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F1 LOGISTICS SIMULATION

All things that could go wrong

TODAY'S AGENDA

1

What is this Logistics we
are talking about?

2

What If?

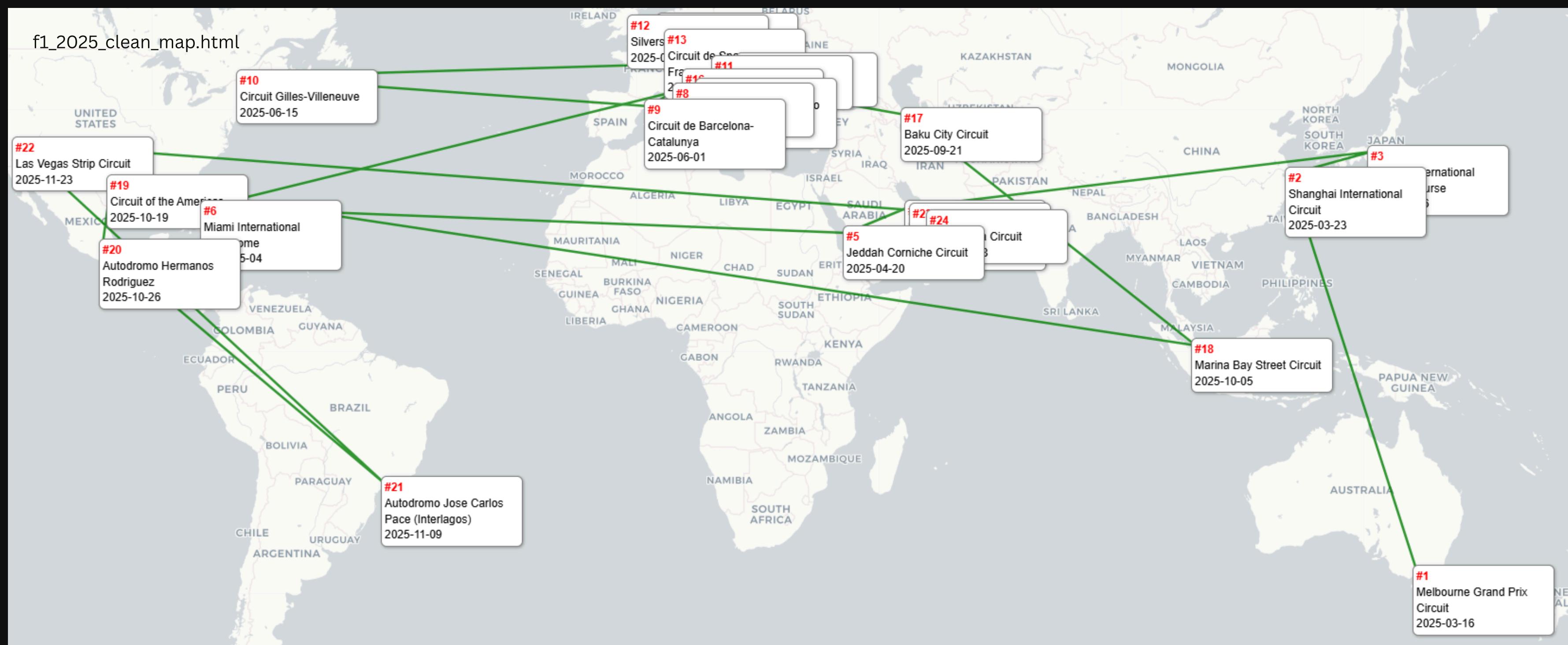
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MC Simulation Design,
Validation and
Experimentation

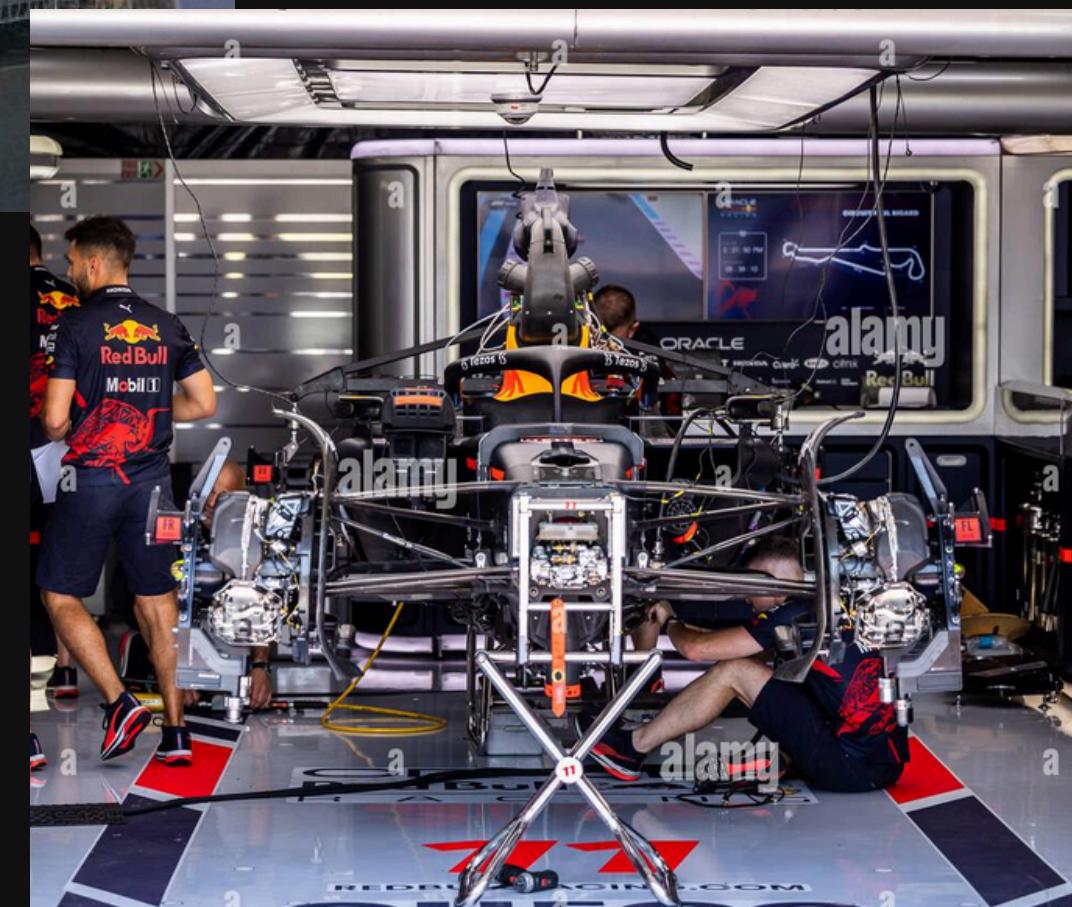
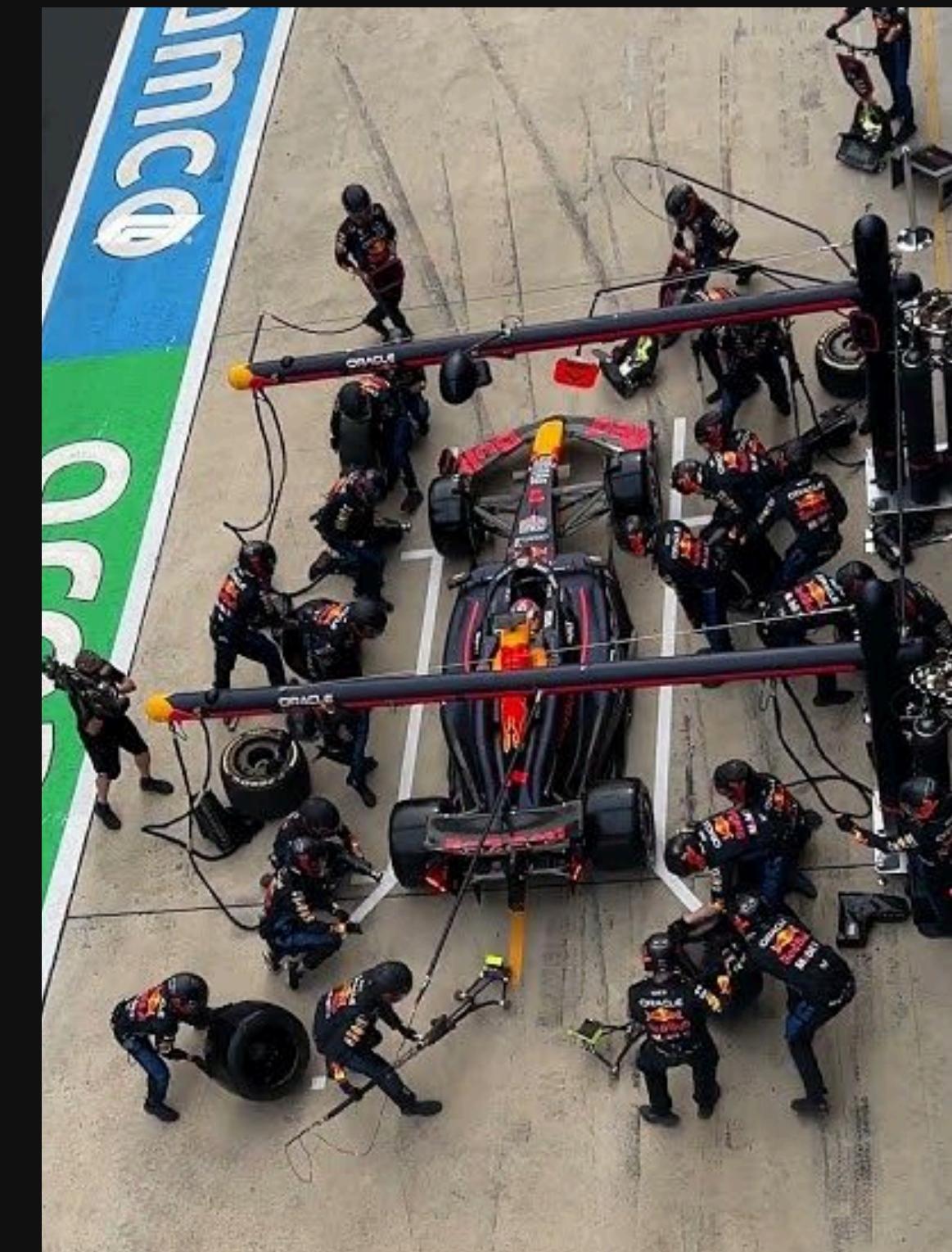
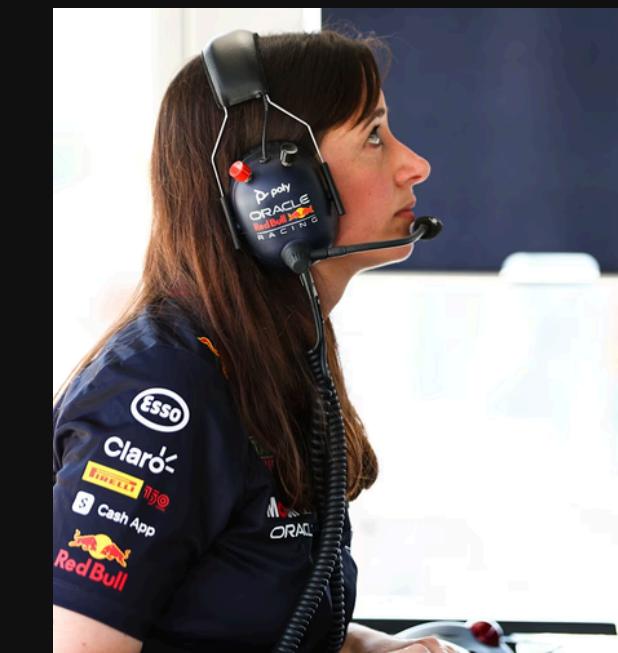
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Results and Challenges/
To Do list

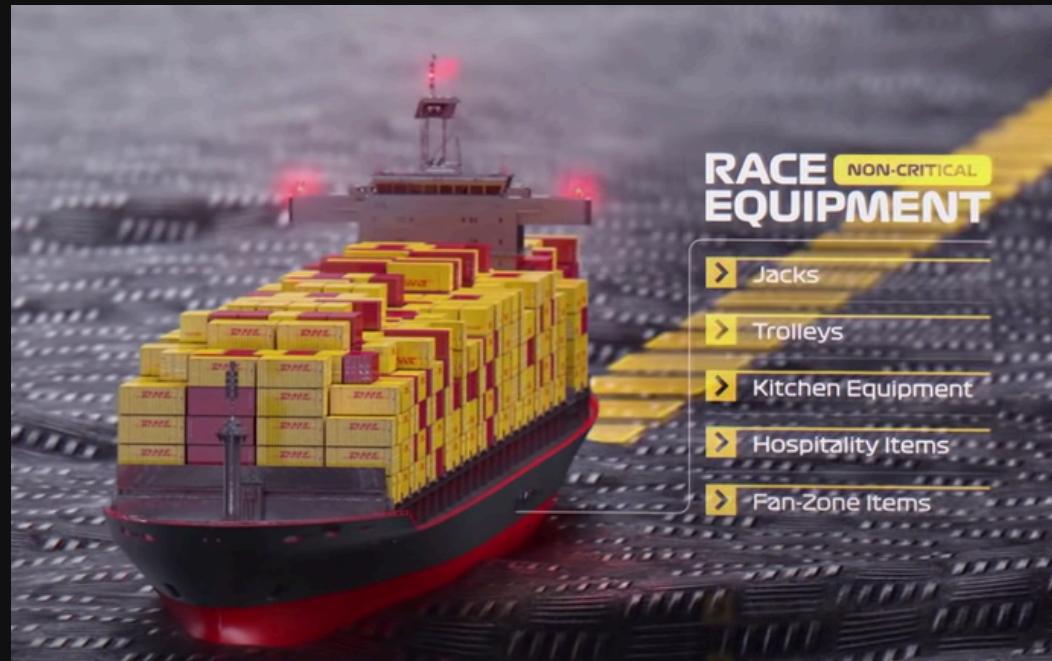
F1 LOGISTICS



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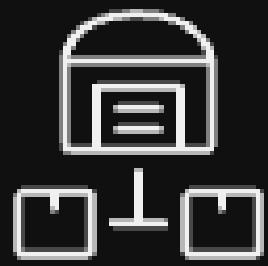
Non-priority
palettes vs.
Priority palettes

Consecutive
races Vs. non-
consecutive
races

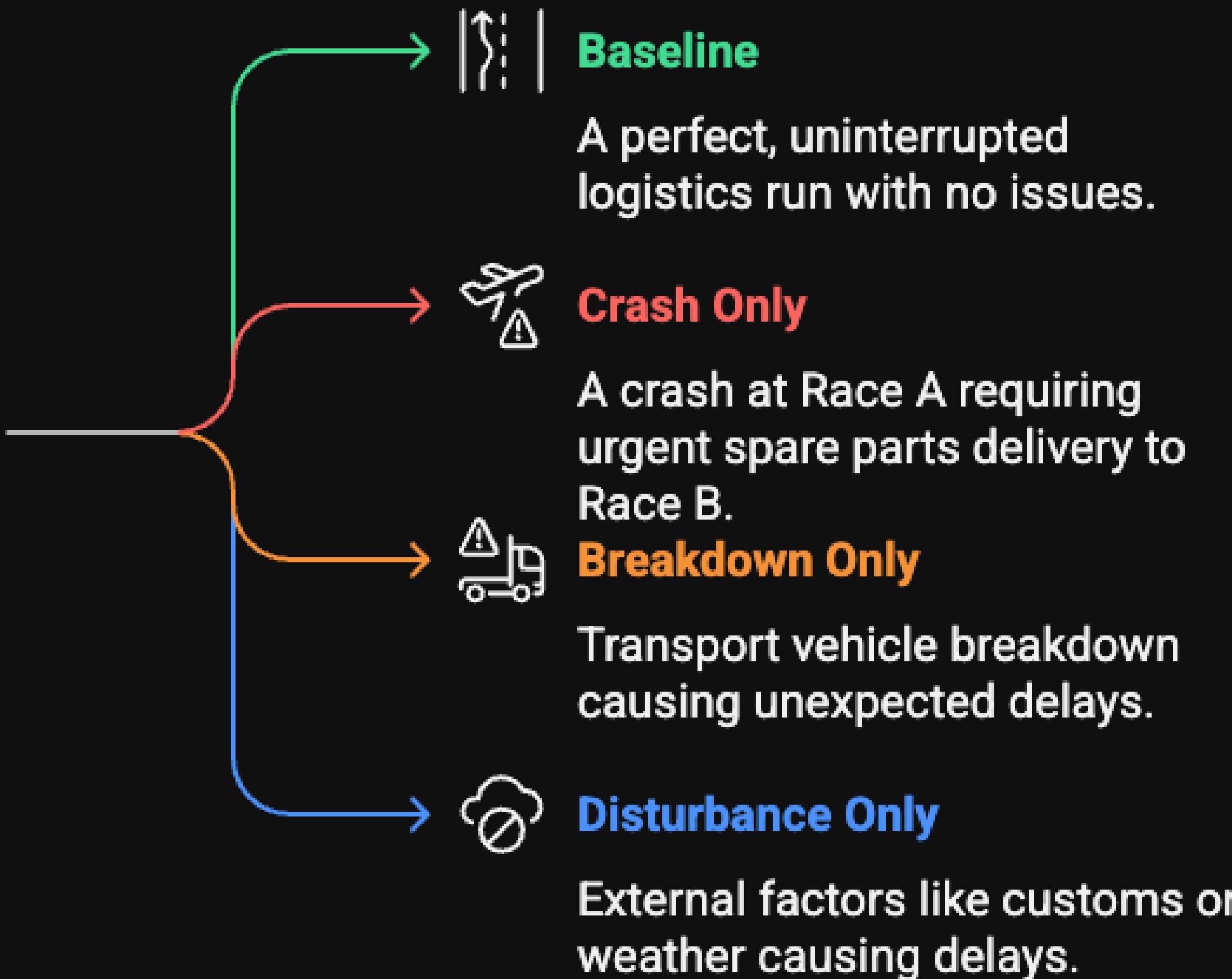
WHAT SHOULD HAPPEN?

1. de-rig the whole garage, pit and motor homes
2. pack them into specially made containers
3. transport them to next location, where ever that is
4. should reach the destination by Wednesday (tuesday night)!
5. Thursday, Friday - PR events and Practice sessions happen
6. Saturday - Qualifying session
7. Sunday the race happens
8. Could end at 11pm or 2pm

WHAT IF?



Which logistics scenario is most likely to occur?



DISTURBANCE HYPOTHESIS: RACE CANCELLATIONS

| | | |
|------|---|---|
| 2012 |  | Bahrain GP cancelled due to civil unrest |
| 2023 |  | China GP cancelled due to COVID-19 pandemic |
| 2023 |  | Imola GP cancelled due to flooding |

Race Cancellation and Cargo Rerouting Process

Race Cancellation

The race is cancelled due to severity threshold exceeding 1.

Cargo Rerouting

Cargo is rerouted to the next race location.

Severity Reduction

The transportation leg experiences other disturbances.

Cargo Arrival

Cargo arrives at the next race location.



PHASE 1: DESIGN - FIXED VARIABLES

| <u>Variable</u> | <u>Type</u> | <u>Value / Logic</u> | <u>Description</u> |
|---------------------------|-------------|--|--|
| HQ Location | Fixed | Milton Keynes, UK | HQ (Dispatch point after a crash) |
| Race Calendar | Fixed | Official 2025 F1 Schedule | Used to generate track pairs and event intervals |
| Distance (Track A → B) | Fixed | Calculated using geographiclib | Geodesic distance between circuits |
| Distance (HQ → Any Track) | Fixed | Also calculated using geographiclib | For delivery from HQ in crash scenario |
| Mode of Transport | Derived | Roadways/Airways | Decided dynamically per simulation |
| Delivery Deadline | Fixed | 58 hours (back to back headers) 65 hours (others) | Maximum time |

PHASE 1: DESIGN - RANDOM VARIABLES

| <u>Random Variable</u> | <u>PERT Range (Best, Likely, Worst)</u> | <u>Description</u> |
|----------------------------|---|--|
| Road Speed (km/h) | (100,80,48) | Speed of trucks on highways |
| Air Speed (km/h) | (800, 700, 600) | Speed of cargo planes over long distances |
| Local Road Speed (km/h) | (32.19, 40.23, 48.28) | Truck speed from/to airport. real-world bottleneck reference |
| Fabrication Time (hrs) | (12, 18, 36) | Time to manufacture spare parts after crash |
| Buffer Time Allowed | (4,5,10) | Loading/Unloading Time |
| Breakdown Delay (Road) | (1, 3, 12) | Time lost due to truck breakdown (diagnosis + repair) |
| Breakdown Delay (Air) | (2, 3, 12) | Delay in air transport (runway, loading issues) |
| Disturbance Duration (hrs) | (2, 6, 48) | Duration of external disruptions (e.g., customs/weather) |
| Disturbance Severity | (0.1, 0.2, 1.1) | Multiplier applied to disturbance duration, based on impact severity |

PHASE 2: VALIDATION USING H_0



- Includes road & air scenarios
- Roadways = loading + unloading
- Airways = loading +unloading at airport + loading into the cargo plane + unloading from the cargo plane + loading into a truck then reaching the destination → Buffer = 5hrs
- Roadways = same continents AND distance ≤ 4000 Km

Back-to-Back races: 58hrs ~ little more than 2 days for Wednesday assembly!

ROAD or AIR?

- Within the same continent
- less than 4000km

Non-consecutive races: more time
It is not failure if they take more than 58hrs, they just have time to spare
ROAD or AIR?

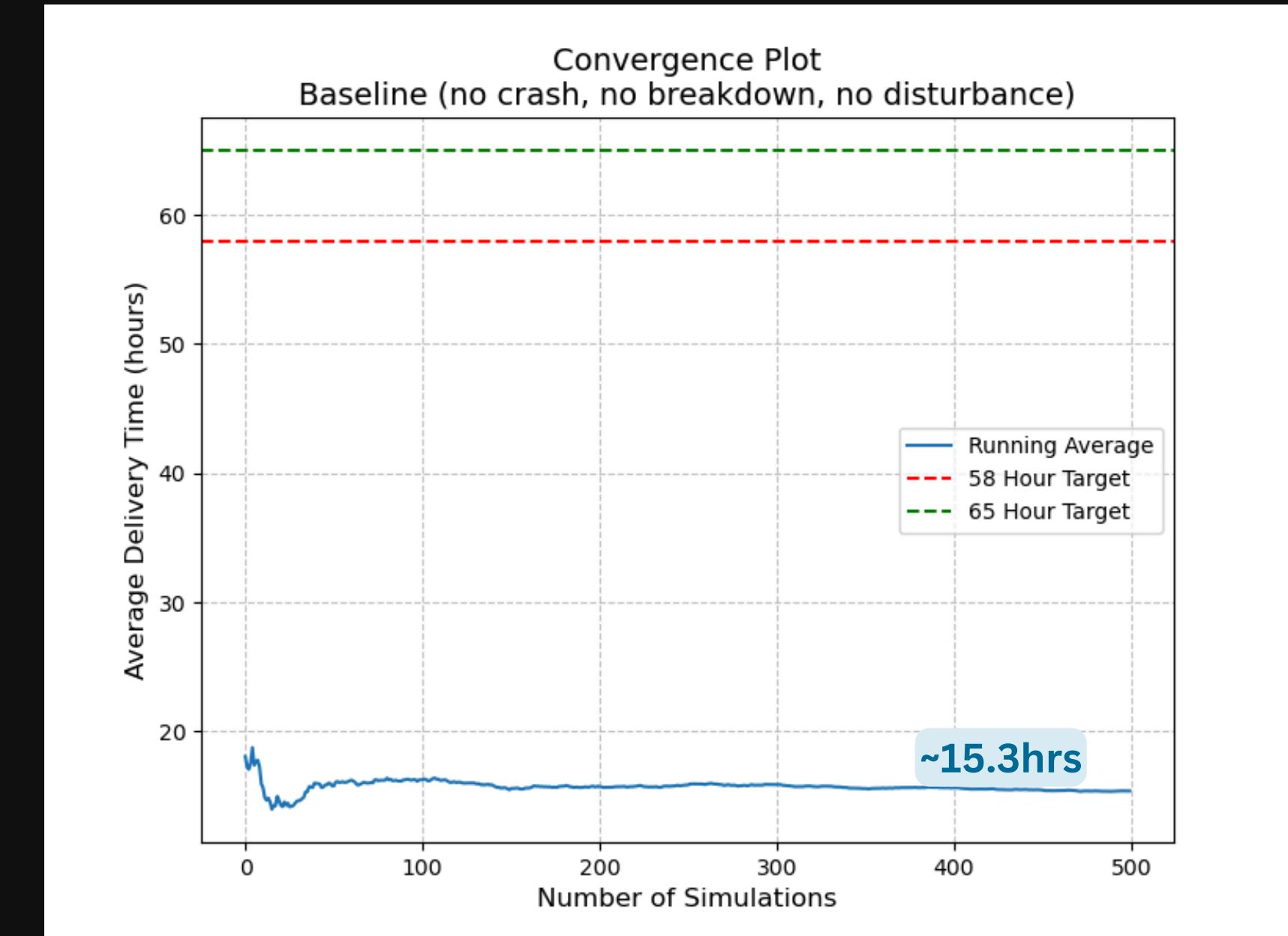
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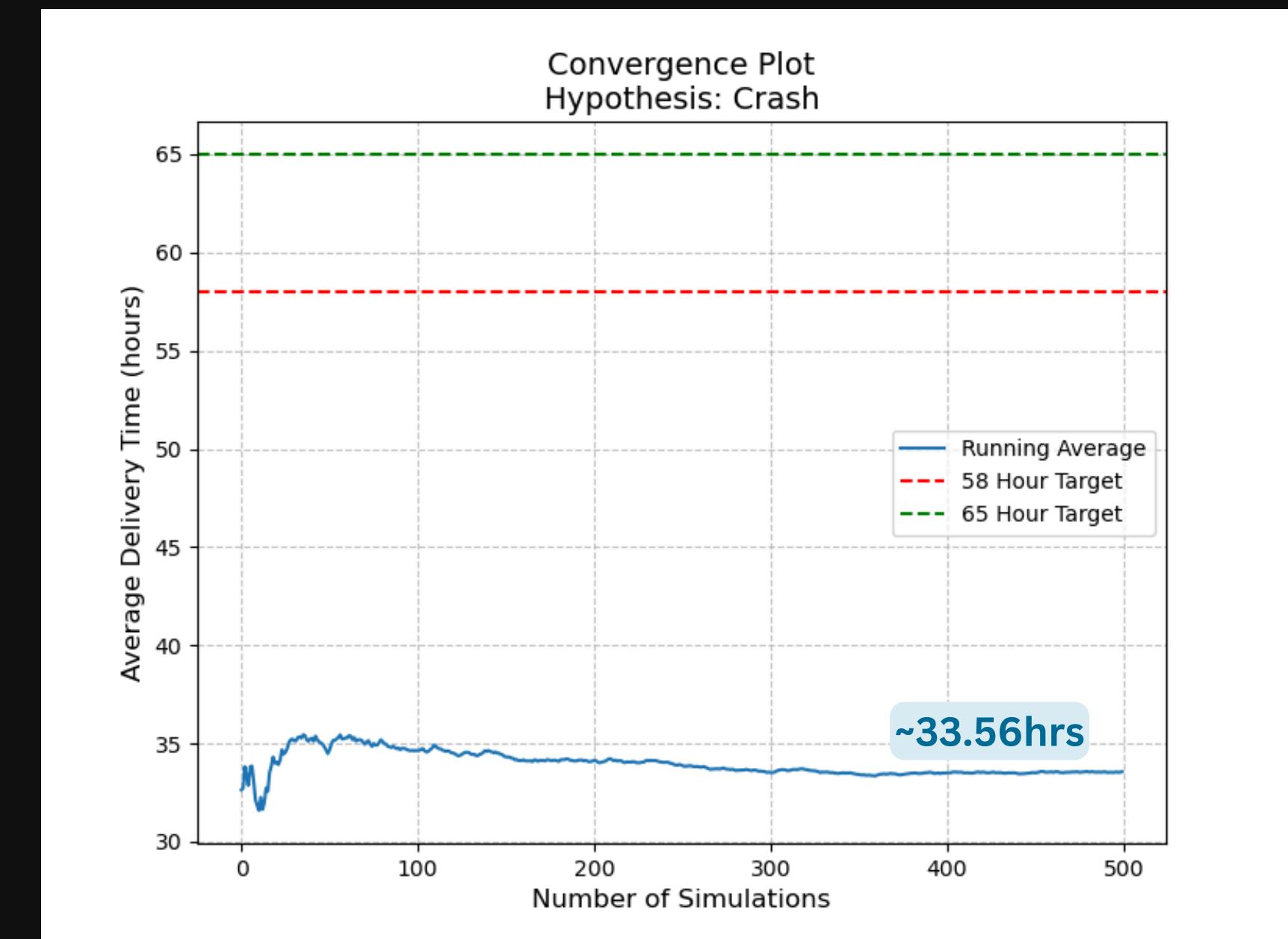
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ROAD or AIR?



Simulations run: 500
Average Time: 15.39 hrs
Minimum Time: 3.71 hrs
Maximum Time: 32.51 hrs
Standard Deviation: 6.09 hrs

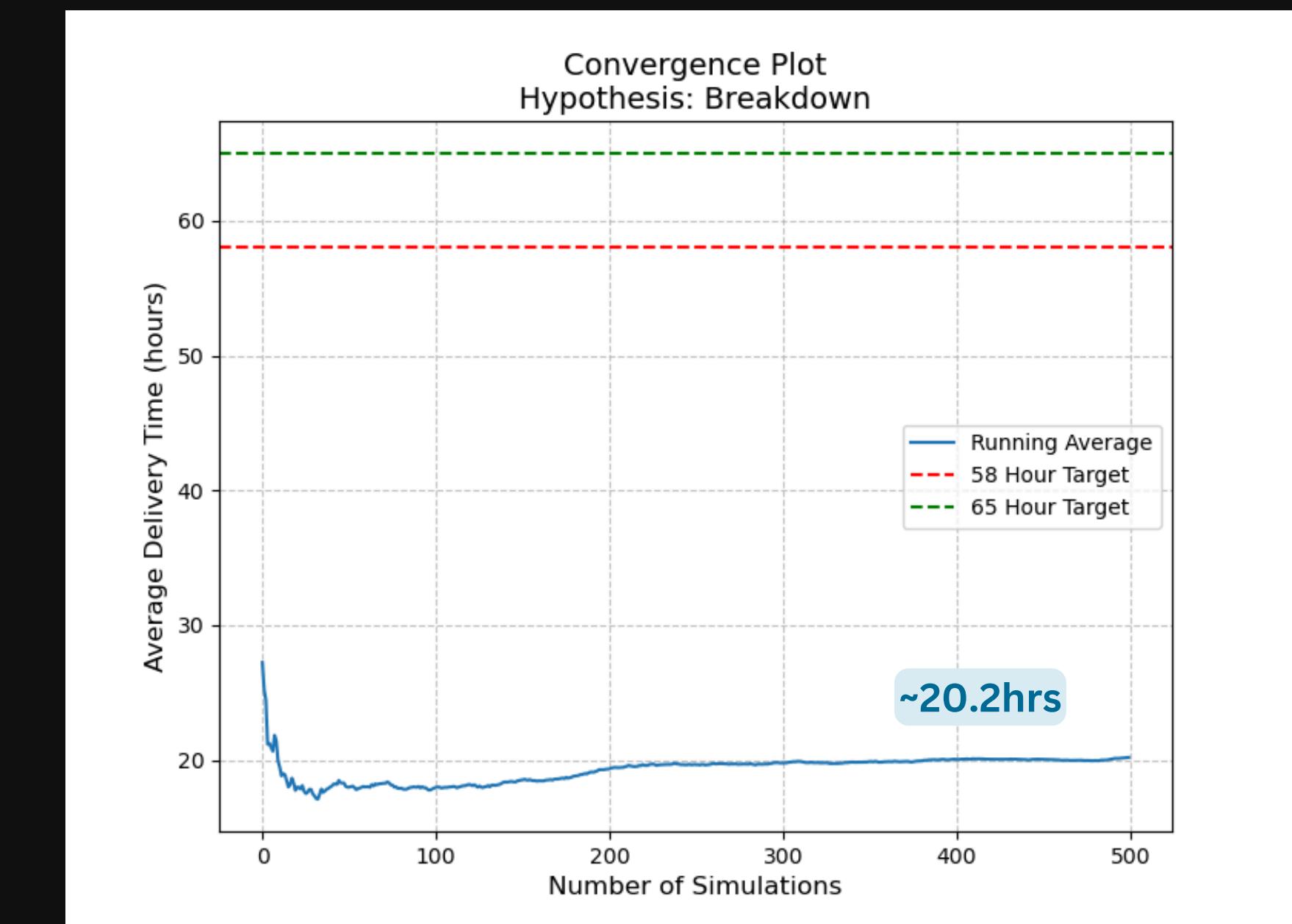
PHASE 3: EXPERIMENT H_1 - CRASH



- in none of the 500 runs, delivery time was less than ~19hrs
- it took almost 58hrs, ie closer to the deadline

Simulations run: 500
Average Time: 33.56 hrs
Minimum Time: 19.08 hrs
Maximum Time: 51.79 hrs
Standard Deviation: 6.83 hrs

PHASE 3: EXPERIMENT H₂



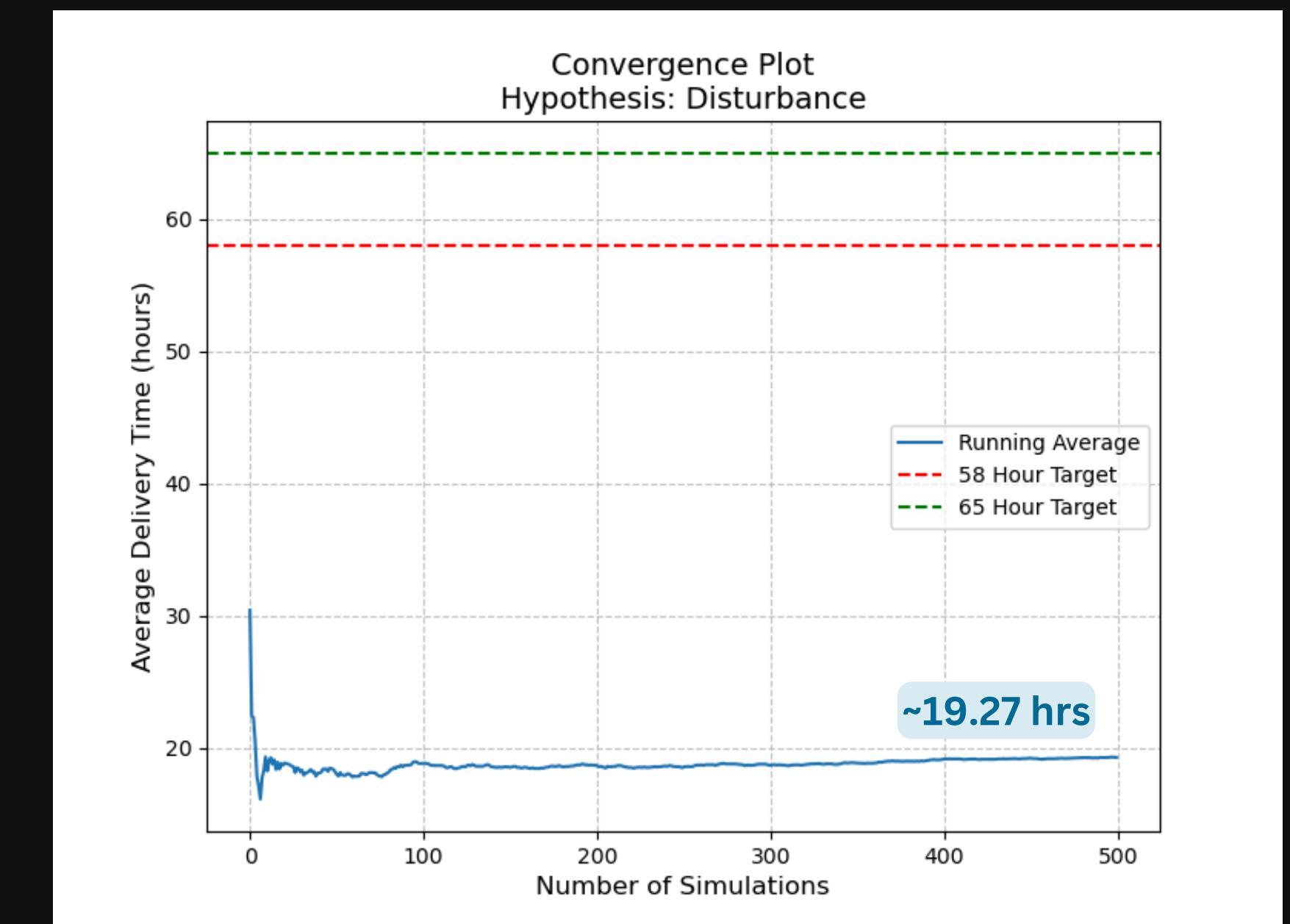
- it took almost 58hrs, ie closer to the deadline

Simulations run: 500
Average Time: 20.2 hrs
Minimum Time: 5.1 hrs
Maximum Time: 38.86 hrs
Standard Deviation: 6.55 hrs

PHASE 3: EXPERIMENT H₃



- it took almost 58hrs, ie even closer to the deadline!



Simulations run: 500
Average Time: 19.27 hrs
 Minimum Time: 4.84 hrs
 Maximum Time: 43.67 hrs
 Standard Deviation: 6.7 hrs

PHASE 3: EXPERIMENT - RESULTS

BASELINE

Simulations run: 500
Average Time: 15.39 hrs
Minimum Time: 3.71 hrs
Maximum Time: 32.51 hrs
Standard Deviation: 6.09 hrs

PARTS FROM HQ

Simulations run: 500
Average Time: 33.56 hrs
Minimum Time: 19.08 hrs
Maximum Time: 51.79 hrs
Standard Deviation: 6.83 hrs

BREAKDOWN

Simulations run: 500
Average Time: 20.2 hrs
Minimum Time: 5.1 hrs
Maximum Time: 38.86 hrs
Standard Deviation: 6.55 hrs

DISTURBANCE

Simulations run: 500
Average Time: 19.27 hrs
Minimum Time: 4.84 hrs
Maximum Time: 43.67 hrs
Standard Deviation: 6.7 hrs

If the numbers we assumed like the speed, are reasonable, then this system works well! **EVEN IN CASE OF CRASH, BREAKDOWN, DISTURBANCE**

Using road ways for races within the **same continent**, and when distance is **less than 4000km** (all other cases airways)

**THANK
YOU!**