3RD SIIV INTERNATIONAL WINTER SCHOOL

The European CCAM Ecosystem and the i4Driving Project

Vincenzo Punzo, *University of Naples FEDERICO II*

i4Driving

integrated **4D** dri**v**er modelli**ng** under uncertainty

SCIENCE ADVANCES | RESEARCH ARTICLE

ECONOMICS

Do transportation network companies decrease or increase congestion?

Gregory D. Erhardt[1]*, Sneha Roy[1], Drew Cooper[2], Bhargava Sana[2], Mei

This research examines whether transportation network companies (TNCs), suc
their stated vision of reducing congestion in major cities. Existing research ha
and has been hampered by a lack of data. Using data scraped from the appli
of two TNCs, combined with observed travel time data, we find that contrar
biggest contributor to growing traffic congestion in San Francisco. Between 2
hours of delay increased by 62% compared to 22% in a counterfactual 2016 sce
provide insight into expected changes in major cities as TNCs continue to grov
to integrate TNCs into the existing transportation system.

INTRODUCTION

Transportation network companies (TNCs) have grown rapidly in

miles traveled (VMT) in New
Whether a trip made by TNC adds traffic to the
which mode would have been used for the trip if TNC

Section:GDN BE PaGe:1 Edition Date:170616 Edition:01 Zone:N Sent at 15/6/2017 21:45

- Death toll rises to 17, as relatives face agonising wait for news
- May makes low-key visit to scene and announces public inquiry

£2.00 (IR €2.50)
Friday 16.06.17
Published in London
and Manchester
theguardian.com

theguardian

What if Uber kills off public transport rather than cars?

"All the News That's Fit to Print"

The New York Times

National Edition
Clouds and sunshine north. Afternoon showers. Partly cloudy south. Highs in the 40s north to 60s south. Cloudy north tonight. Clear south. Weather map appears on Page A16.

VOL. CLXVI . . . No. 57,529 © 2017 The New York Times Company TUESDAY, MARCH 7, 2017 Printed in Chicago $2.50

Flocking to Uber and Lyft, Commuters Inch Through New York

By EMMA G. FITZSIMMONS and WINNIE HU

When Uber arrived in New York City in 2011, subway ridership was soaring and the medallions required to drive a yellow cab were selling for a sky-high $1 million.

But Uber had an enticing offer: Your ride could appear at the touch of a button.

Six years later, Uber and other ride-hailing apps are booming, an army of nearly 50,000 licensed vehicles that ferry hundreds of thousands of people across the city every day.

Ride-hailing apps, like Uber and Lyft, are rapidly transforming

Nude Images of Female Marines Spur Inquiry of Male-Only Group

By DAVE PHILIPPS

Some photographs show female Marines posing topless in their dress uniform slacks, or with their camouflage blouses open, in pictures they thought would forever be secret. Others show private moments swiped from their personal social media sites.

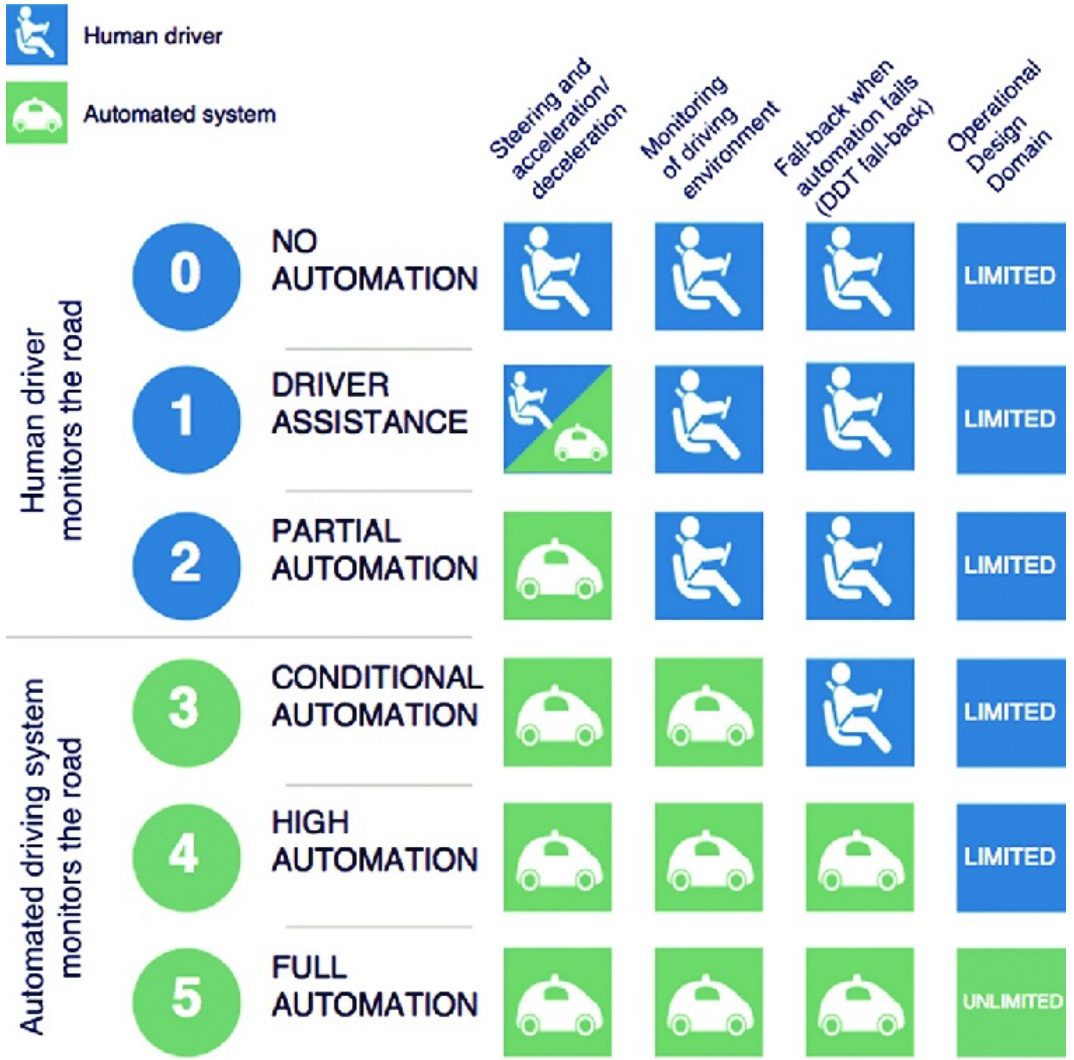
In one photograph, surreptitiously taken in February, a female corporal from Camp Lejeune, in North Carolina, is shown bent over from behind. The image, once posted online, was flooded with derogatory comments, including dozens of women's names, ranks, social media handles and where they are stationed.

The Marine Corps quickly condemned the all-male group, saying in a statement on Sunday that Marines United's conduct "destroys morale, erodes trust and degrades the individual." The Naval Criminal Investigation service has opened an investigation, and the Marine Corps said that any Marine who "directly participates in, encourages or condones" illicit activity could face court-martial. The Marine Corps declined

WHAT'S A REASONABLE FUTURE FOR CCAM?

- Competing goals and interests
- Road safety vs. traffic efficiency
- Market vs. regulation
- Competitiveness, economics, geopolitics, sustainability

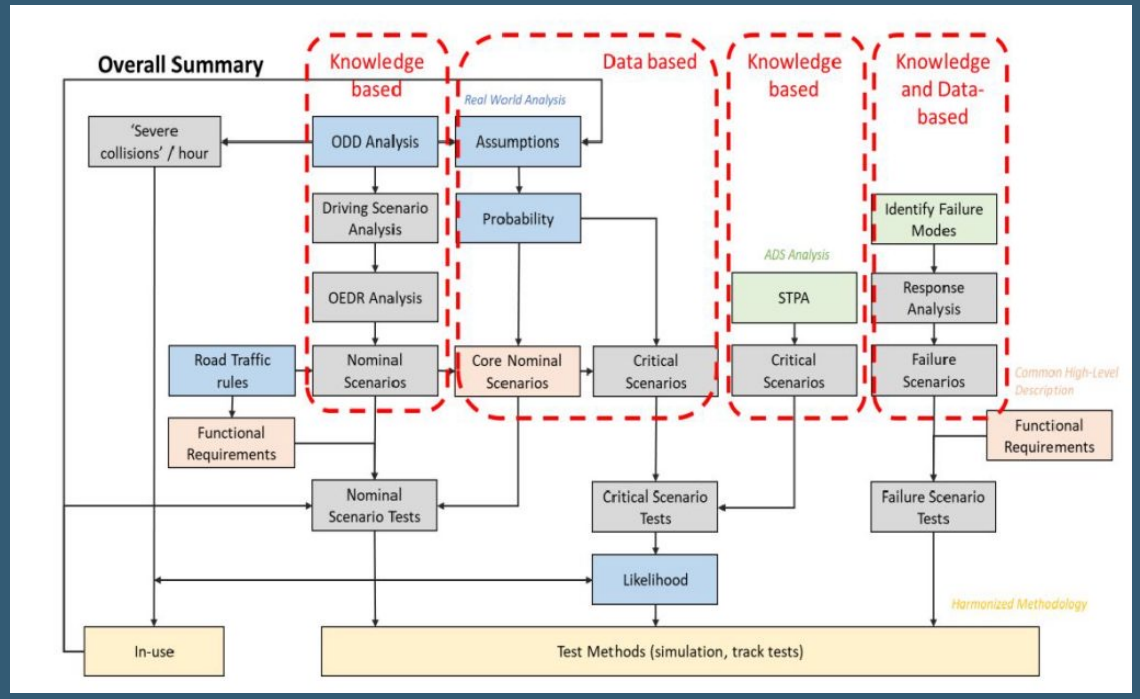
SAE LEVELS OF DRIVING AUTOMATION



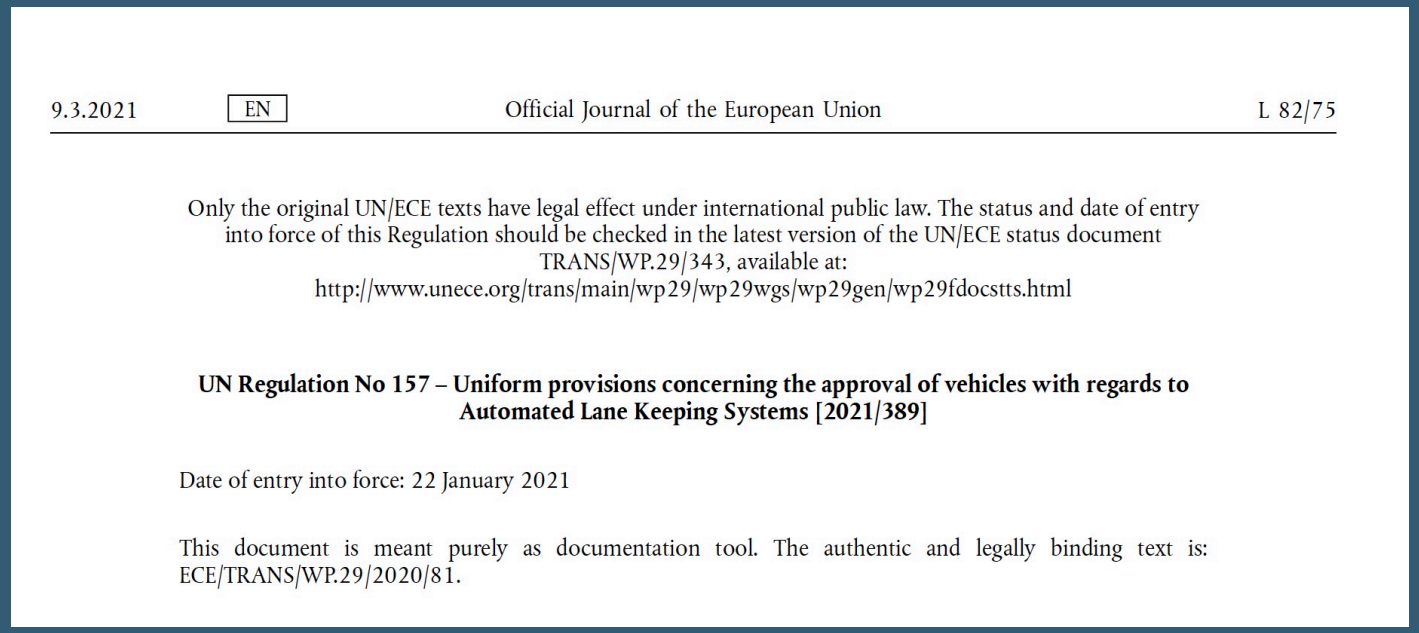
REGULATORY APPROACH: US VS. EU

- **Self certification:** The responsibility for the fulfilment of the regulations lies exclusively with the manufacturer. Authorities do not require or provide proof of premarket testing but reserve the right to inspect any vehicle on the road at any time. This system is used in North America (**USA and Canada**). https://youtu.be/kK772Vv0UIA

- **Third party system:** The authorities undertake the verification (**type approval**) and assign an independent third or expert to carry out and document the test. This system is established in **Europe.** If countries do not have their own regulations, they generally accept vehicles that are already registered in the known markets.



EUROPEAN REGULATION



9.3.2021 EN Official Journal of the European Union L 82/75

Only the original UN/ECE texts have legal effect under international public law. The status and date of entry into force of this Regulation should be checked in the latest version of the UN/ECE status document TRANS/WP.29/343, available at: http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29fdocstts.html

UN Regulation No 157 – Uniform provisions concerning the approval of vehicles with regards to Automated Lane Keeping Systems [2021/389]

Date of entry into force: 22 January 2021

This document is meant purely as documentation tool. The authentic and legally binding text is: ECE/TRANS/WP.29/2020/81.

UN REGULATION 157 ON ALKS

General Requirements Of Automated Lane Keeping Systems - ALKS

- ALKS controls the **lateral and longitudinal movement** of the vehicle for extended periods without further driver command. ALKS is a system whereby the activated system is in primary control of the vehicle.
- Regulation limits the operational speed to **60 km/h maximum** ("*traffic jam chauffeur*") and passenger cars (M1 vehicles).
- The activated system shall perform the DDT, shall manage all situations including failures, and shall be free of **unreasonable risks** for the vehicle occupants or any other road users.
- The activated system shall not cause any collisions that are reasonably **foreseeable and preventable**
- The activated system shall comply with **traffic rules** relating to the DDT in the country of operation

Traffic Disturbance Critical Scenarios

- TRAFFIC CRITICAL SCENARIOS
- Traffic disturbance critical scenarios are those which have conditions under which ALKS may not be able to avoid a collision.
- (a) **Cut-in**: the ‘other vehicle’ suddenly merges in front of the ‘ego vehicle’; (b) **Cut-out**: the ‘other vehicle’ suddenly exits the lane of the ‘ego vehicle’; (c) **Deceleration**: the ‘other vehicle’ suddenly decelerates in front of the ‘ego vehicle’;
- PERFORMANCE MODEL OF ALKS
- Traffic critical scenarios of ALKS are divided into preventable and unpreventable scenarios. The threshold for preventable/unpreventable is based on the simulated performance of a **skilled and attentive** human driver. It is expected that some of the ‘unpreventable’ scenarios by human standards may actually be preventable by the ALKS system.

Definitions

- ‘Operational Design Domain (ODD)’ of the automated lane keeping system defines the specific operating conditions (e.g. environmental, geographic, time-of-day, traffic, infrastructure, speed range, weather and other conditions) within the boundaries fixed by this regulation under which the automated lane keeping system is designed to operate without any intervention by the driver.
- ‘Dynamic Driving Task (DDT)’ is the control and execution of all longitudinal and lateral movements of the vehicle.
- ‘Transition demand’ is a logical and intuitive procedure to transfer the Dynamic Driving Task (DDT) from the system (automated control) to the human driver (manual control). This request is given from the system to the human driver.
- ‘Minimum Risk Manoeuvre (MRM)’ means a procedure aimed at minimising risks in traffic, which is automatically performed by the system after a transition demand without driver response or in the case of a severe ALKS or vehicle failure.
- ‘Emergency Manoeuvre (EM)’ is a manoeuvre performed by the system in case of an event in which the vehicle is at imminent collision risk and has the purpose of avoiding or mitigating a collision.

Special requirements for safety of alks: definitions

- ‘Operational Design Domain (ODD)’ of the automated lane keeping system defines the specific operating conditions (e.g. environmental, geographic, time-of-day, traffic, infrastructure, speed range, weather and other conditions) within the boundaries fixed by this regulation under which the automated lane keeping system is designed to operate without any intervention by the driver.
- ‘Functional safety’: absence of unreasonable risks under the occurrence of hazards caused by a malfunctioning behaviour of electric/electronic systems (safety hazards resulting from system faults).
- ‘Operational safety’ means the absence of unreasonable risk under the occurrence of hazards resulting from functional insufficiencies of the intended functionality (e.g. false/missed detection), operational disturbances (e.g. environmental conditions like fog, rain, shadows, sunlight, infrastructure) or by reasonably foreseeable misuse/errors by the driver, passengers and other road users (safety hazards – without system faults).
- ‘Unreasonable risk’ means the overall level of risk for the driver, vehicle occupants and other road users which is increased compared to a competently and carefully driven manual vehicle.

Verification snd Tests

- The Type approval authority shall verify ‘The System’ under non-failure conditions by testing on a track a number of selected functions from those described by the manufacturer in paragraph 3.2 above, and by checking the overall behaviour of the system in real driving conditions including the compliance with traffic rules.
- The reaction of ‘The System’ shall be checked under the influence of a faults in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal failure within the unit.
- The Type Approval Authorities shall also check a number of scenarios that are critical for the Object and Event Detection and Response (OEDR) and characterization of the decision-making and HMI functions of the system (e. g. object difficult to detect, when the system reaches the ODD boundaries, traffic disturbance scenarios) as defined in the regulation
- Simulation tool and mathematical models for verification of the safety concept may be used in accordance with Schedule 8 of Revision 3 of the 1958 Agreement, in particular for scenarios that are difficult on a test track or in real driving conditions. Manufacturers shall demonstrate the scope of the simulation tool, its validity for the scenario concerned as well

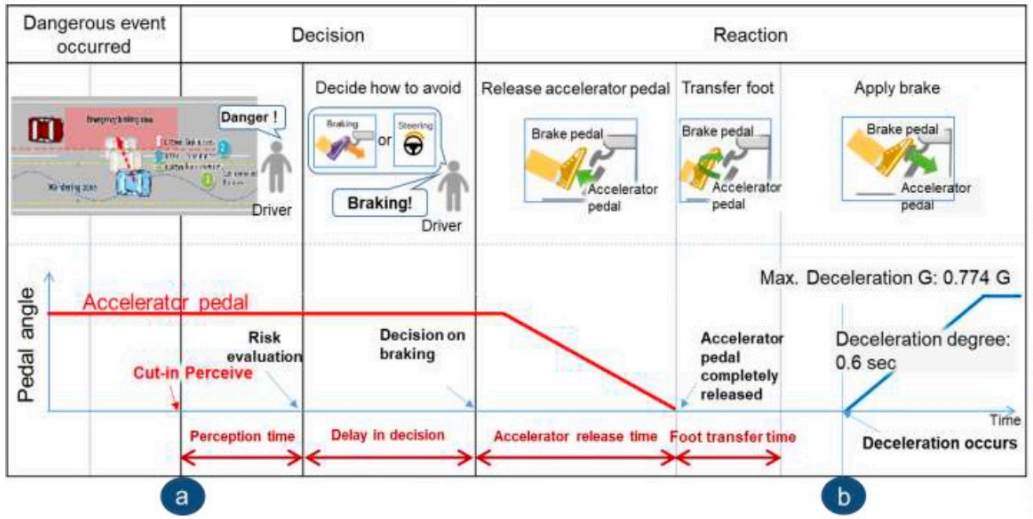
Definition of Preventable and practical implementation of criteria

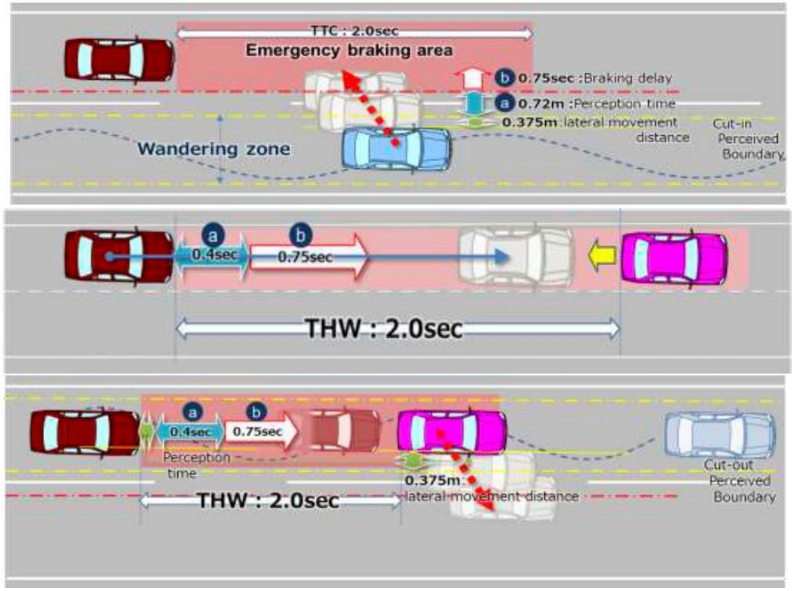
Preventable = Avoidable by a competent and careful human driver

? Does this criteria change depending on country due to different driving culture?

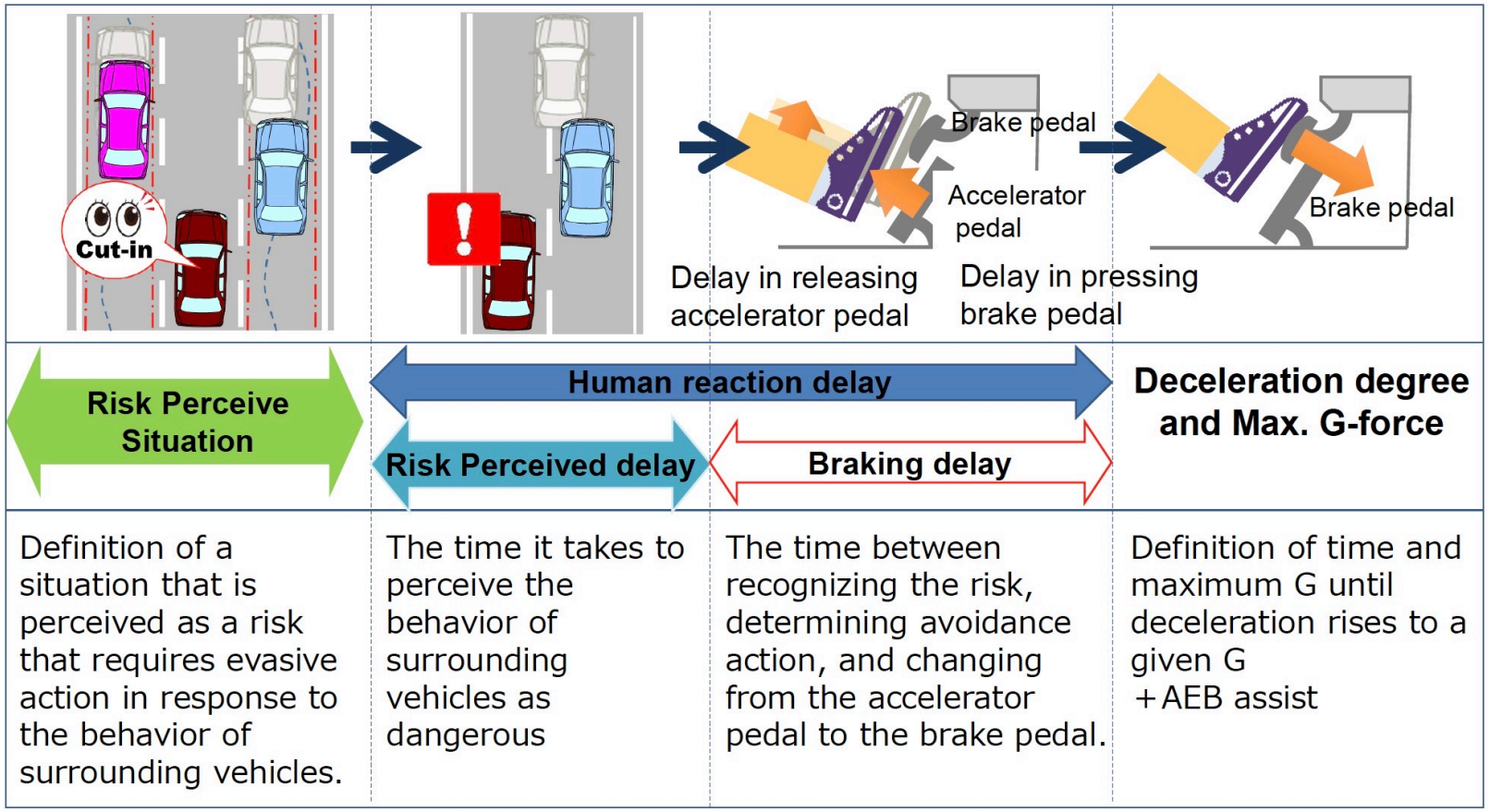
Should Not: sufficient capability of drivers is harmonized globally through international driver license.

Competent and careful human driver model for ALKS defined in UN157.





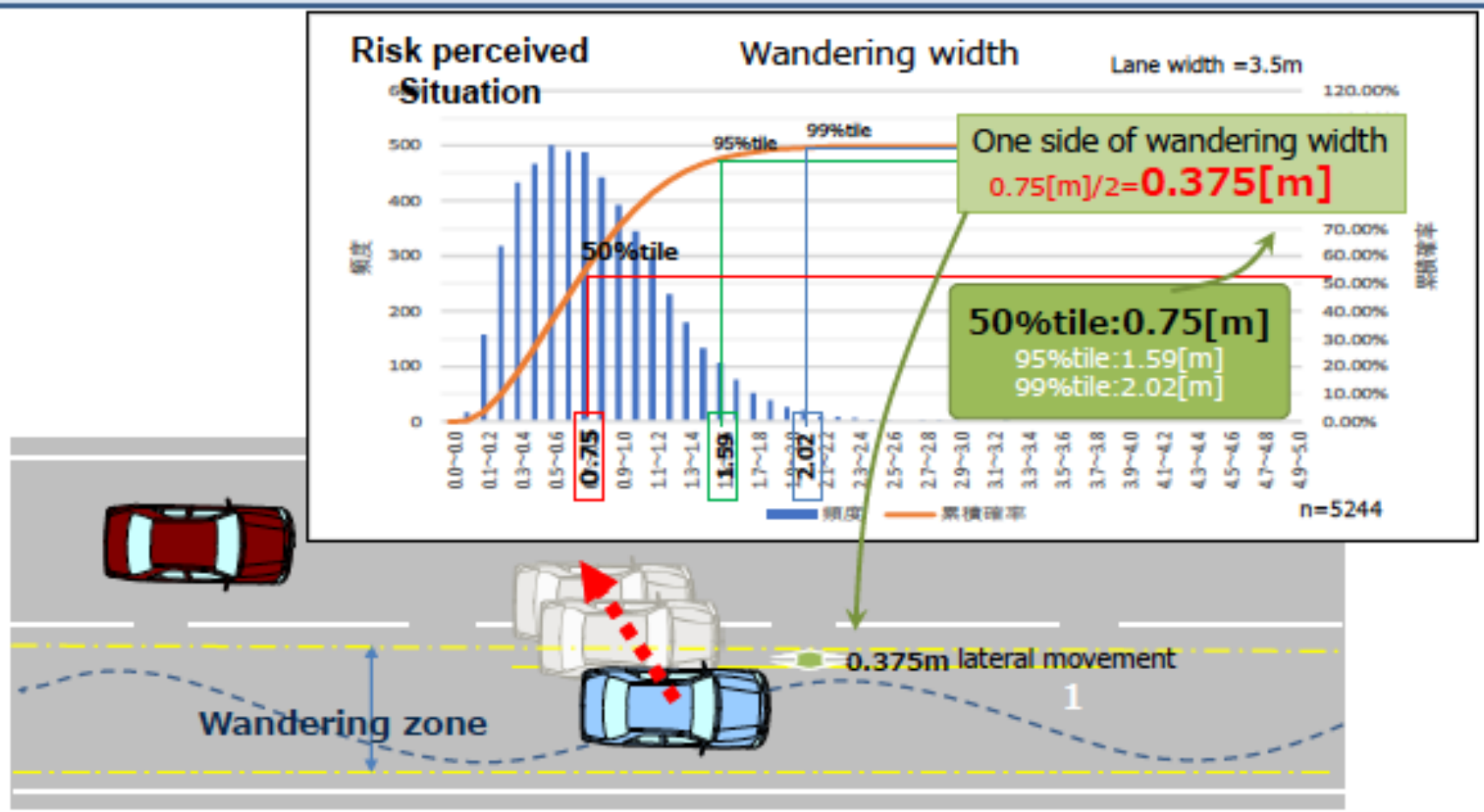
Driver Model Structure



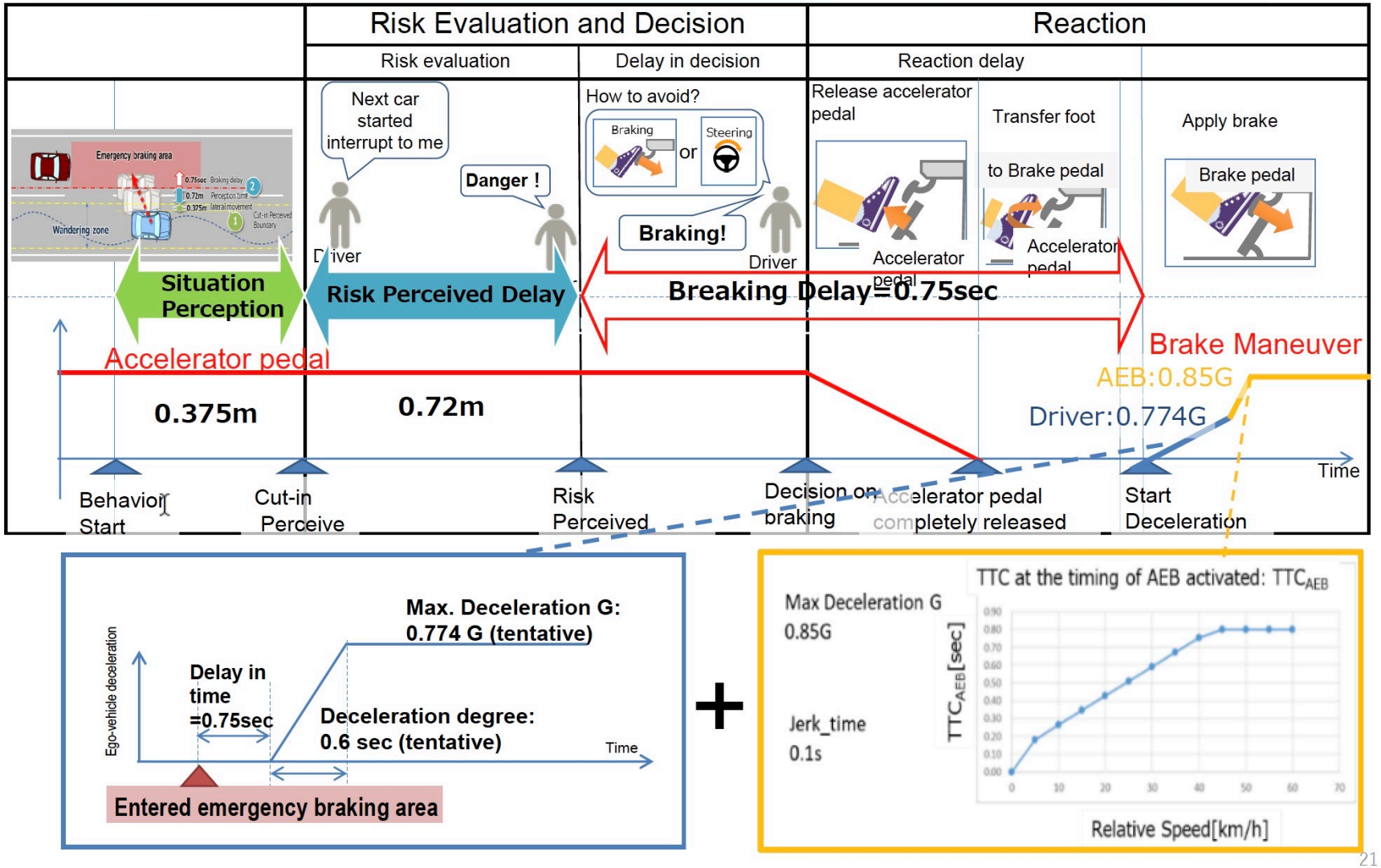
Risk Perceived Boundary by Lateral Movement

When the other vehicle is wandering within its own lane, it is unlikely that the ego-vehicle perceives the possibility of cut-in

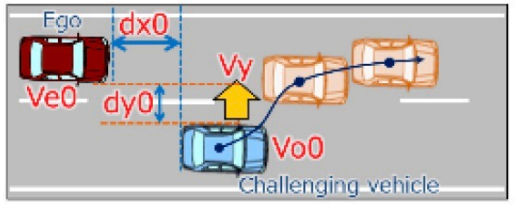
Define the cut-in perceived boundary based on the lateral movement range of other vehicle wandering within its own lane



Competent and Careful human driver performance model



Preventable Vs. Unpreventable Scenarios

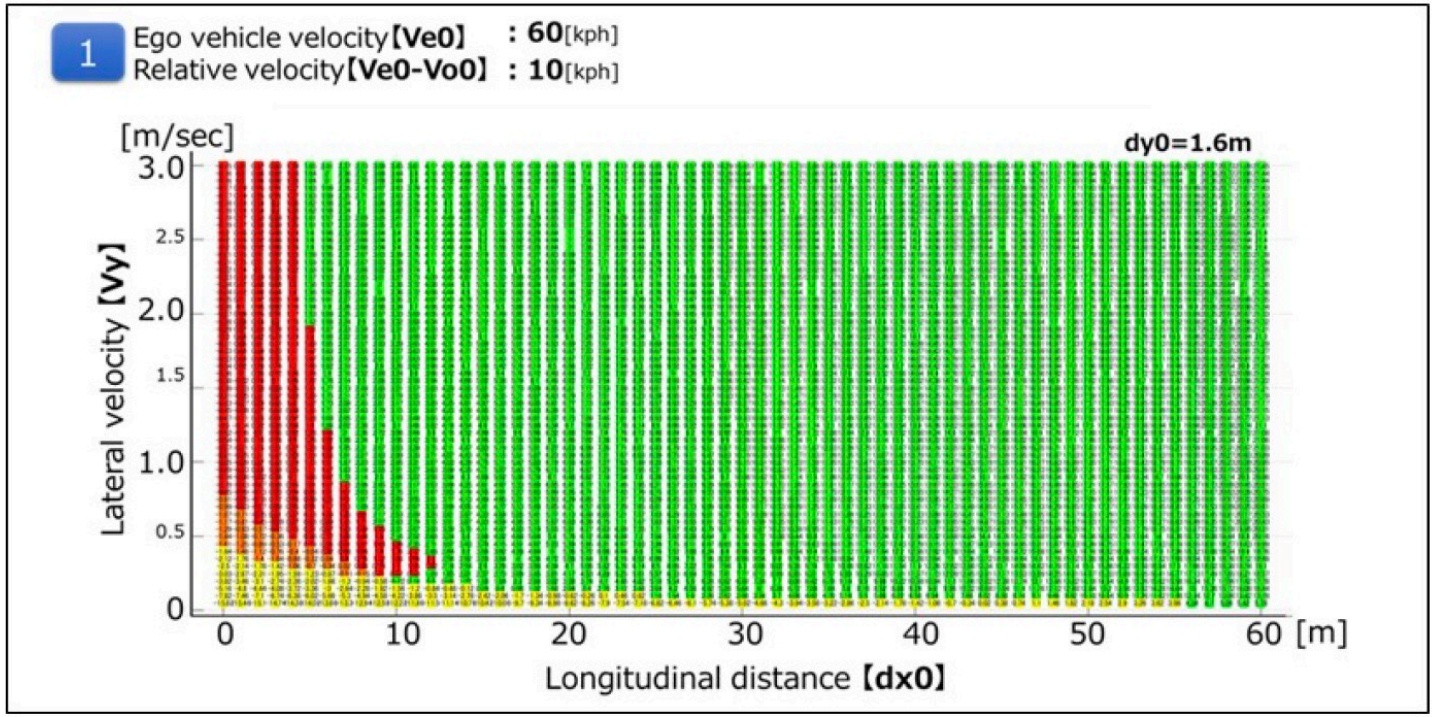


Initial condition	Initial velocity	【Ve0】	Ego vehicle velocity
		【Ve0-Vo0】	Relative velocity
	Initial distance	【dy0】	Latteral distance※
		【dx0】	Longitudinal distance
Vehicle motion	Lateral motion	【Vy】	Lateral velocity

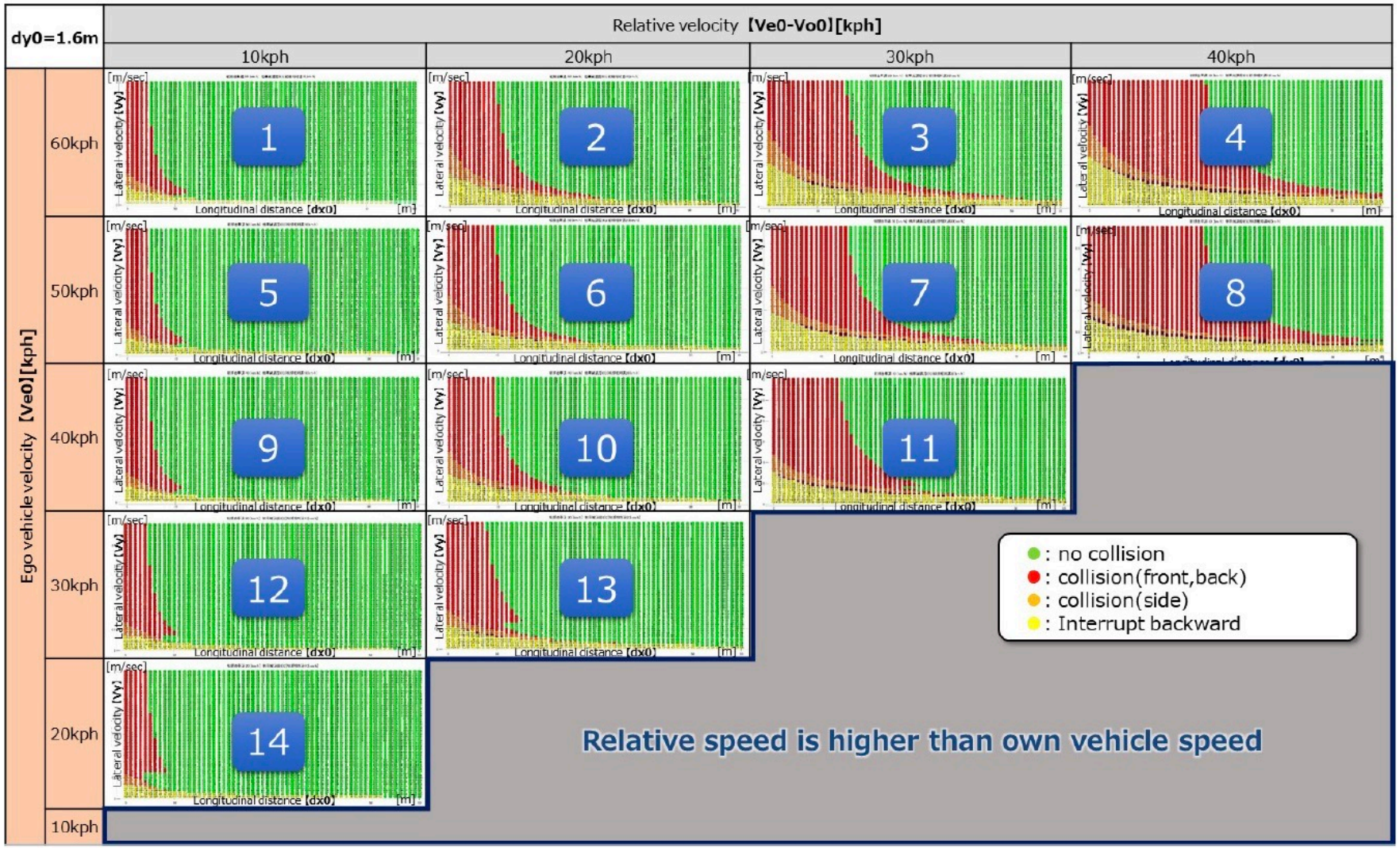
※Latteral distance

ex) Lane width : 3.5[m]
Vehicle width:1.9[m]
Driving in the center of the lane
dy=1.6[m]

Ve0：60[kph]



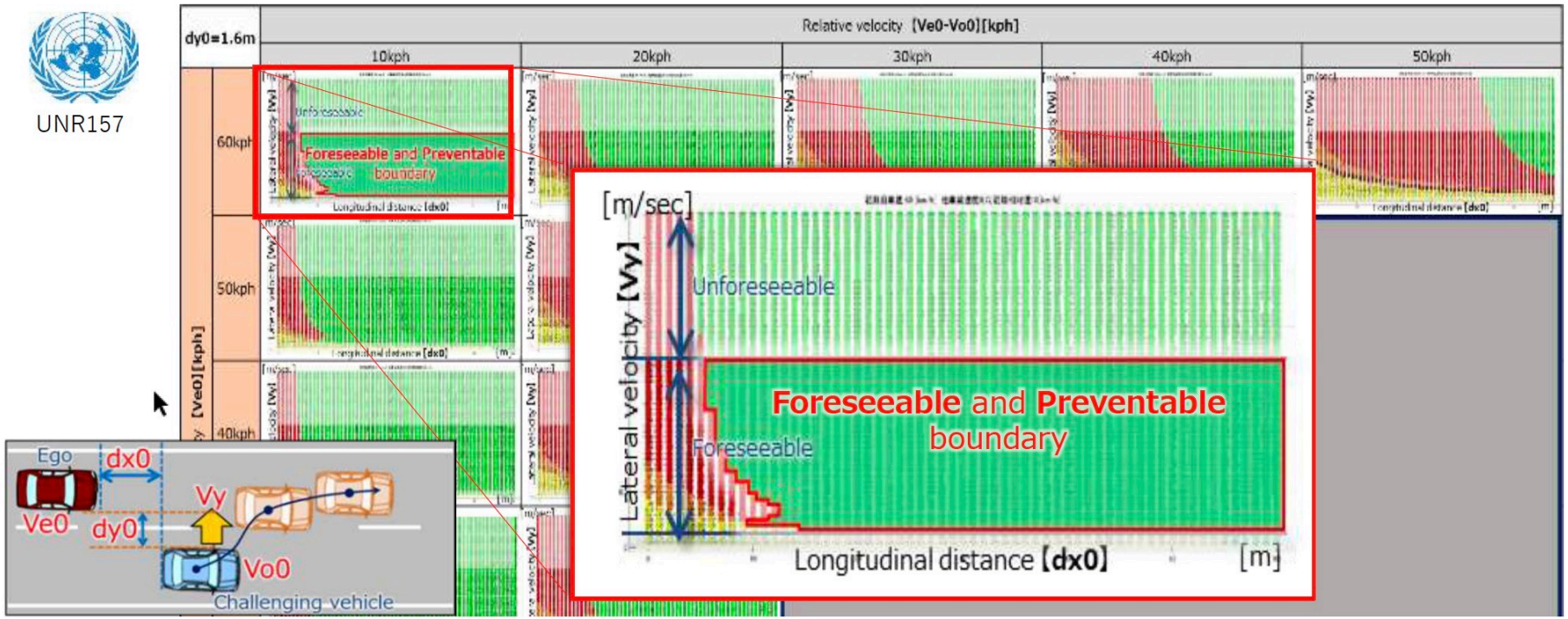
● : no collision
● : collision(front,back)
● : collision(side)
● : Interrupt backward


dy0=1.6m
Relative velocity 【Ve0-Vo0】[kph]
10kph
20kph
30kph
40kph
Ego vehicle velocity 【Ve0】[kph]
60kph
50kph
40kph
30kph
20kph
10kph
[m/sec]
Lateral velocity [Vy]
Longitudinal distance 【dx0】
[m]
1
2
3
4
5
6
7
8
9
10
11
12
13
14
: no collision
: collision(front,back)
: collision(side)
: Interrupt backward
Relative speed is higher than own vehicle speed

Foreseeable and Preventable Boundary

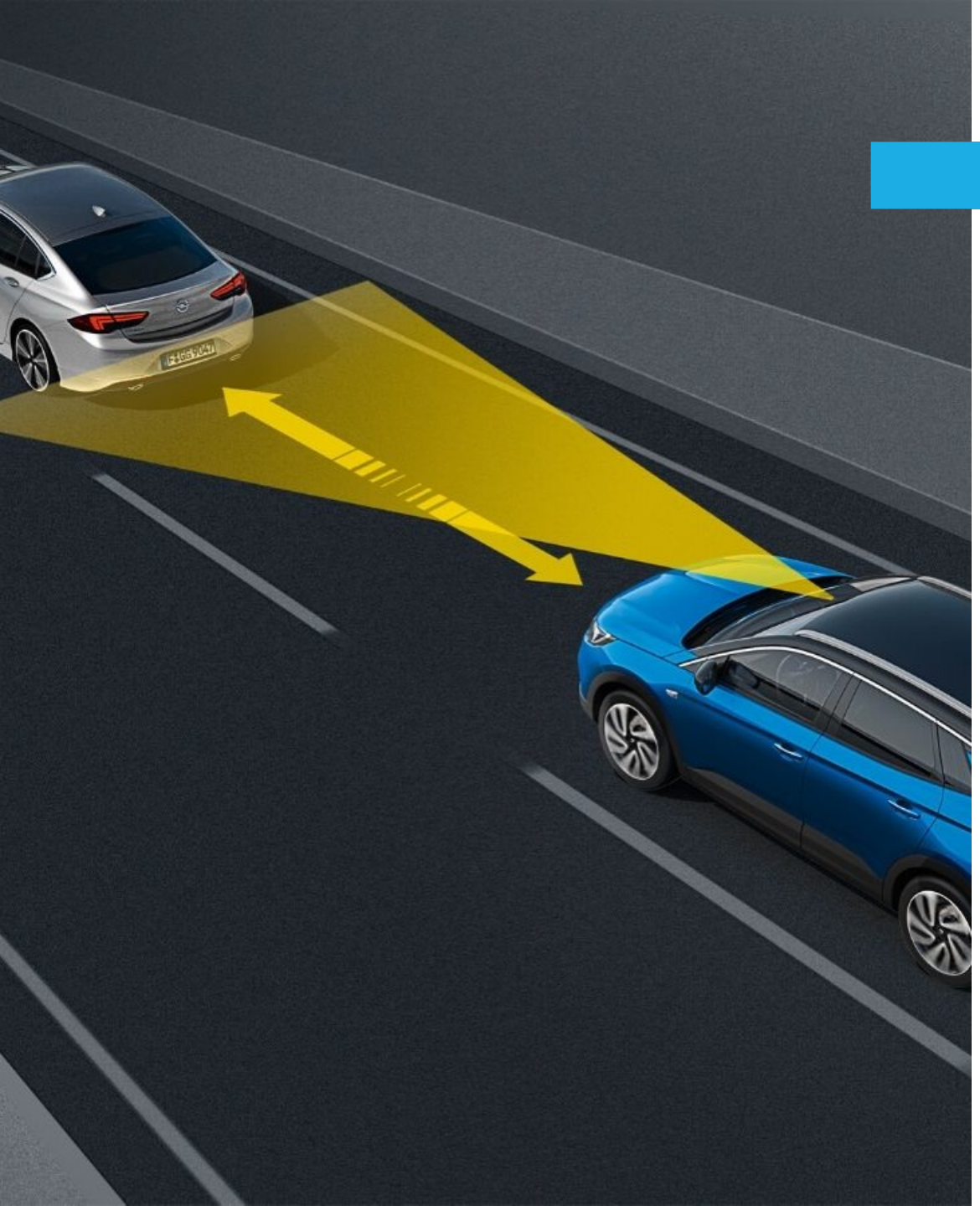
Preventable and foreseeable criteria is implemented into the ALKS regulation as quantitative pass fail boundary.

UNR157



SOME LIMITATIONS OF UN 157

- Simplistic modelling
- Parameters values
- Limited number of scenarios
- Scenario approach
- No two-way interaction with traffic
- No emerging traffic phenomena (e.g. string stability)



A CASE FOR STRING STABILITY

Transportation Research Part C 130 (2021) 103305

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Requiem on the positive effects of commercial adaptive cruise control on motorway traffic and recommendations for future automated driving systems

Biagio Ciuffo [a], Konstantinos Mattas [a], Michail Makridis [a,b], Giovanni Albano [f], Aikaterini Anesiadou [g], Yinglong He [c], Szilárd Josvai [d], Dimitris Komnos [h], Marton Pataki [d,e], Sandor Vass [e], Zsolt Szalay [d,e,*]

[a] European Commission – Joint Research Centre, Ispra, VA, Italy
[b] ETH Zürich, Institute for Transport Planning and Systems (IVT), Zürich, CH, Switzerland
[c] University of Birmingham, Edgbaston, Birmingham B15 2TT, UK
[d] ZalaZONE - Automotive Proving Ground Zala Ltd., Zalaegerszeg, Hungary
[e] Department of Automotive Technologies, Budapest University of Technology and Economics, Budapest, Hungary
[f] Seidor Italia Srl, Milan, Italy
[g] Independent Consultant
[h] Fincons Group, Vimercate, Italy

ARTICLE INFO

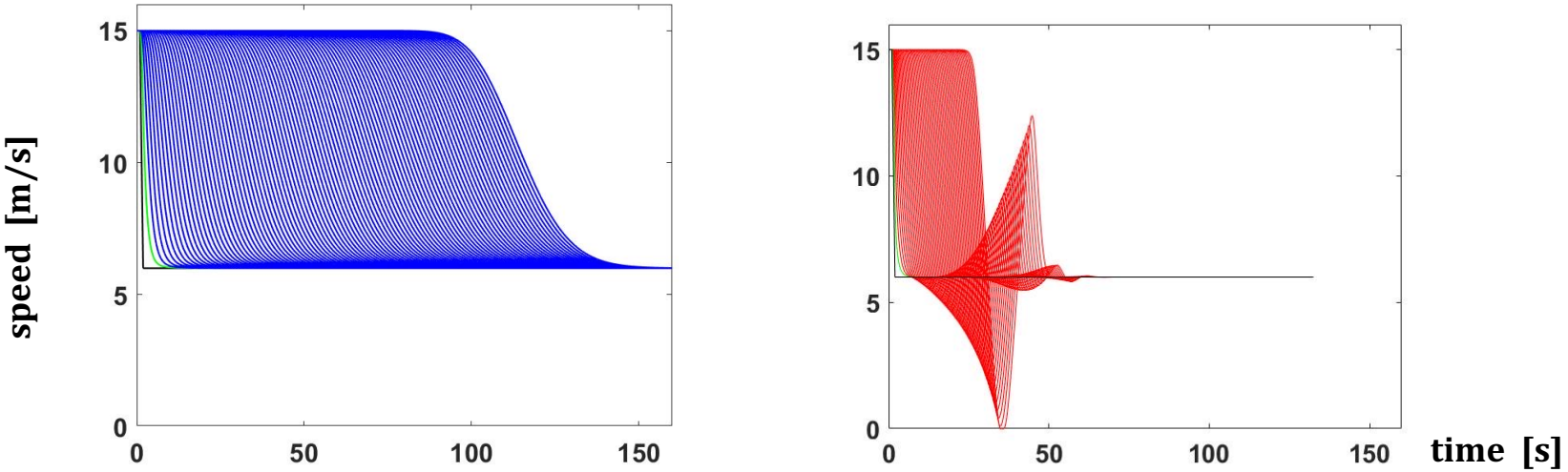
Keywords:
Adaptive cruise control
Automated vehicles
Car-following experiments
Traffic string instability
Traffic hysteresis
Energy consumption
Vehicle safety

ABSTRACT

Connected and automated vehicles (CAVs) promise to significantly improve road traffic. To a certain extent, this situation is similar to the expectations at the end of the last century about the positive effects that the introduction of Adaptive Cruise Control (ACC) systems would have had on motorway traffic. The parallelism is interesting because ACC equipped vehicles represent the first level of vehicle automation and are now widely available on the market. In this light, studying ACC impacts can help to anticipate potential problems related to its widespread application and to avoid that AVs and CAVs will lead to the same problems.

EC JRC Experimentation (Zalazone, October 2019)

STRING STABILITY



Transportation Research Part B 144 (2021) 133–154

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

On string stability of a mixed and heterogeneous traffic flow: A unifying modelling framework

Marcello Montanino, Vincenzo Punzo*

Associate Professor, Università degli Studi di Napoli Federico II, Via Claudio, 21, 80125 Napoli, NA, Italy

https://doi.org/10.1016/j.trb.2020.11.009

- Removing the unrealistic assumption of flow homogeneity
- Introducing uncertain transfer functions to map the probability distributions of car-following model parameters into a L2 stability measure of a mixed and heterogeneous traffic.
- a mathematical justification of the equivalence between the asymptotic stability of a closed-loop platoon system –which has been studied through the famous "traffic wave ansatz" on a ring-road –and the L 2 stability of an open-loop platoon system.

Transportation Research Part B 146 (2021) 136–154

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

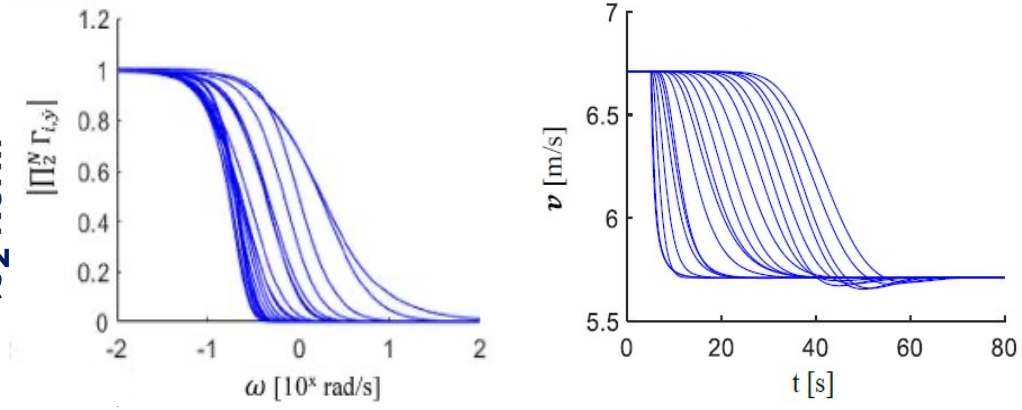
From homogeneous to heterogeneous traffic flows: $\mathcal{L}_p$ String stability under uncertain model parameters

Marcello Montanino[a], Julien Monteil[b], Vincenzo Punzo[c,*]

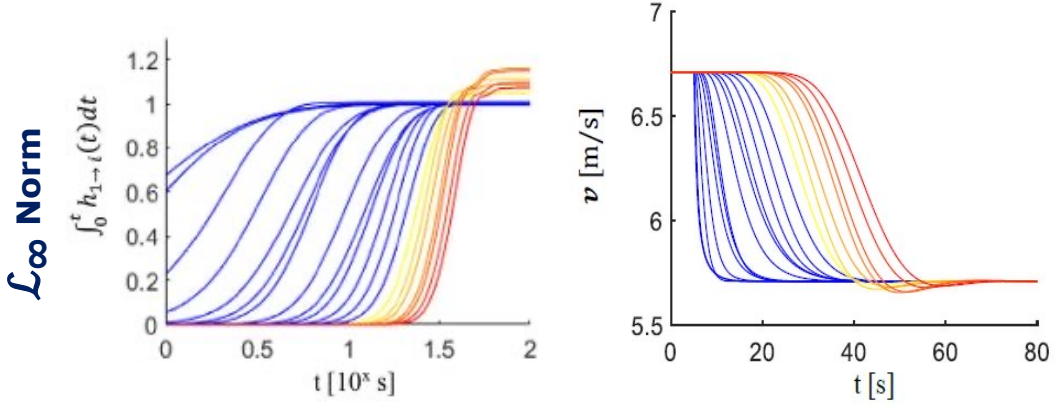
[a] Università degli Studi di Napoli Federico II, Via Claudio, 21, 80125 Napoli, NA, Italy
[b] IBM Research, Ireland Lab, Dublin, Ireland
[c] Università degli Studi di Napoli Federico II, Via Claudio, 21, 80125 Napoli, NA, Italy

https://doi.org/10.1016/j.trb.2021.01.009

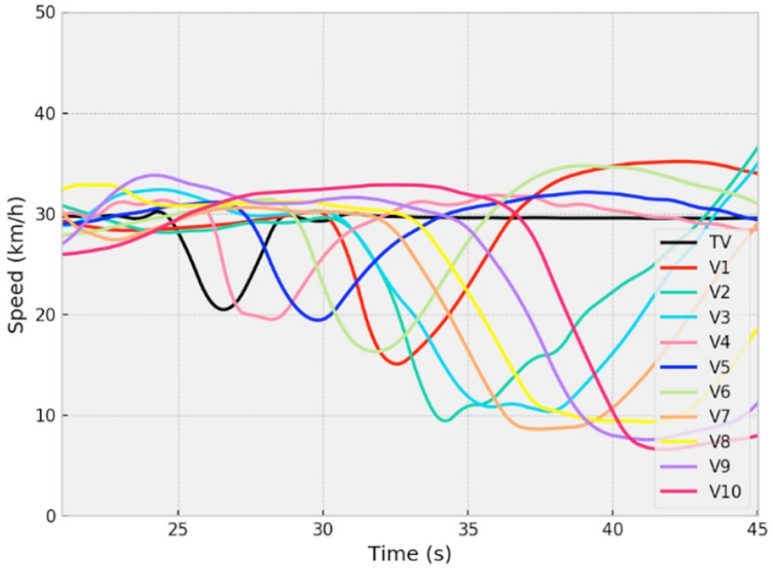
$\mathcal{L}_2$ Norm



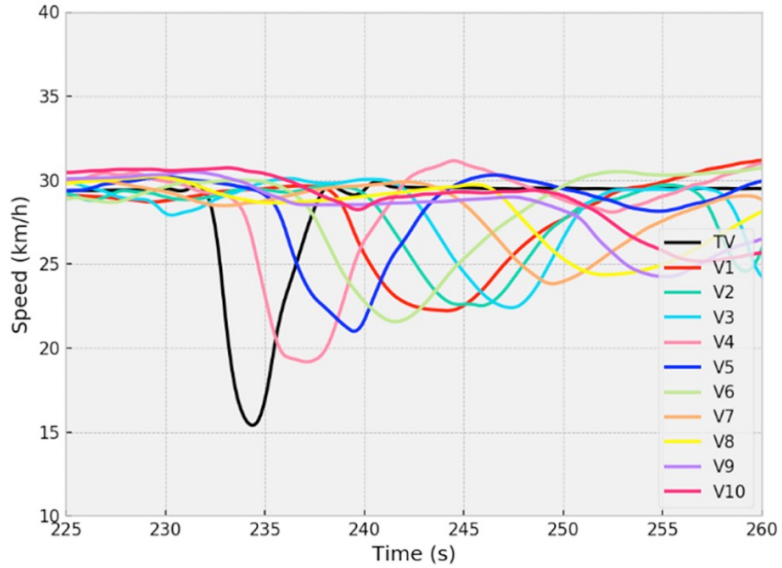
$\mathcal{L}_\infty$ Norm



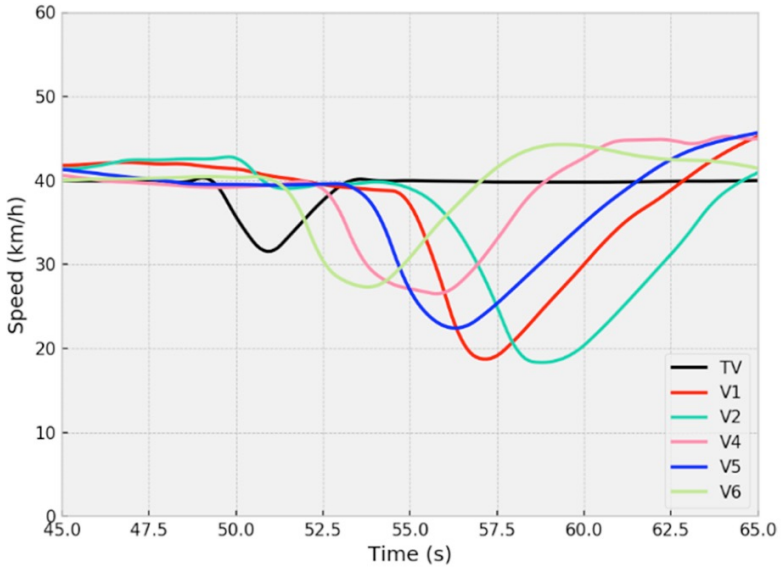
Short Vs. Long Gaps



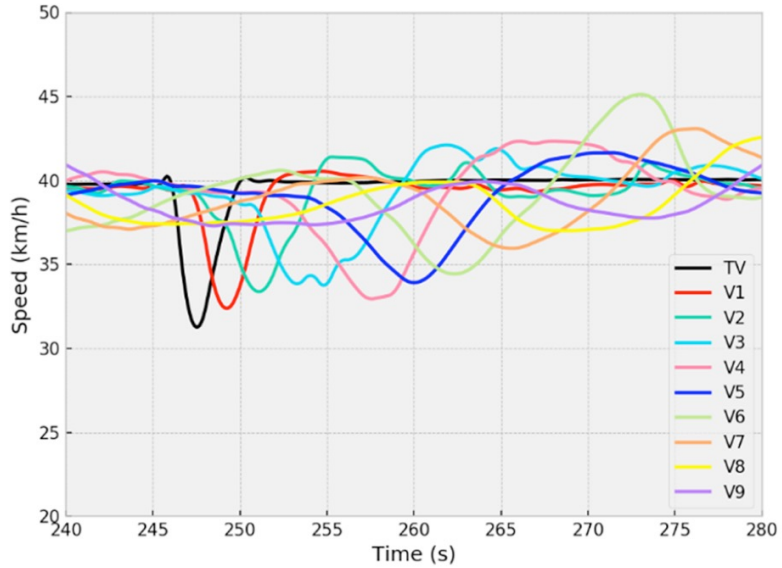
a)



b)



c)



d)

- A recent amendment of the UN157 regulation includes string stability as a requirement of ALKS

26.8.2022 EN Official Journal of the European Union L 221/1

II

(Non-legislative acts)

REGULATIONS

COMMISSION IMPLEMENTING REGULATION (EU) 2022/1426

of 5 August 2022

laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

EU regulation on the type approval of the automated driving systems (ADS) of fully automated vehicles

THE NEW EU ADS REGULATION (2022)

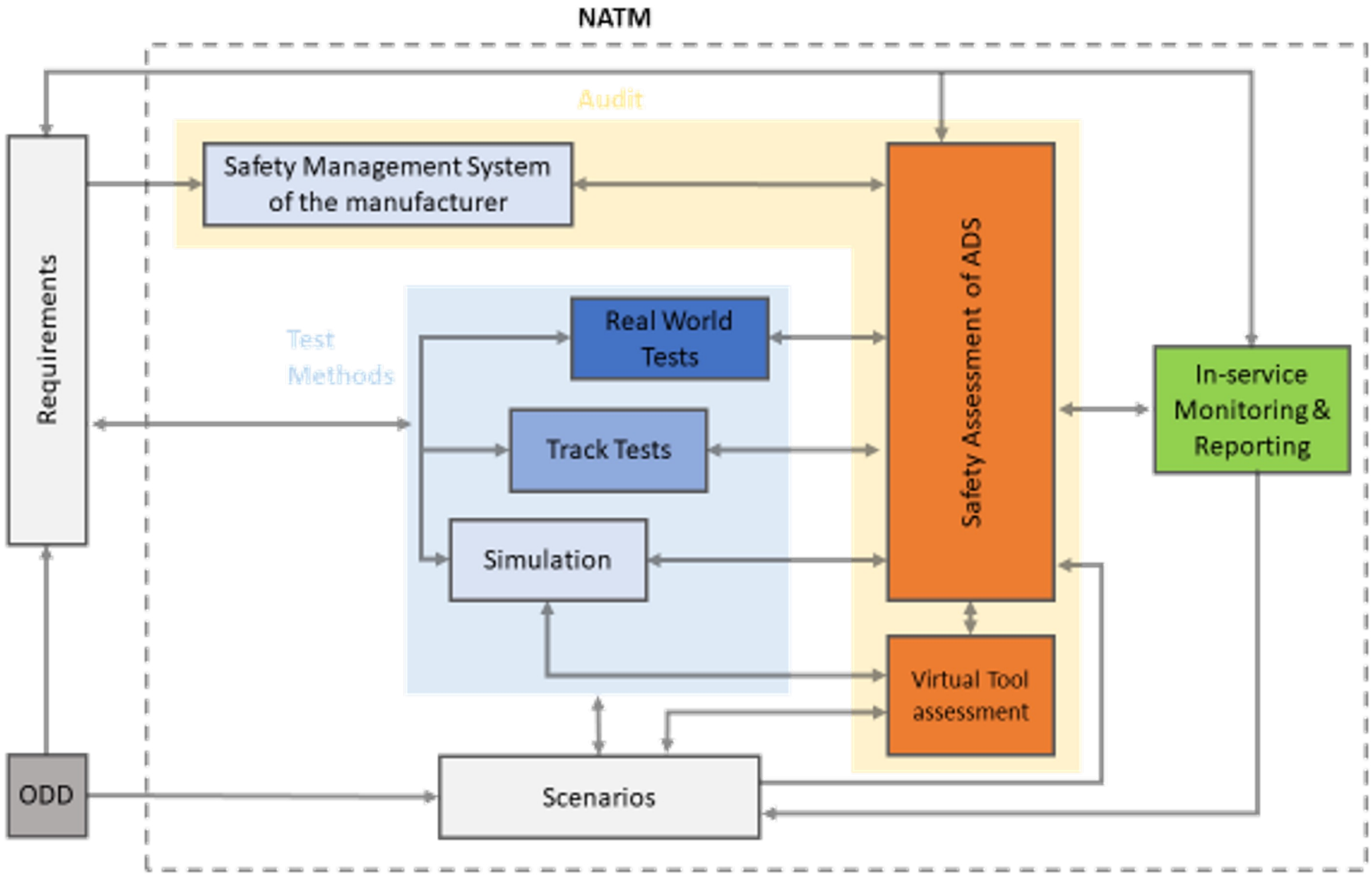
Commission Implementing Regulation laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of motor vehicles with regard to their automated driving system (ADS)

ANNEXES to the Commission Implementing Regulation

1) Information Document
2) Performance Requirements
3) Compliance Assessment
   - PART 1 Traffic Scenarios
   - PART 2 Audit of SMS and safety assessment
   - PART 3 Tests
   - PART 4 Guidelines for the credibility assessment
   - PART 5 In-service reporting
4) EU Type approval certificate

Commission Implementing Regulation (EU) 2022/1426 of 5 August 2022

VMAD NATM


NATM
Audit
Safety Management System of the manufacturer
Requirements
Test Methods
Real World Tests
Track Tests
Simulation
Safety Assessment of ADS
In-service Monitoring & Reporting
Virtual Tool assessment
ODD
Scenarios

PART 4 - CREDIBILITY ASSESSMENT

- Principles for the credibility assessment for using virtual toolchain in ADS validation
- The credibility assessment framework provides a general description of the main aspects considered for assessing the credibility of an M&S solution together with guidelines of the role played by third parties assessors in the validation process with respect to credibility.
- Team's Experience and Expertise is also assessed
- “Simulation Handbook” providing evidence of the credibility assessment

SIMULATION AND VIRTUAL TESTING

- Simulation tools needed to tackle the complexity of ADS
- Lower testing cost/time, safer, repeatable…
- Tools/tool-chains validation and results reliability

NOT ADDRESSED IN VMAD/FRAV YET

- L4 use-cases for public transport: 2 phases for market introduction
- Remote control centre / remote operation
- Infrastructure & communication
- Overarching framework to
  - ensure the highest common level of safety
  - improve accessibility and use of safety information

THE HORIZON EUROPE CCAM PARTNERSHIP

CCAM

CONNECTED, COOPERATIVE
& AUTOMATED MOBILITY

ONE OF THE PARTNERSHIPS FOR HORIZON EUROPE

ccam.eu

European Partnerships

- The aim of European partnerships in Horizon Europe to deliver on global challenges and modernise industry.
- European Partnerships are key implementation tools, contributing significantly to achieving the EU's political priorities.
- The Partnerships are formed between the European Commission and private and public stakeholder addressing Europe's most pressing challenges through coordinated research and innovation actions.
- By bringing private and public partners together, European Partnerships help to avoid the duplication of investments and contribute significantly to leveraging public funding through private investments.

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

Increase safety in road transport

Reduce negative impacts from road transport on environment

Strengthen competitiveness of European industries

Ensuring inclusive mobility and goods access for all

CCAM

CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

EUROPEAN LEADERSHIP IN SAFE AND SUSTAINABLE ROAD TRANSPORT THROUGH AUTOMATION

CHALLENGES TO DEPLOY CCAM SOLUTIONS

Problem Driver 1:

Insufficient demand as society does not yet understand the potential benefits of CCAM enabled mobility. The long-term implications, benefits and impacts of integrating CCAM solutions into the mobility system are not sufficiently examined.

Problem Driver 2:

CCAM solutions are not yet sufficiently mature for market take-up, and current investment levels in CCAM R&I are inadequate to maintain and extend EU industrial leadership.

Problem Driver 3:

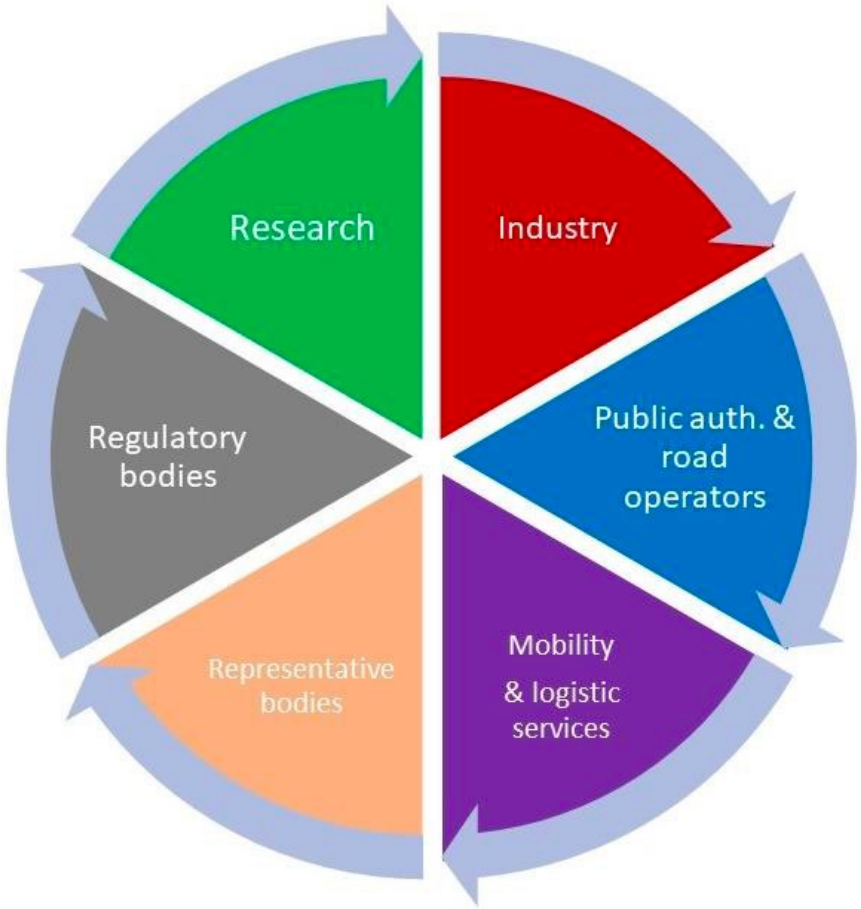
Current R&I efforts are fragmented and **lack a coherent, longer-term vision and strategy** for targeting systemic solutions.

Problem Driver 4:

Demonstration and scale-up is limited, since a well organised, extensive and complex cross-sectorial value chain is still required to build complete CCAM solutions.

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

CCAM stakeholders categories



Industry	- Automotive industry, including supply chain - ITS solutions, telecom providers, connectivity - Data handling and storage industry, ...
Public authorities & road operators	- Cities and regions - Transport authorities, road authorities and operators - Member States
Mobility & logistic services	- Public transport providers - Mobility and logistics service providers - Insurance, maintenance, ...
Representative bodies	- Road users - Stakeholder associations - Road safety, society, the environment, ...
Regulatory bodies	- National, European and international
Research	- Universities - Public research institutes - Private research institutes

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

CCAM ACTIVITIES AND TIMEFRAME

- Contributing to shape the CCAM Horizon Europe research call topics.
- Networking opportunities at the European and international levels.
- Updating the CCAM Strategic Research and Innovation Agenda (SRIA) with the selected research projects' results.
- Joint actions with many other European and international stakeholders.
- Contributing to the development of European standardisations and regulations.

PHASE 1 (2021-2024) **Developing the building blocks**

PHASE 2 (2025-2027) **Advancing technical maturity**

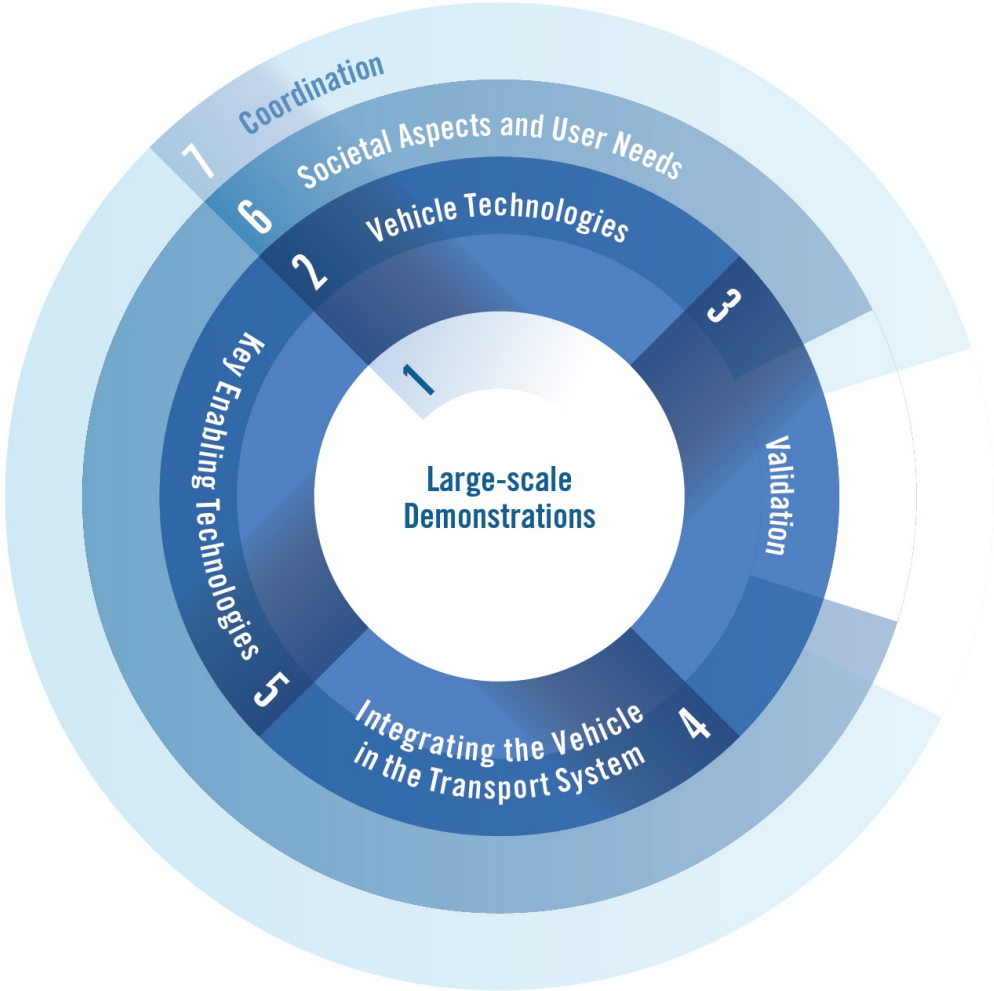
PHASE 3 (2028-2030) **Large-scale Demonstrations**

CCAM CLUSTERS

Successful implementation requires understanding:

- the **user needs and societal aspects** of mobility
- technical details, contributions, requirements and risks from **key enabling technologies**
- the overall **transport system** requirements and set-up
- what **vehicle technologies** are required and how to implement them
- how to **validate** safe system functioning

Finally **demonstrate** all aspects at a **large scale**



CCAM
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CCAM WORK PROGRAMME 2023

Access here the WP23-24

Topic #	CCAM Cluster	Topic title	Type of action	Budget (EUR million)	# of projects expected to be funded
HORIZON-MISS-2023-CIT-01-01	1	Co-designed smart systems and services for user-centred shared zero-emission mobility of people and freight in urban areas (2Zero, CCAM and Cities' Mission)	IA	50	2
HORIZON-CL5-2023-D6-01-01	2	User-centric development of vehicle technologies and solutions to optimise the on-board experience and ensure inclusiveness	RIA	8	2
HORIZON-CL5-2023-D6-01-02	3	Generation of scenarios for development, training, virtual testing and validation of CCAM systems	RIA	20	1
HORIZON-CL5-2023-D6-01-03	4	Infrastructure-enabled solutions for improving the continuity or extension of Operational Design Domains (ODDs)	IA	12	2
HORIZON-CL5-2023-D6-01-04	6	Integrating European diversity in the design, development and implementation of CCAM solutions to support mobility equity	RIA	8	2
HORIZON-CL5-2023-D6-01-05	6	CCAM effects on jobs and education, plans for skills that match the CCAM development, and prerequisites for employment growth	RIA	2	1

The large-scale demo topic, drafted among CCAM, 2Zero, and the Cities Mission, is published under the Cities Mission Work Programme. The call will be open from **10 January 2023 until 27 April 2023**.

For all the other CCAM topics, the total indicative budget is 50 M€. The calls will open on **4 May 2023 and close on 5 September 2023**.

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

CCAM WORK PROGRAMME 2024

Access here the WP23-24

Topic #	CCAM Cluster	Topic title	Type of action	Budget (EUR million)	# of projects expected to be funded
HORIZON-CL5-2024-D6-01-01	2	Centralised, reliable, cyber-secure & upgradable in-vehicle electronic control architectures for CCAM connected to the cloud-edge continuum	RIA	12	2
HORIZON-CL5-2024-D6-01-02	3	Scenario-based safety assurance of CCAM and related HMI in a dynamically evolving transport system	RIA	14	1
HORIZON-CL5-2024-D6-01-03	4	Orchestration of heterogeneous actors in mixed traffic within the CCAM ecosystem	IA	12	2
HORIZON-CL5-2024-D6-01-04	5	AI for advanced and collective perception and decision making for CCAM applications	RIA	10	2
HORIZON-CL5-2024-D6-01-05	7	Robust Knowledge and Know-How transfer for Key-Deployment Pathways and implementation of the EU-CEM	CSA	4	1

The total indicative budget is 52 M€. The call will open on **7 May 2024 and close on 5 September 2024**.

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

STARTED CCAM PROJECTS 2021

CCAM Cluster	Topic title	
2	More powerful and reliable on-board perception and decision-making technologies addressing complex environmental conditions	EVENTS ROADVIEW
3	Common approaches for the safety validation of CCAM systems	SUNRISE
4	Physical and Digital Infrastructure (PDI), connectivity and cooperation enabling and supporting CCAM	PODIUM AUGMENTED CCAM
5	Cyber secure and resilient CCAM	SELFY CONNECT
6	Analysis of socio-economic and environmental impacts and assessment of societal, citizen and user aspects for needs based CCAM solutions	MOVE2CCAM SINFONICA
7	Framework for better coordination of large-scale demonstration pilots in Europe and EU-wide knowledge base	FAME connected automated driving.eu

CCAM
CONNECTED, COOPERATIVE

STARTED CCAM PROJECTS 2022

CCAM Cluster	Topic title	
1	European demonstrators for integrated shared automated mobility solutions for people and goods	MODI A LEAP TOWARDS SAE L4 AUTOMATED DRIVING FEATURES ULTIMO
2	Reliable occupant protection technologies and HMI solutions to ensure the safety of highly automated vehicles	AWARE2ALL
3	Human behavioural model to assess the performance of CCAM solutions compared to human driven vehicles	i4Driving
4	Integrate CCAM services in fleet and traffic management systems	CONDUCTOR IN2CCAM
5	Artificial Intelligence (AI): Explainable and trustworthy concepts, techniques and models for CCAM	AI4CCAM Althena

CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

integrated 4D driver modelling
under uncertainty

i4Driving

I4Driving ambition

- Overarching objective of i4Driving is to deliver a new library of ***credible*** models of ***heterogeneous*** human driver behaviours which provides a ***human road safety baseline*** for ***CCAM virtual assessment***.
- The i4Driving library will lay the foundation for a new standard for CCAM assessment methodologies to accelerate the uptake of CCAM technologies and improve our understanding of how these can be designed to improve traffic safety for all drivers

PARTNERS

i4Driving Team

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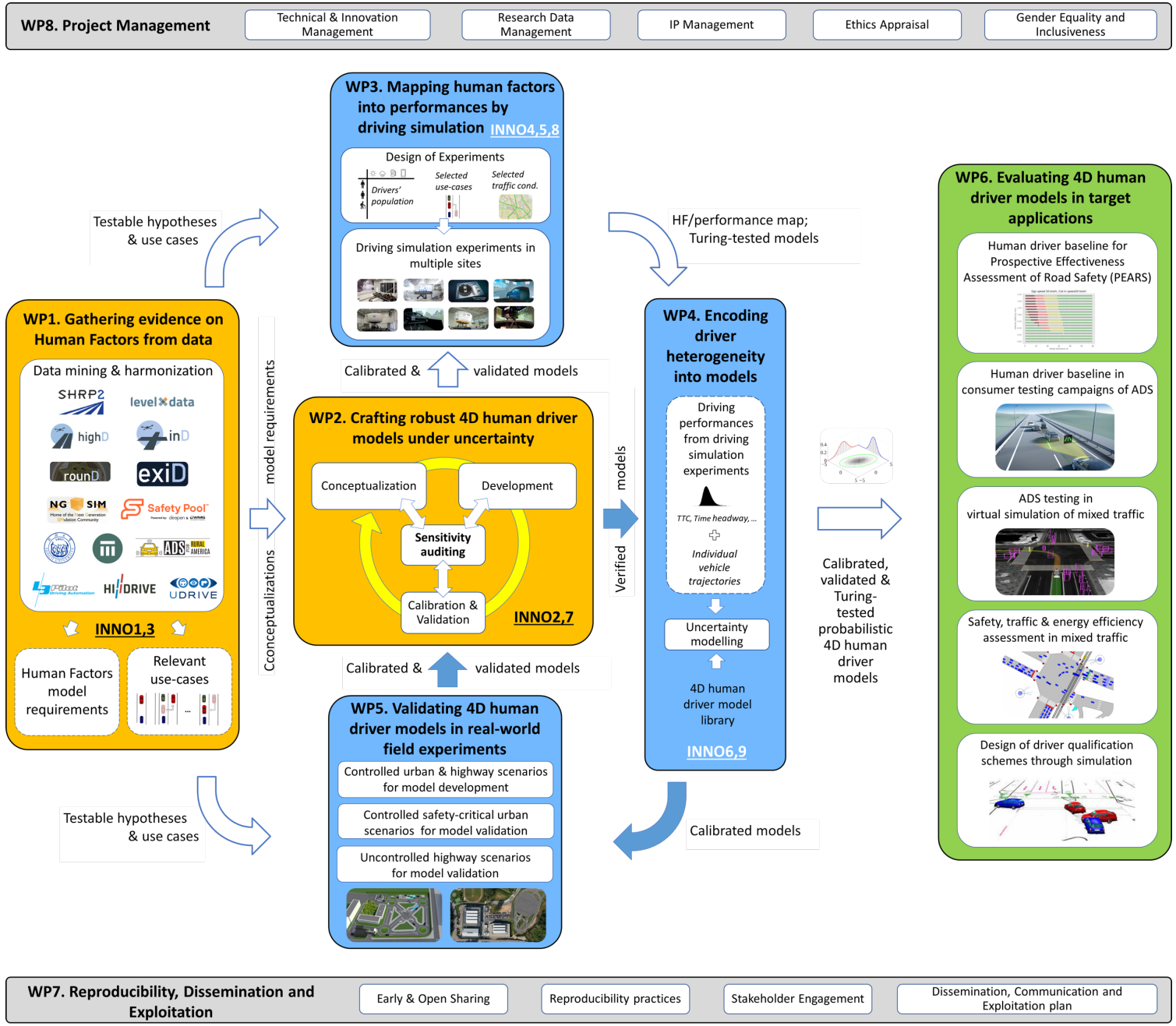
i4Driving METHODOLOGY



Experimental Facilities

i4Driving INNOVATIONS

1. INNO1 – Existing and innovative data mining techniques
2. INNO2 – Augmenting available models with a 4D cognitive layer
3. INNO3 – A methodology to identify relevant use-cases and safety-critical scenarios
4. INNO4 – An approach to automatically generate critical driving situations and continuously challenge human drivers in a DSE
5. INNO5 – An approach for standardization of experimentations on different DSs
6. INNO6 – Robust methodology to encode driver heterogeneity into probabilistic human behavioural models
7. INNO7 – "Modelling of the Modelling Process"
8. INNO8 – Turing test of i4Driving library of models in DSE
9. INNO9 - A probabilistic framework to validate i4Driving models at multiple scales

i4Driving CHALLENGES

i4Driving goes to the very core of scientific modelling

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Complexity: numerosity, nature, heterogeneity, randomness

i4Driving CHALLENGES

i4Driving goes to the very core of scientific modelling

Complexity: numerosity, nature, heterogeneity, randomness

A modelling tool which is ***highly reliable*** to capture the ***highly improbable***

DIFFERENT CONCEPTUAL VIEWPOINTS ON SAFETY

HUMAN DRIVEN VEHICLES

Rear-end collision

Rare event due to unpredictable concurrent causes.

DIFFERENT CONCEPTUAL VIEWPOINTS ON SAFETY

HUMAN DRIVEN VEHICLES

Rear-end collision

Rare event due to unpredictable concurrent causes.

AUTOMATED VEHICLES

Quasi rear-end collision

“Systematic” event due to badly designed controllers.

DIFFERENT CONCEPTUAL VIEWPOINTS ON SAFETY

HUMAN DRIVEN VEHICLES

Rear-end collision

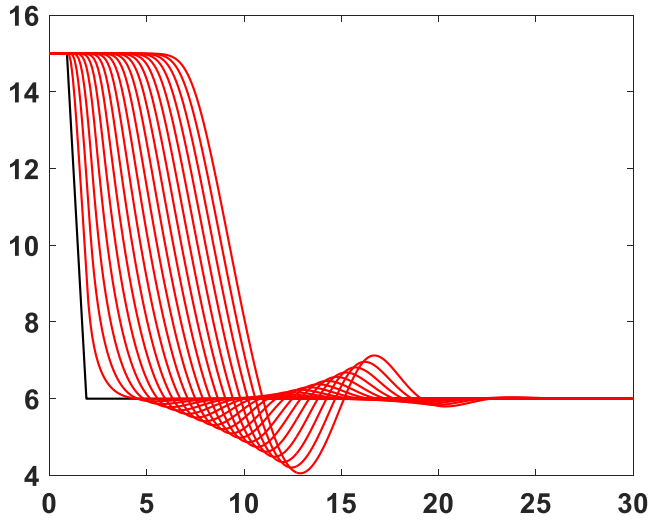
Rare event due to unpredictable concurrent causes.

AUTOMATED VEHICLES

Quasi rear-end collision

Systematic event due to badly designed controllers.

Crash avoided by human intervention.



IDM – INTELLIGENT DRIVER MODEL

No rear-end collision (but string instability)

Homogeneous string unstable platoon.

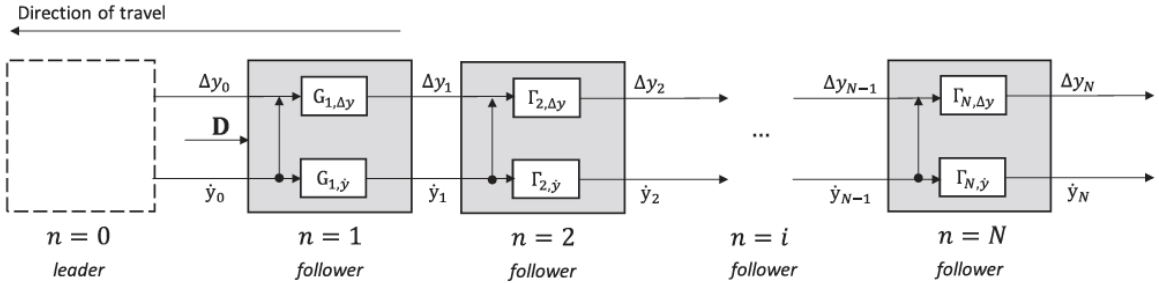
Never leading to a rear end-crash beyond the first-follower.

INTERNALLY ‘ENTAILED’ SYSTEMS

VS

HUMAN DRIVING

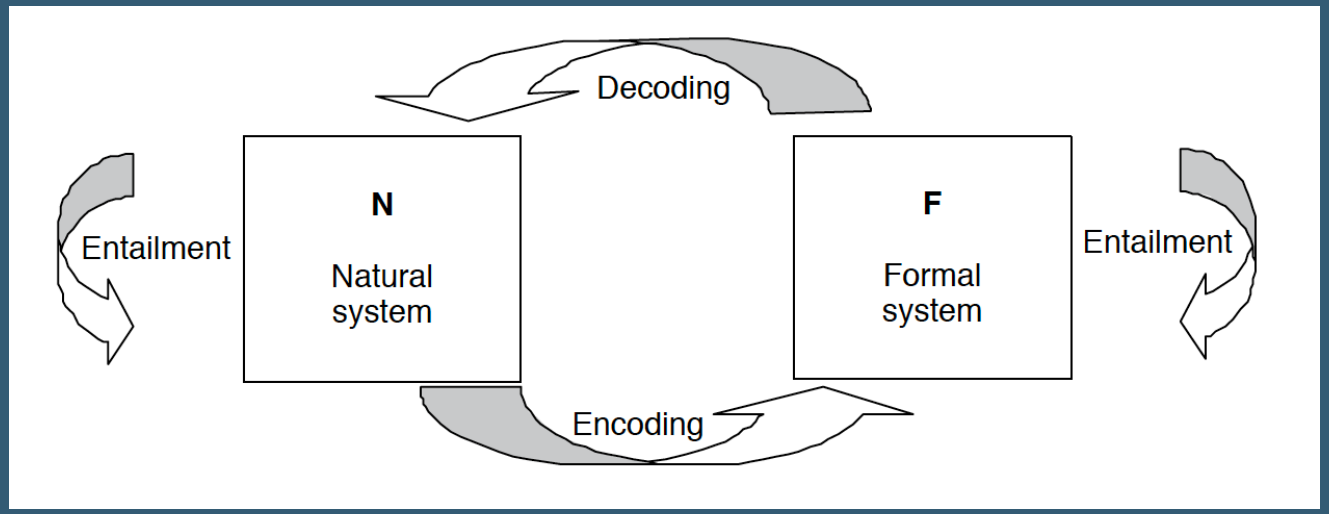
CAR-FOLLOWING MODELLING



$$\begin{cases} \ddot{y}_1 + (f_{1,\Delta v} - f_{n,v})\dot{y}_1 + f_{1,\Delta x} y_1 \approx d_1 \\ \ddot{y}_2 + (f_{2,\Delta v} - f_{2,v})\dot{y}_2 + f_{2,\Delta x} y_2 \approx f_{2,\Delta v}\dot{y}_1 + f_{2,\Delta x} y_1 \\ \dots \\ \ddot{y}_i + (f_{i,\Delta v} - f_{i,v})\dot{y}_i + f_{i,\Delta x} y_i \approx f_{i,\Delta v}\dot{y}_{i-1} + f_{i,\Delta x} y_{i-1} \\ \dots \end{cases}$$

MODELLING AFTER ROSEN, 1991

"The intuition of Rosen is that while *human drivers* in the world obey rules, and the *differential equations* in the model have 'rules' as well, whether formal or mathematical, no 'rule' whatsoever can dictate how one should map the hypothesized rules in the world onto the rules in the model" (Saltelli et al., 2008)

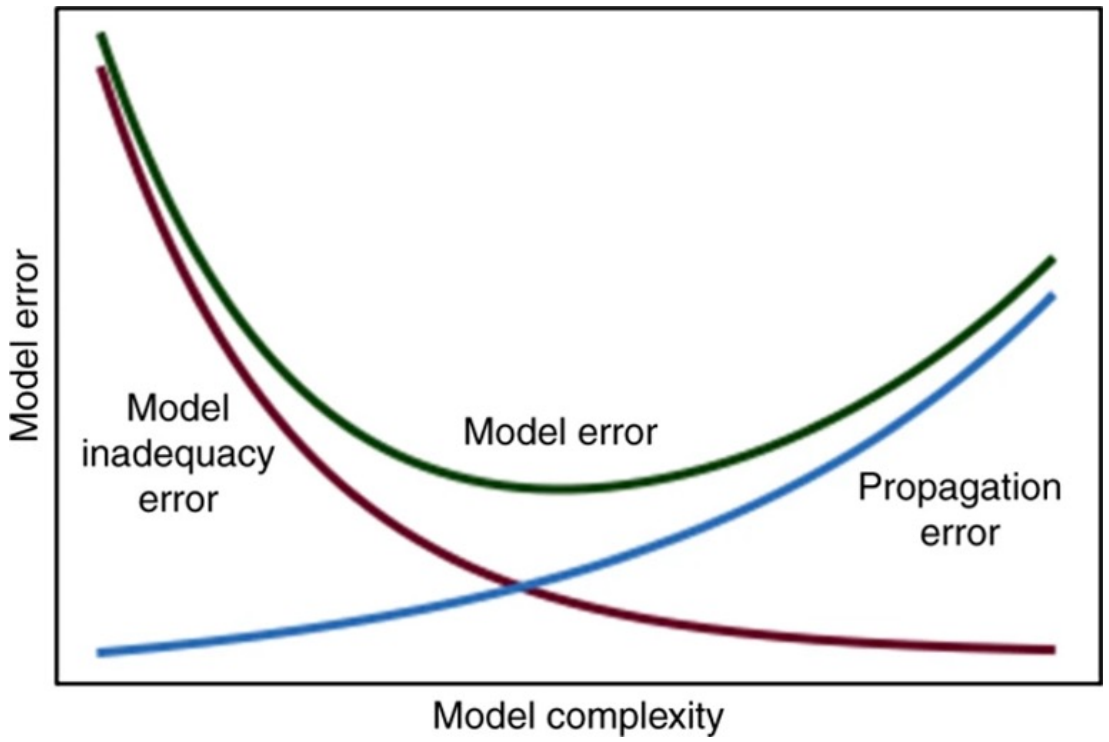


MODEL COMPLEXITY VS. MODEL ERROR

- "The portion of the world captured by the model is an arbitrary '**enclosure**' of an otherwise open, interconnected system" (Saltelli et al., 2008)

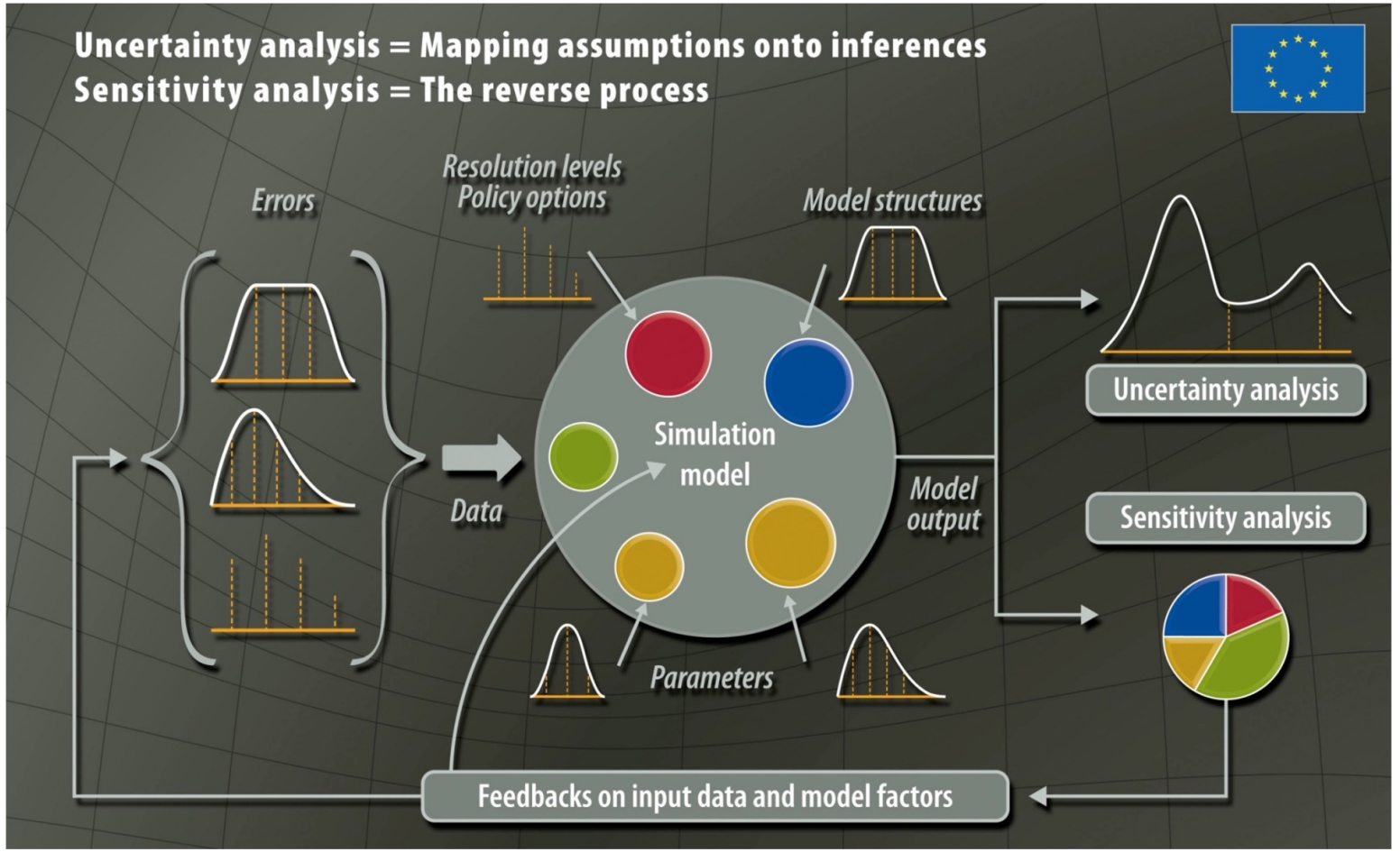
- **Uncertainty** is "any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system" (Walker et al., 2003)

- "**Complexity can be the enemy of relevance**" (Saltelli et al., 2020)

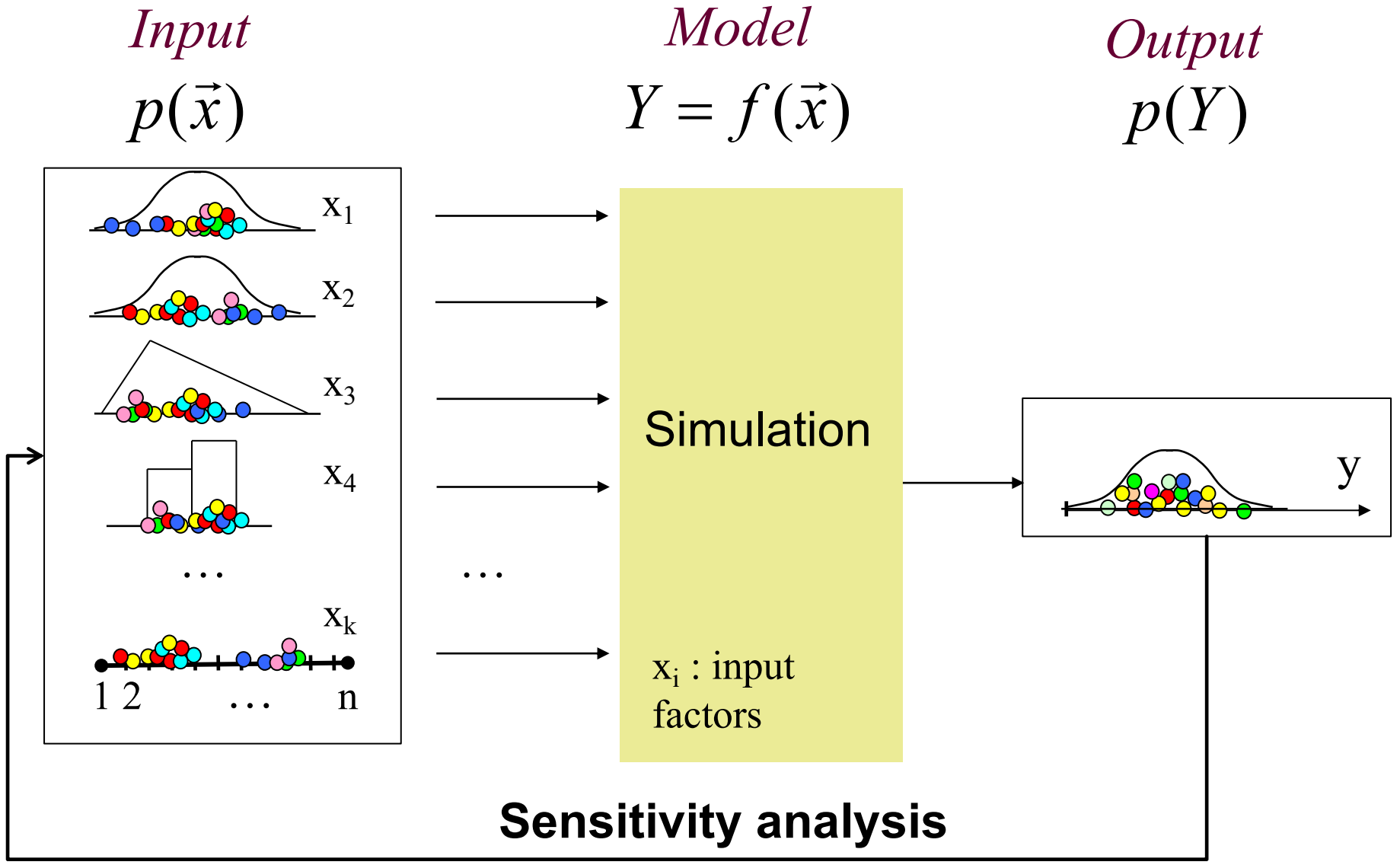


“MODELLING OF THE MODELLING PROCESS”

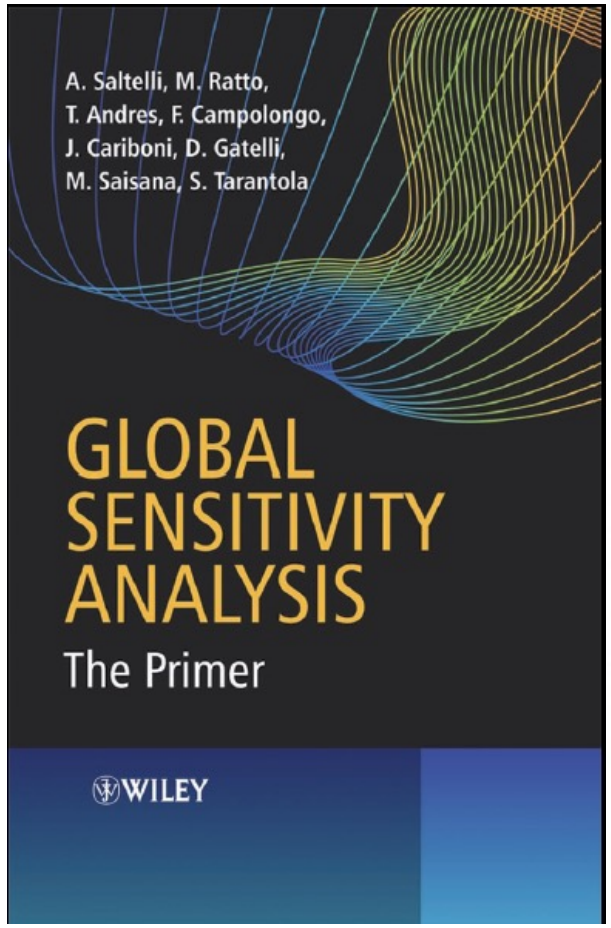
- Global uncertainty and sensitivity analysis

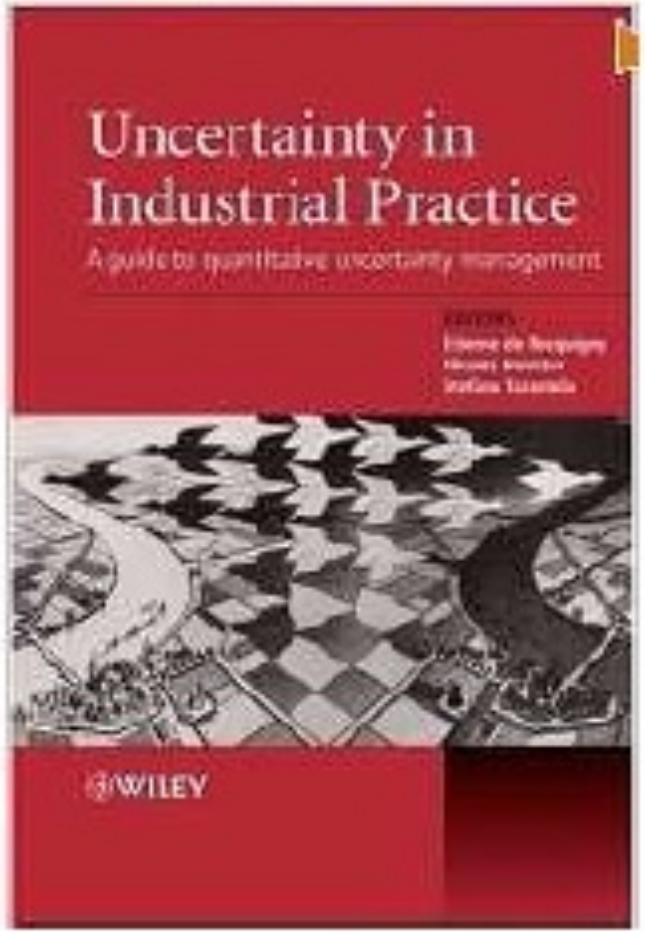


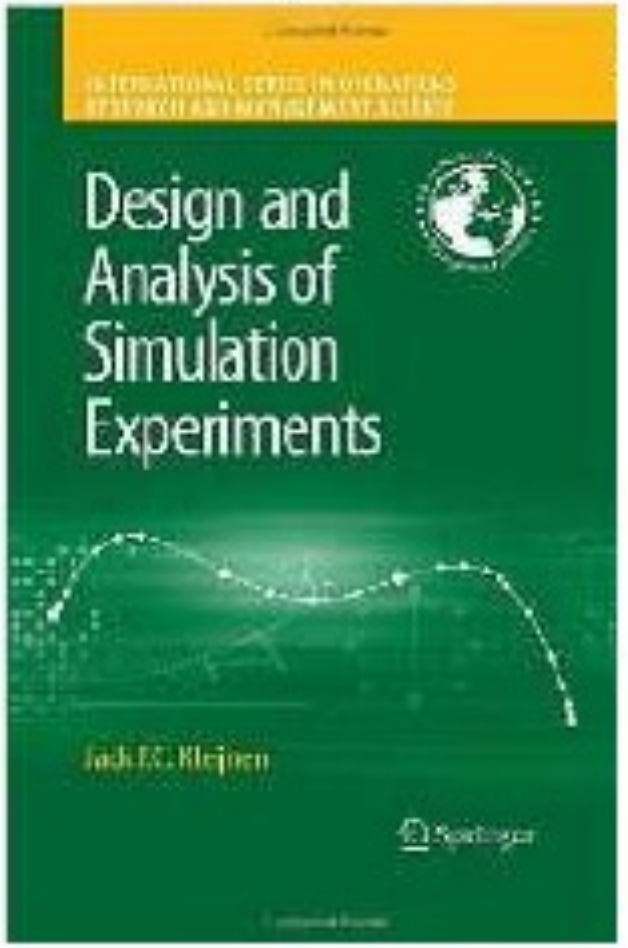
UNCERTAINTY IN MONTE CARLO FRAMEWORK

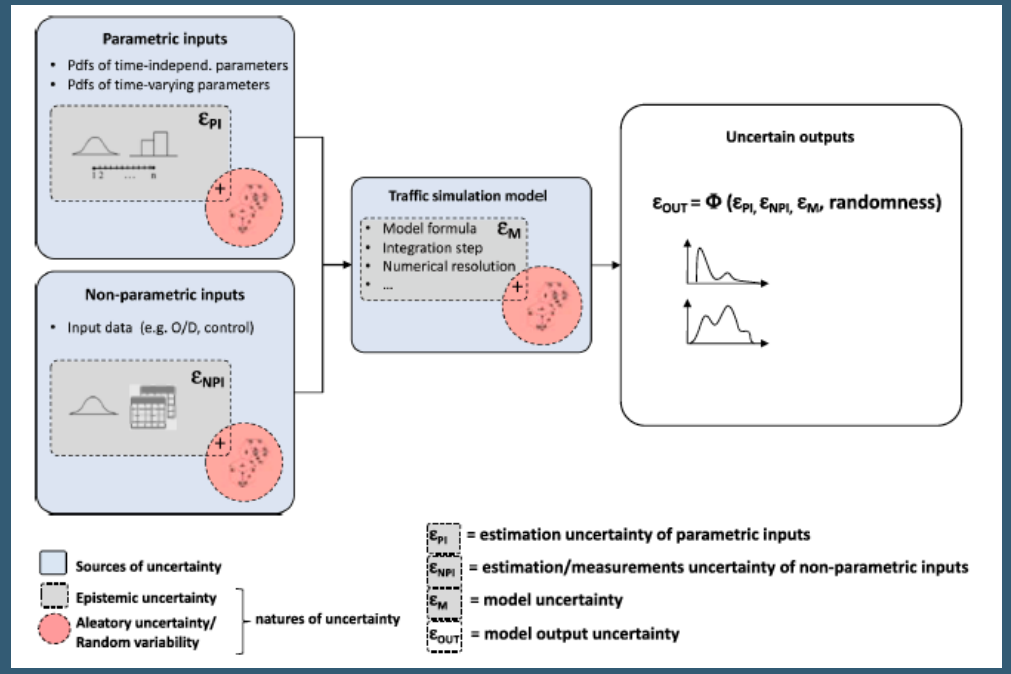


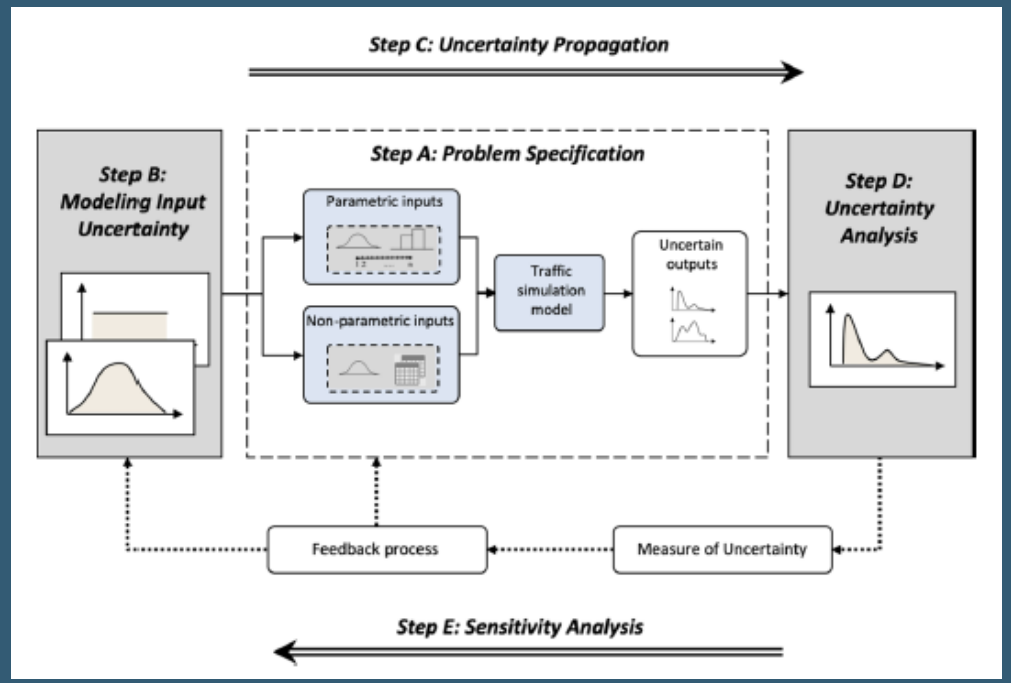
SOME USEFUL BOOKS











UNCERTAINTY SPECIFICATION AND MANAGEMENT FLOW

(Punzo and Montanino, 2020)

“The sculpture is already complete within the marble block, before I start my work. It is already there, I just have to chisel away the superfluous material.” (Michelangelo)

FARNESE HERCULES
Museo Archeologico Nazionale, Naples

CONTACT US

LinkedIn
https://linkedin.com/company/i4driving

Twitter
@i4driving

Email
vinpunzo@unina.it

Phone
+39 335 5721806