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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?

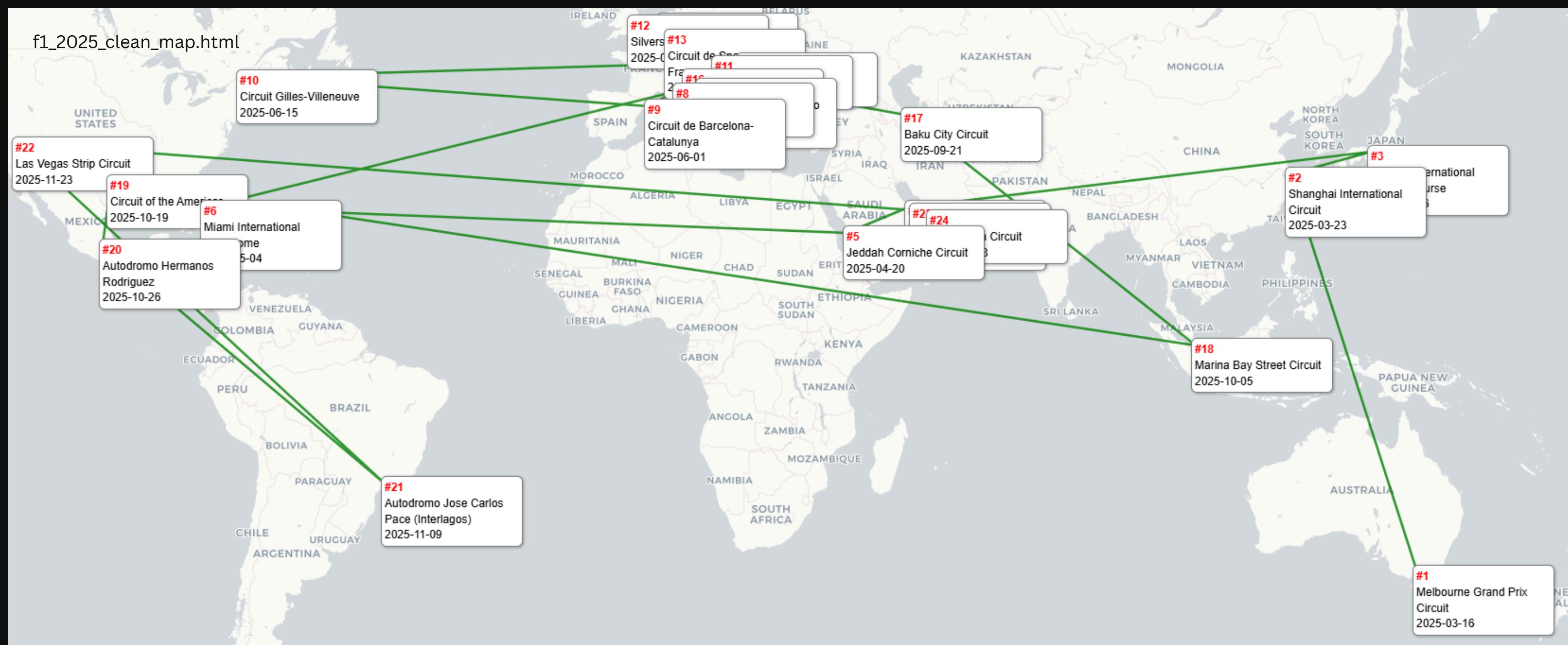
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MC Simulation Design,
Validation and
Experimentation

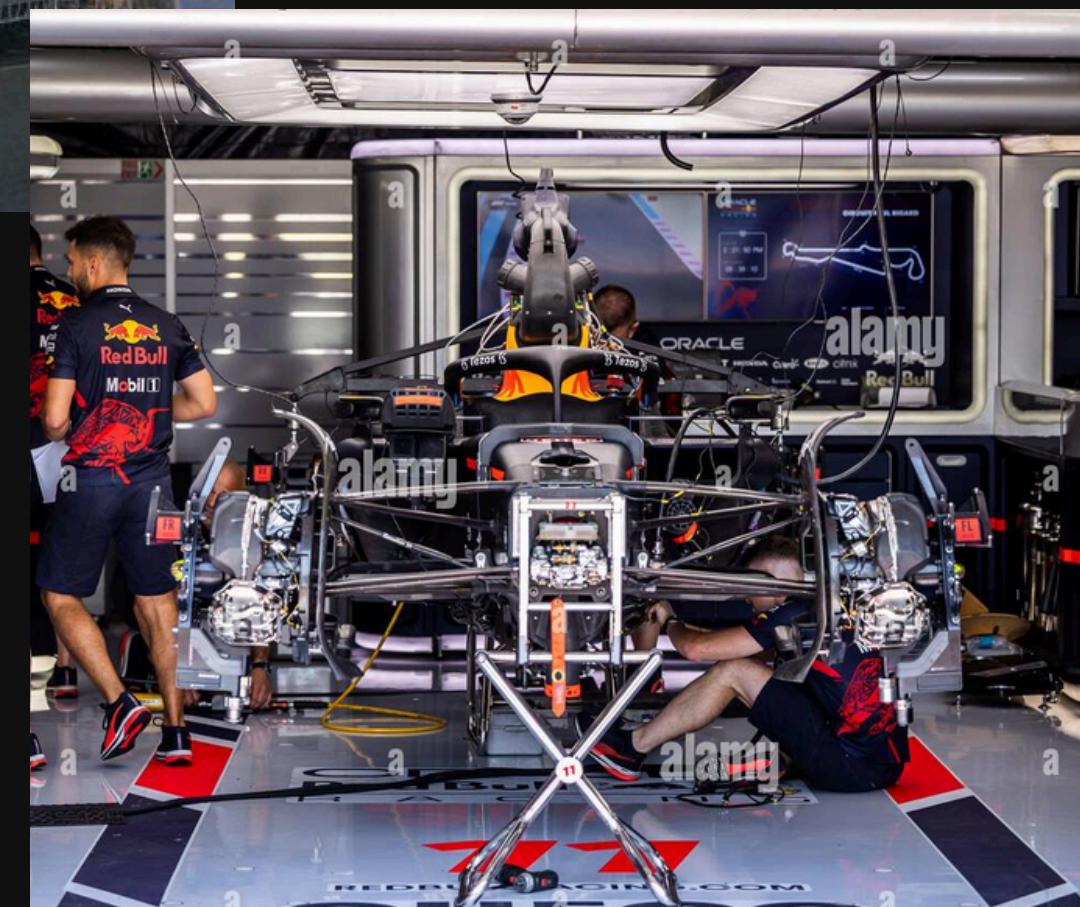
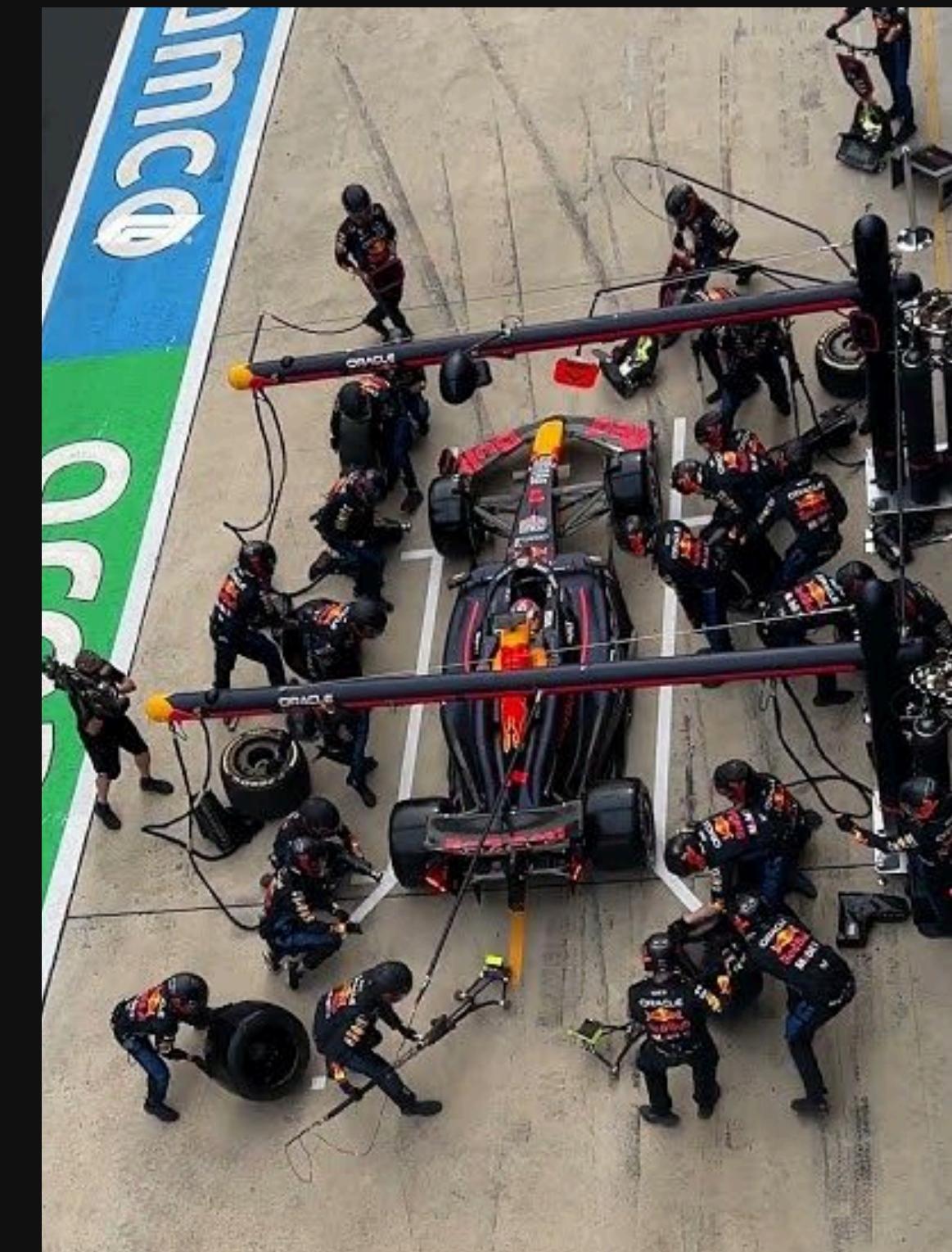
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Results and Challenges/
To Do list

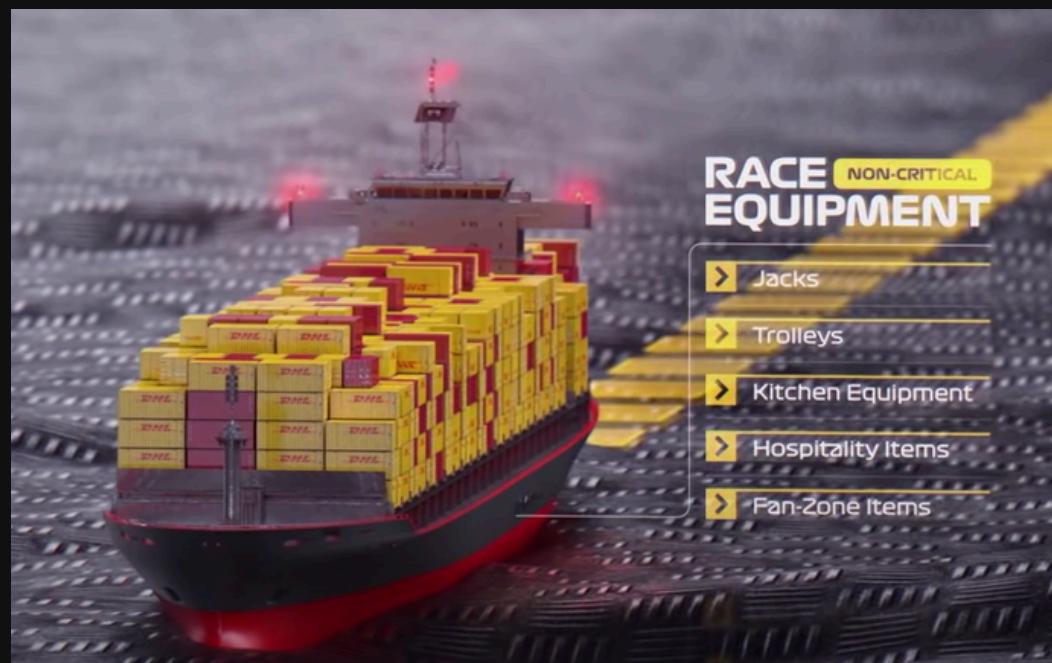
F1 LOGISTICS



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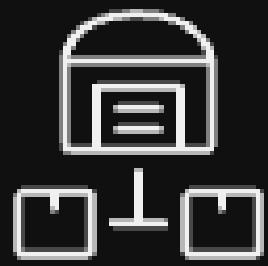
Non-priority palettes vs.
Priority palettes

Consecutive races Vs. non-consecutive races

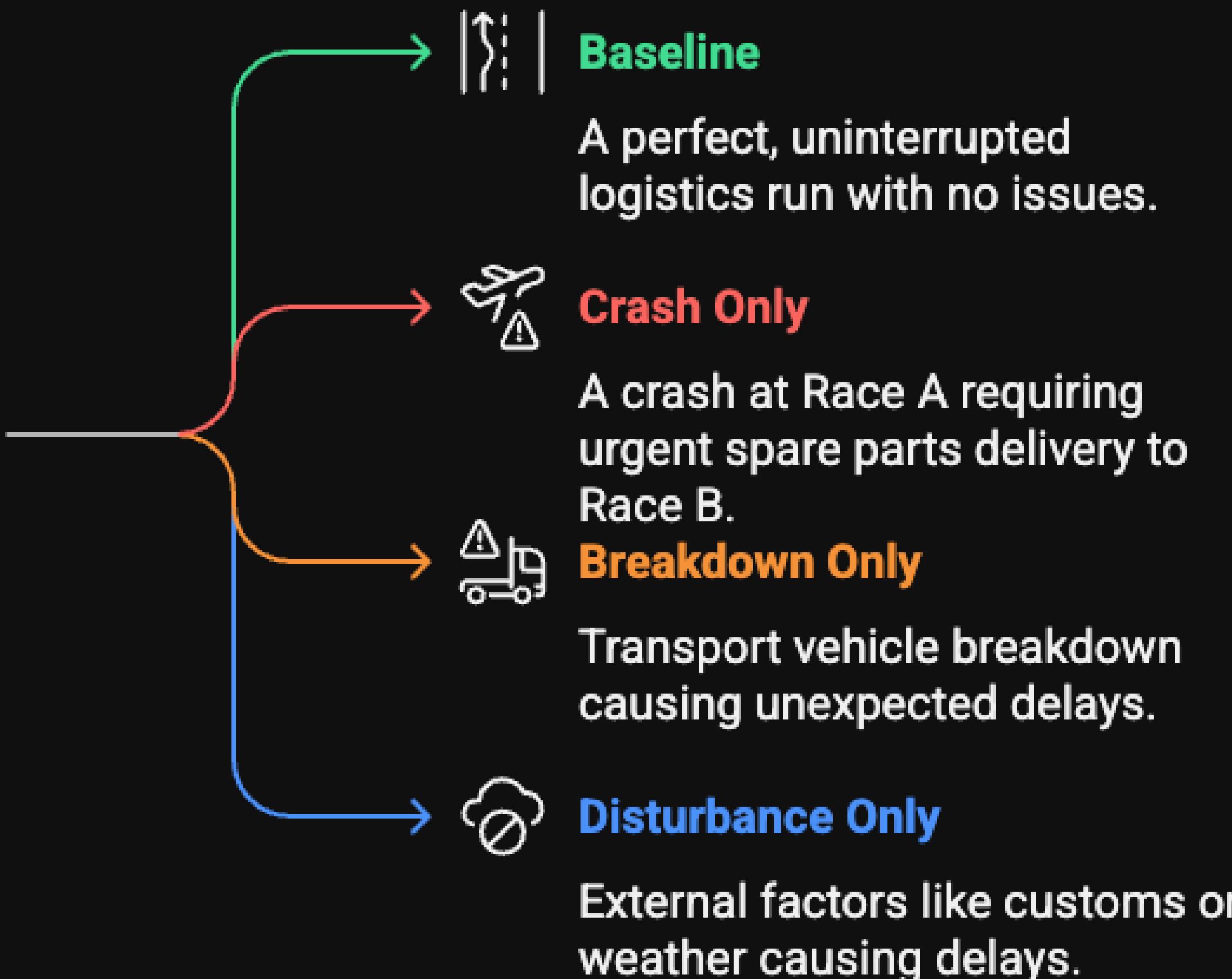
WHAT SHOULD HAPPEN?

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?



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
Buffer Time Allowed	Fixed	5 (Only for Airways)	Loading/Unloading Time
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
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)	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

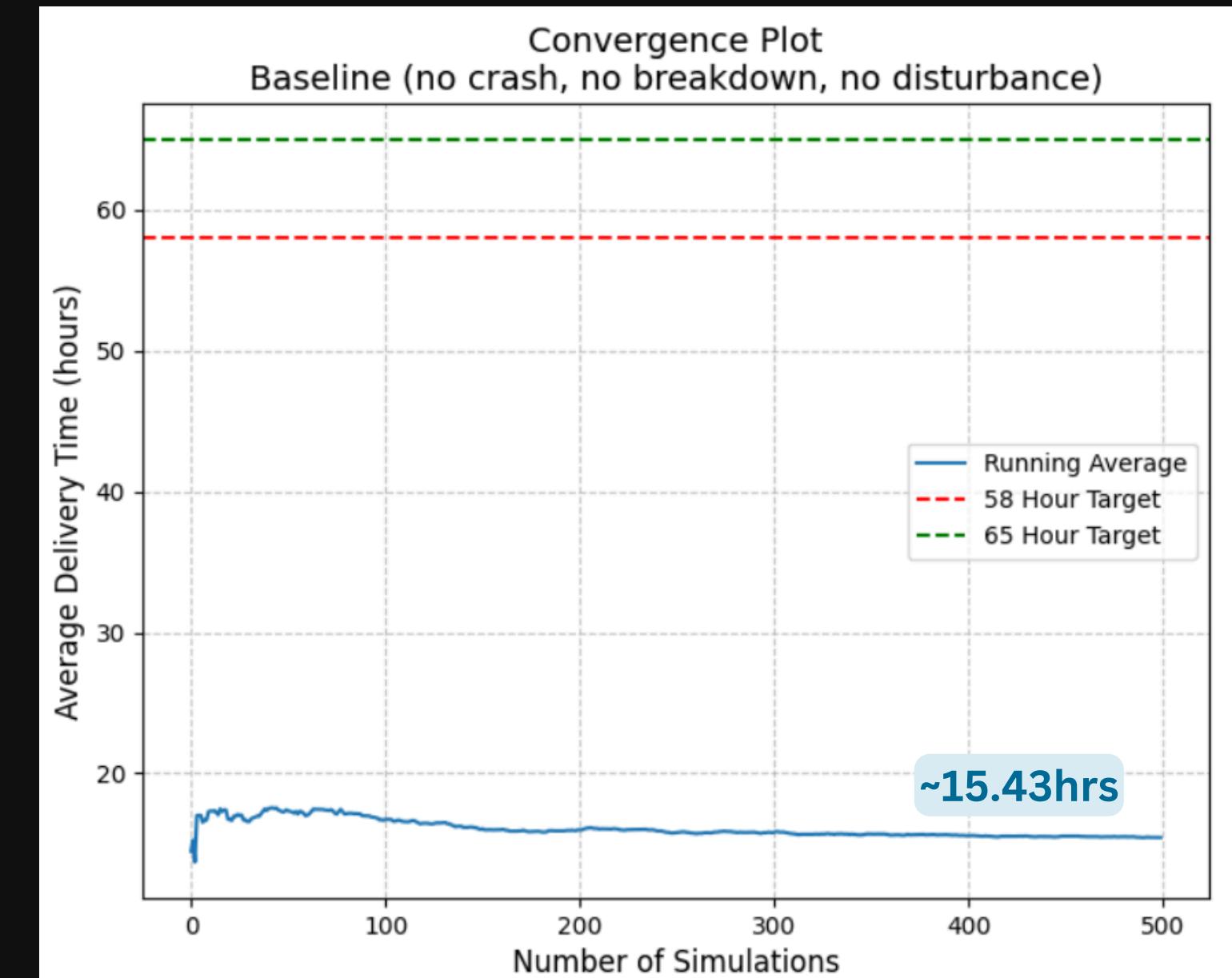
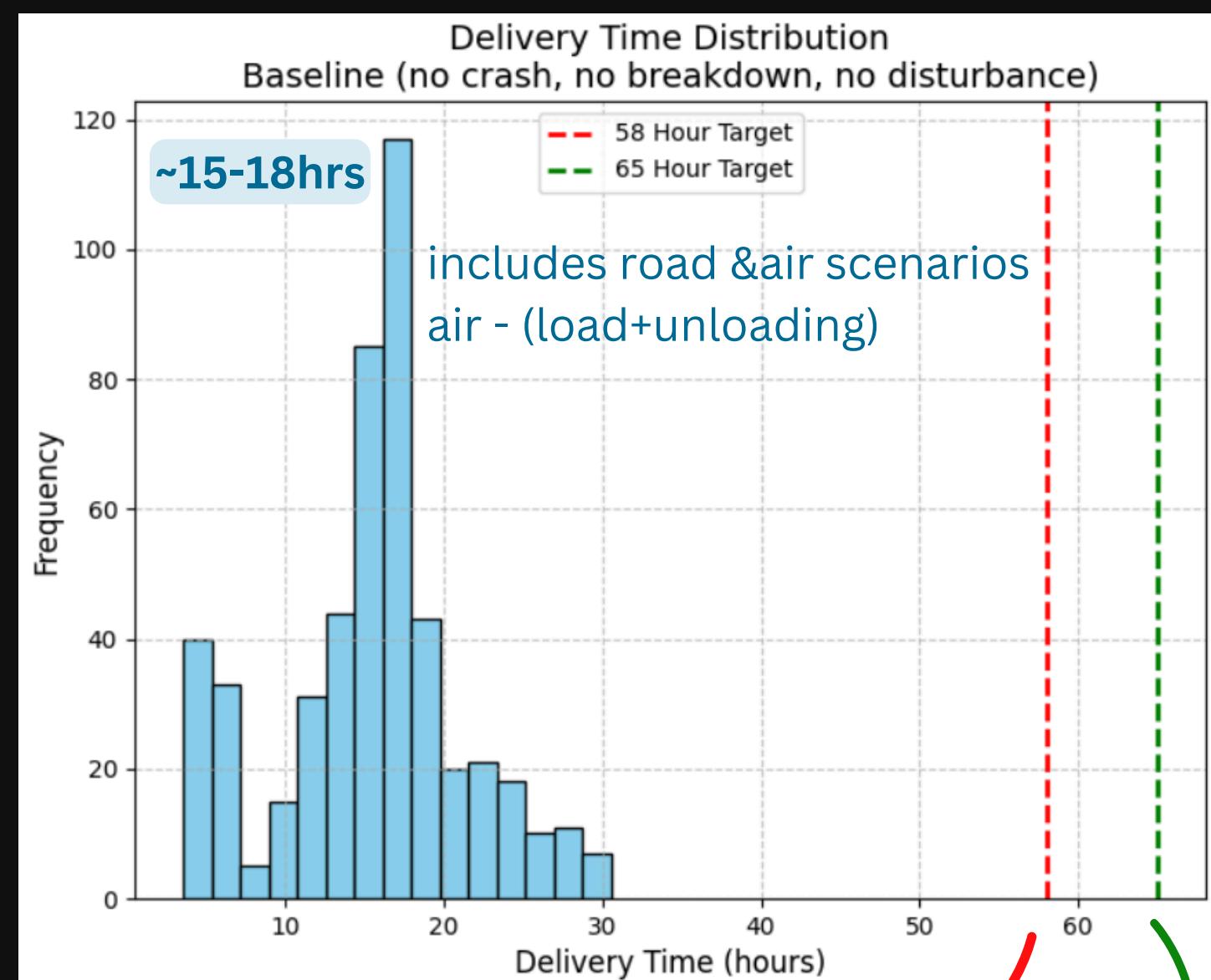
Back-to-Back races: 58hrs ~ little more than 2 days for Wednesday assembly!

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?

PHASE 2: VALIDATION USING H_0



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

ROAD or AIR?

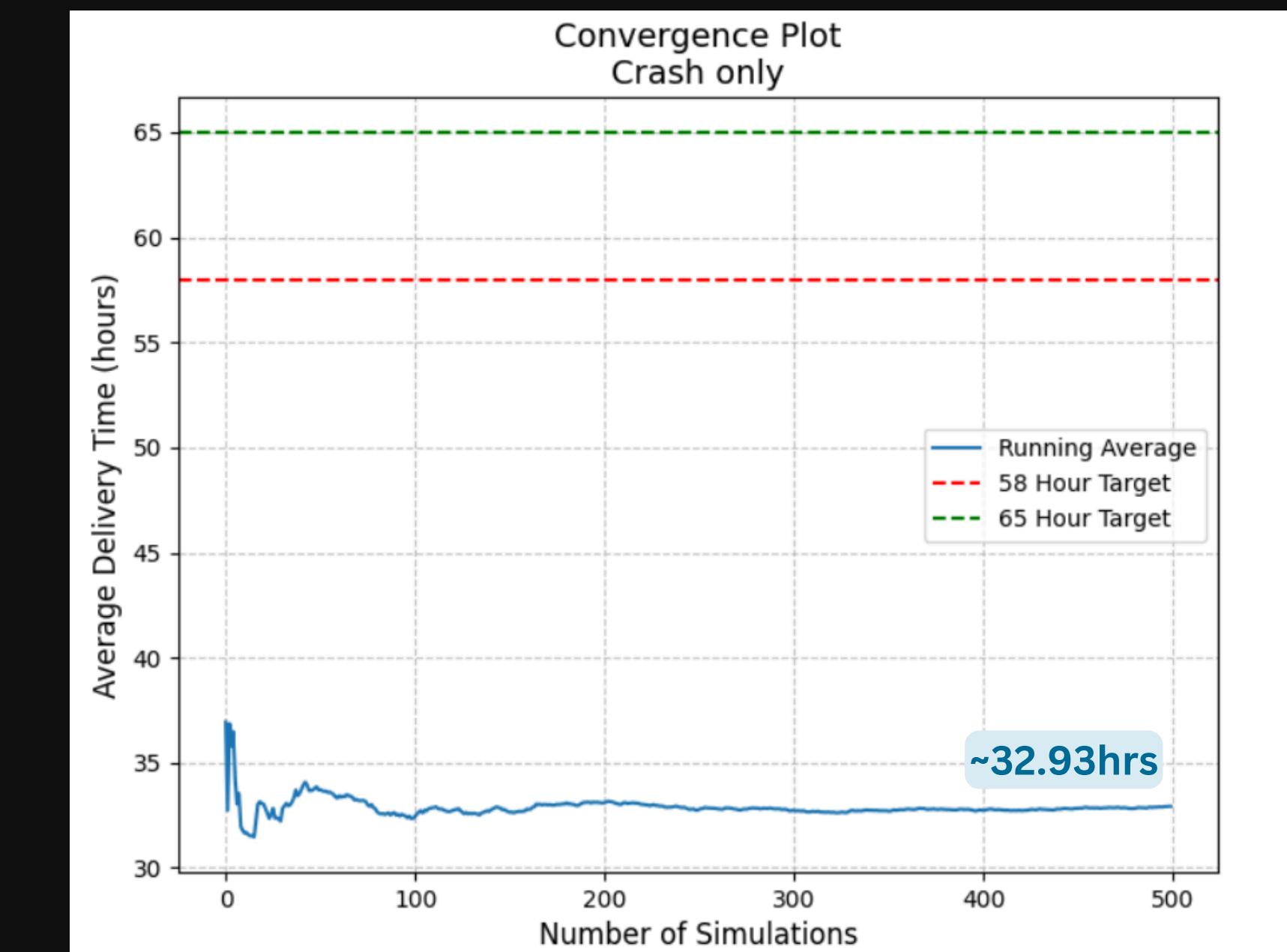
- Within the same continent
- less than 4000km

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

ROAD or AIR?

Simulations run: 500
Average Time: 15.43 hrs
Minimum Time: 3.55 hrs
Maximum Time: 30.54 hrs
Standard Deviation: 5.85 hrs

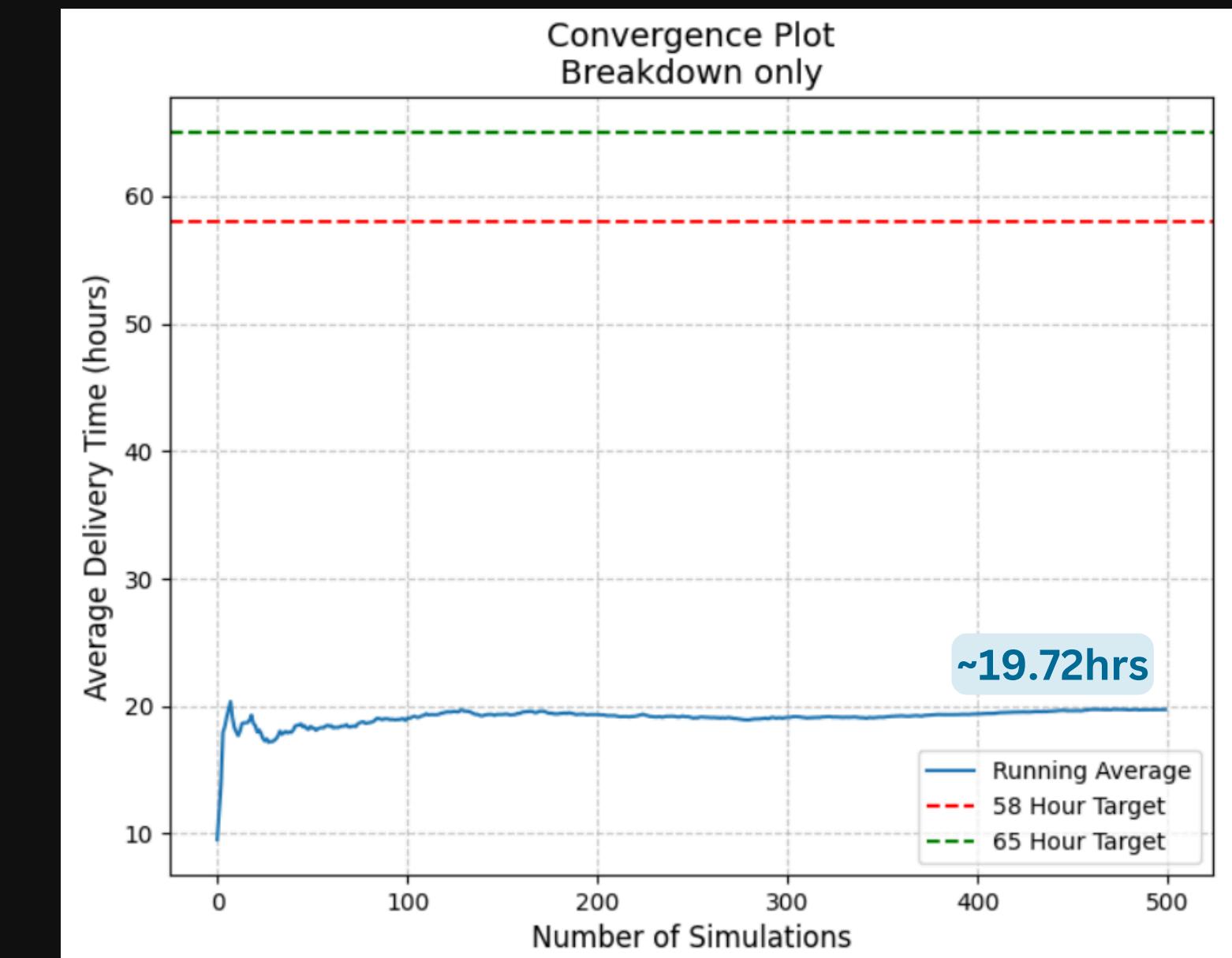
PHASE 3: EXPERIMENT H₁ - CRASH



- 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: 32.93 hrs
 Minimum Time: 19.31 hrs
 Maximum Time: 52.65 hrs
 Standard Deviation: 6.25 hrs

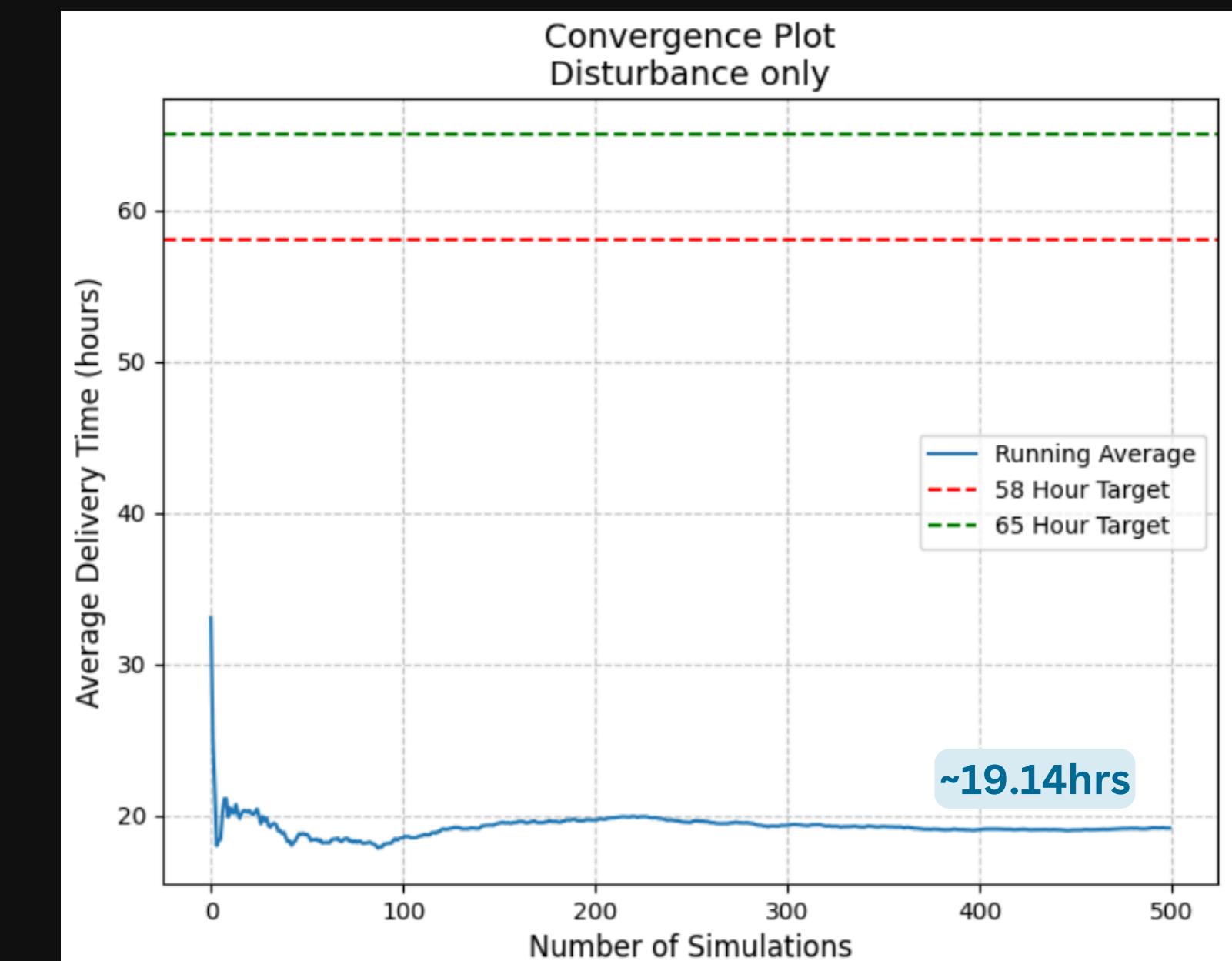
PHASE 3: EXPERIMENT H₂



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

Simulations run: 500
Average Time: 19.72 hrs
 Minimum Time: 5.36 hrs
 Maximum Time: 38.5 hrs
 Standard Deviation: 6.39 hrs

PHASE 3: EXPERIMENT H₃



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

Simulations run: 500
Average Time: 19.14 hrs
 Minimum Time: 4.18 hrs
 Maximum Time: 40.25 hrs
 Standard Deviation: 6.7 hrs

PHASE 3: EXPERIMENT - RESULTS

BASELINE

Simulations run: 500
Average Time: 15.43 hrs
Minimum Time: 3.55 hrs
Maximum Time: 30.54 hrs
Standard Deviation: 5.85 hrs

PARTS FROM HQ

Simulations run: 500
Average Time: 32.93 hrs
Minimum Time: 19.31 hrs
Maximum Time: 52.65 hrs
Standard Deviation: 6.25 hrs

BREAKDOWN

Simulations run: 500
Average Time: 19.72 hrs
Minimum Time: 5.36 hrs
Maximum Time: 38.5 hrs
Standard Deviation: 6.39 hrs

DISTURBANCE

Simulations run: 500
Average Time: 19.14 hrs
Minimum Time: 4.18 hrs
Maximum Time: 40.25 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) loading & unloading taking 5hrs or less

TO DO:

- Simulate using PERT - loading, unloading times too, not just assume 5hrs
- Include locations of airports and find the distance between tracks and the airports instead of assuming 20kms
- Crash Hypothesis - now we're considering the distance between "HQ" and the destination alone, but the other parts still come from the previous track
- more realistic - speed *cargo flights not trucks

We'd appreciate any suggestions from you!

1....

2....

**THANK
YOU!**