RDW

What if technology takes over all driving tasks?

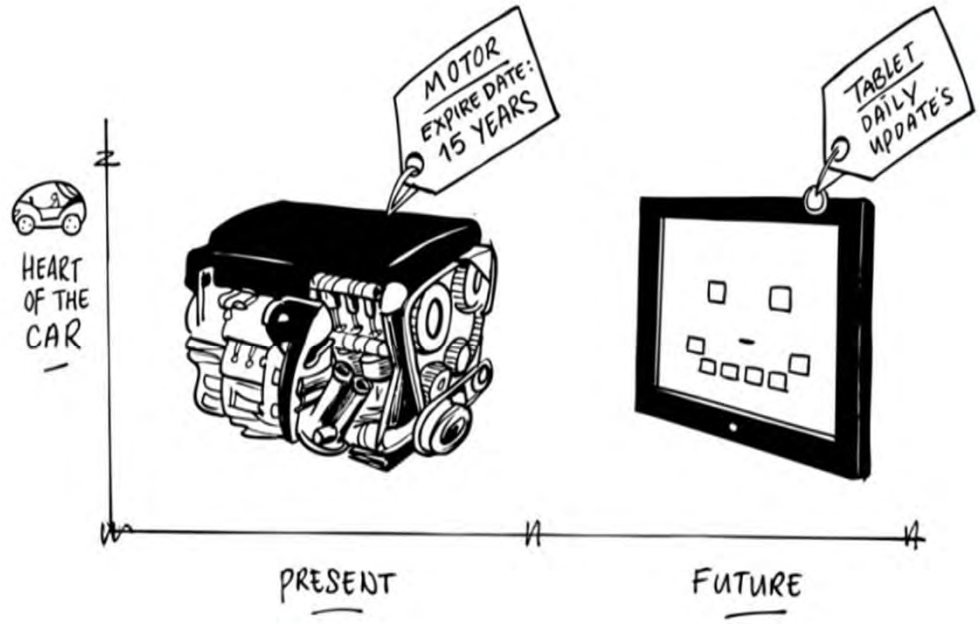
VSCC and MOTC Delegation Visit

Gerben Feddes

05-07-2018

Agenda

1. A sense of urgency…
2. Current possibilities
3. The Dutch approach
4. The Vehicle Driving License



1. A sense of urgency…

William Clay Ford Jr:

“It used to be that the auto industry, and the car itself, were part of a self-contained ecosystem. If there were breakthroughs, they were developed within the industry. […] That’s all been turned on its head; we now have disruption coming from every angle.”

Autonomous Vehicle Tech Eco-System

VSI Labs

Platforms

OEM

FUNCTIONING AV BUILDS

Audi, Ford, Hyundri, Kia Motors, FCA, VW, Toyota, PSA, Nissan, BAIC, Mercedes, Acura, BMW, GM, Honda, Infiniti, Jaguar Land Rover, Renault, Tesla, Volvo, SAIC, Changan, Chery

Others

Waymo, Lyft, nutonomy, Nauto, TORC Robotics, SD, Local Motors, Uber, Easy Mile, 2getthere, Baidu, Zoox, AutoX, JingChi, Navya, May Mobility, Apple

AV Stacks

NXP, ZF, NVIDIA, MAGNA, Continental, Bosch, Delphi, Hitachi, Renesas, Samsung, TTTech, intel, Visteon

Components

PROCESSING

Renesas, NVIDIA, Mobileye, Kalray, Synopsys, NXP, Toshiba, CEVA, Cadence, Imagination, Analog Devices, ARM, AMD, intel, ST, DiBotics, Xilinx, videantis, Altera, Texas Instruments, Marvell, Movidius, Graphcore, Qualcomm, AImotive

SENSING

Bosch, Texas Instruments, Mitsubishi Electric, Continental, ibeo, Valeo, ZF, TRW, Toshiba, Hitachi, Luminar, Autoliv, Kostal, Mobis, Delphi, Innoviz, Pioneer, Denso, LG Innotek, Panasonic, Magna, Harman, Fujitsu Ten, Pepperl+Fuchs, Velodyne LiDAR, Tetravue, Quanergy, ON Semiconductor, Aeye, FLIR Systems, Hella, Navtech, Infineon, Mando, Applanix, NXP, u-blox, LeddarTech, Oryx, Phantom Intelligence, SBG Systems, Omnivision, OSRAM, Mentor Graphics, Melexis, TriLumina, Sony

DATA/CONNECTIVITY

Hitachi, Renesas, NXP, Continental, Texas Instruments, QNX, Bosch, Marvell, Maxim Integrated, Sierra Wireless, intel, Realtek, Cohda Wireless, Broadcom, TTTech, TE Connectivity, Phantom Auto, Valens, Elektrobit, Microchip, Denso, Harman, Infineon, Mentor Graphics

MAPPING

TomTom, here, Google, atlatec, Navinfo, mapscape, sanborn, DeepMap, GeoDigital, Increment P, Baidu, Civil Maps, Mapbox, AND, Zenrin, applanix

SOFTWARE/ALGO

Mobileye, Elektrobit, dSPACE, NVIDIA, AImotive, DeepScale, Five AI, Mitsubishi Electric, Oxbotica, DiBotics, KPIT, Argo AI, Baselabs, drive.ai, Luxoft, Neusoft, Nauto, HCL, Aurora, ottomatika

SECURITY/SAFETY

Harman, Karamba Security, Bosch, Mentor Graphics, Delphi, Continental, Wind River, Hitachi, Vidder, NXP, IBM, Renesas, Argus, Elektrobit, QNX, intel, Denso, ETAS, Green Hills Software, secunet, irdeto, escrypt, Synopsys, KPIT, Rambus, ST, Texas Instruments, Infineon, VECTOR

Tools

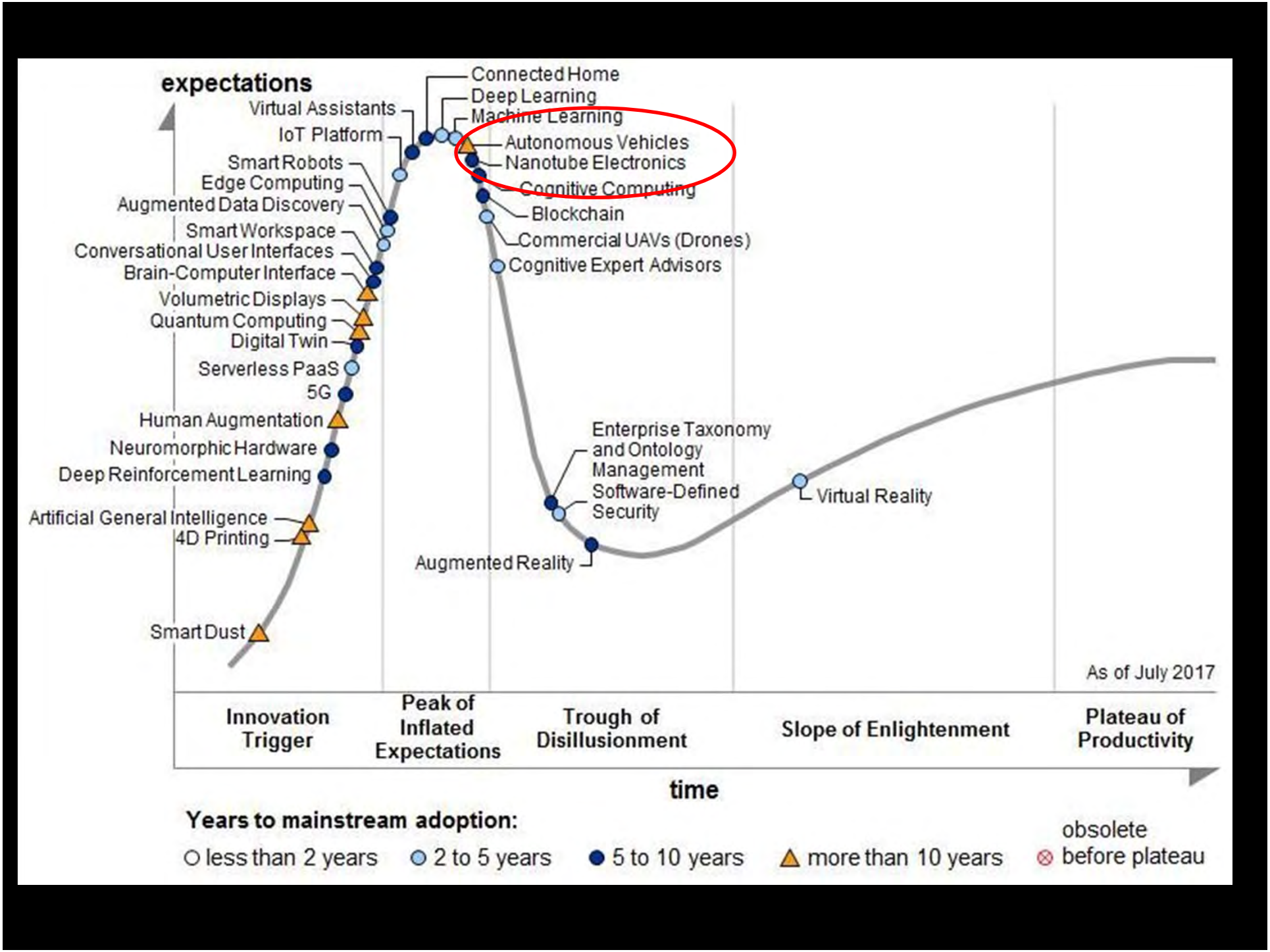
DEVELOPMENT TOOLS

Baselabs, IAR Systems, Dataspeed, LDRA, MathWorks, Synopsys, esi, iav, Elektrobit, KPIT, ARC Core, Mentor Graphics, Xilinx, Maplesoft, PolySync, HCL, Intempora, Mechanical Simulation, tass international, TTTech, dSPACE, ETAS, AdaCore, Siemens, VECTOR, Autonomou.Turf

Ever
changing

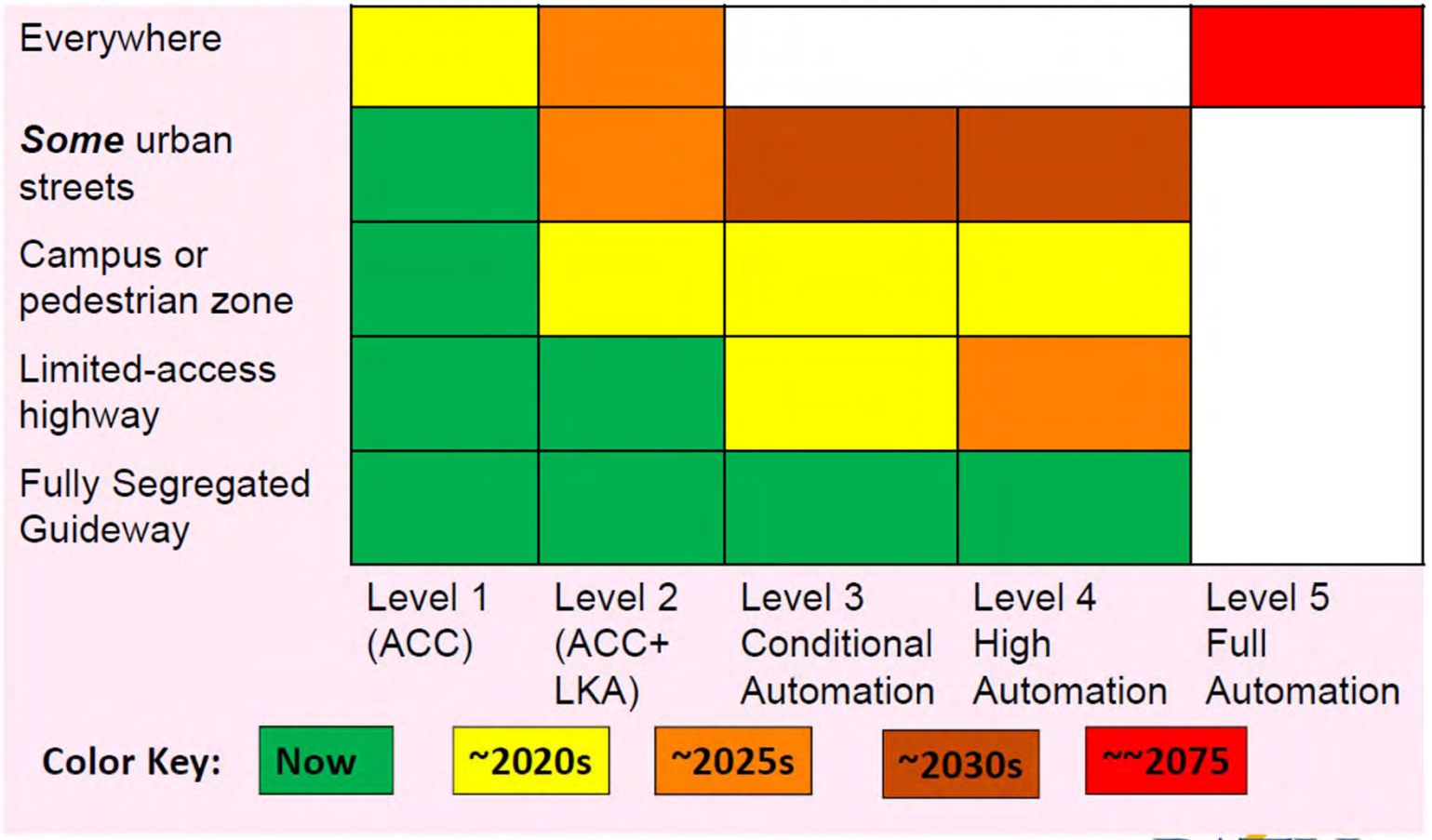
Ever
learning

Ever
communicating


expectations
Connected Home
Deep Learning
Machine Learning
Virtual Assistants
IoT Platform
Autonomous Vehicles
Nanotube Electronics
Smart Robots
Edge Computing
Cognitive Computing
Augmented Data Discovery
Blockchain
Smart Workspace
Commercial UAVs (Drones)
Conversational User Interfaces
Cognitive Expert Advisors
Brain-Computer Interface
Volumetric Displays
Quantum Computing
Digital Twin
Serverless PaaS
5G
Human Augmentation
Enterprise Taxonomy and Ontology Management
Neuromorphic Hardware
Software-Defined Security
Deep Reinforcement Learning
Virtual Reality
Artificial General Intelligence
4D Printing
Augmented Reality
Smart Dust
As of July 2017
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Years to mainstream adoption:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau


WINNER SPEDITION
TRANSPORT
MIĘDZYNARODOWY
I SPEDYCJA
TRANS-OIL
F-3
STOP
STOP
60
Ego

Personal Estimates of Market Introductions *(based on technological feasibility)*



PATH

Source: Steven E. Shladover, Sc.D. University of California, Berkeley

Some realism, within five years:

- Highway pilot
- Valet parking
- Truck platooning
- Solutions for public transport

Automated vehicles in cities: naaah

But: manned drones!

2. Current possibilities

Current possibilities

- The Vienna Convention of 1968:
  - A car can drive itself, as long as the system "can be overridden or switched off by the driver”

- The Framework Directive 2007/46/EC:
  - Dynamic guidelines for ACC, Lane Departure Warning, and Automated Parking (“comfort systems”)
  - Article 20 for new technologies
  - Upcoming: amendments to UN Regulation No. 79 (Steering equipment)

Proposal UN R79.03

- Cat. A, **assists** the driver up to 10 km/h in low speed maneuvering or parking.
- Cat. B1, continuously **assists** the driver in keeping within the lane.

- Cat. B2, continuously **keeps** the vehicle within the lane.

- Cat. C, performs a single maneuver (e.g. lane change) when **commanded by** the driver, always in combination with cat. B1 or B2.
- Cat. D, proposes and performs a single maneuver (e.g. lane change) when **confirmed by** the driver, always in combination with cat. B1 or B2.
- Cat. E, completes maneuvers (e.g. lane changes) for extended periods **without** driver command or confirmation, always in combination with cat. B2.

http://www.unece.org/fileadmin/DAM/trans/doc/2018/wp29/ECE-TRANS-WP29-2018-035e.pdf

A technical solution for human behaviour?

5.6.4.7. Critical situation

A situation is deemed to be critical when, at the time a lane change manoeuvre starts, an approaching vehicle in the target lane would have to decelerate at a higher level than 3m/s², 0.4 seconds after the lane change manoeuvre has started, to ensure the distance between the two vehicles is never less than that which the lane change vehicle travels in 1 second.

The resulting critical distance at the start of the lane change manoeuvre shall be calculated using the following formula:

$$S_{critical} = (v_{rear} - v_{ACSF}) * t_B + (v_{rear} - v_{ACSF})^2 / (2 * a) + v_{ACSF} * t_G$$

Where:

v_{rear}	is	The actual speed of the approaching vehicle or 130 km/h whatever value is lower	
v_{ACSF}	is	The actual speed of the ACSF vehicle	
a	=	3 m/s²	(Deceleration of the approaching vehicle)
t_B	=	0.4 s	(Time after the start of the lane change manoeuvre at which the deceleration of the approaching vehicle starts)
t_G	=	1 s	(Remaining gap of the vehicles after the deceleration of the approaching vehicle).

Levels:

1 hands on

2 assisted

3 hands off

4 eyes off

5 mind off

SAE J2016 Levels of Automation

SAE Level	Name	Narrative Definition	Execution of Steering/ Acceleration/ Deceleration	*Monitoring of* Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

3. The Dutch approach

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“Learning bij doing”

- Existing exceptional road transport (exemptions) decree includes exemptions for testing autonomous functions (2015)

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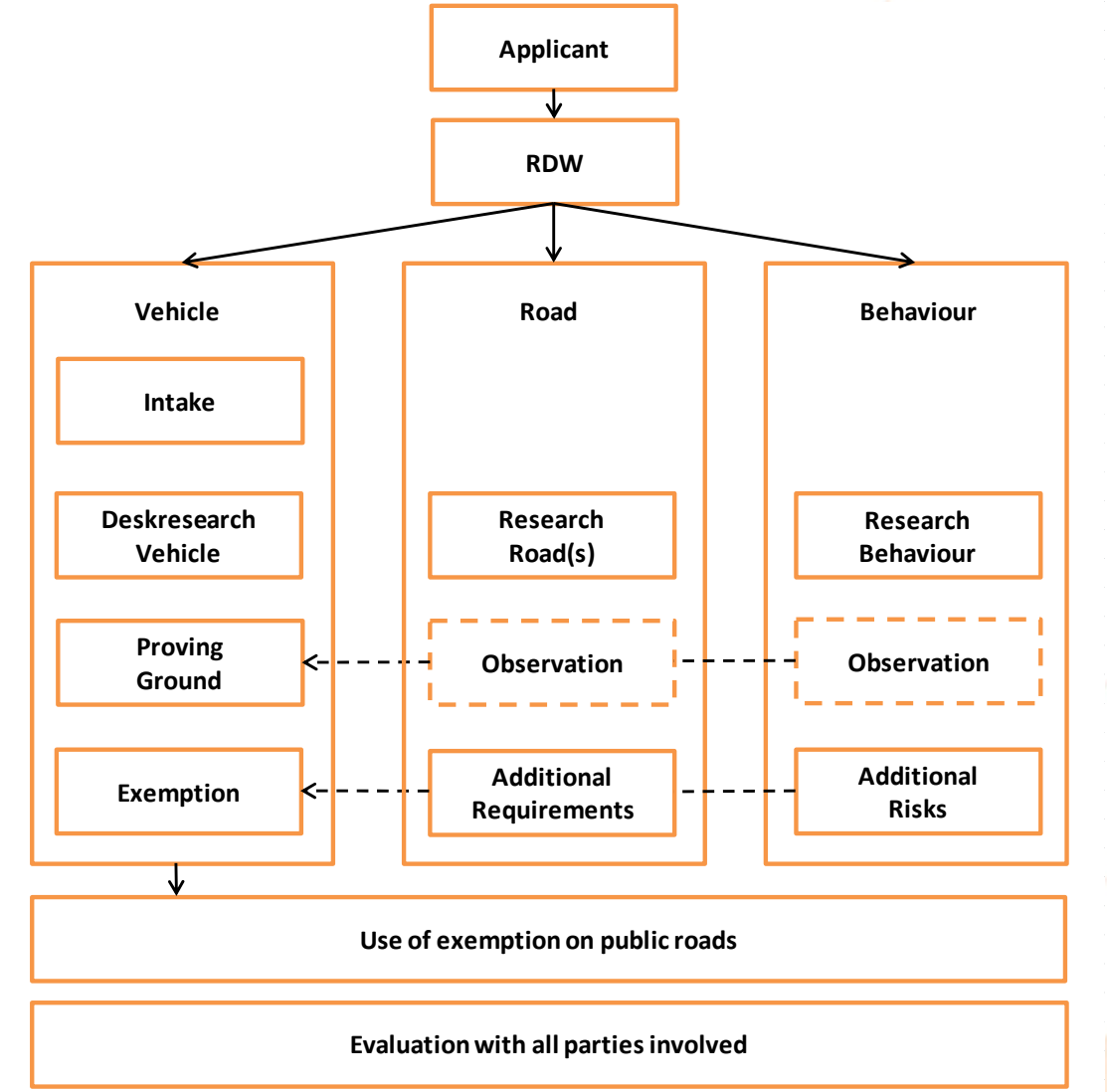
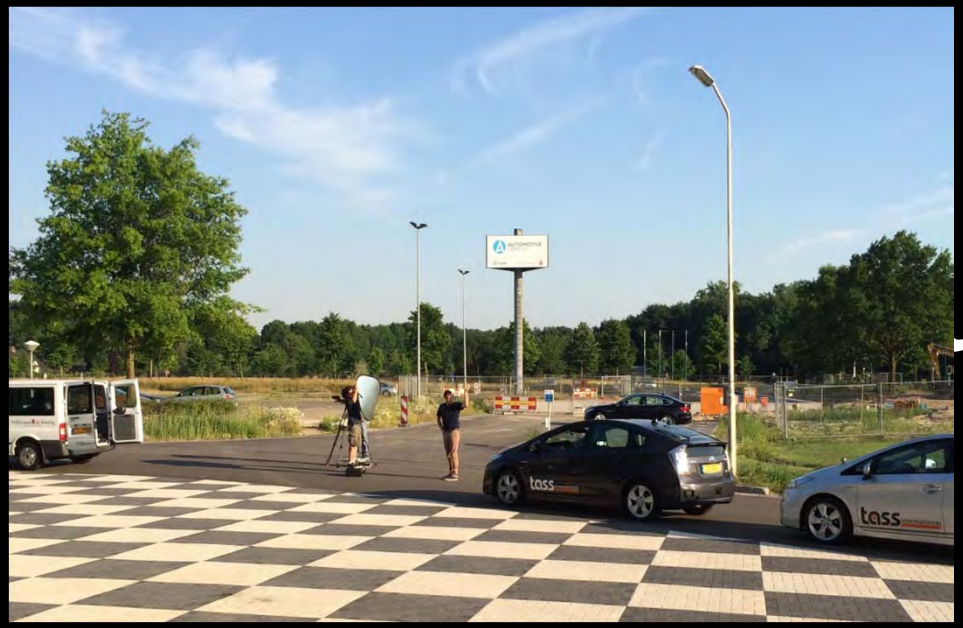
Vehicle, infrastructure and behaviour



RDW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Declaration of Amsterdam

From the speech by the former Minister Schultz van Haegen, Informal Transport Council 14-04-16:

“This is not a call for standardisation and harmonisation: because that’s not stimulating innovation-spirit. But let’s create space by deregulation, and let’s work for systems which are compatible.”

KPMG
Autonomous readiness index 2018

Overall rank	Country	Total score	Policy and legislation		Technology & innovation		Infrastructure		Consumer acceptance	
			Rank	Score	Rank	Score	Rank	Score	Rank	Score
1	The Netherlands	27.73	3	7.89	4	5.46	1	7.89	2	6.49
2	Singapore	26.08	1	8.49	8	4.26	2	6.72	1	6.63
3	United States	24.75	10	6.38	1	6.97	7	5.84	4	5.56
4	Sweden	24.73	8	6.83	2	6.44	6	6.04	6	5.41
5	United Kingdom	23.99	4	7.55	5	5.28	10	5.31	3	5.84
6	Germany	22.74	5	7.33	3	6.15	12	5.17	12	4.09
7	Canada	22.61	7	7.12	6	4.97	11	5.22	7	5.30
8	United Arab Emirates	20.89	6	7.26	14	2.71	5	6.12	8	4.79
9	New Zealand	20.75	2	7.92	12	3.26	16	4.14	5	5.43
10	South Korea	20.71	14	5.78	9	4.24	4	6.32	11	4.38
11	Japan	20.28	12	5.93	7	4.79	3	6.55	16	3.01
12	Austria	20.00	9	6.73	11	3.69	8	5.66	13	3.91
13	France	19.44	13	5.92	10	4.03	13	4.94	10	4.55
14	Australia	19.40	11	6.01	13	3.18	9	5.43	9	4.78
15	Spain	14.58	15	4.95	16	2.21	14	4.69	17	2.72
16	China	13.94	16	4.38	15	2.25	15	4.18	15	3.13
17	Brazil	7.17	20	0.93	18	0.86	19	1.89	14	3.49
18	Russia	7.09	17	2.58	20	0.52	20	1.64	18	2.35
19	Mexico	6.51	19	1.16	17	1.01	17	2.34	19	2.00
20	India	6.14	18	1.41	19	0.54	18	2.28	20	1.91

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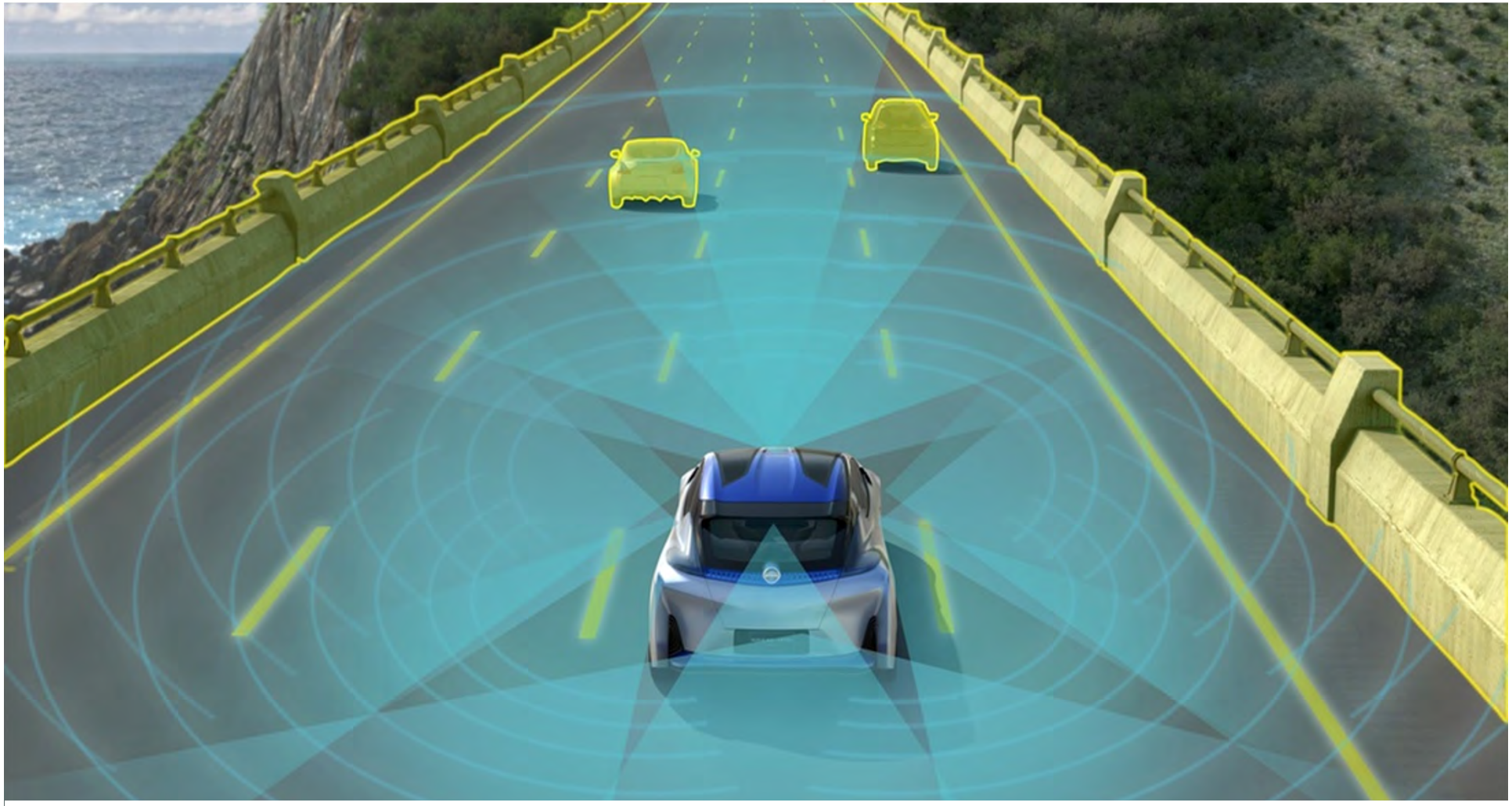
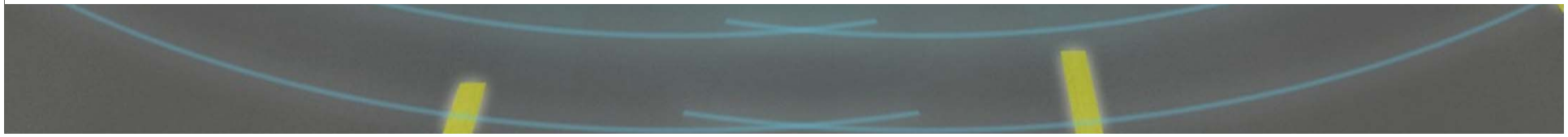
The next step: experimental law

- For FOT’s without a human driver in the vehicle
- Status: to be imlemented 01-01-2019



4. The Vehicle Driving License



Legal driver

- Exemption: human driver is an active part of the safety case. And the legal driver. Goal: large-scale testing
- Experimentation law: human driver is indirectly part of the safety case (remote). Still the legal driver. Goal: FOT without a driver
- Driving license: human driver is not part of the safety case. The system is the legal driver. Goal: towards real admission

Gerben Feddes, senior advisor for intelligent mobility at the Netherlands' vehicle authority, RDW, wants to take testing even further. "In the future, a piece of software might legally be the driver of a production car, making the human driver a passenger in their own car. But where would the knowledge come from to drive that car safely? We believe it should come from the same people who devise and administer driving tests for humans. We're suggesting that maybe there should be a driver's license for cars."

Constant change

Feddes also says the evolving nature of software will necessitate radical reform of homologation procedures. "With software being constantly updated, a car is an ever-changing vehicle and there is no point in one-off admittance – you need to apply performance-based requirements," he says. "A car has to perform in a certain way and it's up to the manufacturer to produce acceptable means of compliance. We've learned from aviation and drone legislation – we're moving away from the how and beginning to focus on the what."

Another issue to settle is who is liable if an accident does happen. Where decisions leading to a crash are made by a machine, can some of the blame be laid at the manufacturer's door? With regard to its current, partially automated systems, Mercedes-Benz says "no". The company issued a statement in April 2016, as part of the Daimler Sustainability Report, which puts the onus on the consumer: "The legal situation in Germany and many other countries is clear: with regard to current, partially automated systems, the driver remains responsible. Although systems such as Lane Keeping Assist in the new E-Class provide support, the driver must still control the vehicle." However, the report did concede that "manufacturers are responsible for damages from product defects".

(Above) Ford is testing its third generation of autonomous technologies at sites including the Mcity 32-acre proving ground in Michigan, USA

(Left) Ford has also started testing its technology in snowy conditions

"WITH SOFTWARE BEING CONSTANTLY UPDATED, A CAR IS AN EVER-CHANGING VEHICLE AND THERE IS NO POINT IN ONE-OFF ADMITTANCE"

Gerben Feddes, *senior advisor for intelligent mobility at the Netherlands' vehicle authority, RDW*

30% wanting the latest technology

84%

of those who reject semi-autonomous features think the technology won't live up to their driving skills; **60%** think the technology is too new; **57%** don't want to pay for it; **50%** know too little about it; and **45%** find it annoying

23%

of female drivers and

12%

of male drivers rejected the technology, at least partly for being too complicated to use

*Data from an American Automobile Association survey of 1,800 US drivers, published in March 2016

Vehicle driving license

Cora van Nieuwenhuizen, minister van Infrastructuur en Waterstaat, tijdens de **Intertraffic 2018 Amsterdam**:

“I’m going to create legal framework for automated driving. Laying down requirements for reliability and safety that cars must meet before they can hit the road. A driving licence for self-driving cars, if you like. Not for the driver – but for the car itself!”

RDW

Vehicle driving license

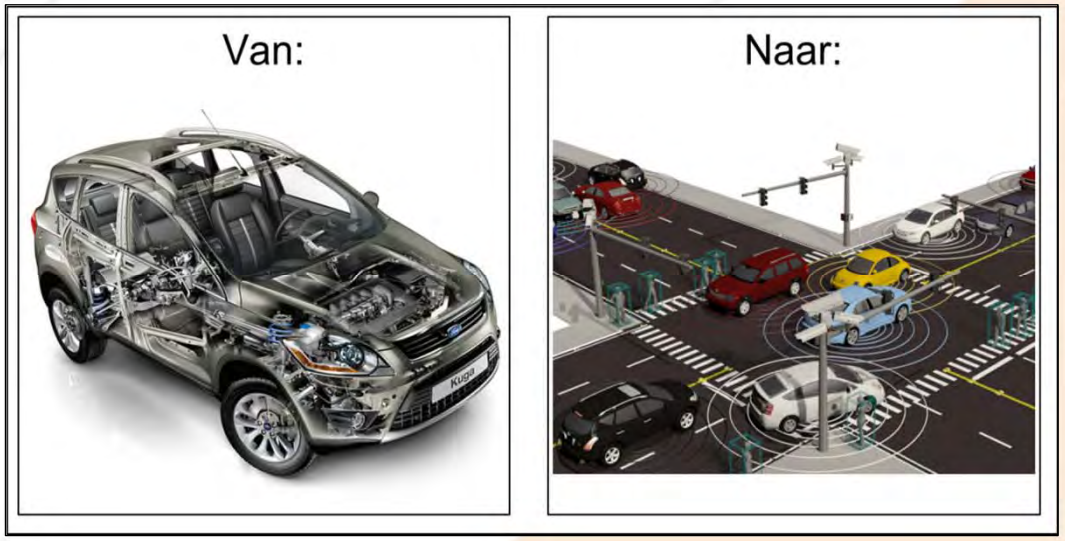
Assumptions (1/2):

- For SAE level 4 and 5 systems
- Human drivers will be on the road for the coming years, so the automated vehicle has to act like a human
- It’s about showing safe and predictable driving behavior related to human performance
- Automated systems will have a stepped admission to public roads
- Driving simulators can speed up the assessment process
- The safety assessment of driving skills should be a relative measurement. The human peer group sets the base-line
- Performance Based Standards are needed to ensure room for innovation

Vehicle driving license

Assumptions (2/2):

- It’s a system approach (vehicle-infrastructure-behavior)
- From: vehicle – To: traffic
- From: separate responsibilites – To: shared responsibilities.
- From: rule based requirements – to: performance based requirements
- From: risk mitigation in the column – To: risk mitigation on a system level



Vehicle driving license

1 Virtual Environment	2 Scale Modelling	3 Proving Ground
4 Driving Exam	5 Driving License	6 In Service Conformity

cbr

robotTUNER

RDW

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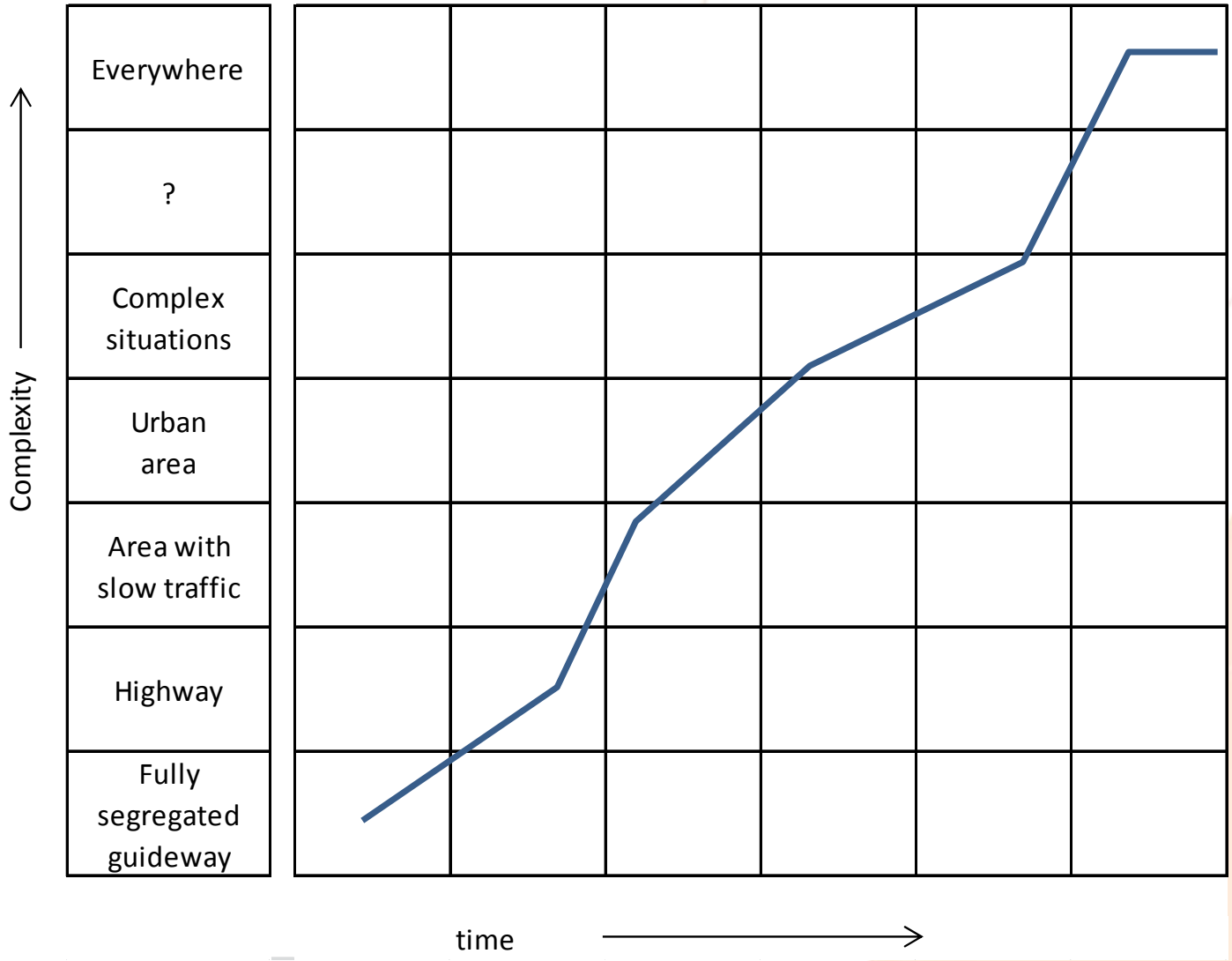
Stepped admission



RDW robotTUNER

Vehicle driving license

Three tracks:

- National: the fast track. Can it be done?
- Worldwide: the knowledge track. Creation of an ISO standard
- European: the admittance and surveillance track. Knowledge from the national and worldwide track is input

Conclusions

- A sense of urgency: Realism needed
- Current possibilities: An end to what you can solve technically
- The Dutch approach: Taking infrastructure and behaviour into account
- The Vehicle Driving License: Automation related to human behaviour

Gerben Feddes

RDW

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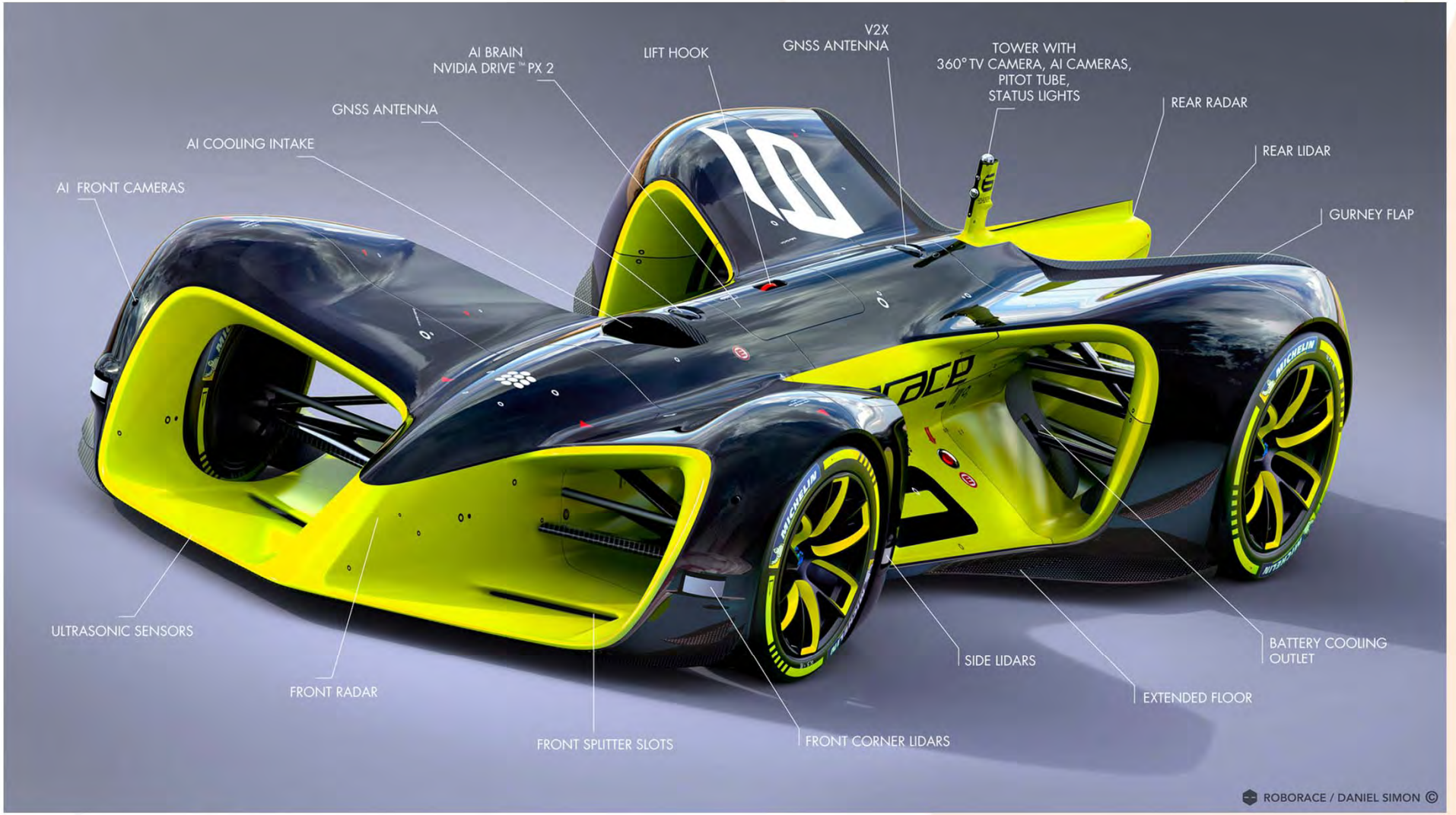
תודה
Dankie Gracias
Спасибо شكراً
Merci Takk
Köszönjük Terima kasih
Grazie Dziękujemy Dėkojame
Ďakujeme Vielen Dank Paldies
Kiitos Täname teid 谢谢
Thank You Tak
感謝您 Obrigado Teşekkür Ederiz
Σας Ευχαριστούμ 감사합니다
ขอบคุณ
Bedankt Děkujeme vám
ありがとうございます
Tack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NVIDIA DRIVE ™ PX 2
LIFT HOOK
V2X
GNSS ANTENNA
TOWER WITH
360° TV CAMERA, AI CAMERAS,
PITOT TUBE,
STATUS LIGHTS
REAR RADAR
REAR LIDAR
GURNEY FLAP
GNSS ANTENNA
AI COOLING INTAKE
AI FRONT CAMERAS
ULTRASONIC SENSORS
FRONT RADAR
FRONT SPLITTER SLOTS
FRONT CORNER LIDARS
SIDE LIDARS
EXTENDED FLOOR
BATTERY COOLING
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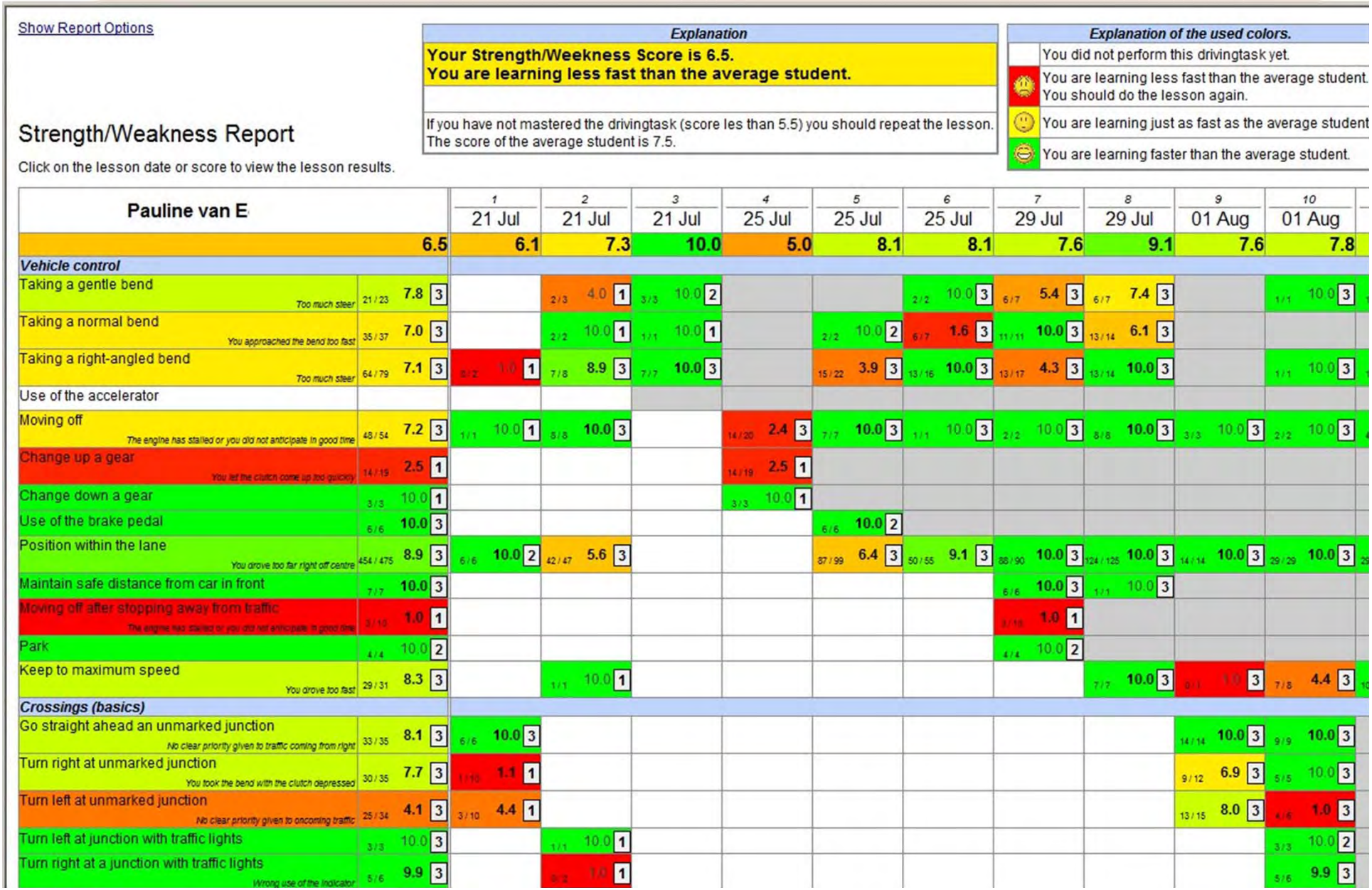
RDW

A driving license for an automated vehicle



Show Report Options

Explanation

Your Strength/Weekness Score is 6.5.
You are learning less fast than the average student.

If you have not mastered the drivingtask (score les than 5.5) you should repeat the lesson.
The score of the average student is 7.5.

Explanation of the used colors.

- You did not perform this drivingtask yet.
- You are learning less fast than the average student. You should do the lesson again.
- You are learning just as fast as the average student
- You are learning faster than the average student.

Strength/Weakness Report

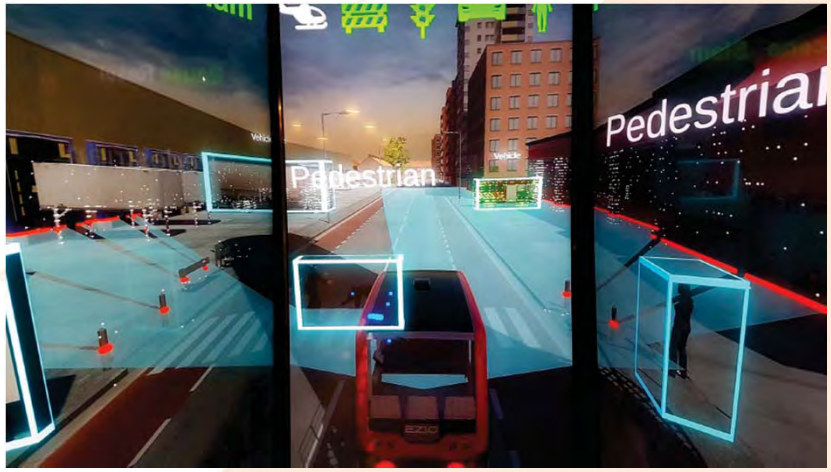
Click on the lesson date or score to view the lesson results.

Pauline van E			1 21 Jul	2 21 Jul	3 21 Jul	4 25 Jul	5 25 Jul	6 25 Jul	7 29 Jul	8 29 Jul	9 01 Aug	10 01 Aug
		6.5	6.1	7.3	10.0	5.0	8.1	8.1	7.6	9.1	7.6	7.8
Vehicle control												
Taking a gentle bend *Too much steer*	21 / 23	7.8 3		2 / 3 4.0 1	3 / 3 10.0 2			2 / 2 10.0 3	6 / 7 5.4 3	6 / 7 7.4 3		1 / 1 10.0 3
Taking a normal bend *You approached the bend too fast*	35 / 37	7.0 3		2 / 2 10.0 1	1 / 1 10.0 1		2 / 2 10.0 2	6 / 7 1.6 3	11 / 11 10.0 3	13 / 14 6.1 3		
Taking a right-angled bend *Too much steer*	64 / 79	7.1 3	0 / 2 1.0 1	7 / 8 8.9 3	7 / 7 10.0 3		15 / 22 3.9 3	13 / 16 10.0 3	13 / 17 4.3 3	13 / 14 10.0 3		1 / 1 10.0 3
Use of the accelerator												
Moving off *The engine has stalled or you did not anticipate in good time*	48 / 54	7.2 3	1 / 1 10.0 1	5 / 8 10.0 3		14 / 20 2.4 3	7 / 7 10.0 3	1 / 1 10.0 3	2 / 2 10.0 3	8 / 8 10.0 3	3 / 3 10.0 3	2 / 2 10.0 3
Change up a gear *You let the clutch come up too quickly*	14 / 19	2.5 1				14 / 19 2.5 1						
Change down a gear	3 / 3	10.0 1				3 / 3 10.0 1						
Use of the brake pedal	6 / 6	10.0 3					6 / 6 10.0 2					
Position within the lane *You drove too far right off centre*	454 / 475	8.9 3	6 / 6 10.0 2	42 / 47 5.6 3			87 / 99 6.4 3	50 / 55 9.1 3	88 / 90 10.0 3	124 / 125 10.0 3	14 / 14 10.0 3	29 / 29 10.0 3
Maintain safe distance from car in front	7 / 7	10.0 3							6 / 6 10.0 3	1 / 1 10.0 3		
Moving off after stopping away from traffic *The engine has stalled or you did not anticipate in good time*	3 / 10	1.0 1							3 / 10 1.0 1			
Park	4 / 4	10.0 2							4 / 4 10.0 2			
Keep to maximum speed *You drove too fast*	29 / 31	8.3 3		1 / 1 10.0 1						7 / 7 10.0 3	0 / 1 1.0 3	7 / 8 4.4 3
Crossings (basics)												
Go straight ahead an unmarked junction *No clear priority given to traffic coming from right*	33 / 35	8.1 3	6 / 6 10.0 3								14 / 14 10.0 3	9 / 9 10.0 3
Turn right at unmarked junction *You took the bend with the clutch depressed*	30 / 35	7.7 3	1 / 10 1.1 1								9 / 12 6.9 3	5 / 5 10.0 3
Turn left at unmarked junction *No clear priority given to oncoming traffic*	25 / 34	4.1 3	3 / 10 4.4 1								13 / 15 8.0 3	4 / 6 1.0 3
Turn left at junction with traffic lights	3 / 3	10.0 3		1 / 1 10.0 1								3 / 3 10.0 2
Turn right at a junction with traffic lights *Wrong use of the indicator*	5 / 6	9.9 3		0 / 2 1.0 1								5 / 6 9.9 3

A driving license for an automated vehicle

1. Virtual environment:

- From simulators used for training humans, we know how the ‘average human driver’ performs in a broad set of ‘traffic situations’ (use cases, or Operational Design Domain).
- The AI-driver ‘competes’ in a virtual environment against this average human driver.
- Knowledge and skills are tested and related to human performances and risk profiles.



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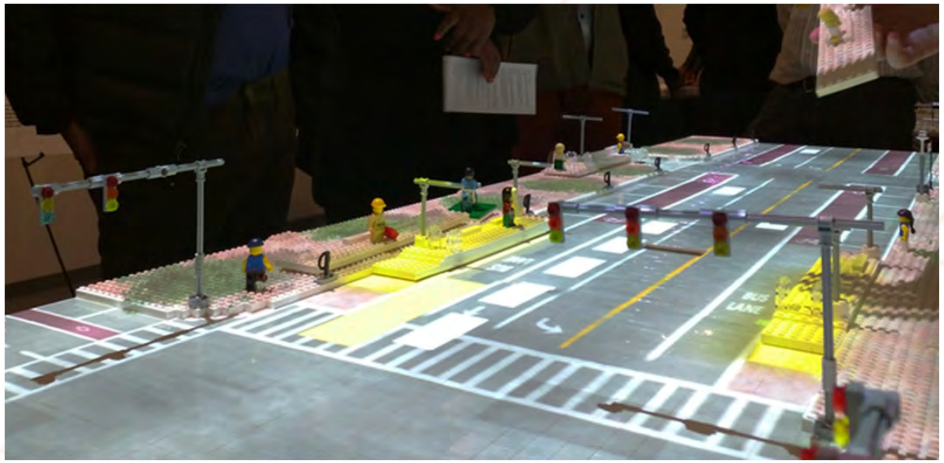
2. Scale Modelling:

- The validity of simulation output is not proven yet. Scale modelling is a (traditional) cost effective method for live tests.
- The impact on the traffic system can be assessed using scale modelling and augmented reality. Stress testing (e.g. hacking) can show vulnerabilities.
- Standard hardware is used. Only the software is tested (sensor testing belongs to vehicle testing).



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3. Proving Ground:

- To make sure the software and hardware are integrated well by the manufacturer, a real life test on a closed proving ground is performed for validation purposes.
- Happy flow tests and stress tests (aviation).

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4. Driving Exam:

- Just as for humans, the last step is a driving exam on public roads. In this exam (45 min- 1 hour) some situations from a predetermined list should be negotiated positively.
- Validation of safe interaction in complex traffic situations

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5. Driving License:

- For the specific use cases / Operational Design Domain's, the AI-software obtains the driving license (ISO certificate) = stepped admission.
- The innovation strength / reliability of a manufacturer counts.

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6. Surveillance:

- Given the ever-changing software, monitoring is needed when the vehicle is used on public roads. Unsafe software updates, hacking or malicious software would otherwise not be noticed.
- Traffic flow is monitored for detection of anomalies Abnormal behavior such as ignoring traffic rules or endangering other road users. Those vehicles that are detected as an anomaly need to be rechecked by auditors, or pulled of the roads if necessary.
- Software version shows the fitness of the software.

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