



Anushree Udhayakumar  
Rahul Balasubramani

April 30, 2025

# F1 LOGISTICS SIMULATION

All things that could go wrong

# TODAY'S AGENDA

1

What is this Logistics we  
are talking about?

2

What If?

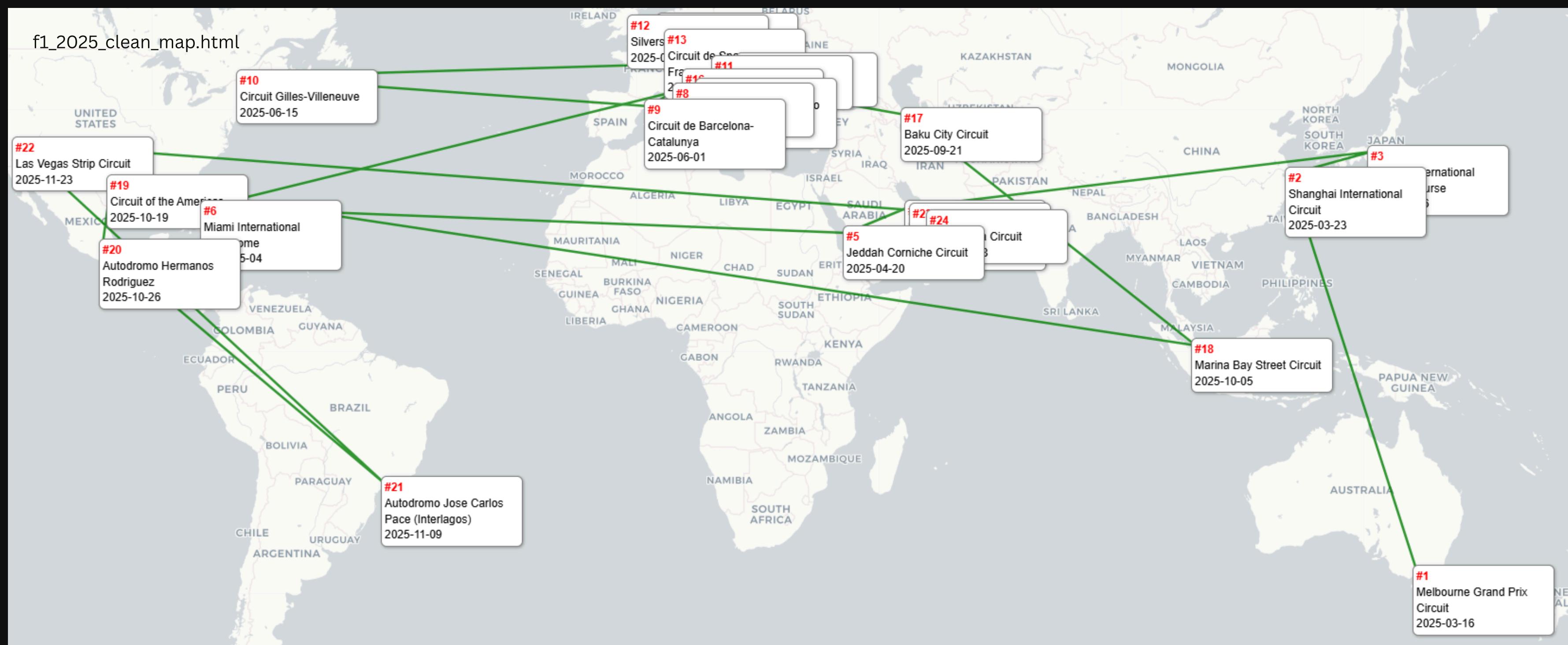
3

MC Simulation Design,  
Validation and  
Experimentation

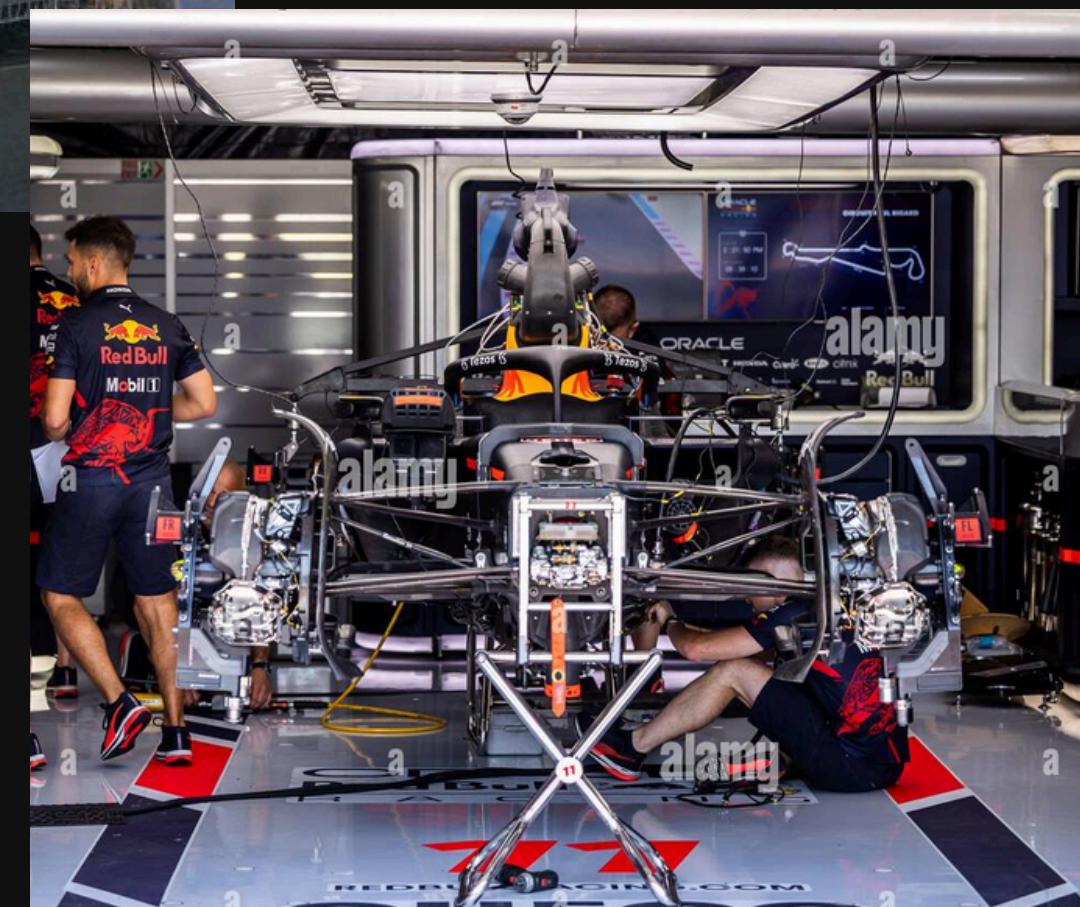
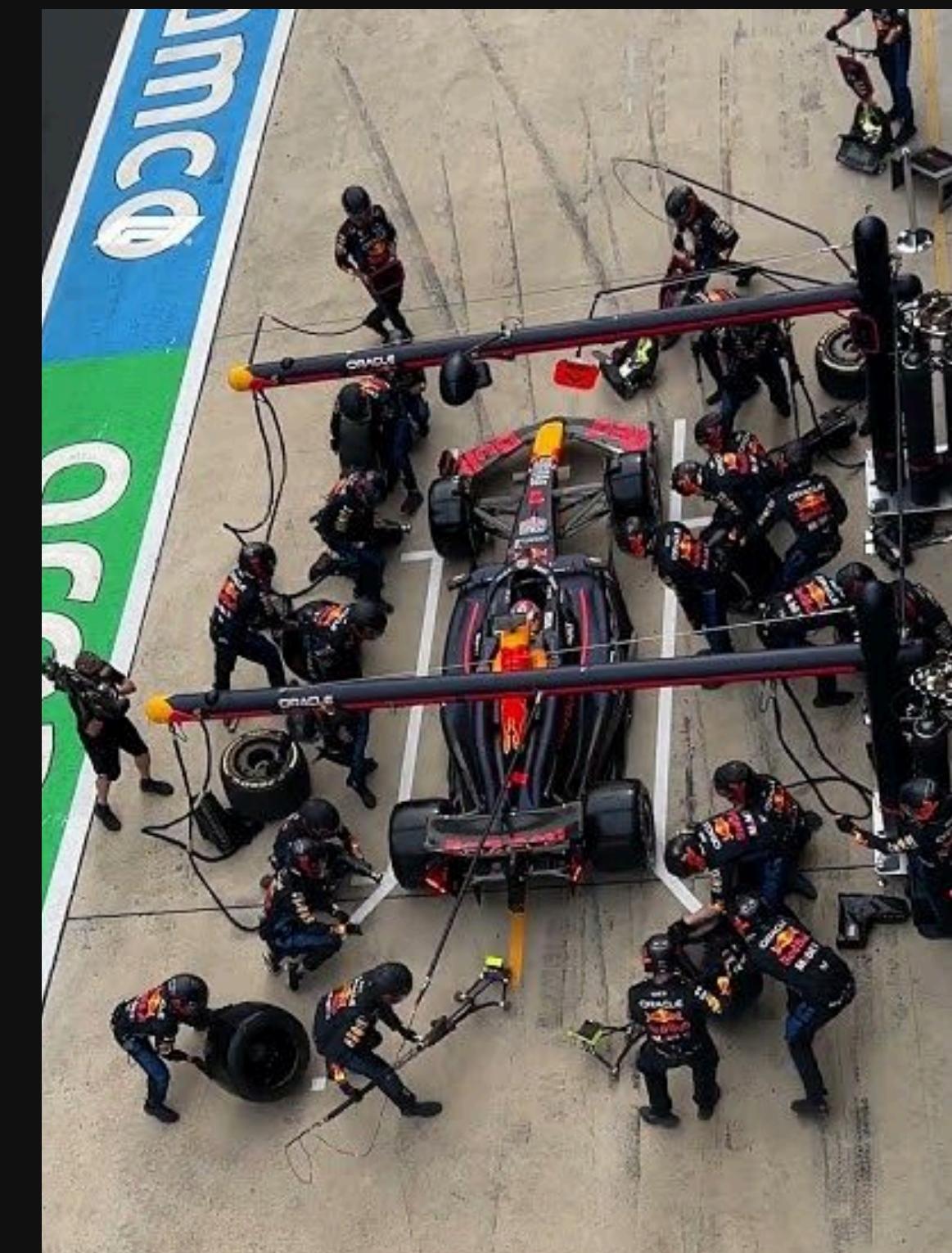
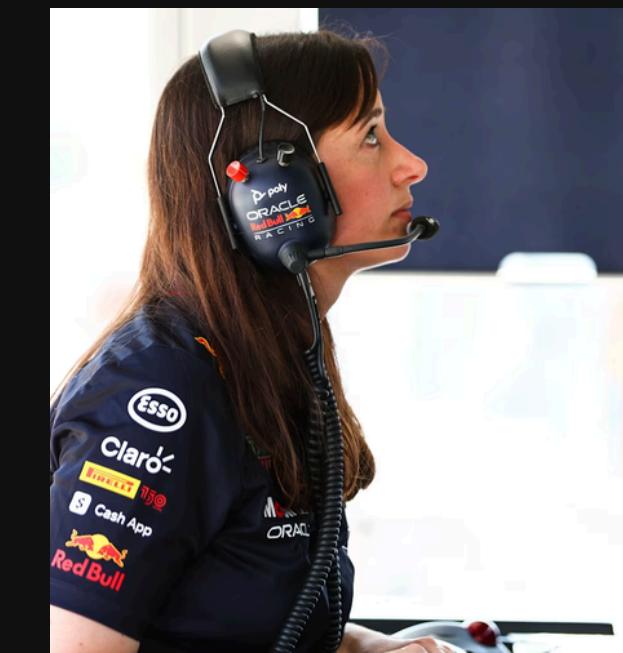
4

Results and Challenges/  
To Do list

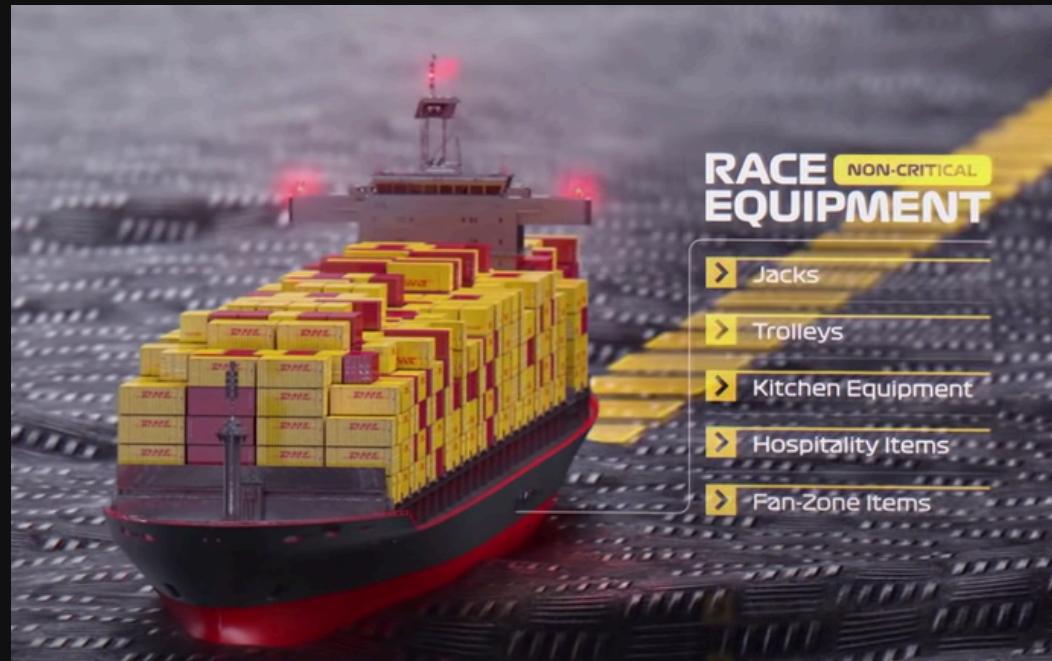
# F1 LOGISTICS



# F1 LOGISTICS



# F1 LOGISTICS



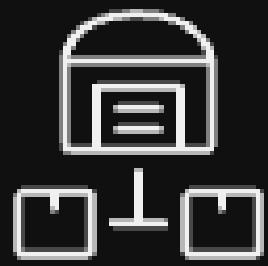
Non-priority palettes vs.  
Priority palettes

Consecutive races Vs. non-consecutive races

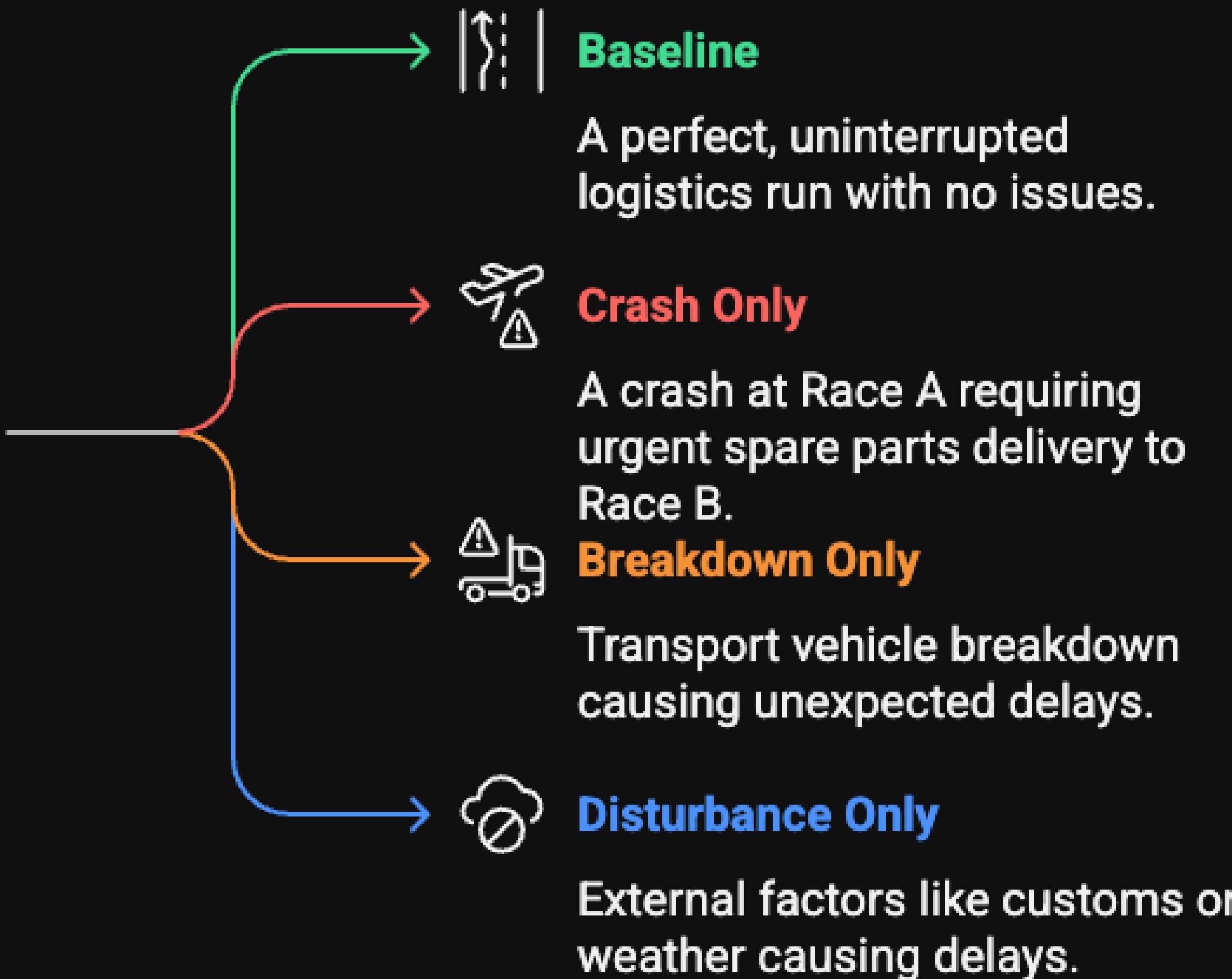
# WHAT SHOULD HAPPEN?

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

A race is cancelled due to severity threshold



### Cargo Rerouting

Cargo is rerouted to the next race location



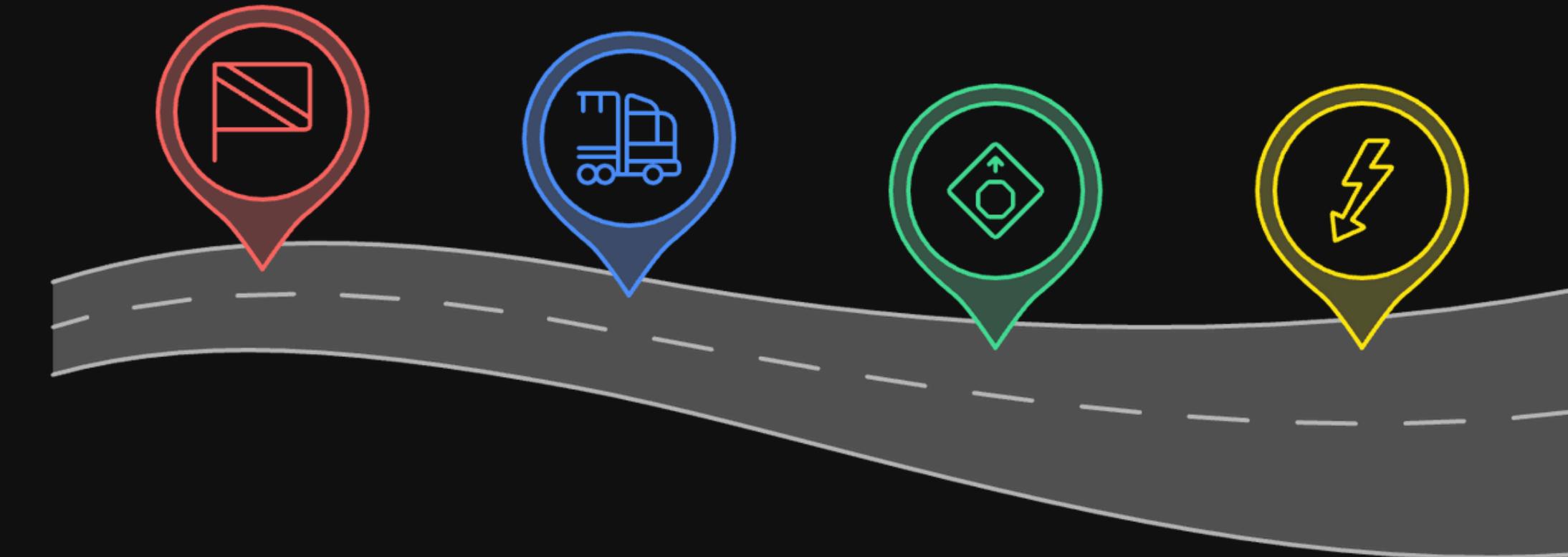
### Cargo Arrival

Cargo arrives at the next race location



### Severity Reduction

The transportation leg experiences disturbances



# 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  $\leq 4000$  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?

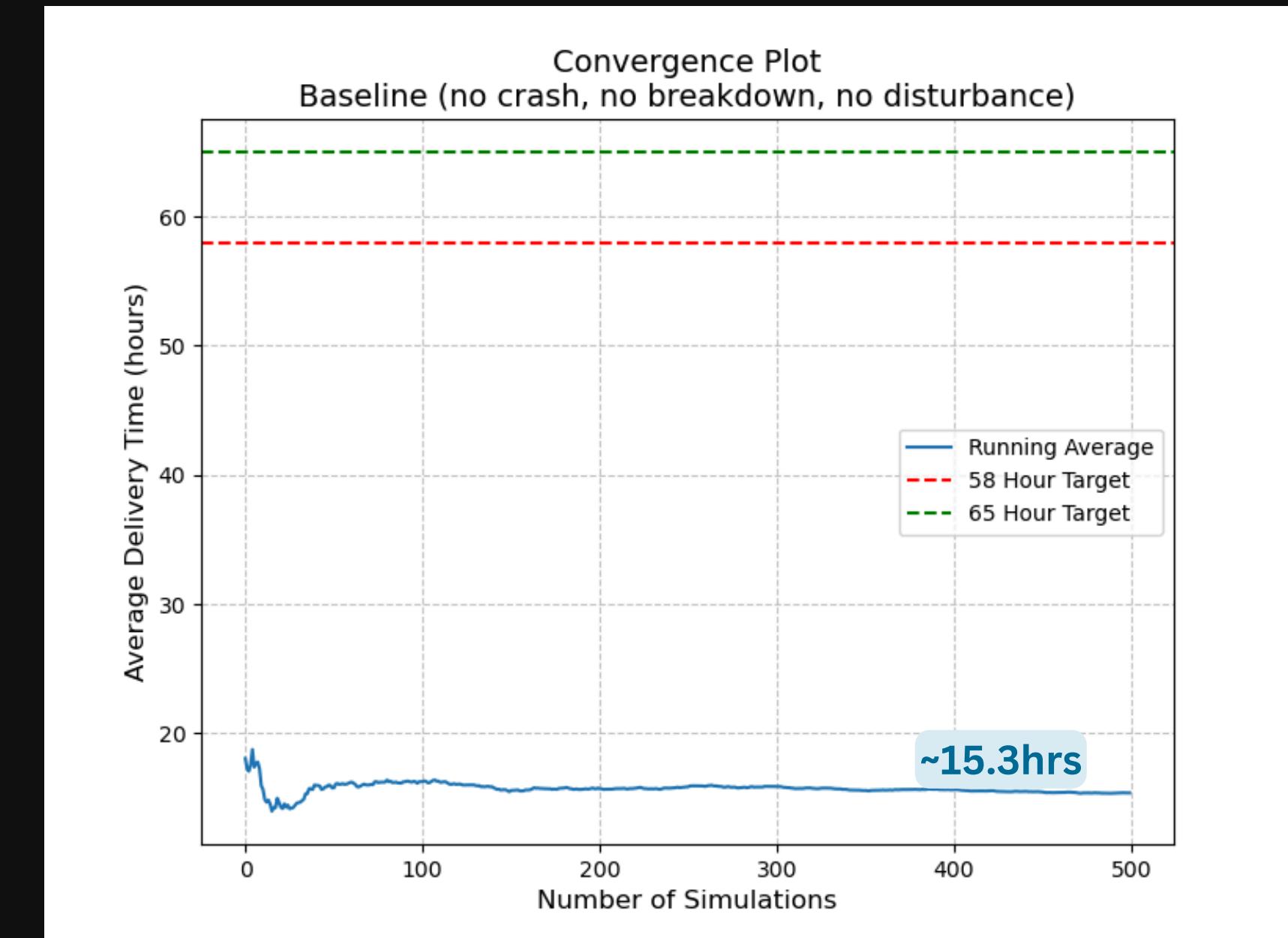
# PHASE 2: VALIDATION USING $H_0$



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

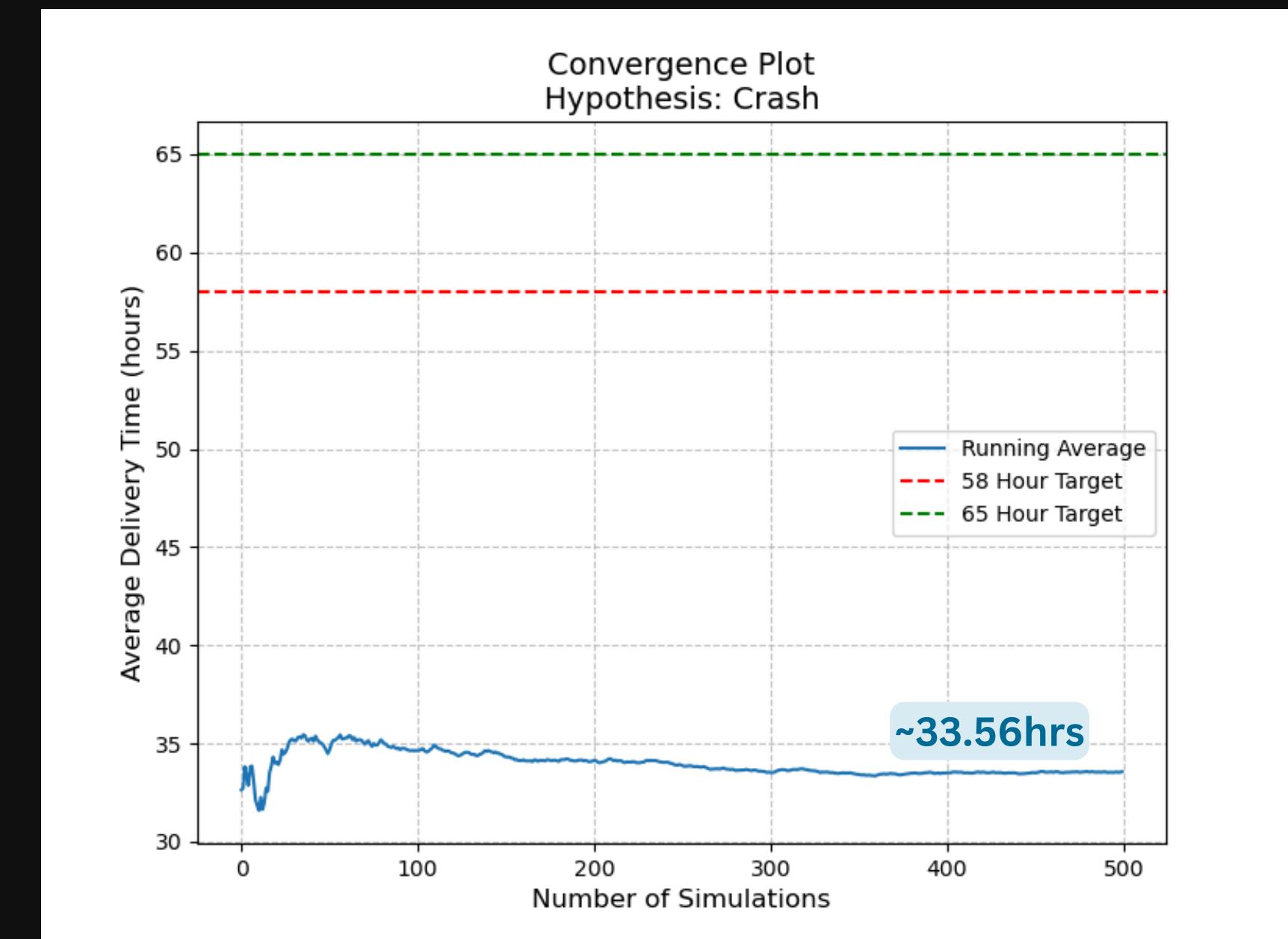
- Within the same continent
- less than 4000km

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: 15.39 hrs**  
Minimum Time: 3.71 hrs  
Maximum Time: 32.51 hrs  
Standard Deviation: 6.09 hrs

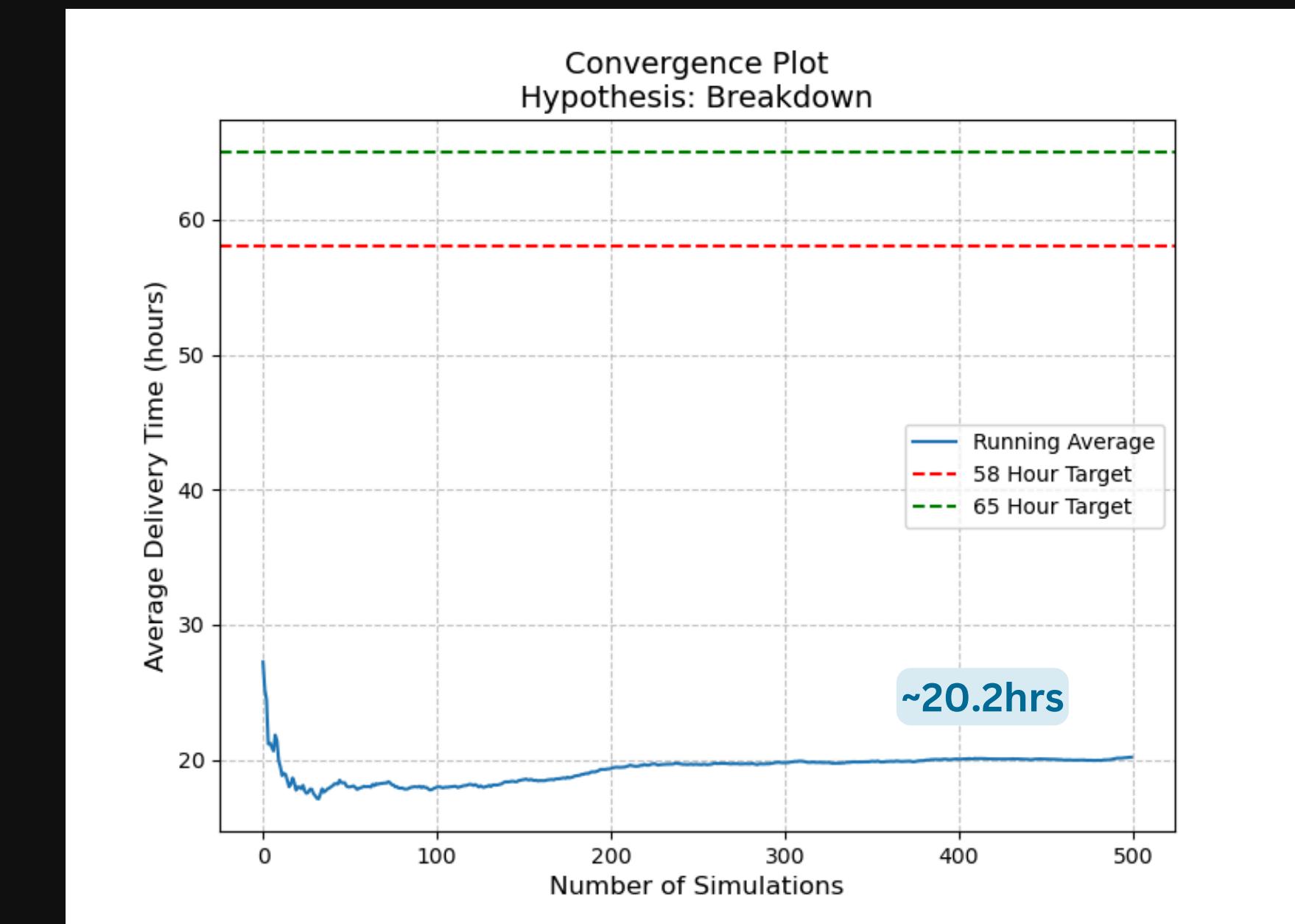
# PHASE 3: EXPERIMENT $H_1$ - CRASH



- 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 H<sub>2</sub>



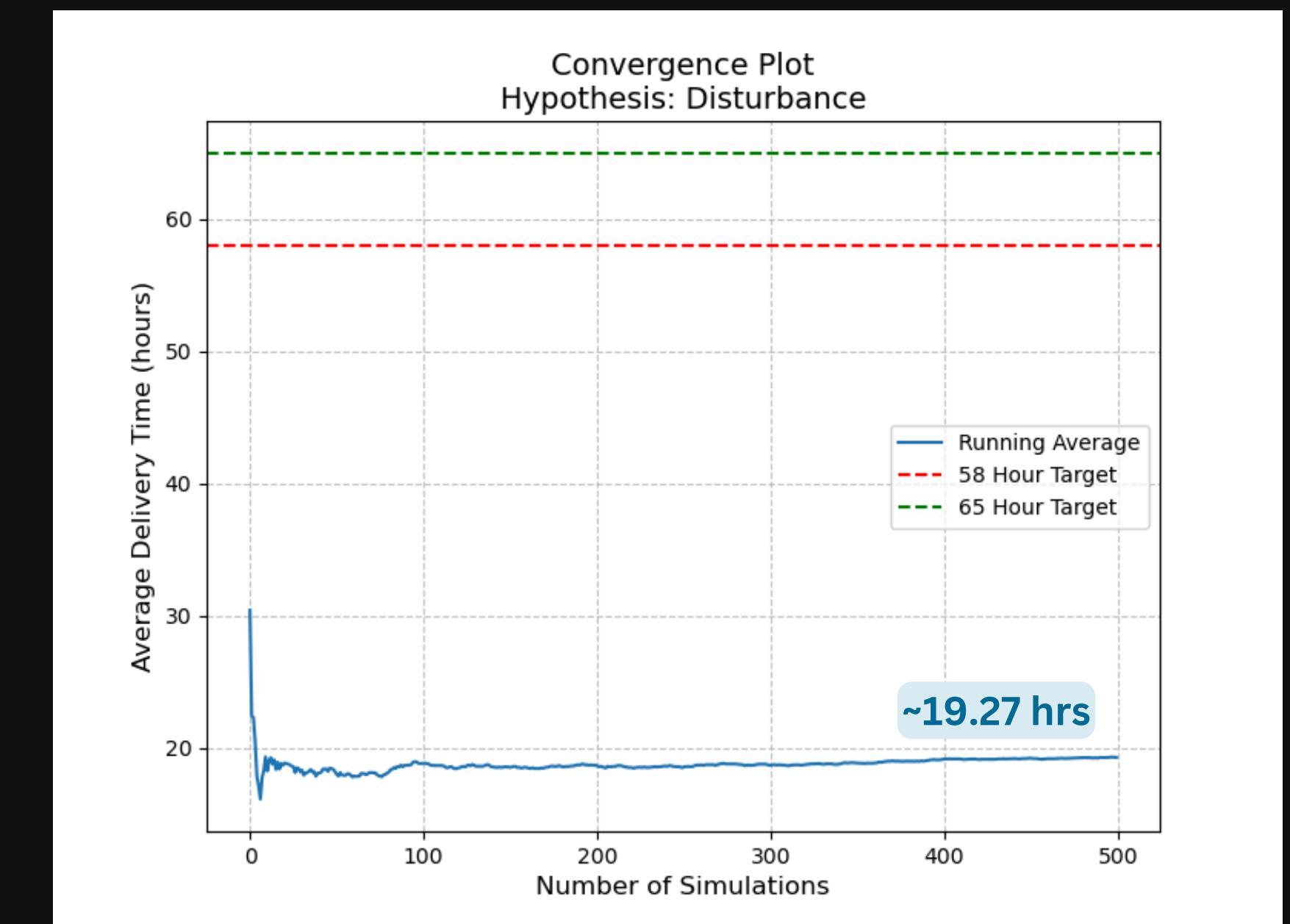
- it took almost 58hrs, ie closer to the deadline

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 H<sub>3</sub>



- 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!**