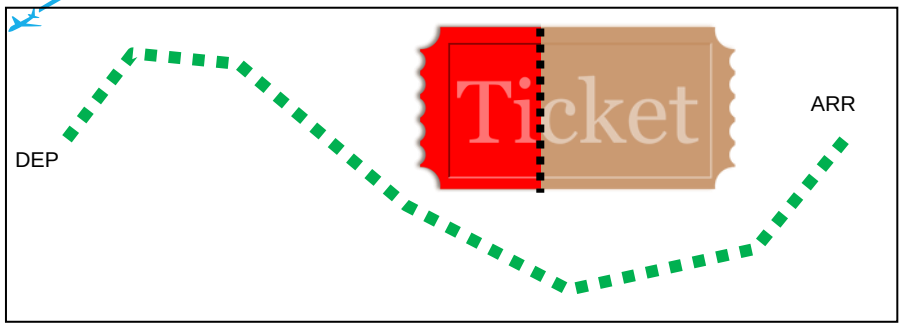
Dedicated to innovation in aerospace

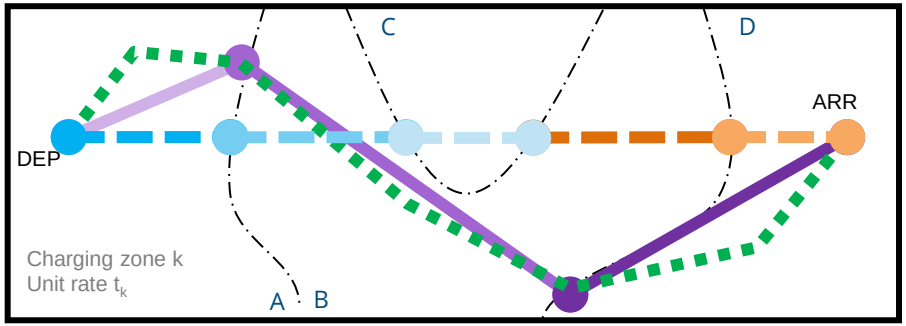
Why aircraft fly more fuel-efficiently on FRIDAY

The FRIDAY route charges method

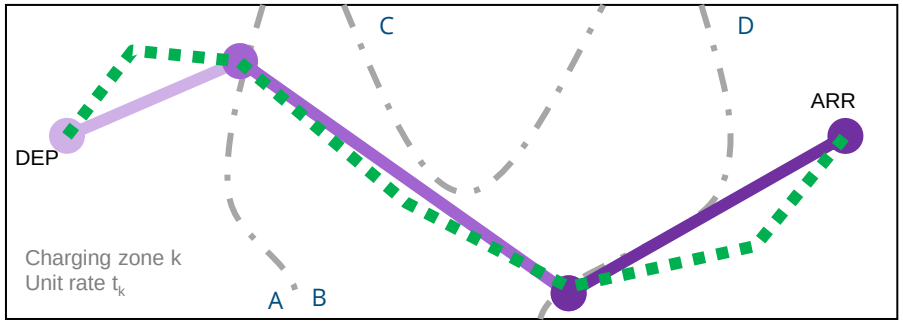
René Verbeek MSc, June 22, 2016



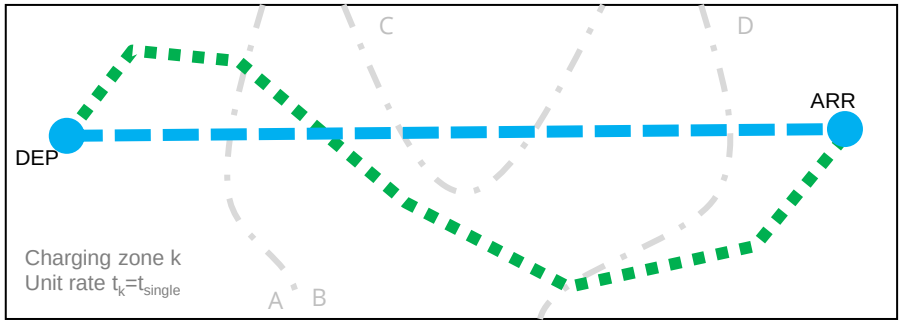
Ticket tax



FRIDAY route charges method

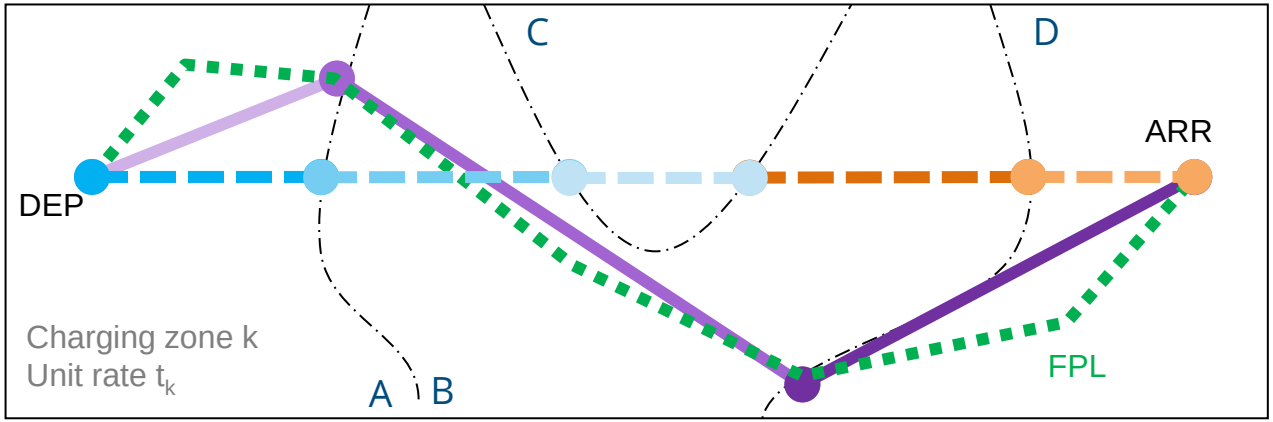


Eurocontrol route charges system



Single unit rate

FRIDAY route charges method

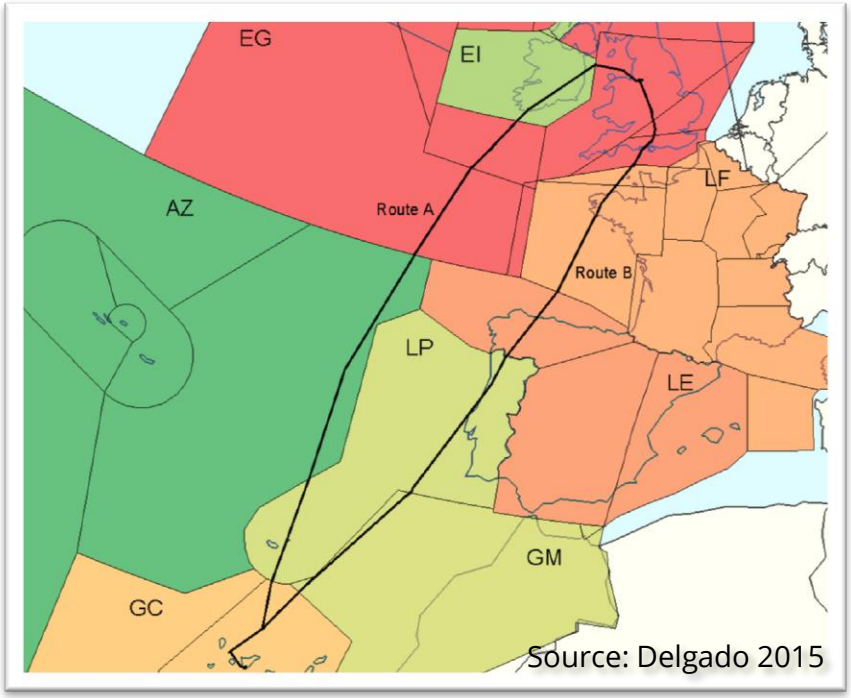


Two step approach:

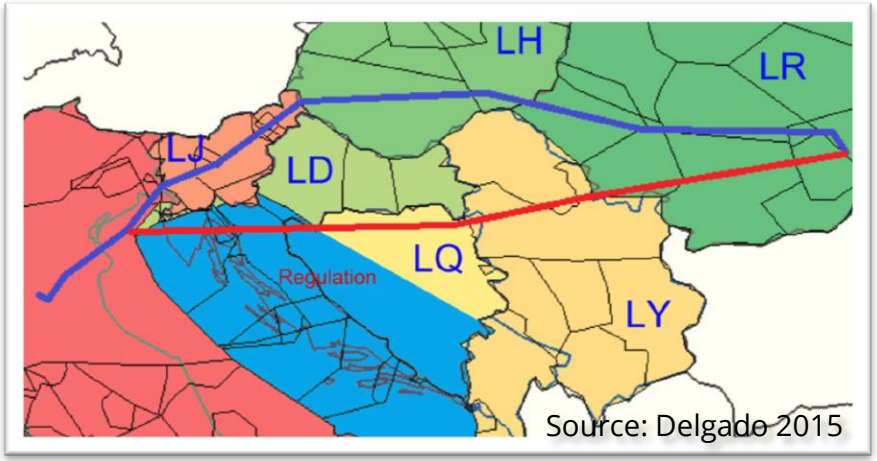
1. Charges are calculated along the great circle line from airport to airport
2. Collected charges are distributed to servicing ANSPs according to CRCO route

Problems with Eurocontrol common route charges system

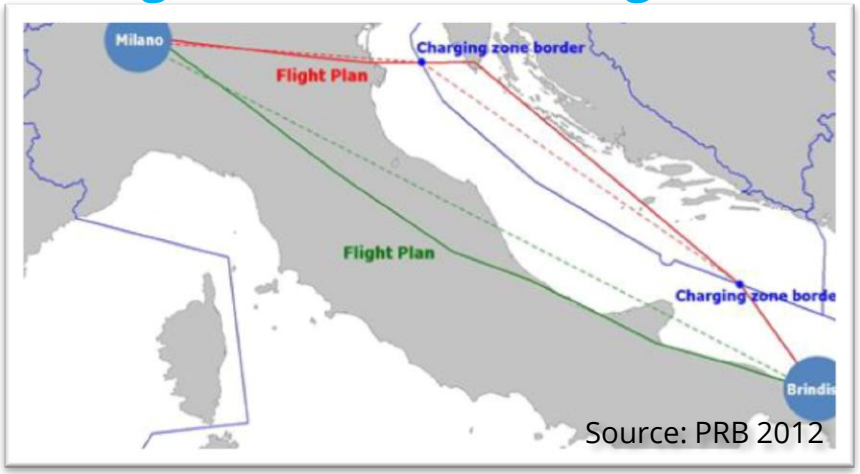
Differences in unit rates result in detours



FPL avoiding a congested area may result in higher charges

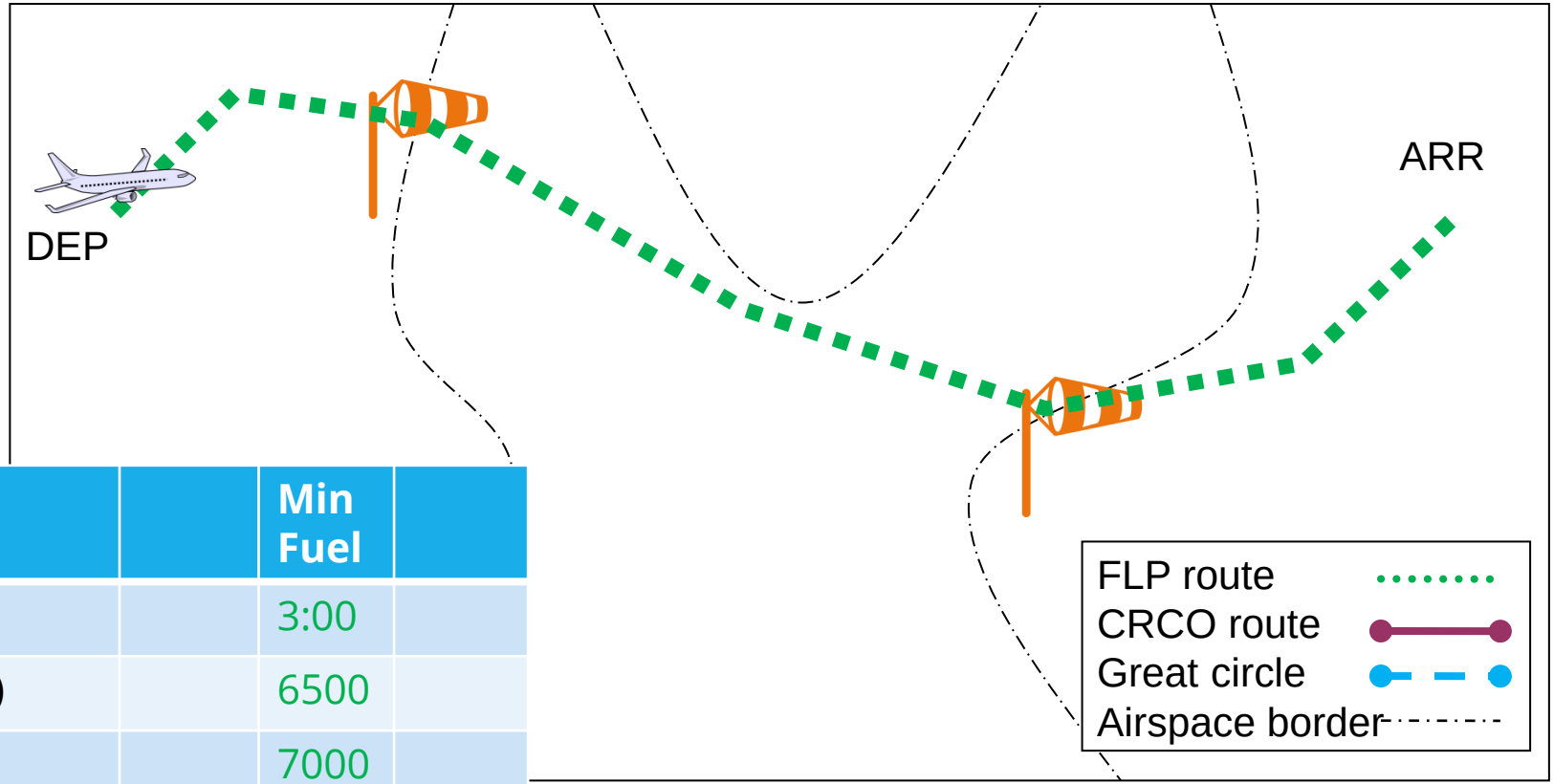


Filing indirect, and asking direct



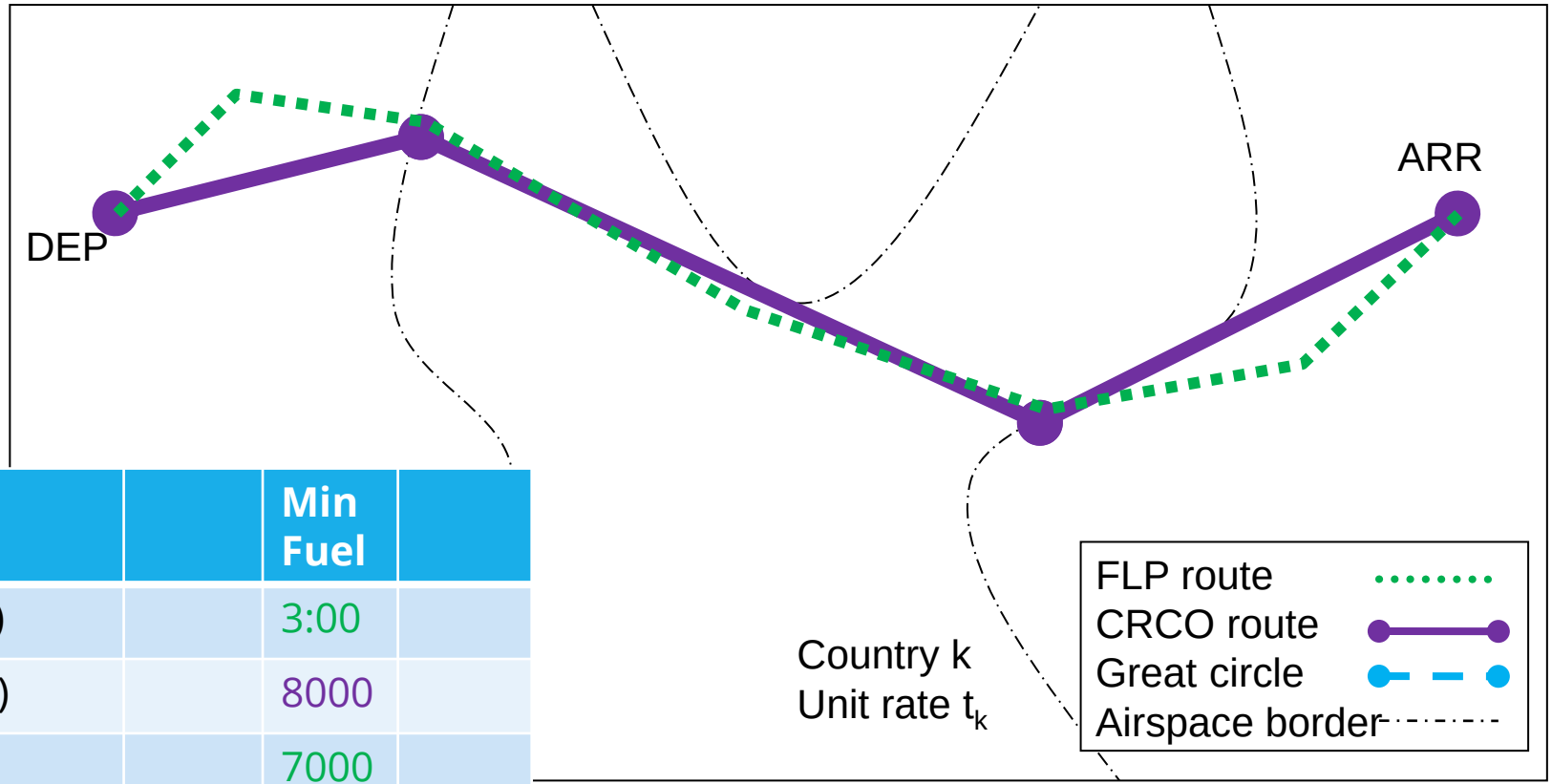
Underlying mechanism

Flight plan



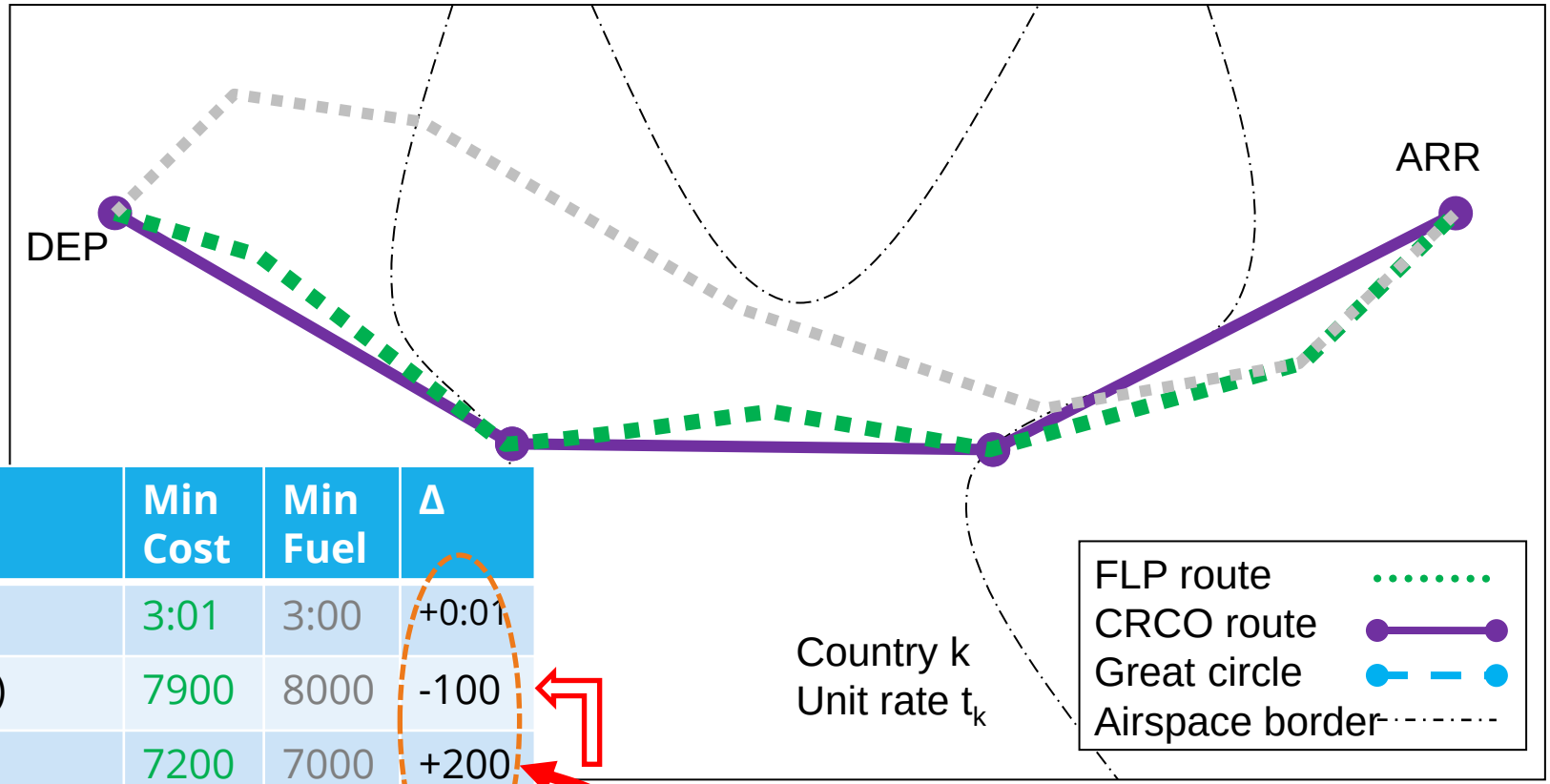
Flight		Min Fuel	
Time (h:mm)		3:00	
Total Cost (€)		6500	
Tripfuel (kg)		7000	

Eurocontrol Route Charges System



Flight		Min Fuel	
Time (h:mm)		3:00	
Total Cost (€)		8000	
Tripfuel (kg)		7000	
ATC costs (€)		1500	

Eurocontrol Route Charges System



Flight	Min Cost	Min Fuel	Δ
Time (h:mm)	3:01	3:00	+0:01
Total Cost (€)	7900	8000	-100
Tripfuel (kg)	7200	7000	+200
ATC costs (€)	1300	1500	-200

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/CO_2 ↓**
- No need for incentive schemes for fuel efficient trajectories

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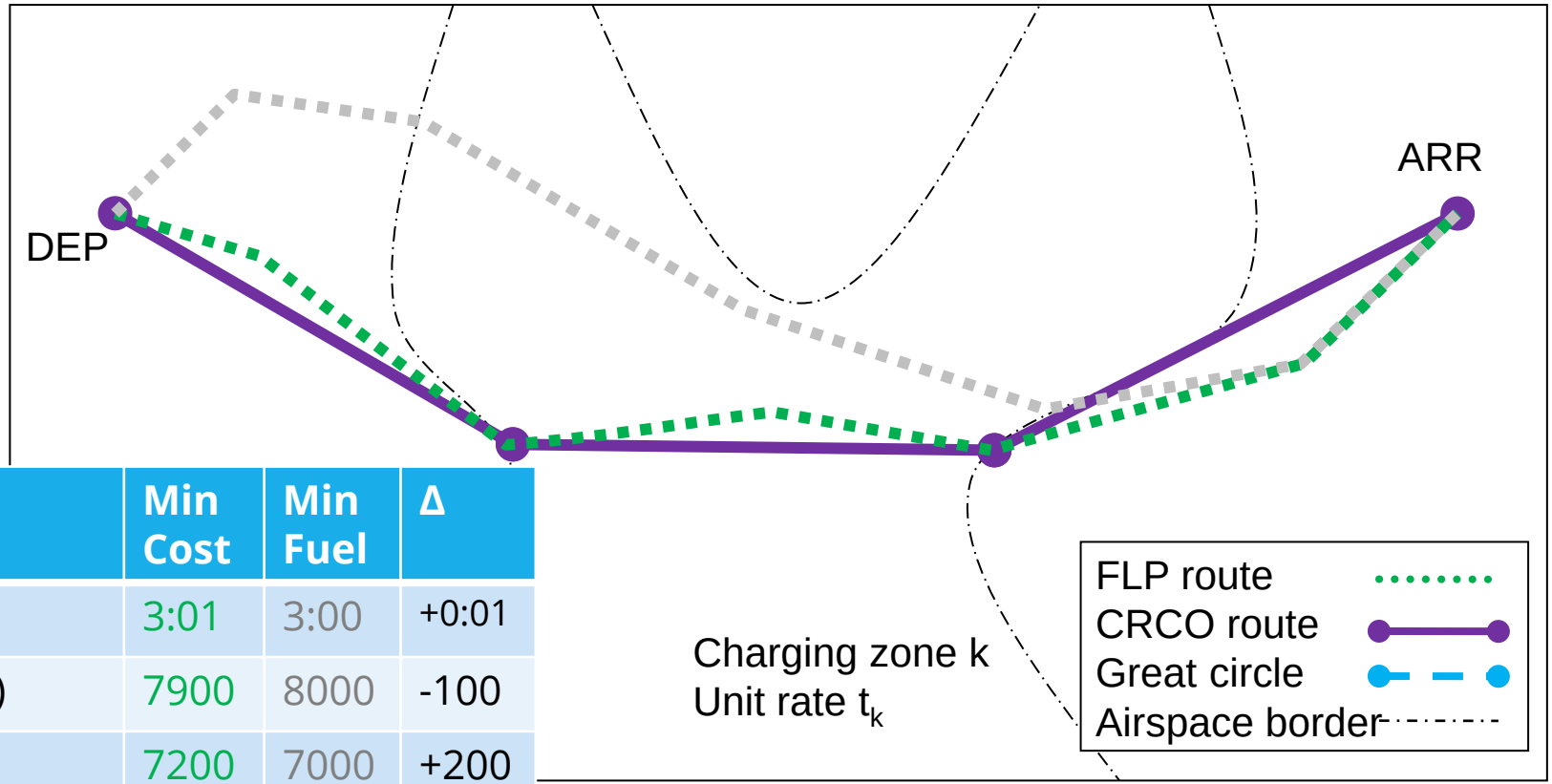

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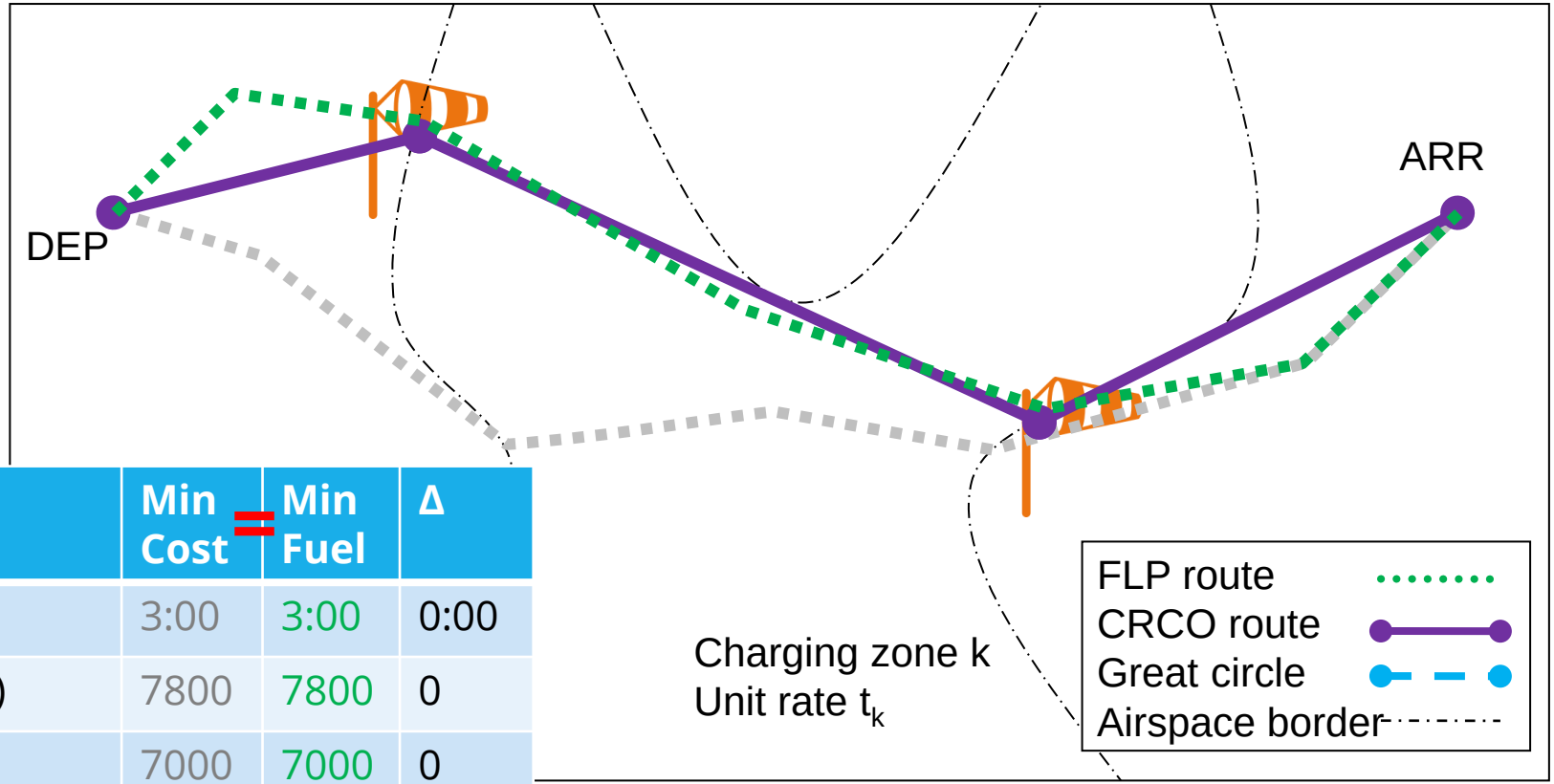
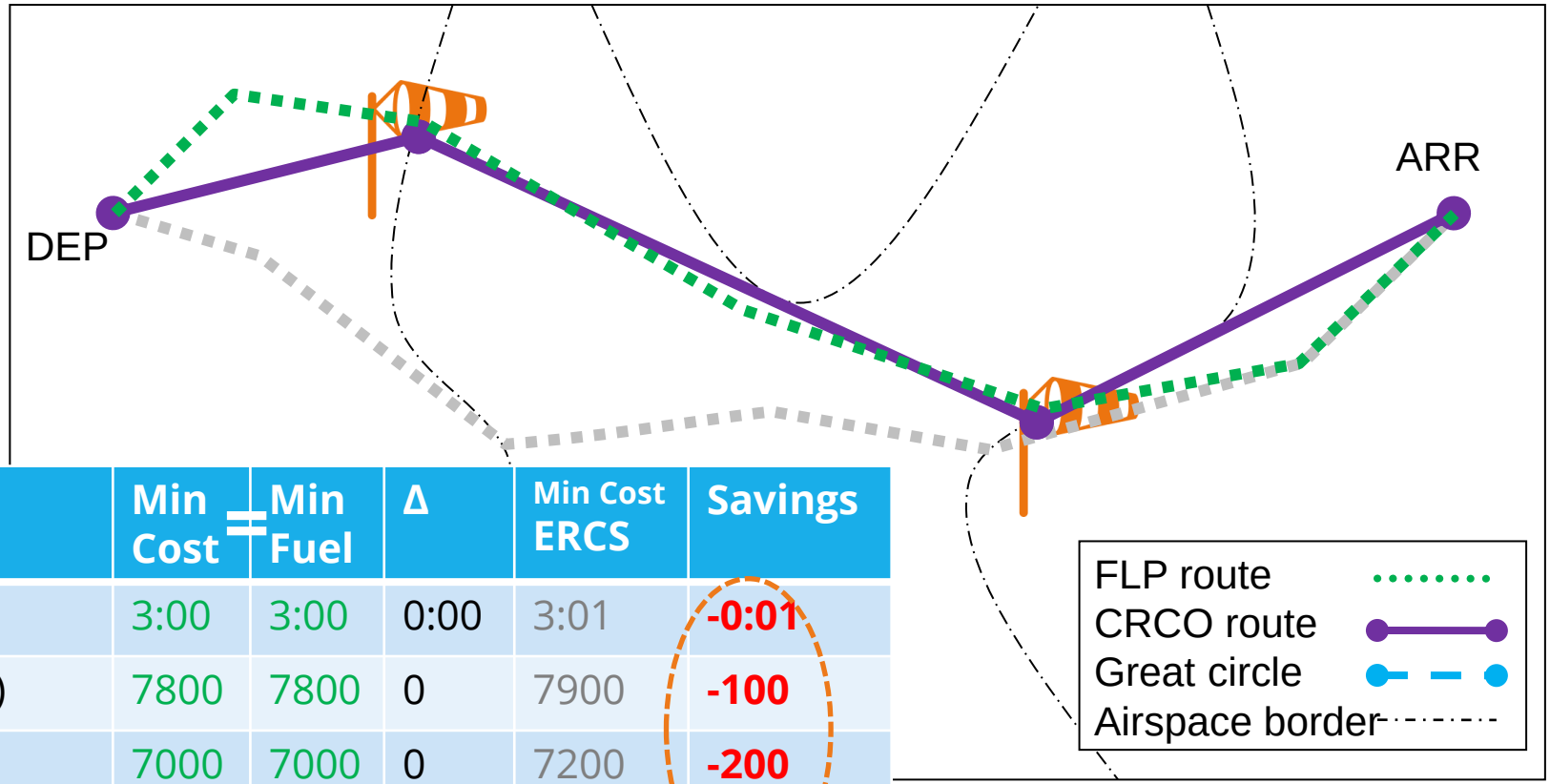
Desired outcome



Flight	Min Cost =	Min Fuel	Δ
Time (h:mm)	3:00	3:00	0:00
Total Cost (€)	7800	7800	0
Tripfuel (kg)	7000	7000	0
ATC costs (€)	1300	1300	0

Desired outcome



Flight*	Min Cost = Min Fuel	Δ	Min Cost ERCS	Savings
Time (h:mm)	3:00	0:00	3:01	-0:01
Total Cost (€)	7800	0	7900	-100
Tripfuel (kg)	7000	0	7200	-200
ATC costs (€)	1300	0	1300	0

*for illustrative purposes

Alternative route charges systems

WIN-LOSE-SOLUTIONS

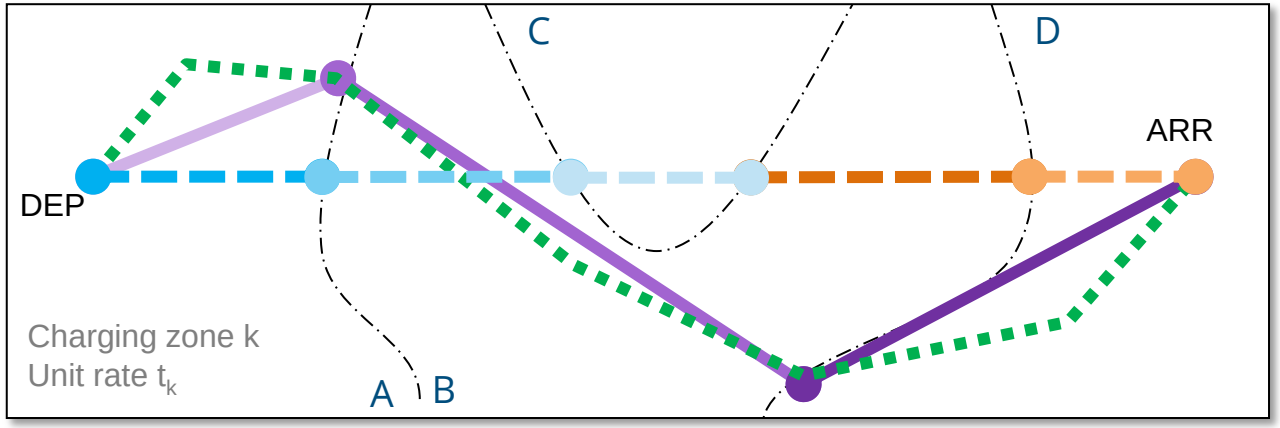
Single unit rate

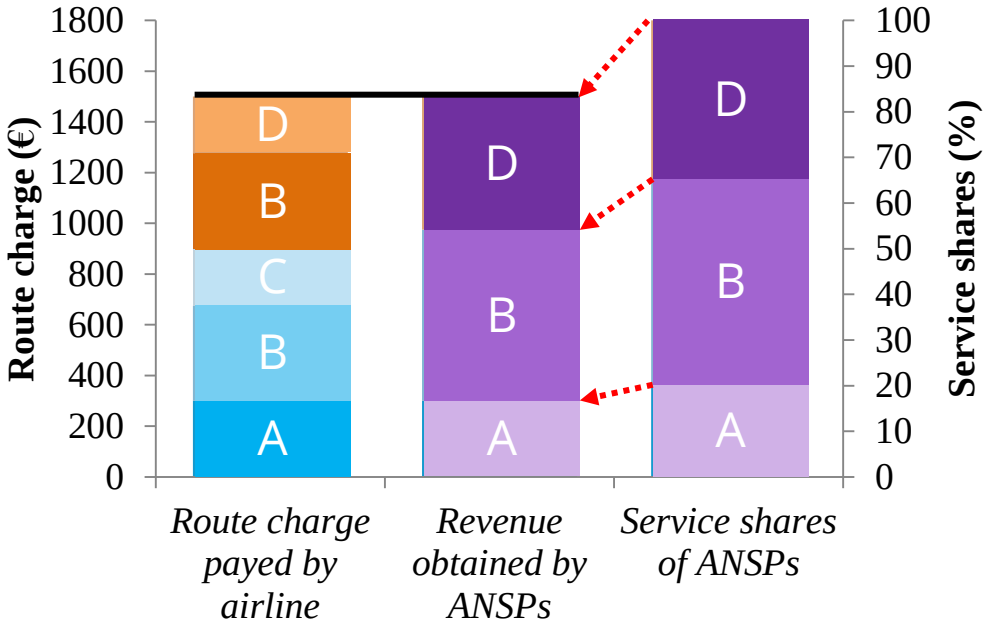
- Has desired outcome, but
  - **Some** airlines will pay **higher charges**
  - Revenues have to be **redistributed**
  - ANSPs need to **agree** on the single unit rate
  - ANSPs need to agree on what to do with **deviations** from expected revenues
  - Considered for **single FAB**, but not for multiple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





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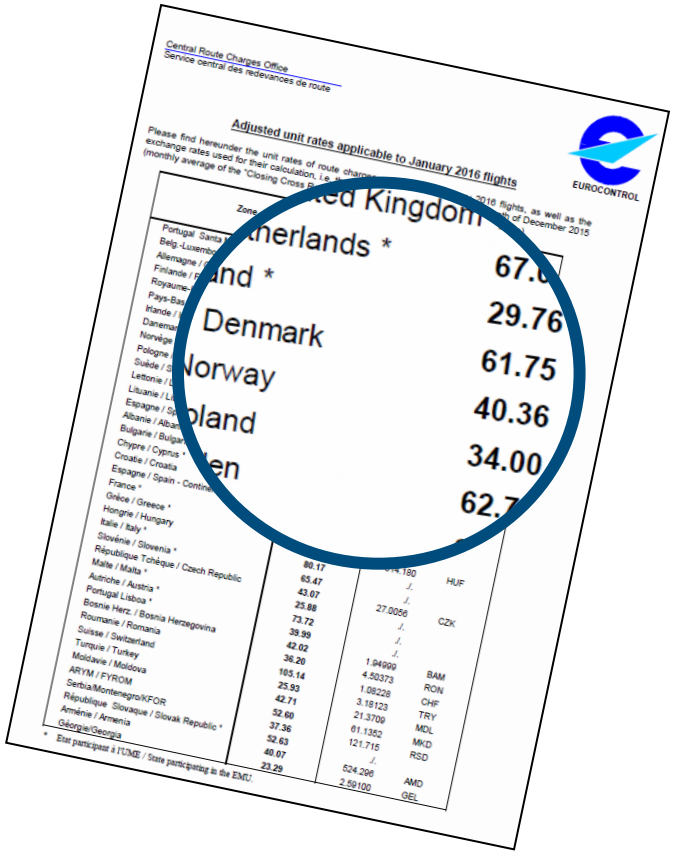
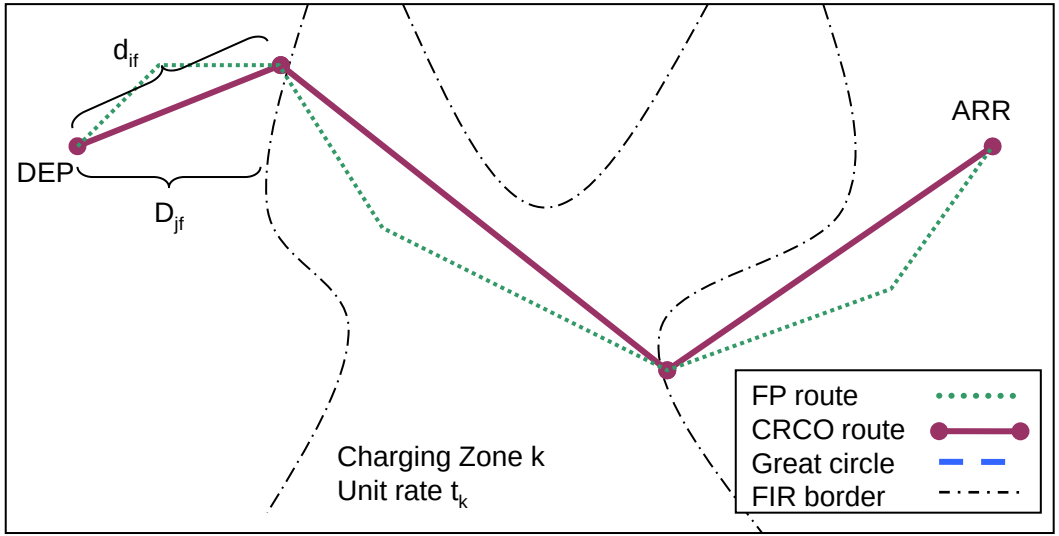
Mathematics behind FRIDAY

Eurocontrol Route Charges System

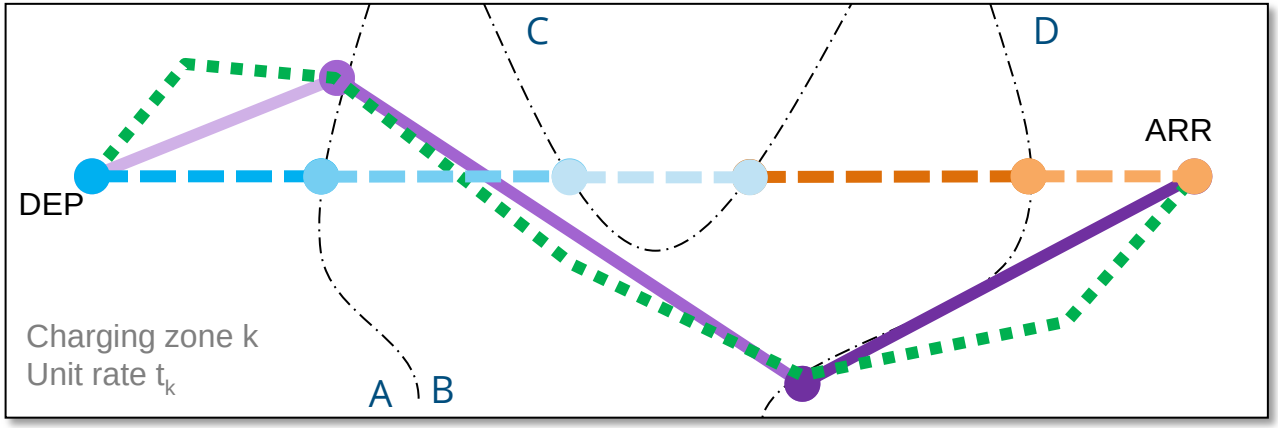




$$R_{CRCO} = \sum_i d_i \times p \times t_i$$

Route charge = f(airspace, distance, weight factor, unit rate)

FRIDAY route charges method



1. What the airline pays:

$$R_{great\ circle} = \sum_j D_j \times p \times t_j$$

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

2. What the airline would pay according to CRCO:

$$R_{CRCO} = \sum_i d_i \times p \times t_i$$

Route charge = f(airspace, distance, weight factor, unit rate)

3. What the ANSP gets payed:

$$r_i = \frac{R_{great\ circle}}{R_{CRCO}} d_i \times p \times t_i$$

Influence of route charges on Flight Planning

MAKE INDEPENDENT

Objective function for flight planning:

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

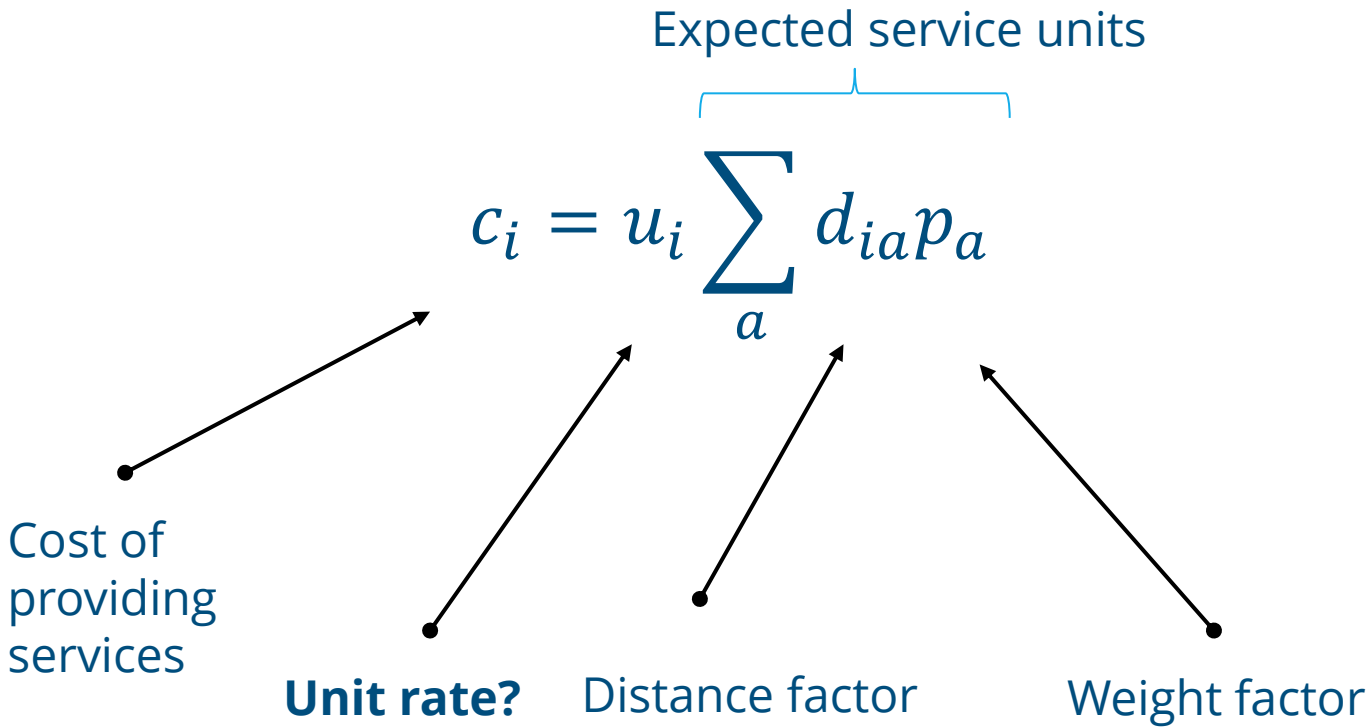
Flight time

Time cost coefficient

Fuel cost coefficient

Route charges

Setting unit rates (Eurocontrol Route Charges System)



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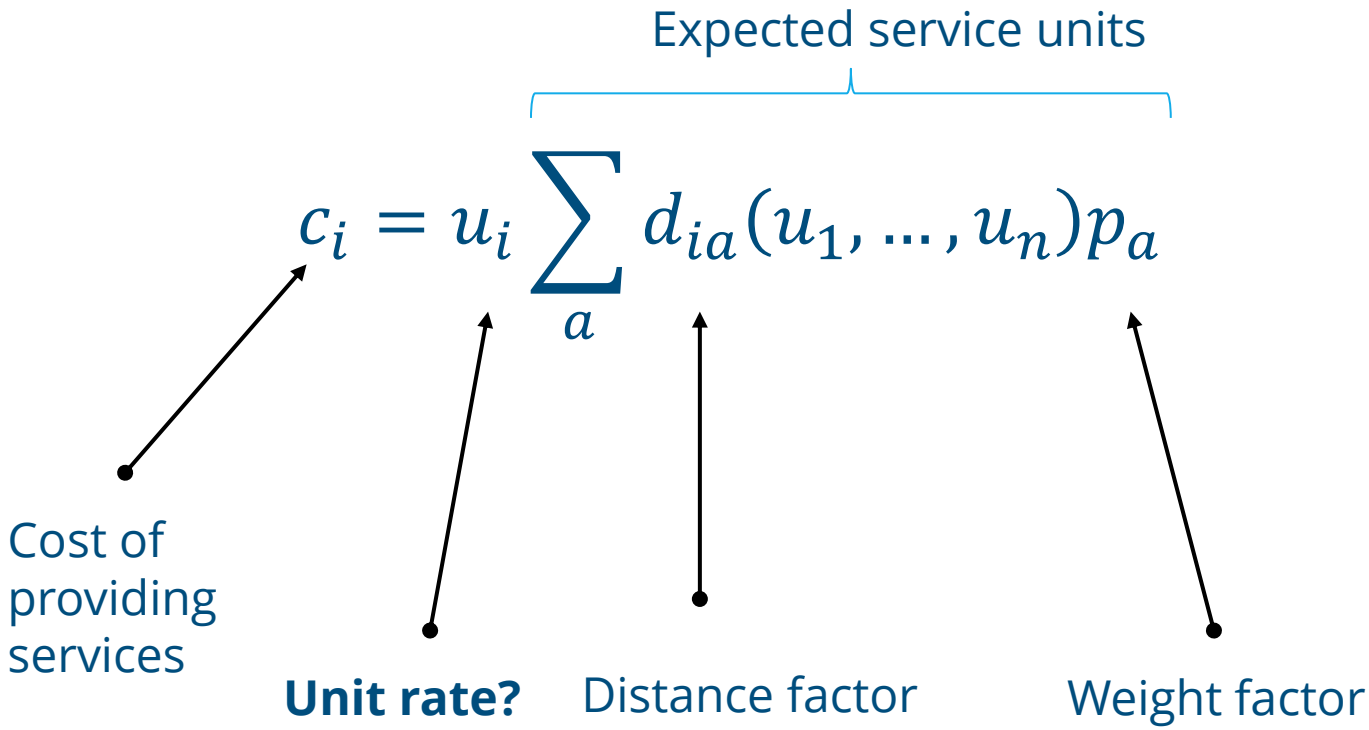

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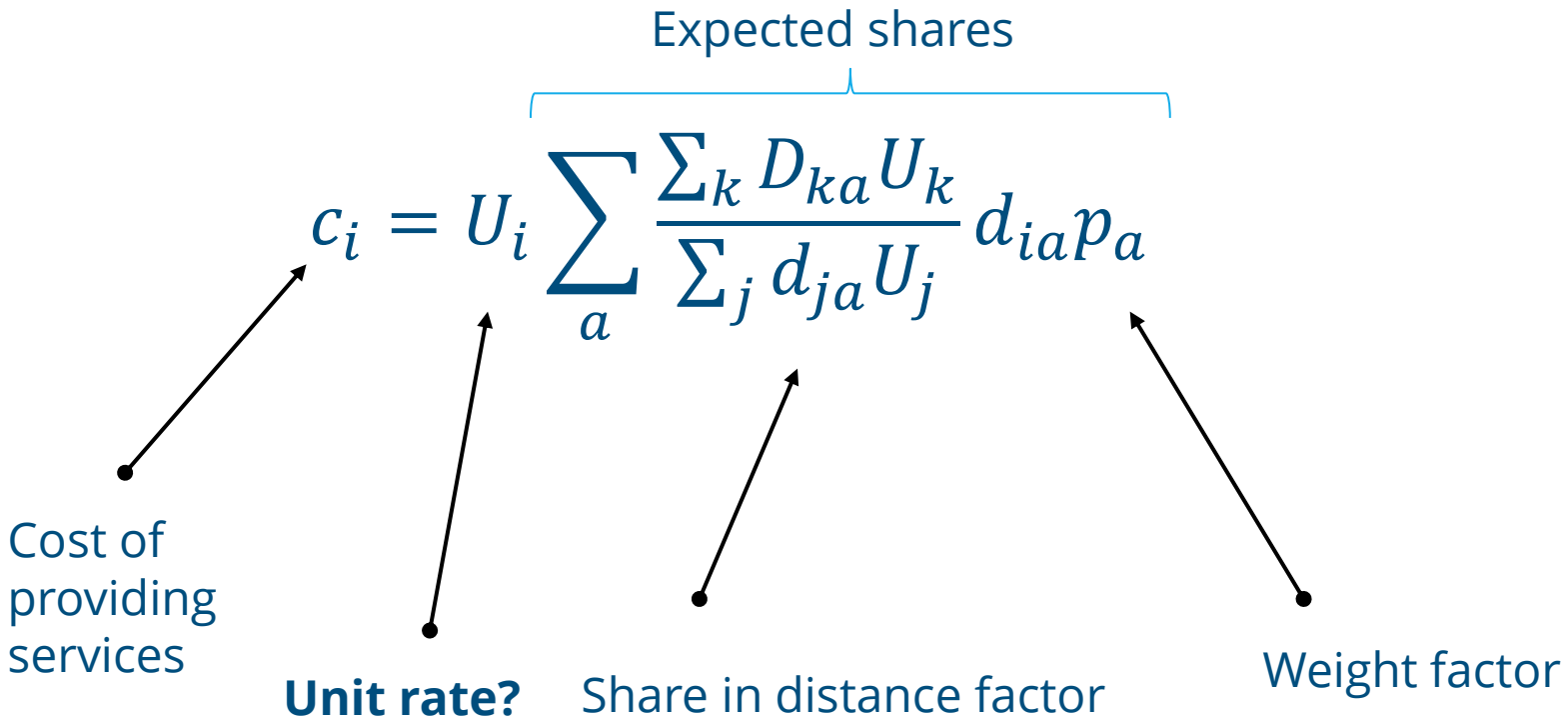


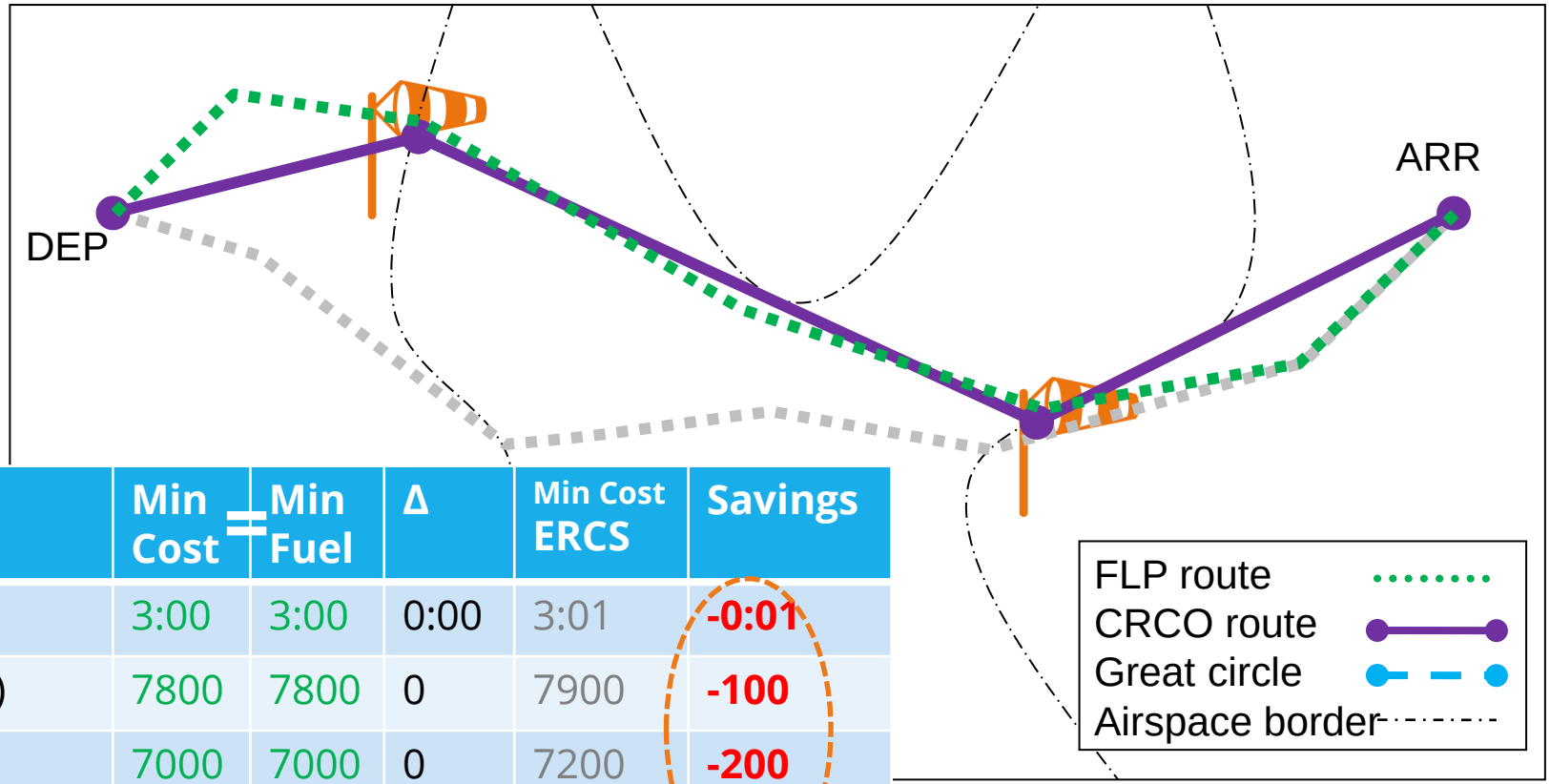
Setting unit rates (FRIDAY)

System of non-linear equations:

$$c_i = f_i(U_1, \ldots, U_n)$$

- 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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*for illustrative purposes

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

Society

- Emissions/CO_2 ↓
- No need for incentive schemes for fuel efficient trajectories
- ANSPs can attract more traffic when they provide more efficient routes

WIN-WIN-WIN-SOLUTION

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Next steps?

Research questions

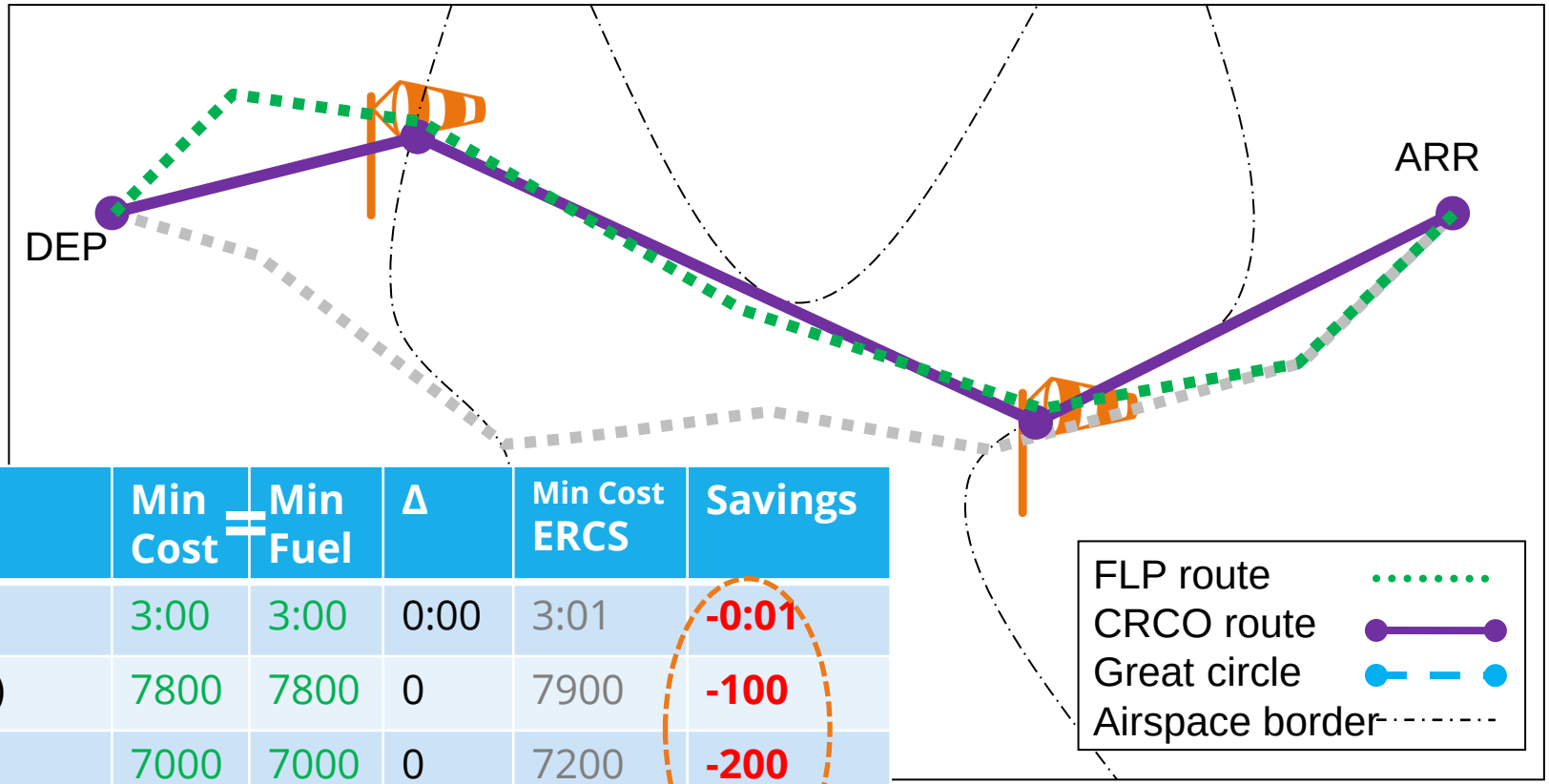
- What is the difference in performance between FRIDAY/ERCS/Single Unit Rate?
- What is the effect of uncertainties (weather/traffic numbers/…)?
- Is unit rate estimation method giving correct results?

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

Discussion

FRIDAY route charges method



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Fully engaged

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