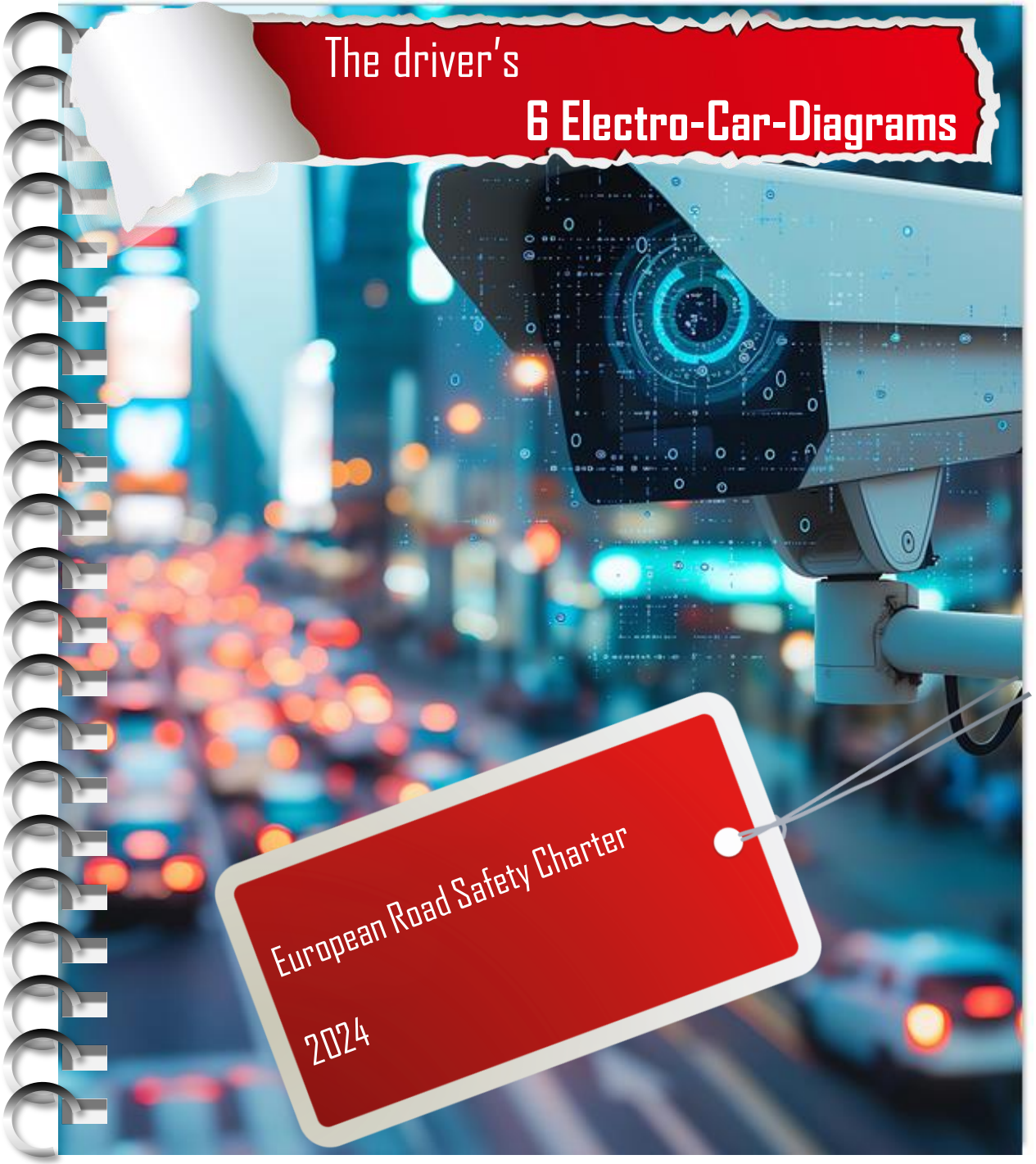

The driver's
6 Electro-Car-Diagrams
European Road Safety Charter
2024

Summary

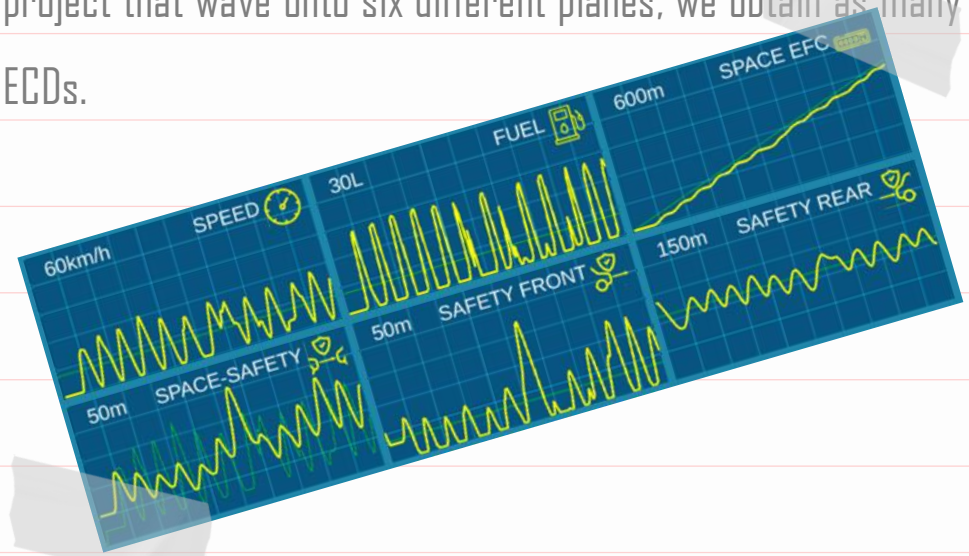
"It is mathematically impossible to drive with the idea of maintaining a safe distance and not causing traffic jams."

We are the traffic engineering team that has generated the new equations for a new mobility. Eliminating the dynamics of a traffic jam in just 10 seconds or making it disappear with the sole behavior modification of one driver are achievements we have demonstrated some time ago.

However, the most outstanding part of our work is that we have created the 6 Driver's Electro-Car Diagrams.

This represents a milestone that could change the world of education in Road Safety, Mobility, and Sustainability, for which we received the National Award for Occupational Risk Prevention in Spain in 2019 (pre-COVID).

These 6 ECDs derive from our demonstration that, in terms of lane mobility, a driver is nothing more than a wave, and if we project that wave onto six different planes, we obtain as many ECDs.



Benefits

Studies conducted over the past 10 years have shown that when drivers understand traffic dynamics and know themselves through the ECDs, the following occurs:

- Fuel consumption and pollutant emissions decrease.
- Accident rates decrease.
- Stress and anxiety while driving diminish.
- So-called Phantom Traffic Jams vanish.
- Travel times got reduced.
- Driver fatigue diminishes.
- The efficiency of infrastructure is improved.
- Enhances safety in emergency situations, such as population evacuations.
- Creates awareness of collective driving.

Compatibility

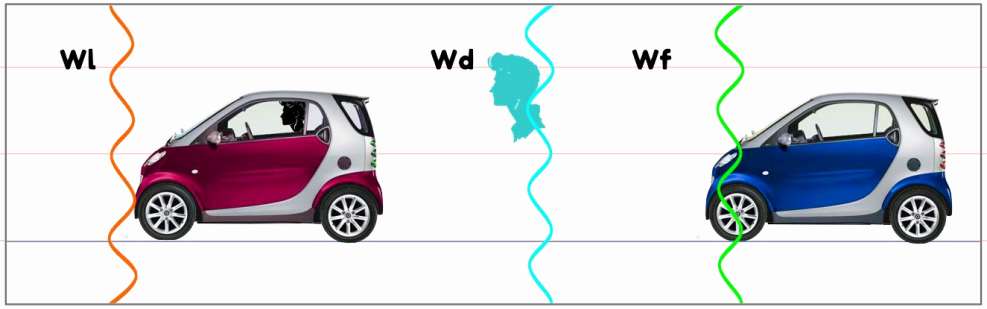
Inertial driving is compatible with:

- All traffic regulations in all countries.
- All types of vehicles: heavy or light.
- All fuels: fossil or electric.
- All drivers: human or autonomous.
- All safe driving techniques, such as preventive and defensive driving.
- Connected vehicles.

On May 6, 2015, we eliminated the dynamics of a traffic jam in 10 seconds by giving a message to a single driver.

Equations

" The movement wave of a vehicle traveling in a lane is the movement wave of the vehicle ahead plus the wave of its driver."



W follower = W leader + W driver

What do we do in our course?

We modify the driver's wave!

From the previous equation, we draw the following conclusions: for there to be no traffic jams, every driver must meet the following conditions:

1. Never get closer than a safe distance.
2. Maintain the highest possible average speed.
3. Keep a uniform speed.
4. Occupy only the necessary space to meet the above conditions.

From a mathematical point of view, each condition is an equation, and for the system to have a solution, the driver must use as many variables as there are equations: 4.

However, the driver who drives with the idea of maintaining a safe distance uses only two variables:

1. Speed
2. Safe Distance

That is why phantom traffic jams occur:

4 equations vs 2 variables

How do we solve it?

Drive to keep 'distance' vs 'inertia'

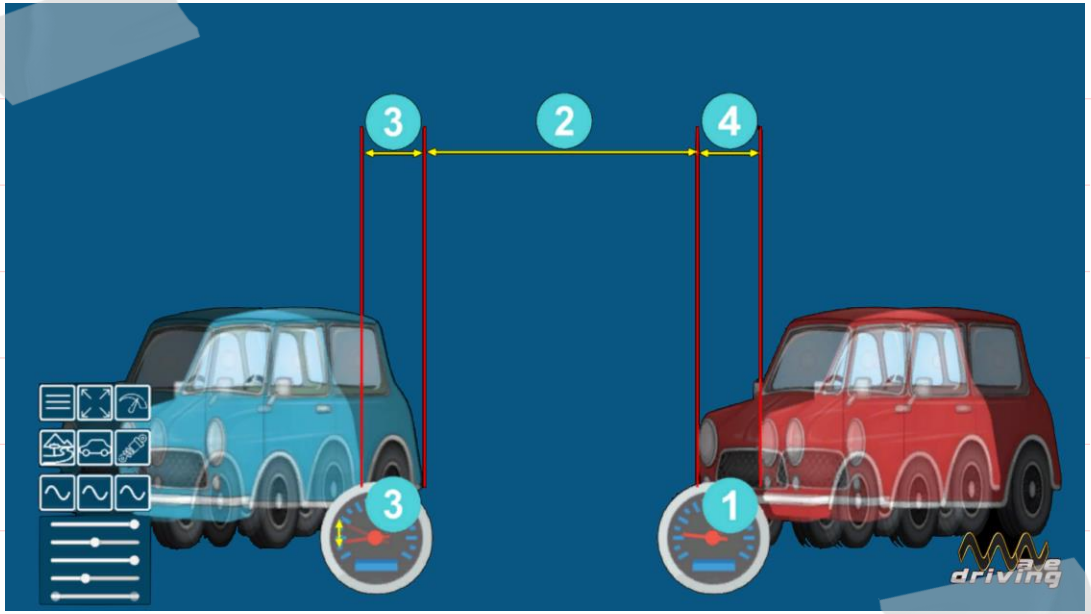
For the system to have a solution, it is necessary to use another way of interpreting the movement in the lane: 'inertial driving' which uses 4 variables:

1. The average speed variable.
2. The usual safe distance variable.
3. The speed adaptation variable.
4. The required space adaptation variable.

But all this sounds very complex. If driving with two variables is already complex, how are we going to add two more variables?

TD: Traditional Driving or 'Distance'

WD: Wavedriving® or 'Inertial' Driving



The 4 variables.

Analogical Reasoning

It is common to use mental analogies to explain certain physical phenomena to students. For example, to explain the law of gravitation, it is said that it is as if the earth were a large magnet and objects were metallic elements attracted to it.

In psychology, this is called **analogical reasoning**.

Therefore, to help drivers understand traffic dynamics, we will use simple analogies that allow an immediate understanding of the physical phenomenon we want to explain.

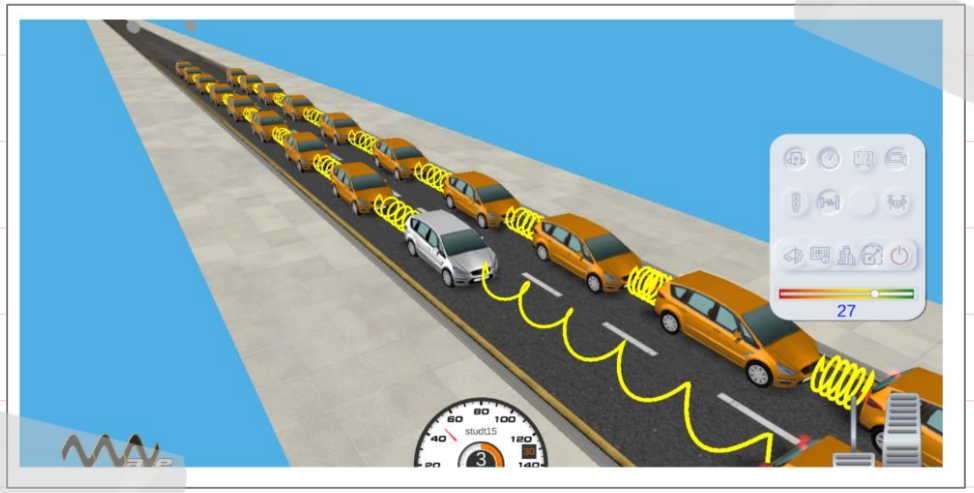
1st Analogy

"A vehicle is nothing more than a traffic light on wheels:

- ***Green*** when moving.
- ***Yellow*** when braking.
- ***Red*** when stopped."

2nd Analogy

"Vehicles do not move because they have a driver controlling them, but because they are connected by springs to the lead vehicle.".



3rd Analogy

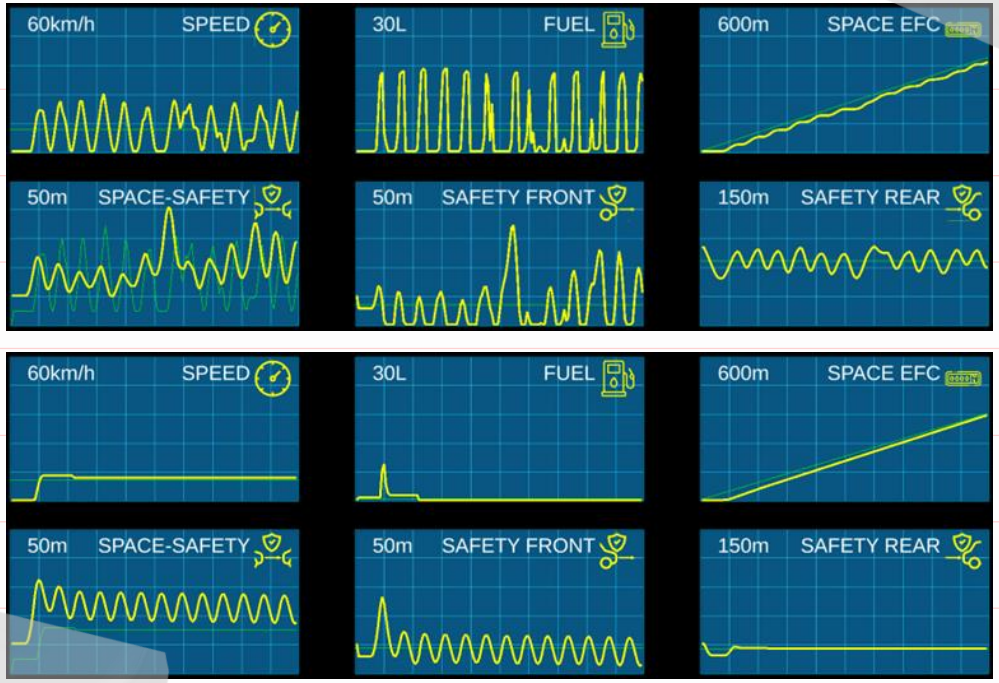
"When you are following another vehicle, you should imagine that your vehicle has two elements on its front:

1. A rigid bar that represents the safety distance.
2. A spring that represents the variable space needed to adjust your speed."

Process

The process that has given the best results to understand traffic dynamics has been the following:

1. ECD self-assessment.
2. One active lane, Leading Player: Visualize how your speed changes affect the vehicles that follow you.
3. Two active lanes, Leading Player: Learn to time with traffic lights in sequence. Comparison with (incorrect) bots strategy occurring in parallel in the second lane.
4. Two active lanes, second vehicle Player: Learn to synchronize with the preceding vehicle. Comparison with (incorrect) bots strategy in parallel in the second lane.
5. ECD self-assessment.



Observe the ECDs at the top. They correspond to the same driver who took our course.

- Do you notice any changes between them?
- Which one seems to be safer, consume less fuel, and be less stressful?

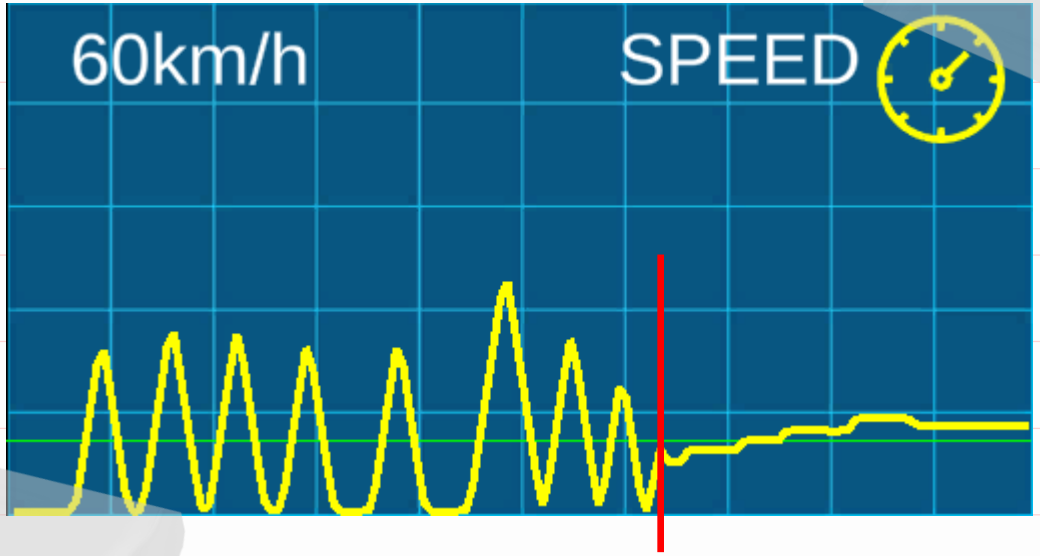
The 6 Electro-Car-Diagrams

Our students take two mandatory evaluation tests:

1. Before starting the training.
2. At the end of the training.

Since the ECDs indicate the 'flaws' in their driving, they can subsequently take as many tests as they wish to perfect their technique. This way, when they are on the 'real' road, they will be able to apply all the knowledge learned.

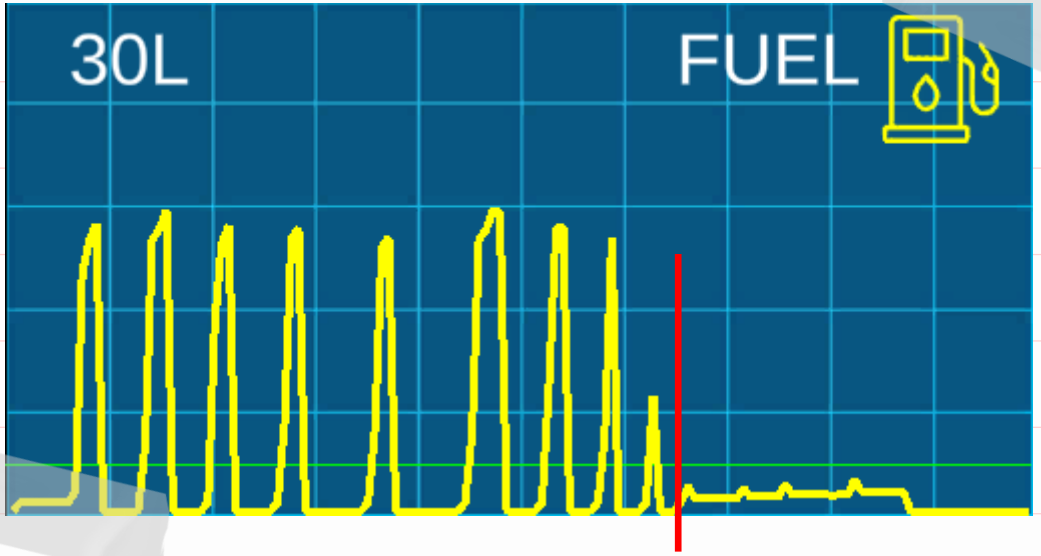
ECD Efficiency in Speed



We are showing, from left to right within the same graph, the result of the two lane-driving techniques. We can see the differences:

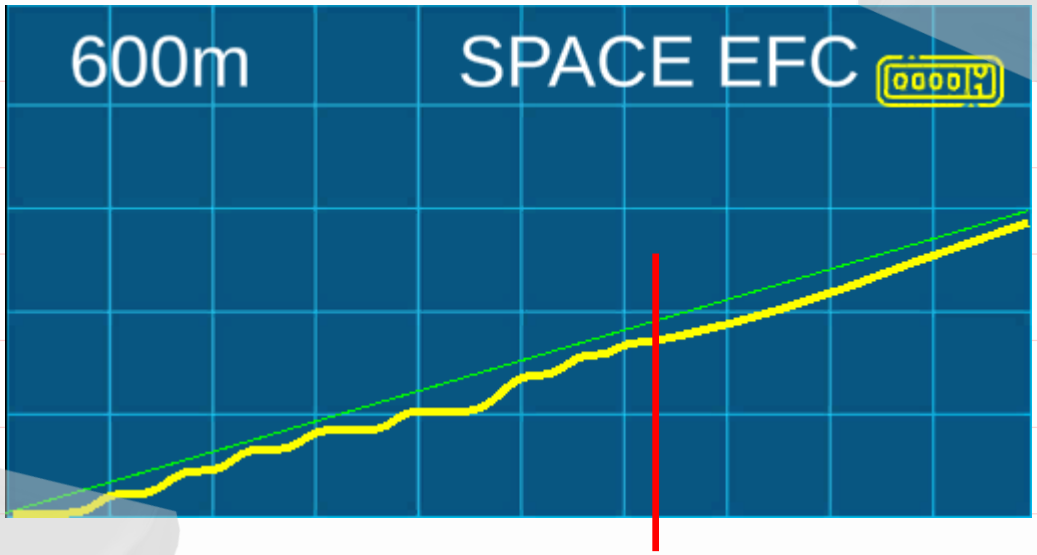
- TD: Highly variable speed, then
- WD: Minimally variable speed.

ECD Efficiency in Consumption/Emissions



1. TD: Very high consumption due to having to give impulse to the vehicle, then
2. WD: Minimal consumption.

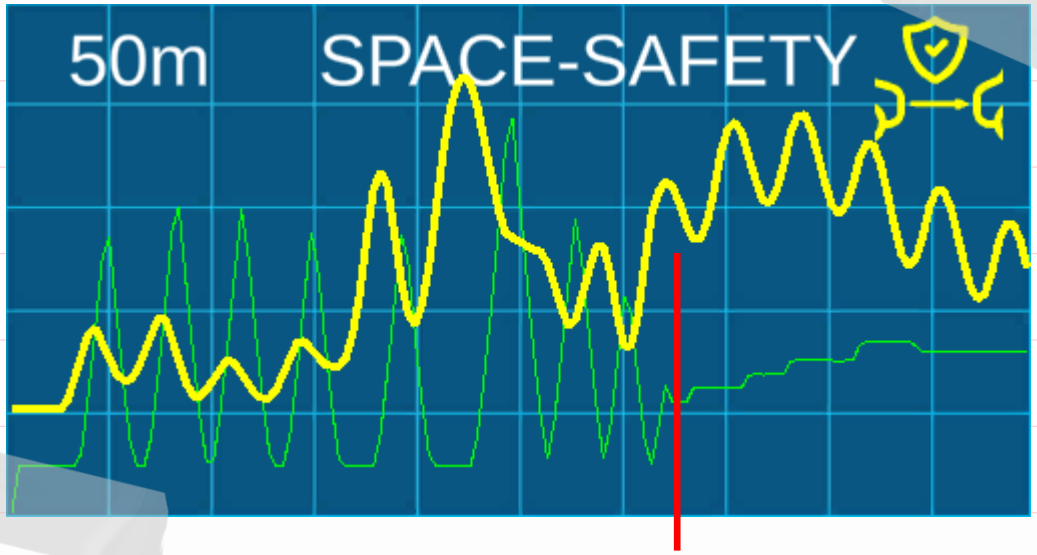
ECD Efficiency in Space



It should be interpreted vertically; the distance between the green and yellow lines indicates the amount of 'asphalt' we need in our driving:

1. TD: Very variable with many stops and starts.
2. WD: Slightly variable and continuous flow.

ECD Managing Distances



In this graph, two lines converge:

- Green: the (safety) distance we need.
- Yellow: the distance we are actually leaving.

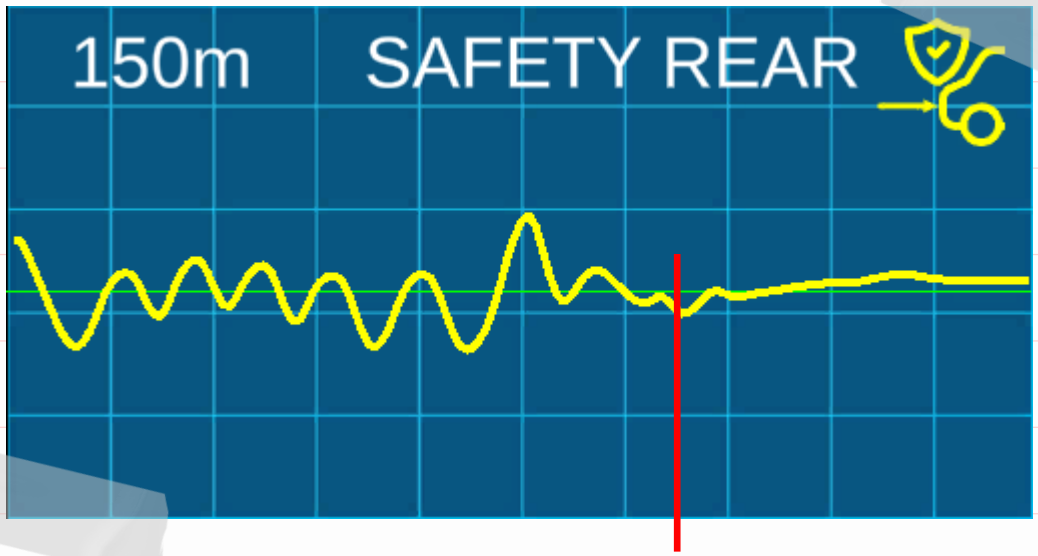
1. TD: Areas where the green is above => Unsafe.
2. WD: Has not invaded the safety distance => Safe..

ECD Road Safety in FRONT

If the waves valleys are flat, it indicates the moments in which the safety distance was not maintained:

- TD: Several sections with flat valleys => Unsafe.
- WD: No flat valleys => Safe.

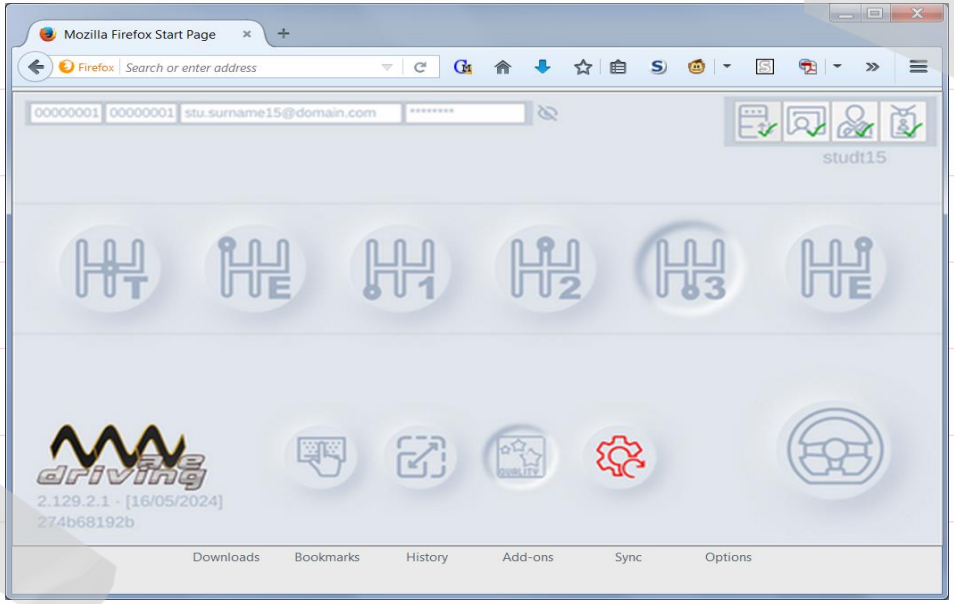
ECD Road safety REAR



This graph indicates what the driver is causing in the platoon following him/her:

- TD: Causing sudden braking and acceleration => Unsafe.
- WD: Generating 'calm traffic' => Safe.

6 ECD How are they obtained?



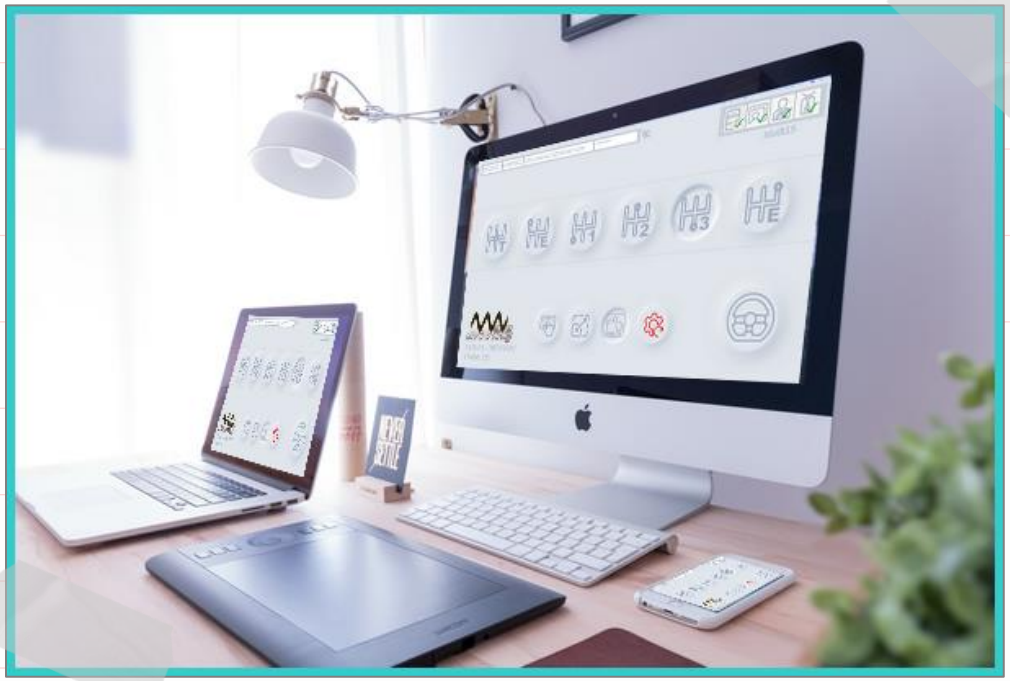
Different devices connected to a computer are not necessary to obtain the 6 ECDs of a driver, just visit our website.

You only need any of these common objects:

- Mobile phone.
- Tablet.
- Personal computer / Laptop.

Upon entering the simulator's website, as the driver reacts to the different elements that appear on the scene, the system automatically collects the corresponding values (speed, consumption, distances...) to later display them in a graphical form.

Super simple!



Who is it addressed to?

In reality, lane mobility goes beyond just having your hands on the steering wheel. Let's remember that the origin of the equations comes from caterpillars that move in a line. We should learn from them. They move without pushing each other.

It has been proven that adding two new variables to a person's mind and brain is permanent, much like riding a bicycle; it is a lifelong learning experience.

Unfortunately, there are situations where Civil Protection must organize an emergency evacuation, and we, the citizens, must help them so they can help us. It is vital to understand and participate in collective movement.

Therefore, inertia-oriented driving should be made known in:

- Schools and Universities.
- Companies, whether they are transporters or not.
- Health Centers (Hospitals, Emergency Services, etc.)
- Driving Schools, naturally.

Autonomous Vehicle / Connected Vehicle

Every behavior of a driver is reflected in the ECDs, and the autonomous vehicle also has its own driver, even if it doesn't have a face.

Currently, we are developing:

- Advance Driver Assistance for the driver by incorporating it into a smartphone (applications like Waze® etc.).
- Advance Driving Assistance in an embedded device.
- Part of the software in the vehicle's AI.

There will come a day when every vehicle on the road will have, at least optionally, the possibility of autonomous driving. However, until that day arrives, the smartphone, when used properly, will be a great ally.

How is the miracle worked?

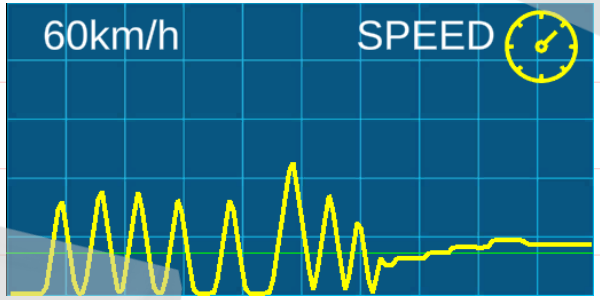
How, in a few minutes, can drivers change their behavior forever? By using two techniques:

1) At all times, the student-driver observes a lane to the left where vehicles with traditional driving operate.

In this way, they compare what happens when driving with one technique or another.

2) Having ADAS that will show the traffic dynamics from perspectives that would otherwise be almost impossible to imagine.

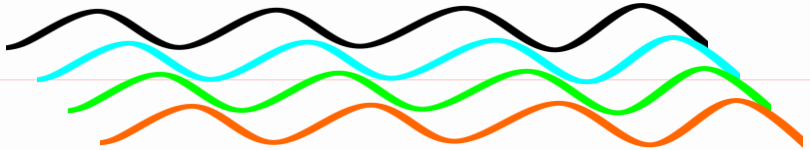
Curiosity



We previously saw the ECD of speed, but could you tell us what units it is measured in?

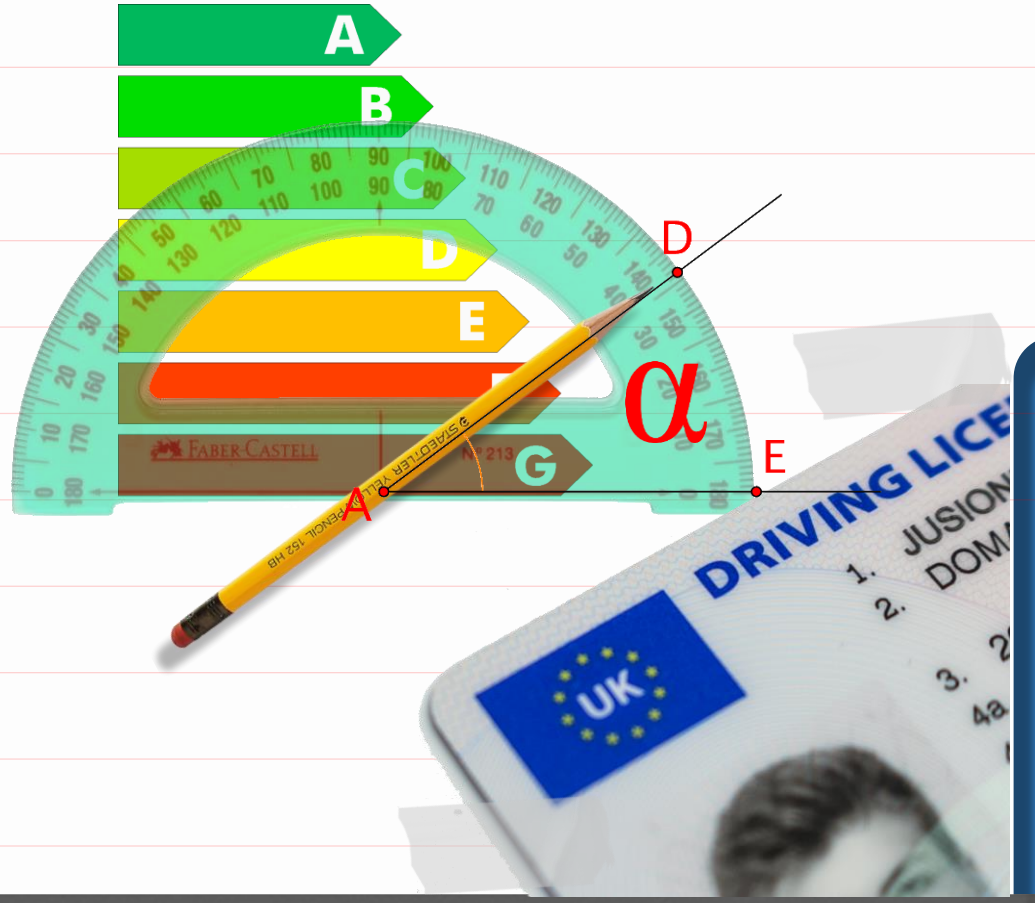
Well, although it seems incredible, the efficiency of speed is...

an angle!



Similarly, the reaction time of a driver (approximately 0.75s) could also be expressed in radians.

Due to the wave interpretation of the movement in the lane, we can establish a comparison between the vehicle's wave and the driver's wave, and from this comparison, obtain the value of the phase shift... which is an angle α.



Phantom traffic jam

If we stayed only in theory, this knowledge would hardly make sense. In the classrooms, alongside the use of the Web Simulator and as a complement to it, videos are shown with real examples of:

- FRONT accidents.
- REAR accidents.
- Phantom traffic jams.
- Unstable dense traffic.
- Lane blocking.
- Etc.

According to our estimates, if just one in every fifty (1/50) drivers practiced inertial driving, 20% of the traffic jams on our roads would disappear.

Recognitions and Achievements

Behind this engineering, there are many years of effort in the labor, economic, technological, and personal fields.

Many of us have put our efforts into achieving the dream of finally understanding traffic dynamics and, at the same time, being able to teach it to other drivers, to the world.

In the following pages, we will show some of the recognitions that have been awarded to us over the years. Leaving some out should not be seen as a shortcoming on our part, but rather to avoid making the document excessively long.

DGT Certificates of Excellence

MINISTERIO DEL INTERIOR

DGT Dirección General de Tráfico

Juan Carlos González Luque

Jefe de la Unidad de Coordinación de la Investigación

D. JUAN CARLOS GONZÁ
LA INVESTIGACIÓN DE L

CONCEDE A

Don Antonio Lucas Alba,

Por su contribución a las
Tráfico y presentar un es
PROPUESTA PARA OPT
propuesta fue presentada

Y para que así conste y s
Madrid a 30 de octubre de

MINISTERIO DEL INTERIOR

DGT Dirección General de Tráfico

Juan Carlos González Luque

Jefe de la Unidad de Coordinación de la Investigación

CERTIFICADO DE EXCELENCIA

D. JUAN CARLOS GONZÁLEZ LUQUE, JEFE DE LA UNIDAD DE COORDINACIÓN DE LA INVESTIGACIÓN DE LA DIRECCIÓN GENERAL DE TRÁFICO,

CONCEDE A

Don Oscar Melchor Galán,

Por su contribución a las Sesiones Técnicas organizadas por la Dirección General de Tráfico y presentar un estudio realizado sobre "LA CONDUCCIÓN ARMÓNICA: UNA PROPUESTA PARA OPTIMIZAR LOS FLUJOS DE TRÁFICO", "WAVEDRIVING". La propuesta fue presentada el 24 de abril de 2013 en la Sede de dicho Organismo.

Y para que así conste y surta los efectos oportunos, expido el presente certificado, en Madrid a 6 de noviembre de 2013.

MINISTERIO DEL INTERIOR
UNIDAD DE COORDINACIÓN DE LA INVESTIGACIÓN
Dirección General de Tráfico

Fdo: Juan Carlos González Luque

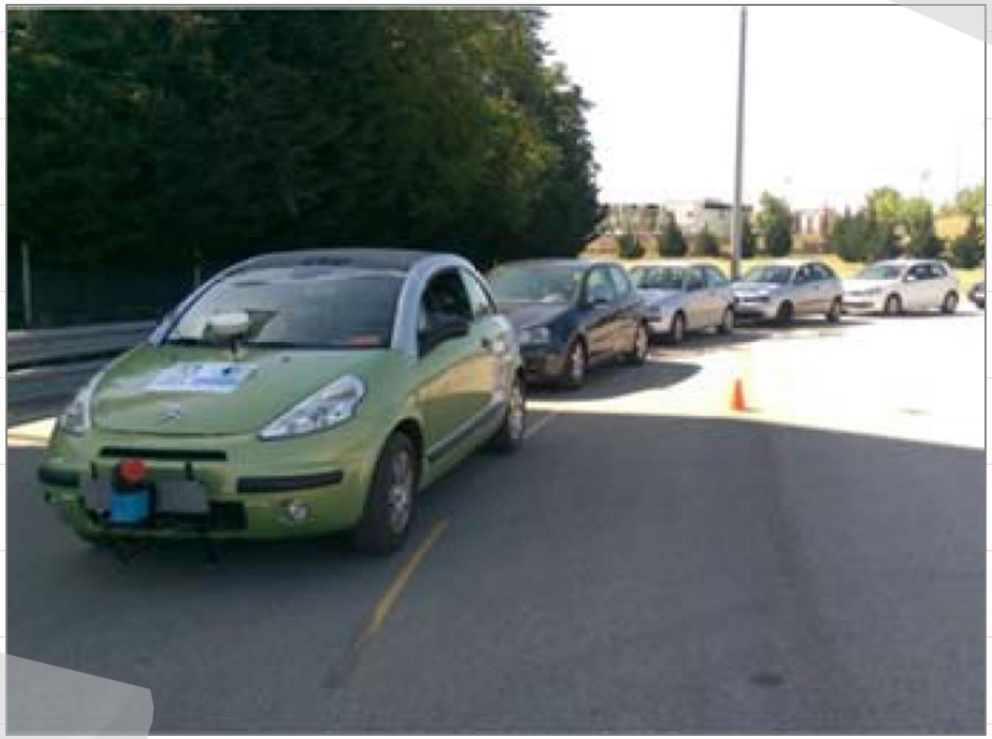
Civil Protection

When the Security Forces provide their services in civil assistance, whether in our own country or another, and it is necessary to evacuate the population, our engineering offers optimal management of the movements.

INSIA

UNIVERSIDAD POLITÉCNICA DE MADRID

Ten seconds were enough to modify the behavior of a single driver and eliminate the traffic jam dynamics.



Mathematics Certification. Universidad Carlos III de Madrid

Copying the equations for movement on the track of the pine processionary caterpillar (*Thaumetopoea pityocampa*).


WAVEDRIVING®

CONDUCIR CON TRES VARIABLES

CONDUCCIÓN ARM

WAVEDR

Autor:
Óscar Melchor Galán
CEO IMPACTWARE SL
Supervisión y adaptación:
Anxo Sánchez Sánchez
Catedrático de Matemática Aplicada
Grupo Interdisciplinar de Sistemas Complejos (G
Departamento de Matemáticas
Universidad Carlos III de Madrid

IMPACTWARE© direccion@impactware.com

UNIVERSIDAD CARLOS III DE MADRID
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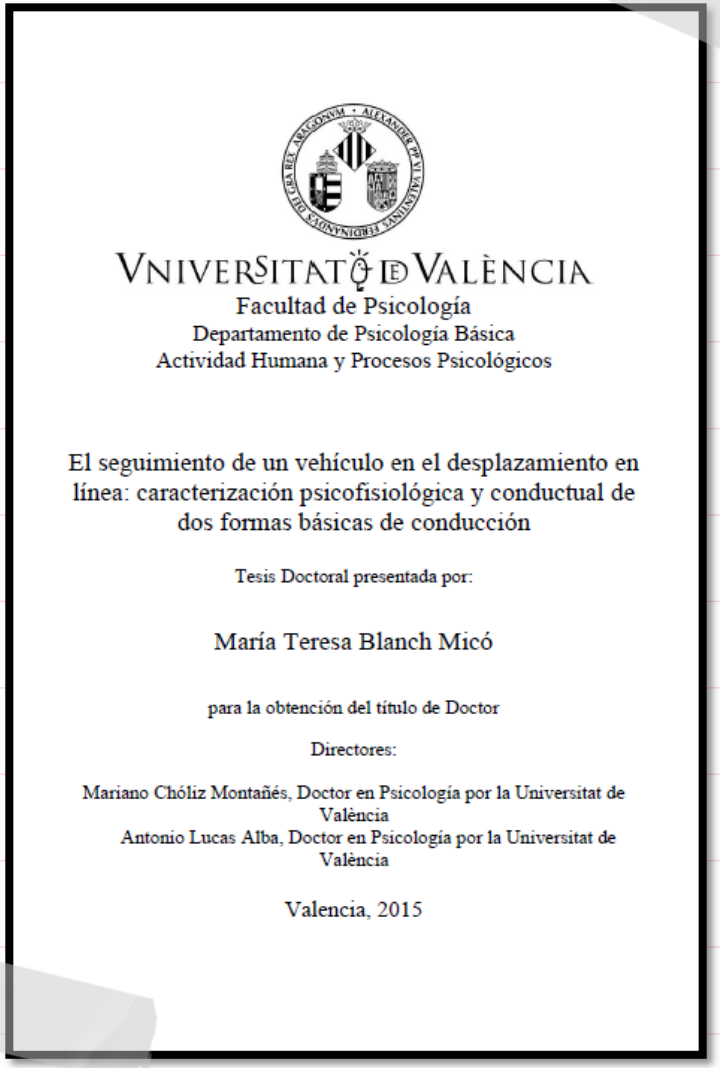
Cognitive Certification. Universitat de València

Doctorate.


VNIVERSITAT DE VALÈNCIA
Facultad de Psicología
Departamento de Psicología Básica
Actividad Humana y Procesos Psicológicos

El seguimiento de un vehículo en el desplazamiento en línea: caracterización psicofisiológica y conductual de dos formas básicas de conducción

Tesis Doctoral presentada por:

María Teresa Blanch Micó

para la obtención del título de Doctor

Directores:

Mariano Chóliz Montañés, Doctor en Psicología por la Universitat de València
Antonio Lucas Alba, Doctor en Psicología por la Universitat de València

Valencia, 2015

National Award PREVER

In the field of Occupational Health and Safety, 'driving protocol'.

OSALAN
Laneko Segurtasun eta Osasunerako Euskal Erakundea
Instituto Vasco de Seguridad y Salud Laborales

EUSKO JAURLARITZA
GOBIERNO VASCO

Consejo General de Relaciones Industriales y Ciencias del Trabajo de España

El Consejo General de Relaciones Industriales y Ciencias del Trabajo de España, a propuesta de la Comisión del Premio Prever, concede el

PREMIO NACIONAL DE PREVENCIÓN DE RIESGOS LABORALES

"PREVER 2018"

CATEGORÍA I+D+i

a

IMPACTWARE

En reconocimiento a su labor en pro de la implantación y divulgación de la Prevención de Riesgos Laborales.

Dado en Bilbao, el 2 de marzo de 2019

El Director de OSALAN — Ilmo.. Sr. D. Alberto Alonso Martín

El Secretario General de CGRICT — Ilmo. Sr. D. Rafael Ruiz Calatrava

El Presidente del CGRICT — Ilmo. Sr. D. José Andrés Magallón Ruiz

EUSKO JAURLARITZA GOBIERNO VASCO — LAN ETA JUSTIZIA SAILA DEPARTAMENTO DE TRABAJO Y JUSTICIA

insst

FESVIAL

A.L.S.O. Asociación Latinoamericana de Salud Ocupacional

CGPSST

Universidad de Granada

Cross of Honor for Occupational Health and Safety.

Although it's nominative, it's an award for the entire team for the years of effort put in.

ONSEJO GENERAL DE PROFESIONALES DE SEGURIDAD Y SALUD EN EL TRABAJO

La Comisión Permanente del Consejo General , a propuesta de la Comisión de Honores, Distinciones y Recompensas en su reunión de 8 de Octubre de 2019, celebrada en Madrid acordó otorgar a la

Oscar Melchor Galán

CRUZ DE HONOR
DE LA SEGURIDAD Y SALUD EN EL TRABAJO

en consideración a los excepcionales méritos que concurren en su persona por su labor en pro de la defensa y difusión de la seguridad y salud en el trabajo en su ámbito de actuación .

Dado en Granada, el 22 de Noviembre de 2019

El Secretario General del Consejo — D. Ramón Luis Torres Hernández

El Presidente del Consejo — Ilmo. Sr. Dr. D. Rafael Ruiz Calatrava

OPEN CALL de INNOVACIÓN Award

Not only in the area of Occupational Risk Prevention are we leaders

These recognitions give us oxygen to continue researching in the areas of knowledge, to improve the quality of life for all citizens.


ALASTRIA

PRIMER OPEN CALL DE INNOVACIÓN

CERTIFICA QUE

IMPACTWARE

Ha desarrollado el mejor prototipo para la solución de los retos del Ecosistema de Coordinación de Alastria de Madrid en el Primer Open Call Alastria 2018.

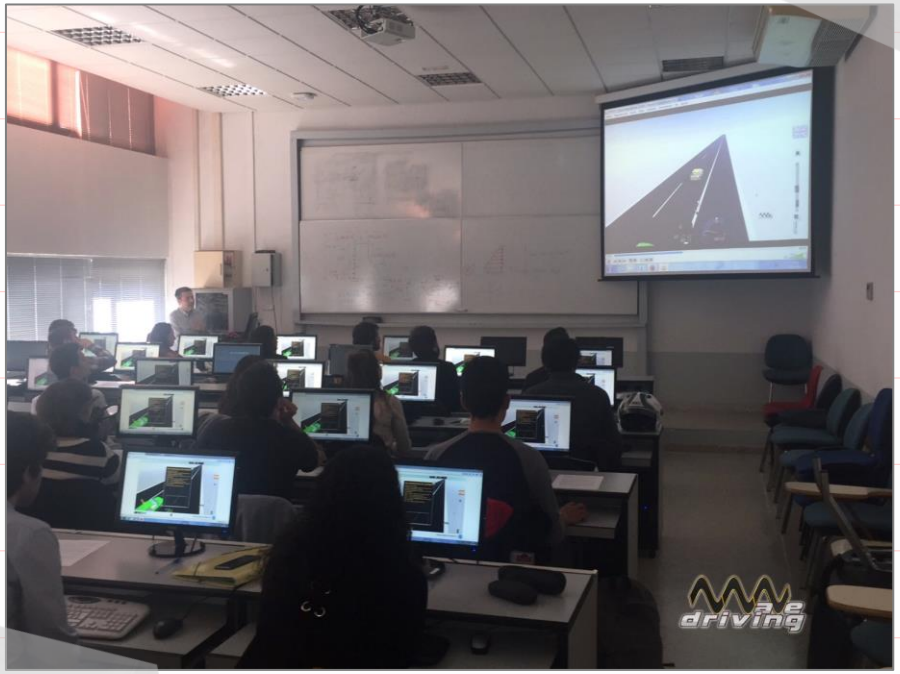
Carmen Chicharro
Líder Comisión de Innovación y Talento Alastria

Fran Gómez
Líder ECO Madrid

19 de noviembre de 2018

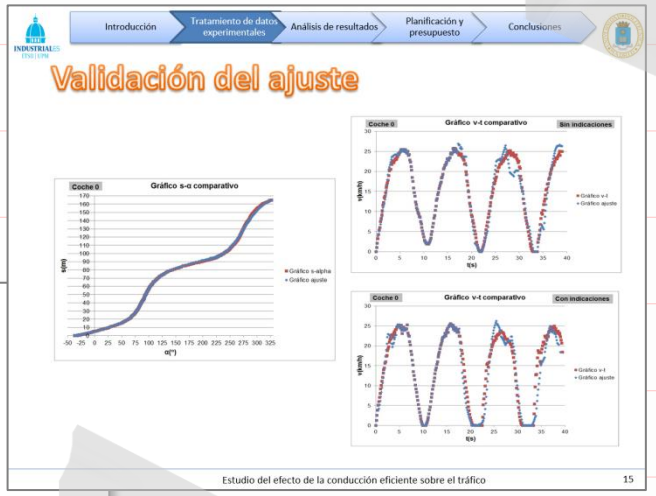
Learning Assessment.

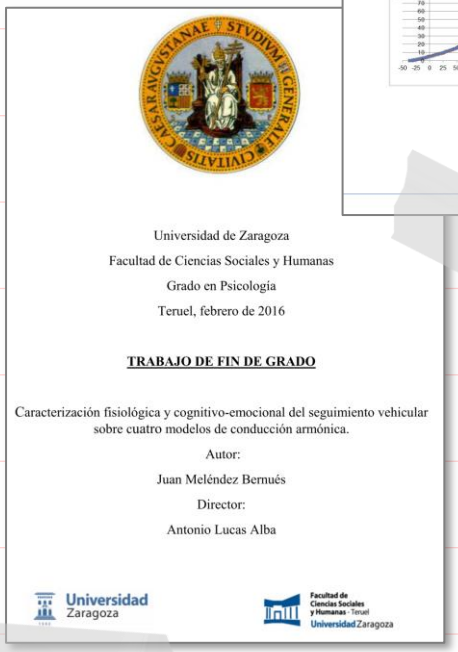
Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos de Madrid.



Final Degree Project

Different Bachelor's Degree Final Projects at different universities.





Universidad de Zaragoza

Facultad de Ciencias Sociales y Humanas

Grado en Psicología

Teruel, febrero de 2016

TRABAJO DE FIN DE GRADO

Caracterización fisiológica y cognitivo-emocional del seguimiento vehicular sobre cuatro modelos de conducción armónica.

Autor:

Juan Meléndez Bernués

Director:

Antonio Lucas Alba

Universidad Zaragoza

Facultad de Ciencias Sociales y Humanas - Teruel Universidad Zaragoza

The Science and Innovation Week of the Community of Madrid. Our work is not only recognized, but also shared, completely free of charge, at annual public events.

Collaboration

We provide training, also free of charge, to students aged between 18 and 22 from different schools, in areas such as video game programming, web page design, market forecasting, etc.

Congresses

TRB

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Universitat Politècnica de València
XII Congreso de Ingeniería del Transporte Valencia
CIT 2016

José V. Colomer Ferrándiz, Ricardo Insa Franco y Tomás Ruiz Sánchez, como Co-Presidentes del XII Congreso de Ingeniería del Transporte CIT 2016

CERTIFICAN que el trabajo titulado:

CAR FOLLOWING TECHNIQUES: THE ROLE OF THE HUMAN FACTOR RECONSIDERED

Ha sido presentado por:

María Teresa Blanch Micó, Antonio Lucas Alba, Teresa Bellés Rivera, Ana Mª Ferruz Gracia, Oscar Manuel Melchor-Galán, Luis Carlos Delgado Pastor, Francisco Ruíz Jimenez, Mariano Chóliz Montañés

En las sesiones científicas del XII Congreso de Ingeniería del Transporte CIT 2016.

Valencia, 7 de junio de 2016

Prof. José V. Colomer Ferrándiz | Prof. Ricardo Insa Franco | Prof. Tomás Ruiz Sánchez

hfes europe chapter HFES Europe chapter

The Human Factors and Ergonomic Society – European Chapter. Prague, 26-28 October, 2016

"Car-following techniques: reconsidering the role of the human factor"

Antonio Lucas-Alba[1], Mª Teresa Blanch[1], Teresa Bellés[1], Ana Mª Ferruz[1], Ana Hernando[1], Oscar M. Melchor[2], Luis C. Delgado[3], Francisco Ruíz[4], Mariano Chóliz[5]

[1]*Universidad de Zaragoza,* [2]*Impactware,* [3]*Universidad de Granada,* [4]*Universidad Konrad-Lorenz,* [5]*Universitat de València*

[1,2,3,5]*Spain,* [4]*Colombia*

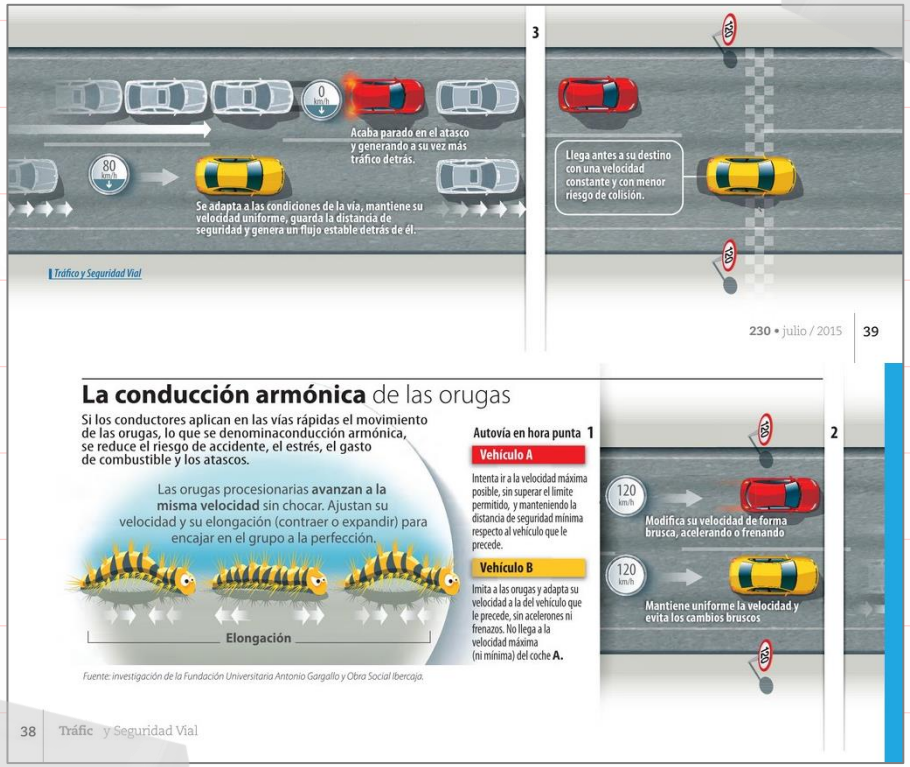
Fundación Universitaria Antonio Gargallo

IMPACTWARE

Universidad Zaragoza 1542

Press

TRÁFICO Y Seguridad Vial
http://revista.dgt.es



https://revista.dgt.es/es/multimedia/infografia/2015/0915La-conduccion-armonica-de-las-orugas.shtml

https://www.alsa.es/-/por-que-se-producen-los-atascos

SEGURIDAD VIAL

Copiar el movimiento de las hormigas o las orugas: el truco de la DGT para evitar atascos y colisiones

• Un estudio citado por Tráfico demuestra que la conducción armónica es más rápida, segura y eficiente

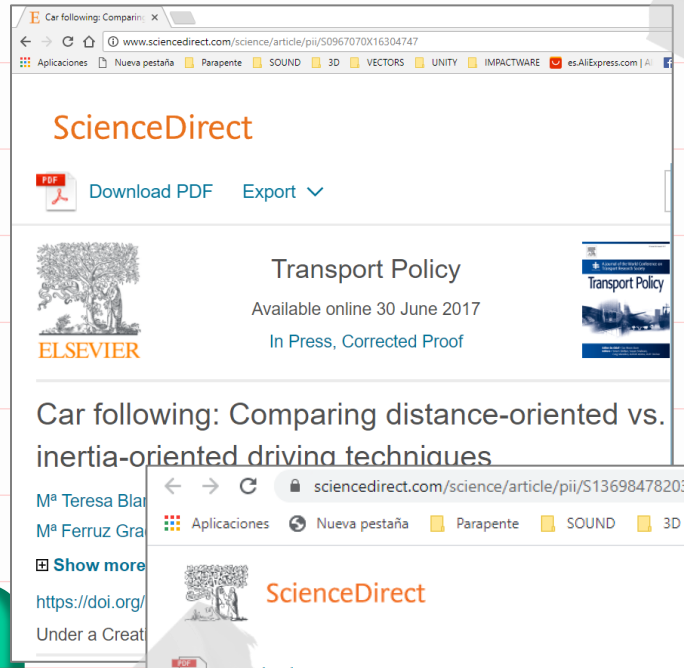
Circular a una velocidad estable y mantener la distancia de seguridad evita la formación de atascos (Getty Images/iStockphoto)

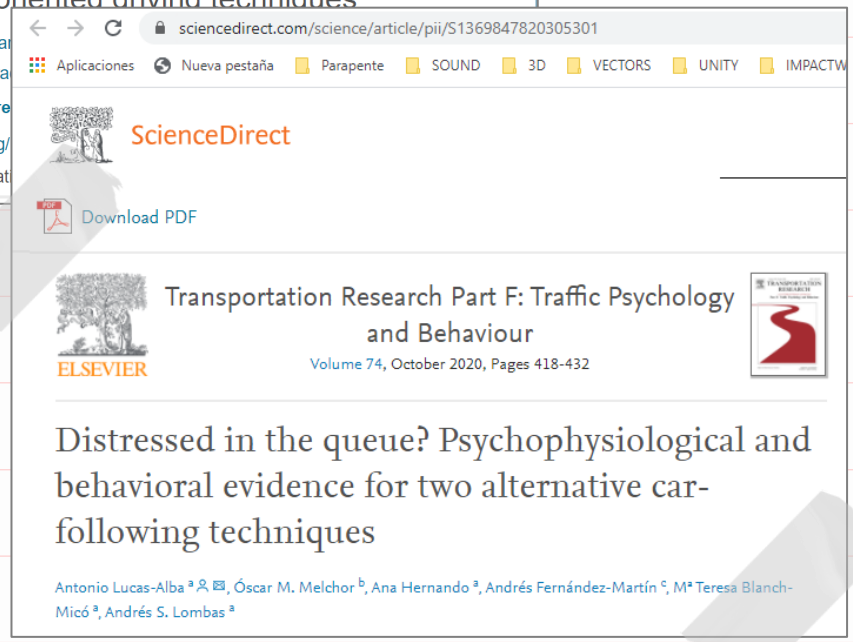
LA VANGUARDIA
BARCELONA
05/12/2023 07:00 | Actualizado a 05/12/2023 07:43

https://www.lavanguardia.com/motor/dgt/20231205/9415848/copiar-movimiento-hormigas-orugas-truco-dgt-evitar-atascos-colisiones-tsc.html

Scientific Papers

Multiple Scientific articles published.





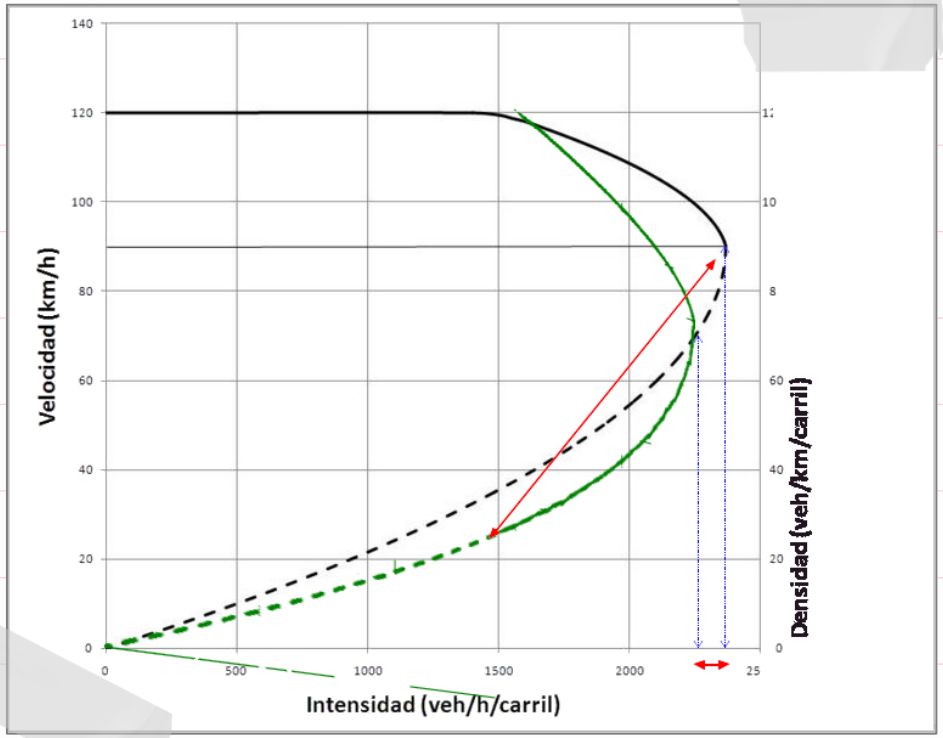
COVID-19.

During the pandemic, the Technion (Israel) conducted a new scientific study, this time adapting its own simulators, and the results were once again conclusive.

Traffic Engineering

Modification of Traffic Flows:

- Reducing travel times,
- Controlling Pollutant Emissions,
- Optimizing Infrastructure Utilization.



Sustainability

It's not just training; WD represents a comprehensive technological solution to the world of Mobility and Sustainability since it can be integrated into technological systems

- both onboard and otherwise,
- in Collective Traffic Control (Management Centers).

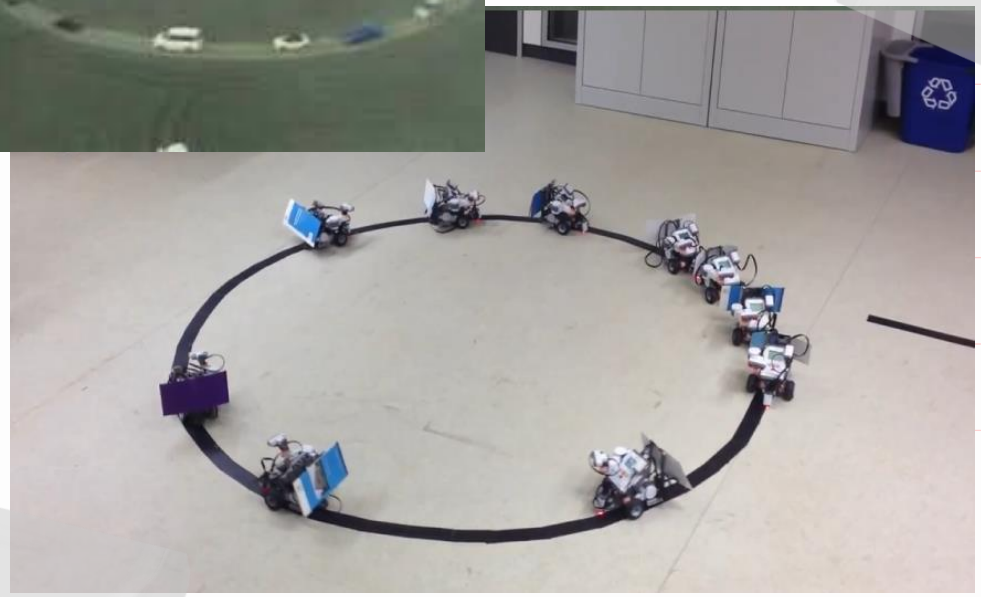
Clearing a real traffic jam

It was enough to modify the behavior of a **single driver** to solve a real traffic jam on the A-42 Madrid-Toledo highway, in the central lane.

With two other drivers, one on the left and one on the right, practicing inertial driving, this traffic jam would have been solved... for 15 minutes.

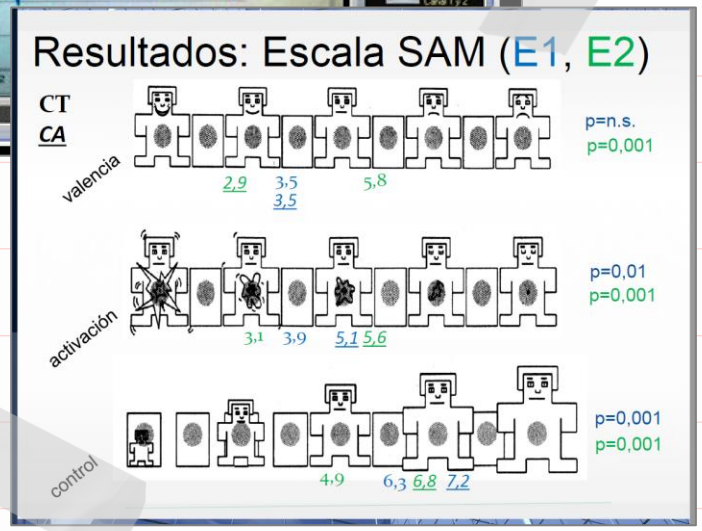
More inertial drivers are needed.

By modifying algorithms in small-scale models (Arduinos) in the laboratory, we were able to learn before transitioning to the real world (Experiment at Nagoya University).



Emotions

It has been proven that understanding traffic dynamics reduces levels of stress and anxiety behind the wheel by between 20 and 80%.



The following have been measured:

- Skin Conductance
- Heart Rate
- Respiratory Rate
- Face Temperature

Departamento de Psicología y Sociología
Universidad Zaragoza
1542

Thanks

Finally, we believe that the 6-Electro-Car-Diagrams will be mandatory elements in driver training in the coming years not only in Europe, but worldwide.

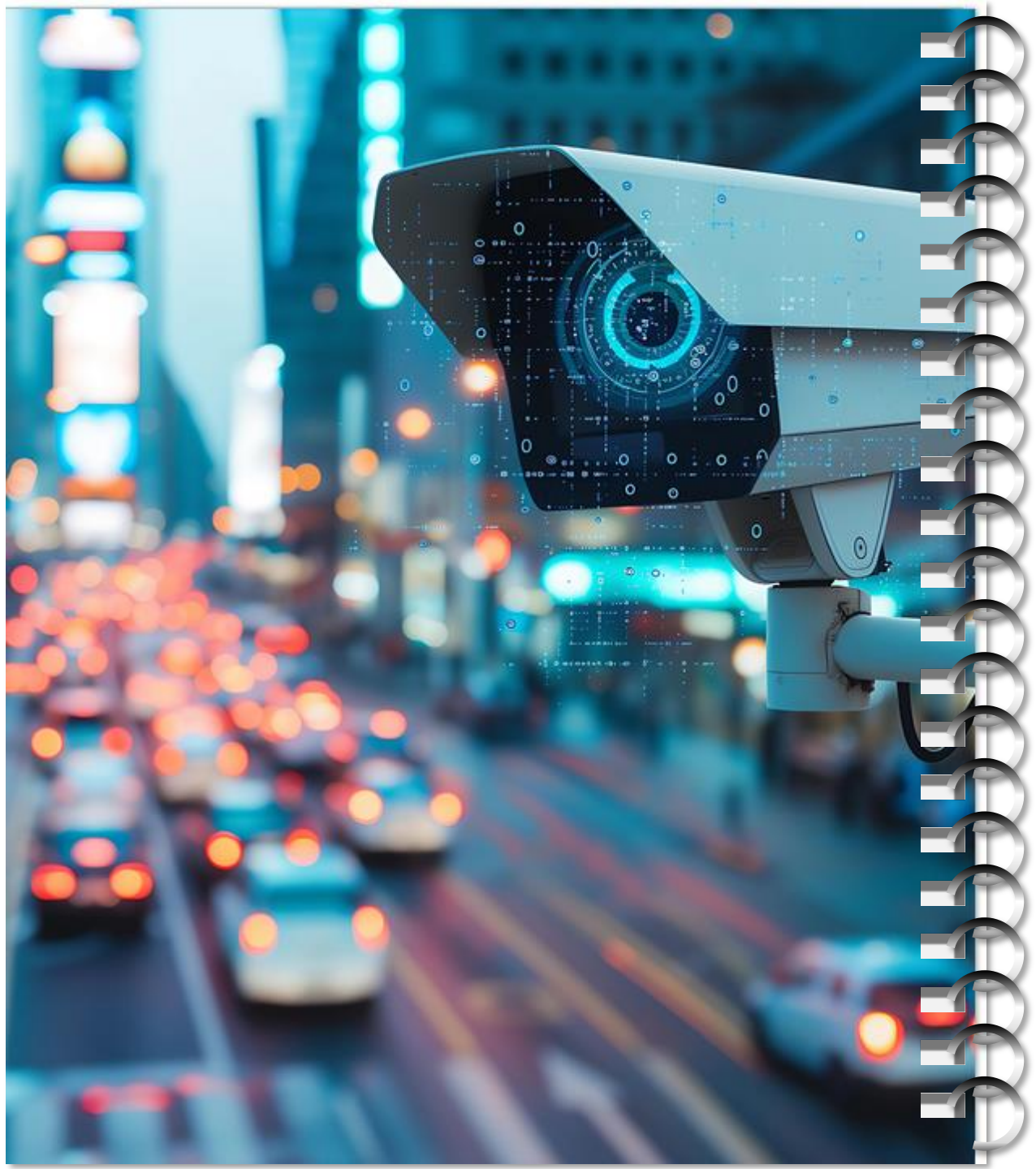
Here we only present a brief summary of years of work in the hope that a new traffic engineering will emerge, with new concepts and new challenges.

We want to thank you for all the attention you have given us, and to let you know that we are at your disposal for any questions or doubts you may have.

Óscar Melchor Galán

Antonio Lucas Alba

contact@wavedriving.online



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