Transport Cost Model:

Creation of Costmatrix:

Geographical distancematrix(in km) is loaded from excel-shead, which contains all trackpairings i -> j.

Cost formulation:

For each connection between two circuits i -> j, the transport cost is defined as:

C{ij} = d{ij} * f_m

where:

- d{ij} = geographic distance (km) from the Excel distance matrix
- f_m = transport-specific weighting factor
- Truck: low factor (baseline)
- Ship: reduced factor (energy-efficient per km)
- Plane: increased factor (high emissions per km)

For each pair of circuits, the cheapest feasible transport mode is selected based on the allowed modes and their respective cost factors.

Transport Mode Assumptions & Constraints

To keep model interpretable and comparable, we apply the following simplifying assumptions:

Truck

- Allowed only if both circuits are on the same continent
- Distance must be below a predefined threshold

Ship

- Allowed only if both origin and destination circuits have access to a harbor (<50km distance). Is used to keep it relatively realistic, as traveling from nearest airport to actualy racetrack in reality may also take some km
- Used primarily for intercontinental

Plane

- Always allowed
- Acts as fallback when cheaper alternative exists

Rules ensure that:

- unrealistic transport choices are avoided
- long intercontinental trips favor maritime transport when possible
- the model remains deterministic and explainable

Parameter values:

```
FACTORS = {
    "truck": 1.0,
    "ship": 0.6,
    "plane": 3.0
}
```

-> Used purely on a rough estimate and are not fact checked to real world values

Multi-Model Scoring Logic

Scoring Formulas

The system evaluates every leg of the trip by calculating two competing scores. The algorithm automatically selects the transport mode with the lower total score.

Road Score: $(Weight_{Dist} \times Distance) + (Weight_{Cost} \times \frac{Fixed_{Truck} + (Dist \times Var_{Truck})}{Normalizer})$

Air Score: $(Weight_{Dist} \times Dist \times SpeedFactor) + (Weight_{Cost} \times \frac{Fixed_{Air} + LogCost + FuelPenalty}{Normalizer})$

Variable Definitions

- Weight_Distance / Weight_Cost: User-defined ratios (e.g., 0.5 and 0.5) that determine the strategic priority of time versus budget.
- Distance: The raw physical kilometers between two race circuits.
- SpeedFactor: A multiplier (default 0.15) that represents the time advantage of air travel. It reduces the "perceived distance" for the algorithm to simulate higher speeds.
- Normalizer: A mathematical constant (default 500) used to scale Euro values down so they can be fairly added to kilometer values without overwhelming the distance metric.

  Without this, a €300,000 cost would mathematically make a 1,000 km distance completely irrelevant because 0.5 * 1000 (km) = 500 while 0.5 * 300.000 (€) = 150.000. total score (without)= 500 (km) + 150.000 (€) = 150.500

  With this normalizer (300,000 / 500) = 600. Then 0.5 * 600 = 300.

  Total score = 500 (km) + 300 (€) = 800

- Fixed_Truck / Fixed_Air: The base "loading and handling" fees that are charged regardless of how far the equipment travels.
- Var_Truck: The variable cost per kilometer for road transport.
- Log_Cost: A non-linear cost calculation for planes where the price per kilometer decreases as the trip gets longer.
- Fuel_Penalty: An exponential cost ($Distance^{2.5}$) applied to long flights to simulate the extra fuel weight required for transcontinental travel.

Summary Constraints multi model

The Continent Guard: forces the use of air transport whenever the origin and destination circuits are located in different geographical regions.

Weight-Based Priority: model uses adjustable ratios to let the user define whether the algorithm should prioritize speed (Distance) or budget (Cost) for each leg.

Non-Linear Air Costs: logarithmic cost factor is applied to planes so that the price per kilometer decreases as the flight distance increases.

The Fuel Paradox: Long-haul flights are penalized with an exponential cost (Distance^(2.5)) to account for the massive amount of extra fuel weight required for transcontinental trips.

Time Proxy (Speed Factor): Air travel is given a "perceived distance" advantage (defaulting to 15% of actual distance) to simulate its significant speed advantage over road transport.

Magnitude Normalization: Financial values are divided by a constant (500) to ensure that Euro costs and Kilometer distances have an equal impact on the final decision score.

Fixed Entry Fees: Every transport mode includes a fixed "loading and handling" fee that must be paid regardless of the total distance traveled.