

Introduction

What shapes road traffic systems?

Interactions between vehicles, other road users, and the environment

But if interactions are so complex, then why do most situations stay safe?

Because drivers continuously adapt to different situation through small adjustments

But research mostly looks at crashes, right?

Yes, that's **Safety-I**, focusing on failures.

Is there another perspective?

Safety-II, it looks at how safety is actively maintained through everyday successful behaviour.

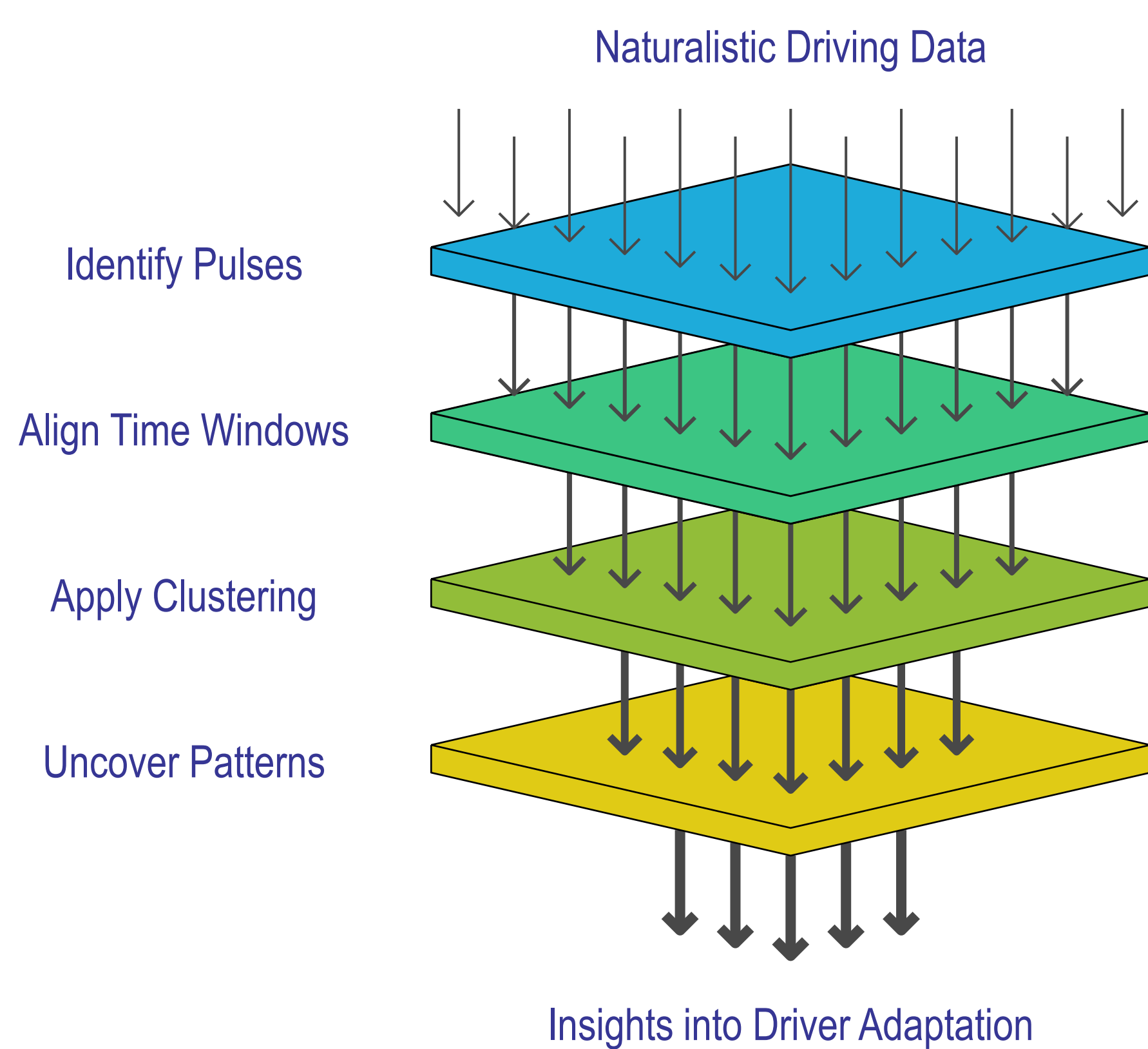
So...which one is better?

[AKWARD SILENCE]
Well! Depends who you ask....

Objectives

This study applies a Safety-II perspective to naturalistic driving data to identify and cluster short adaptation pulses, aiming to uncover recurrent speed-adjustment patterns in everyday driving.

Methodology



Dataset



Funded by EU Horizon 2020, designed to develop a "safety tolerance zone" for drivers

250 Drivers

5 Countries

49,000+ Trips

~2 M Driving minutes

Instruments: OBD-II loggers, Mobileye sensors, Dash cameras, Smartphone telematics, Cardio Gateway

Countries:

52 Drivers

16,748 Trips

~3,950 h of driving

Instruments: Speed, Acceleration, Headway

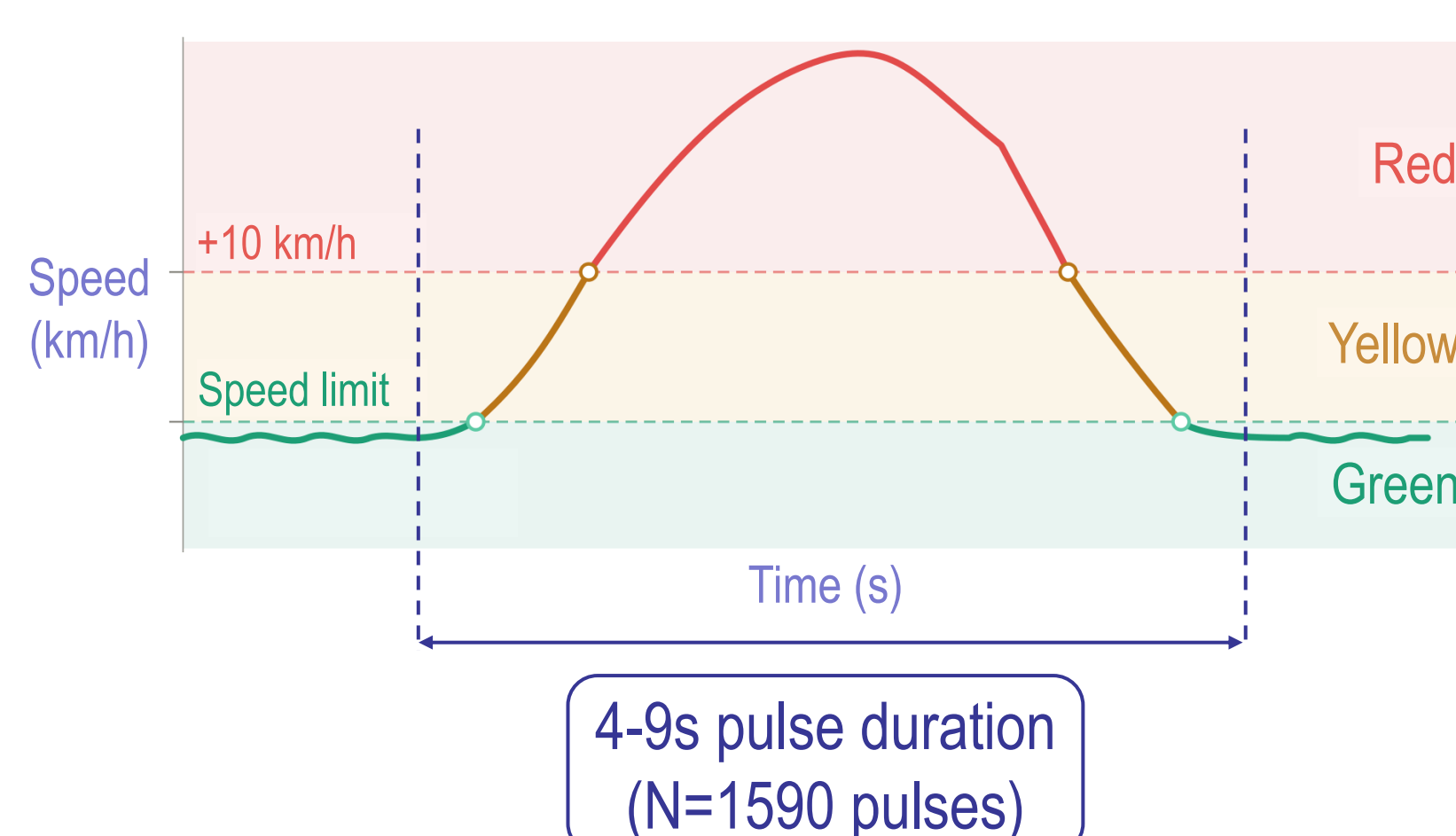
Basis for: Safety layers, Adaptation pulses

Methodology (Contd.)

Safety Layers



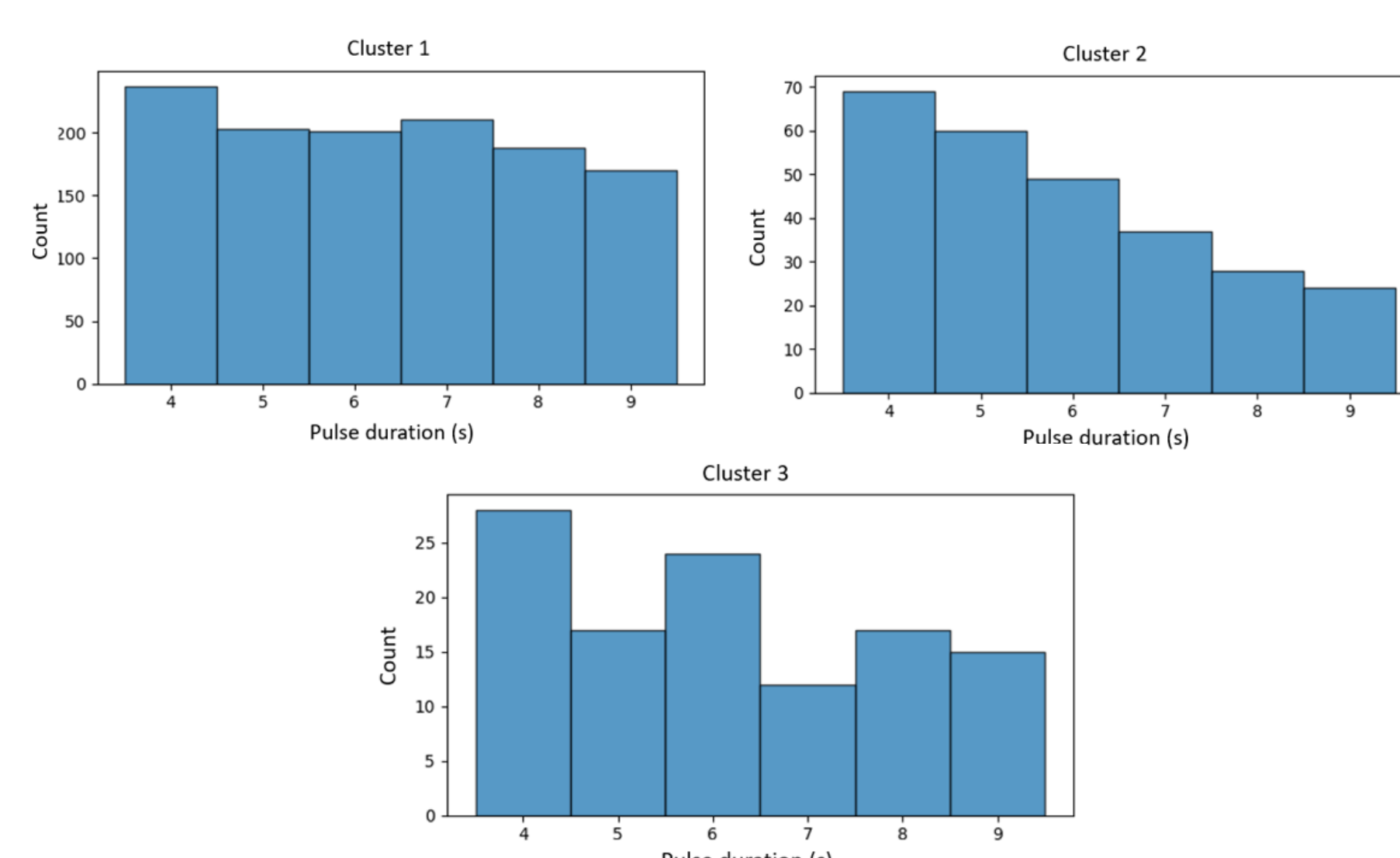
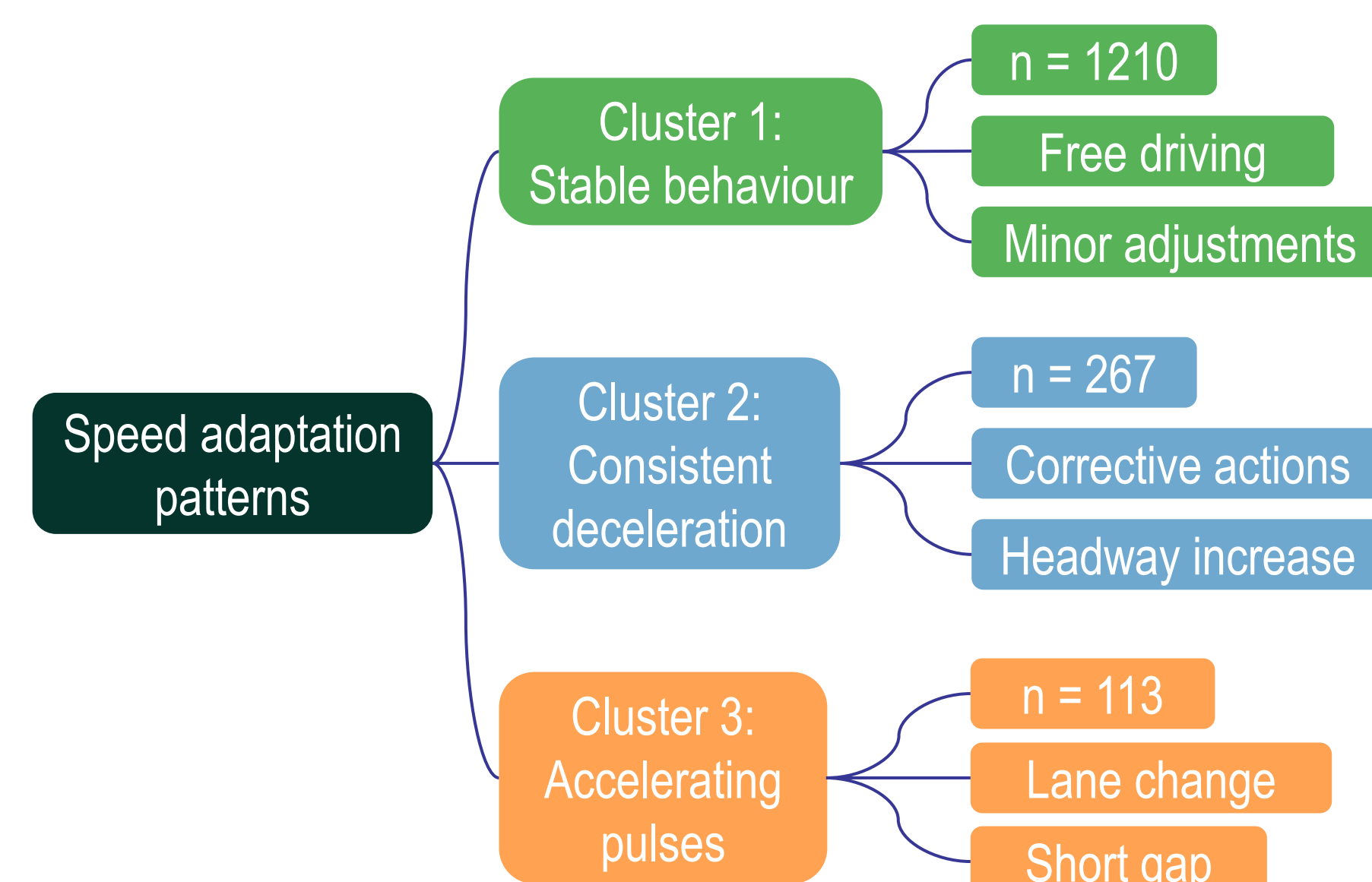
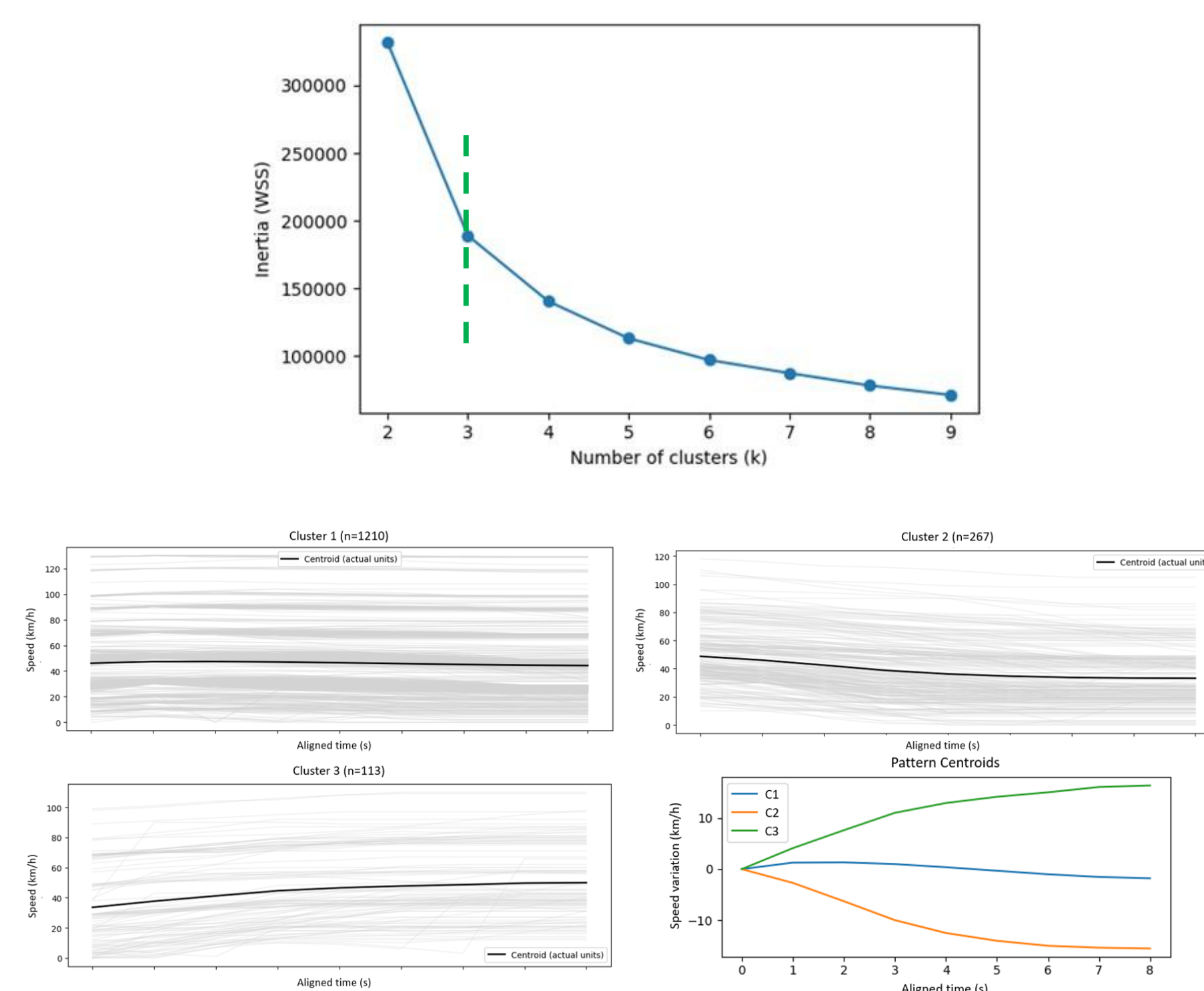
Pulse



Clustering

- Unsupervised **K-means** clustering is applied to identify recurrent speed-adaptation patterns.
- The optimal number of clusters is selected using the **elbow method**, and cluster centroids represent typical adaptation strategies.

Results



Results (Contd.)

How long do drivers remain in each safety layer across clusters?

The fraction of safety layers for each cluster.			
Cluster	Green	Yellow	Red
1	0.51	0.47	0.013
2	0.54	0.38	0.068
3	0.52	0.34	0.122

Conclusion & Future Work

Key Findings

- Three distinct speed-adaptation patterns** demonstrate that driver behaviour can be framed as continuous adaptation, rather than isolated safe or risky events.
- Pulse duration showed that **adaptation unfolds over short time windows, with variations across clusters.**
- Safety layer distributions revealed that **clusters differ in their exposure to Yellow and Red conditions**, indicating varying levels of risk involvement.
- Even a simple clustering of speed data provides initial insight into **how adaptation evolves over time, and how drivers recover from elevated risk.**

This study presents an initial way to frame driver behaviour through adaptation patterns, providing a basis for further analysis using richer data and extended Safety-II perspectives.

Future Works

Enhancing clustering

- Adding variables: Headway / Road Type / Automation intervention
- Better approaches: dynamic time wrapping (DTW)

Investigating recovery dynamics

- Focusing on recovery time distribution to find adaptation style

Using richer dataset

- To have precise safety layers definitions

About Project - IVORY

➤ **IVORY: "AI for Vision Zero in Road Safety"**

➤ **Partners:**

- 4 Universities
- 8 Non-academic partners
- 13 Associated partners
- 10 Countries



➤ **Framework:**

Within the framework of the Horizon Marie Skłodowska-Curie Actions (MSCA), IVORY is an industrial doctorates network, aiming to develop a new framework for the integration of AI in road safety.

➤ **Objectives:**

- Responsible and fair AI for road safety.
- Safe road users and human-vehicle-environment interaction by means of AI.
- Scalable and equitable AI technologies for proactive infrastructure safety management.
- A sustainable learning, knowledge sharing and networking platform on AI for road safety.

Acknowledgements



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101119590

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