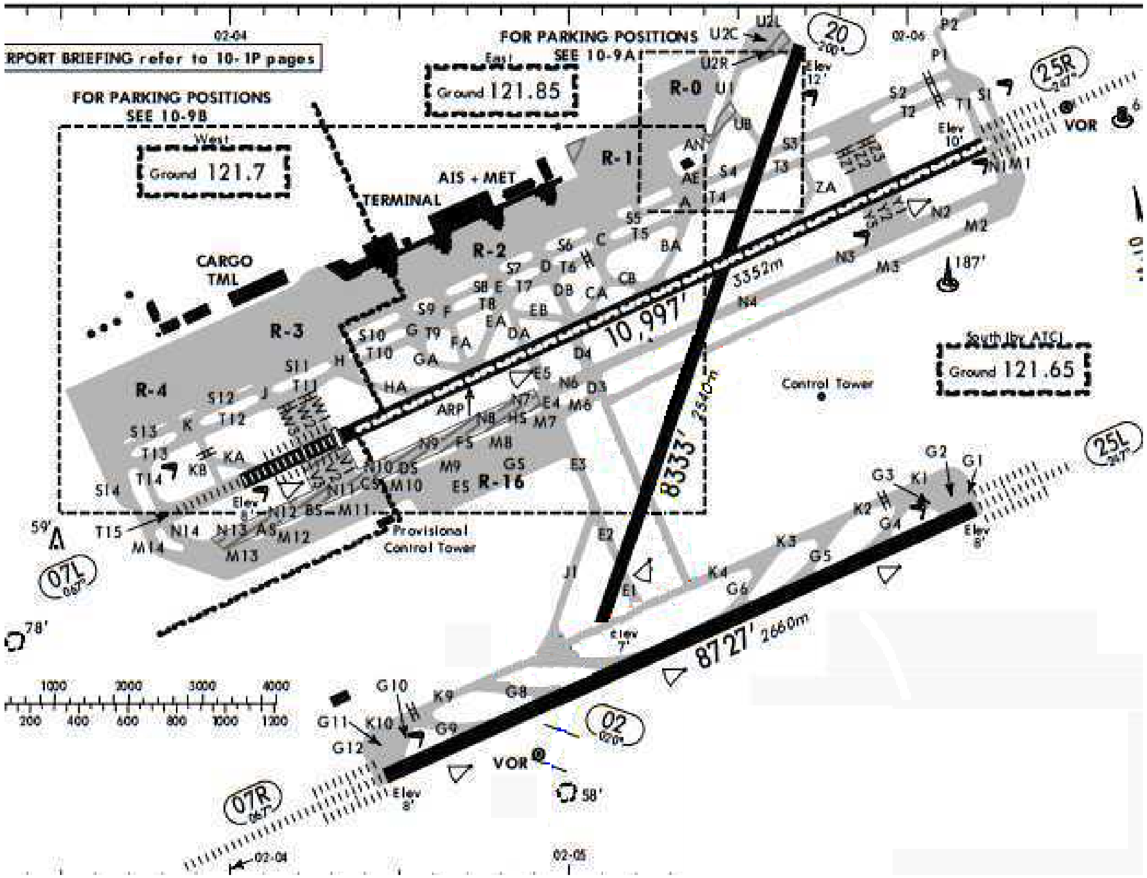
Adopt and airport project



WP3-5

11/10/2024

Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels

UNIVERSITAT POLITÈCNICA DE CATALUNYA

WP 3: Apply GHP

Project planning

Weeks:	1	2	3	4	5	6	7	8	9	10
WP1 (Traffic+Reg)										
WP2 (GDP)										
1p progress report										
WP3 (GHP)										
WP4 (InterModal)										
WP5										
Oral test Deliver paper										

WP 3: GHP objective and considerations

Objective of the problem: we want to **optimize** the arrival times of aircrafts at a given airport.

Using the same traffic data as in WP2:

- use the same regulation as you previously used for GDP
- use as input the affected flights: no need to apply 24h-GHP
- use same slots as in WP2
- as seen in class in the toy problem and in the other WPs, a flight cannot arrive before its ETA
- we want to know the best arrival times (cost-optimized) for all affected flights

WP 3: GHP objective and considerations

Solution

You will obtain a solution as: Aircraft “flight number” arrives at “arrival time” and then compute the same kind of metrics as for GDP total delay/mean delay, number of delayed A/C, air/ground delay, etc.

The problem to solve is: to minimize the following cost function (which depends on each flight delay), that is: $\min \sum_{f} \sum_{t} c_{f\,t} x_{f\,t}$

with $c_{f\,t} = r_f \left(t - e\left(f\right)\right)^{1+\varepsilon}$

and taking into account all constraints.

Use the `intlinprog` function of Matlab to solve this problem (or linear programming solvers from Python).

WP 3: GHP tasks

Task 1: validation task: **do not include it in the report**

For unitary cost (that is: all $r_f = 1$) and $\varepsilon = 0$, calculate the time of arrival of each aircraft and the total cost obtained with a linear programming GHP formulation. You should obtain the same total cost result as with GDP, since here total cost = total delay, check it.

This step is meant to validate that you coded correctly GHP, but this is not a "better" solution than GDP since in all cases we are minimizing the delay (and all costs are equal)

Do not forget to apply: *a flight cannot arrive before its ETA*

WP 3: GHP tasks

Task 2: assign realistic costs, considering non-linearity of cost

You **either** need to set up $0<\varepsilon<1$: you should then study a couple of values of ε ($\neq 0$) for this part

Or, your cost parameters can include non-linearity effects, in that case, ε remains equal to zero.

Set the cost parameters r_f (see in the next slides how r_f should depend on given constraints/priorities and on the passenger data for each flight)

Justify in your report your choice of parameter r_f (there are lots of ways to do it), use recent references from research papers to defend your choices of cost

The choice of r_f also needs to be validated (Examples: “are constraints and priorities fulfilled?”, you should also vary the values of r_f and see its impact, etc.).

WP 3: GHP tasks

Task 2: assign realistic costs

Cost: 1. Constraints/priorities to apply to your GHP

1. Following the philosophy seen in GDP, flights already flying at Hfile (use same file time as in GDP), international flights, long distance flights, and flights ready to depart are exempt flights, they will be assigned air delay. Set a maximum (feasible) value of air delay.

2. Very high ground delays should be avoided since they create long reactionary delay, but they are nevertheless feasible

In all cases you should make a difference between short and long delays: a few minutes of air delay is acceptable, but very long air delay is not. Delay in general creates reactionary delay: see for instance: www.eurocontrol.int/sites/default/files/2021-11/eurocontrol-data-snapshot-20-reactionary-delays.pdf

Note that costs of flights reaching OTP should be low

WP 3: GHP tasks

Task 2: assign realistic costs

Cost: 2. Passenger related

With your airport data, you retrieved data of available seats per aircraft model. You should look for references for realistic seat load factor values and thus calculate the total number of passengers per flight

You should then look for references for realistic values of connecting passengers at your airport (some of the flights have passengers who have to take a subsequent flight in your airport)

→ you then have to think how to take into account these data in the cost function to give more priority to flights that are more costly for the airline

AGAIN: All hypothesis affecting your constraints and/or cost function must be clearly justified in the report

WP 3: GHP tasks

Task 3: obtain relevant KPIs:

As in other WPs you should calculate all relevant KPIs.

For instance calculate AirDelay and GroundDelay and check that the values of AirDelay obtained are feasible, else you need to change some of your parameters to make sure they get feasible. Calculating their corresponding CO_2 emissions

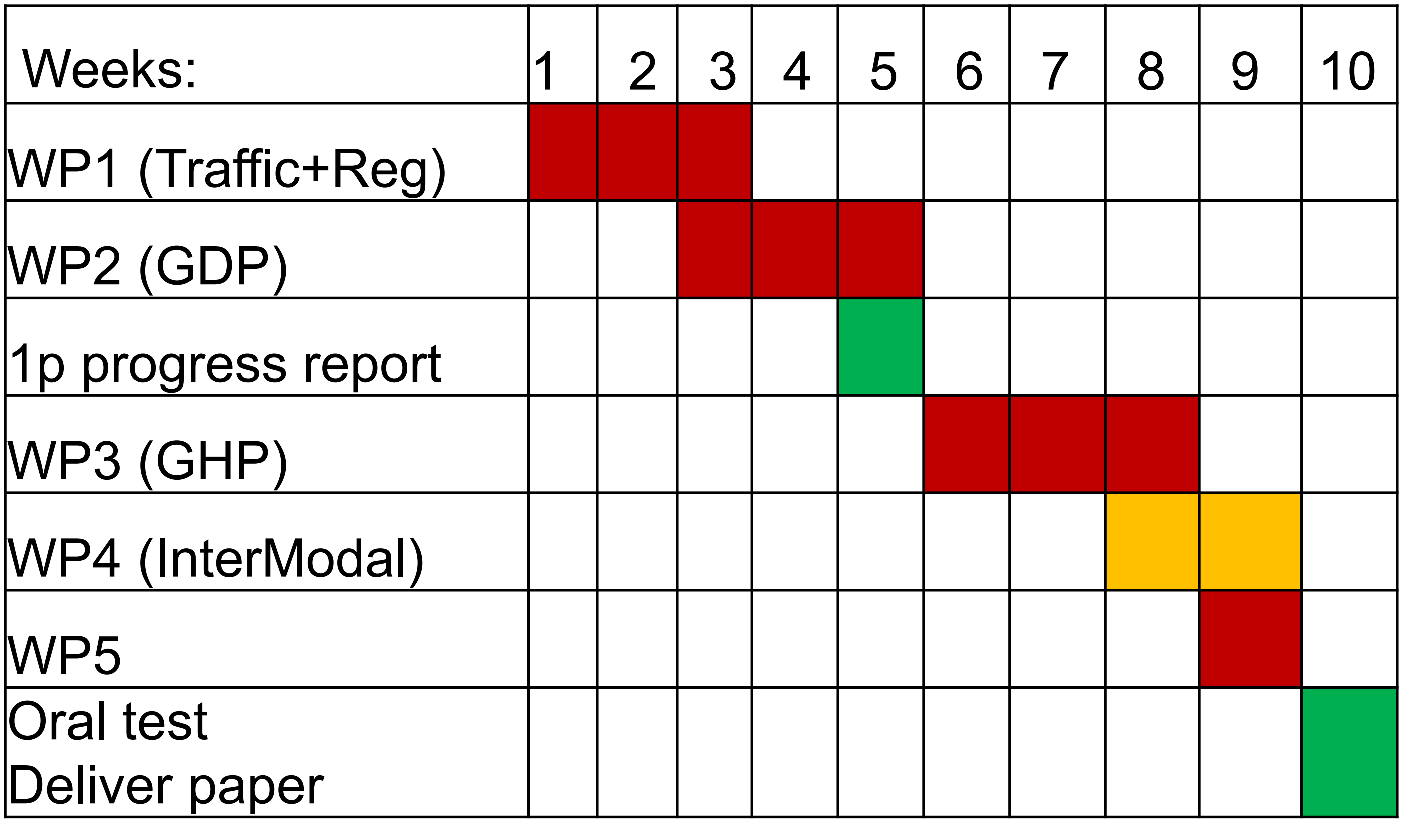
Calculate the total cost of delay (in euros) obtained with a GHP formulation

Calculate additional KPIs related to the cost of delay of the flights at individual level to check if they are realistic

Calculate the corresponding GDP costs of delay obtained using these cost coefficients (same r_f)

WP 4: Intermodality study

Project planning



WP.4: Substitute some flights by rail: motivation

Modal competition and substitution: high-speed rail (HSR) versus air transport

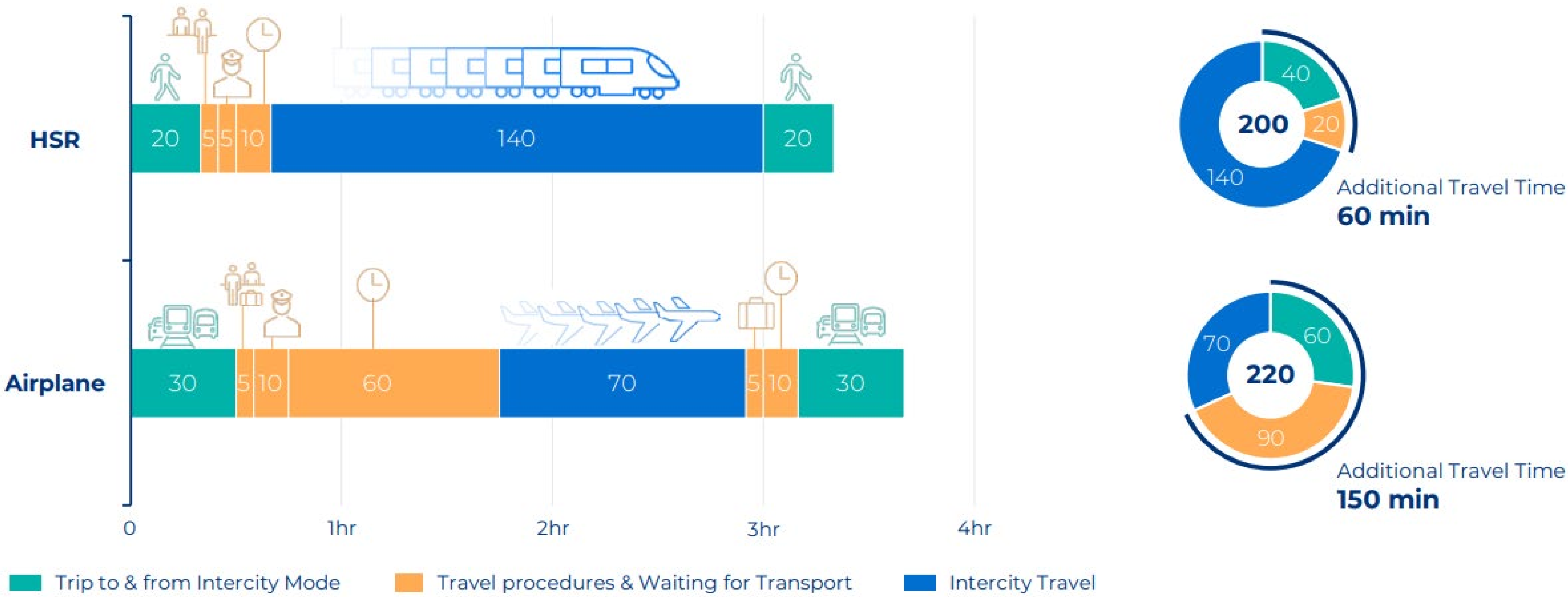
HSR: Shorter door-to-door (D2D) in certain routes due to terminal locations, boarding efficiency, streamlined security, etc., particularly in short to medium-distance (200-600km) journeys

D2D travel time: total time it takes for a traveler to commute from their starting point to their final destination.

https://www.alg-global.com/sites/default/files/2024-06/HSRvsAir.pdf

WP.4: Substitute some flights by rail: motivation

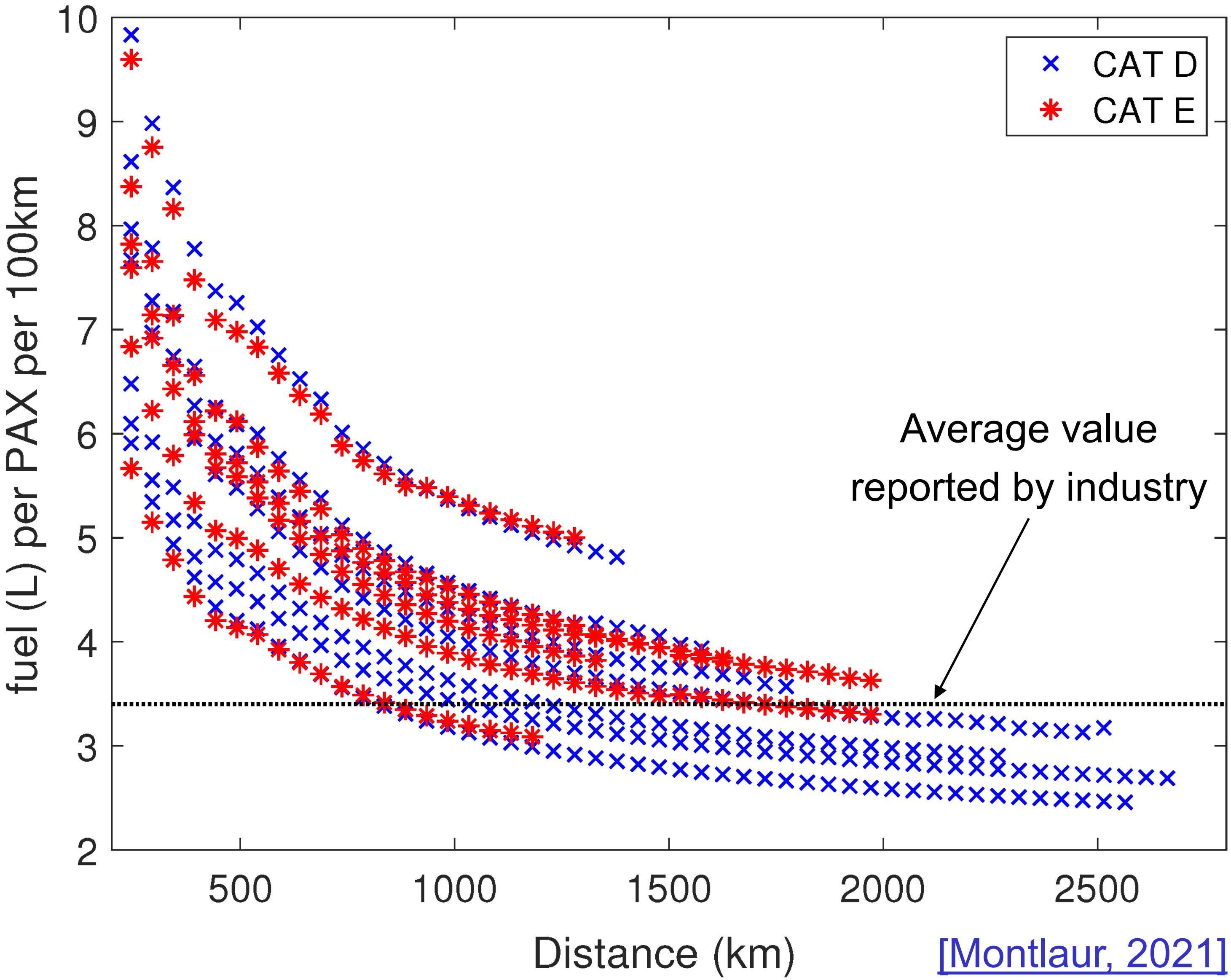
Example: Comparison of estimated D2D travel time by the different steps of travel between rail and air journeys for the London-Paris route



https://www.alg-global.com/sites/default/files/2024-06/HSRvsAir.pdf

WP.4: Substitute some flights by rail: motivation

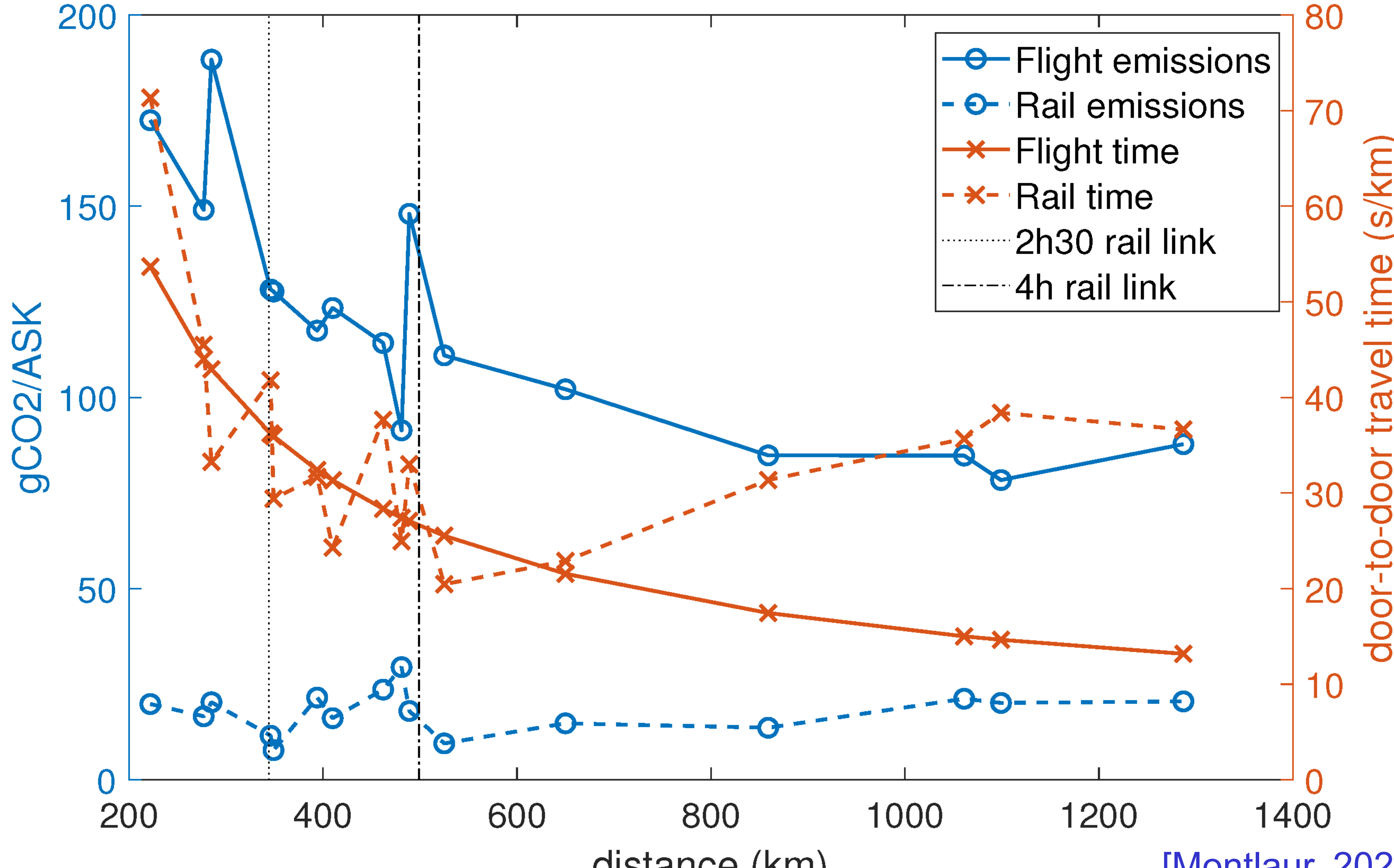
Short flights clearly inefficient from fuel consumption point of view



[Montlaur, 2021]

WP.4: Substitute some flights by rail: motivation

Equivalent D2D times between high-speed train and short flights



[Montlaur, 2021]

WP.4: Substitute some flights by rail

We now want to study if we could have avoided the regulation (or at least reduced its total delay) if the scheduled demand had been lower.

Within the regulation interval (not during 24h), identify the routes that could be substituted by a rail option (direct train with reasonable travel time 4-6 hours maximum for example, check for instance: direkt.bahn.guru or www.chronotrains.com/en)

For these flights substituted by rail, calculate their rail carbon footprint (see for example: www.ecopassenger.org) and their D2D travel times.

Critically compare total CO_2 emissions and D2D travel times of air and rail options for these routes:

- first compare using air travel D2D times without delay,
- then compare them including their respective delays due to the current regulation (obtained from WP2 and/or WP3)

eetac Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels
UNIVERSITAT POLITÈCNICA DE CATALUNYA

WP.4: Substitute some flights by rail

After eliminating these flights from your scheduled demand, apply GDP and GHP to the “new” (reduced) set of flights (with the same hypothesis as before)

Analyze the effect of eliminating these flights from the demand on the new end time of the regulation, the set of affected flights and all other previously computed KPIs.

Compute all corresponding statistics

WP 5: Discussion/final considerations

Project planning

Weeks:	1	2	3	4	5	6	7	8	9	10
WP1 (Traffic+Reg)										
WP2 (GDP)										
1p progress report										
WP3 (GHP)										
WP4 (InterModal)										
WP5										
Oral test Deliver paper										

WP5: Performance assessment: SESAR KPAs

Selection of KPAs uses as reference set of KPAs defined in ICAO framework with refinements to support SESAR requirements

1. Safety
2. Security (e.g.: [EUROCONTROL Data Snapshot Ransomware groups target aviation's supply chain])
3. Environment
4. Capacity
5. Operational Efficiency
6. Predictability
7. Cost effectiveness
8. Flexibility
9. Access and Equity

[PJ19.04]

WP.5: Final results and comparison

Compare GDP/GHP/intermodal solutions considering **environmental KPIs** (among others)

Now that you have results from 2 possible ATFM methods and 2 combining regulation + rail substitution, compare them (using exactly the same parameters for the regulation)

The report should at least include the comparison of total cost of delay for all methods (including the intermodal option) and of emissions of delay for the 4 options.

Any other graph and KPIs that you think will help showing differences between all methods and assessing their performance should be included here.

Identify and relate KPAs and KPIs in this part (this can be through a table)

Conclude on the advantages to use GDP, GHP or intermodal options

About the report

Accuracy and presentation of results, justification of choices made, quality of references used, originality of the results (graphs, chosen metrics, etc.) and **above all analysis of the results** presented will be (between others) some of the evaluation criteria.

Though the use of ChatGPT or other IA tool is tolerated, but presence of invented references or invented / false data (sometimes generated by IA) will lead to a 0 grade of the report.

References

- [Montlaur, 2021] A. Montlaur, L. Delgado, C. Trapote-Barreira, Analytical Models for CO2 Emissions and Travel Time for Short-to-Medium-Haul Flights Considering Available Seats, Sustainability, 13(18), 1040, 2021 doi.org/10.3390/su131810401

- [PJ19.04] PJ19.04: Performance Framework (2019) https://www.sesarju.eu/sites/default/files/documents/awards2021/SESAR%20Performance%20Framework%20ed_%2001_00_01%20-%202019.pdf (Accessed Oct 10th, 2022)

- [SESAR Solution, 2019] SESAR SOLUTIONS CATALOGUE 2019 Third edition www.sesarju.eu/sites/default/files/documents/reports/SESAR_Solutions_Catalogue_2019_web.pdf (Accessed Oct 10th, 2022)