Human Factors in AD: Collaborative perception for AVs & VRUs

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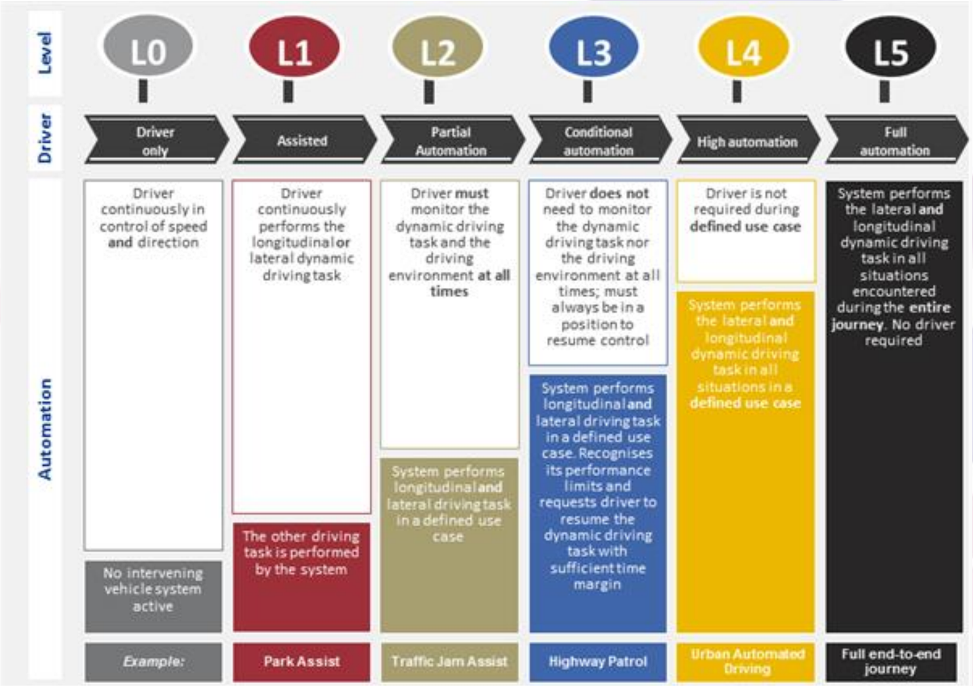
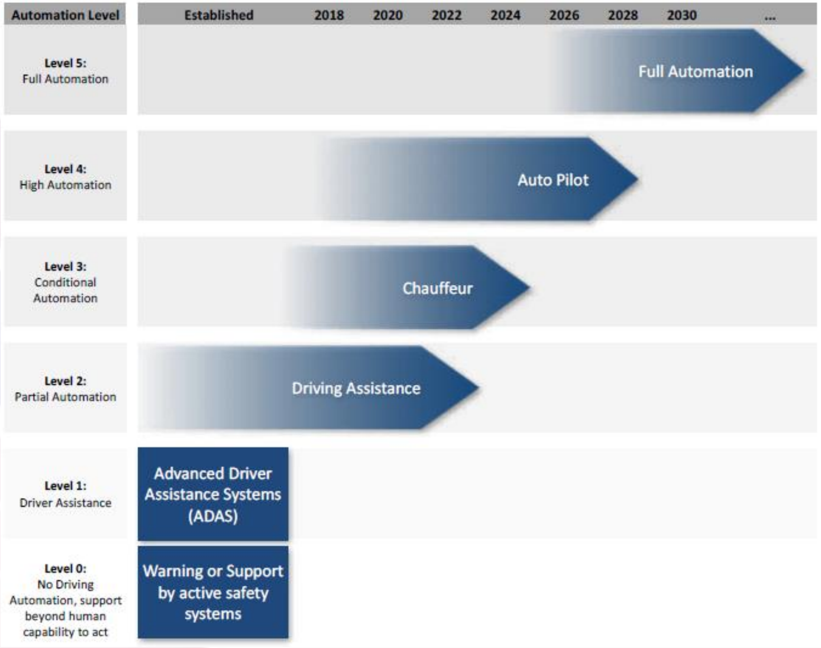
Levels of Road Vehicle Automation

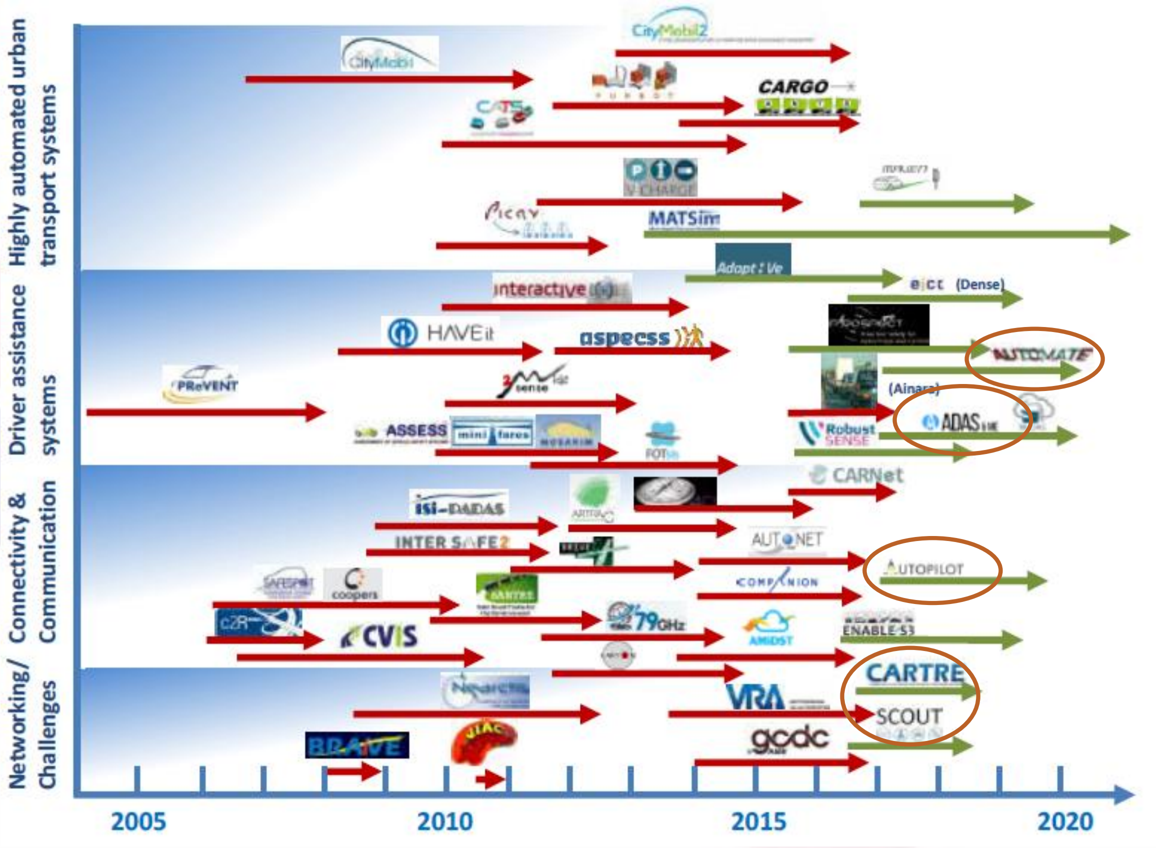


Source: SMMT (2017) based on SAE (2016)



Source: ERTRAC (2017)

EU funded initiatives on Automated Driving



Source: ERTRAC (2017)

connected automated driving.eu

AD systems examples

- **Highway Chauffeur (Level 3/4)**

Highway Chauffer example

- **Highway Pilot (Level 4)**

Highway Pilot example

- **Fully automated vehicle (Level 5)**

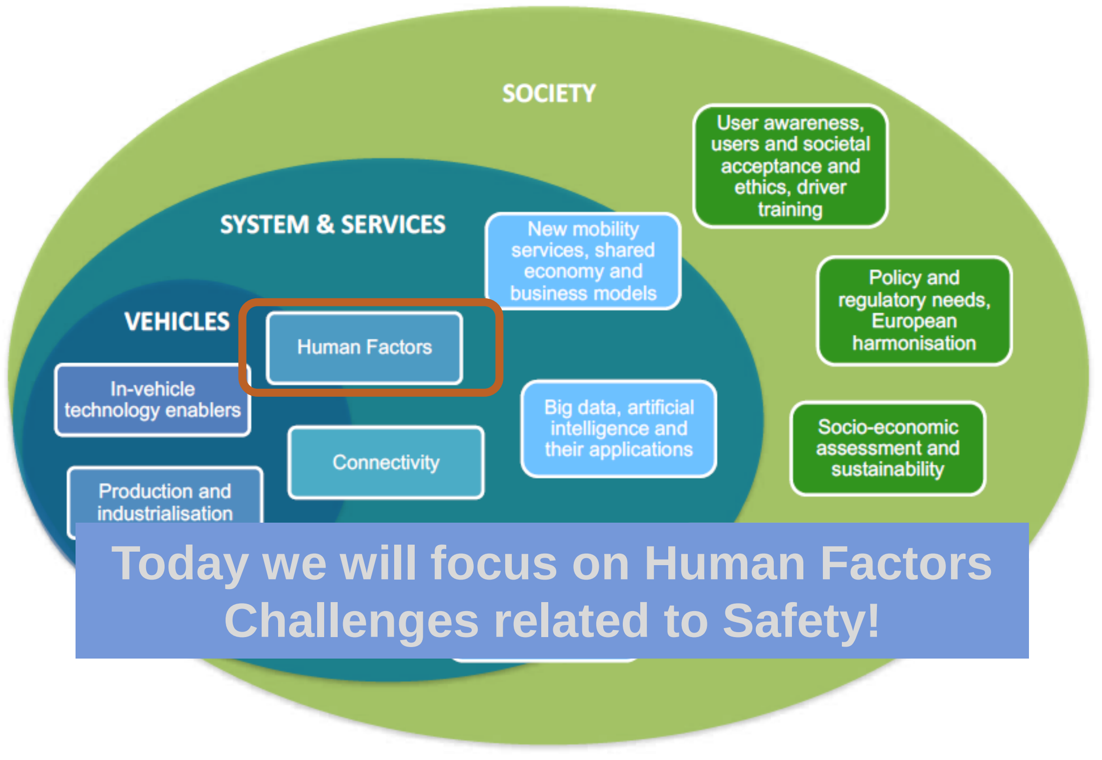
Fully automated vehicle example

Tesla

Catapult

Google car

Key Challenges in Automated Driving



Today we will focus on Human Factors Challenges related to Safety!

Source: ERTRAC (2017)

Human Factors challenges 1/2

The continuous evolution of software integration into systems magnifies the gap between humans and machines, whereas the nature of the human machine interaction is changing rapidly as well.

- Main issue: to provide the ***right integration*** capability at the ***right time*** and in the ***right way***.
- Target: ***Perception*** of situation, its ***comprehension*** and the necessary means of projection in order ***to act*** safely, efficiently and comfortable.

Source: Guy Boy (2013), Orchestrating Human-Centered Design, Springer

Human Factors challenges 2/2

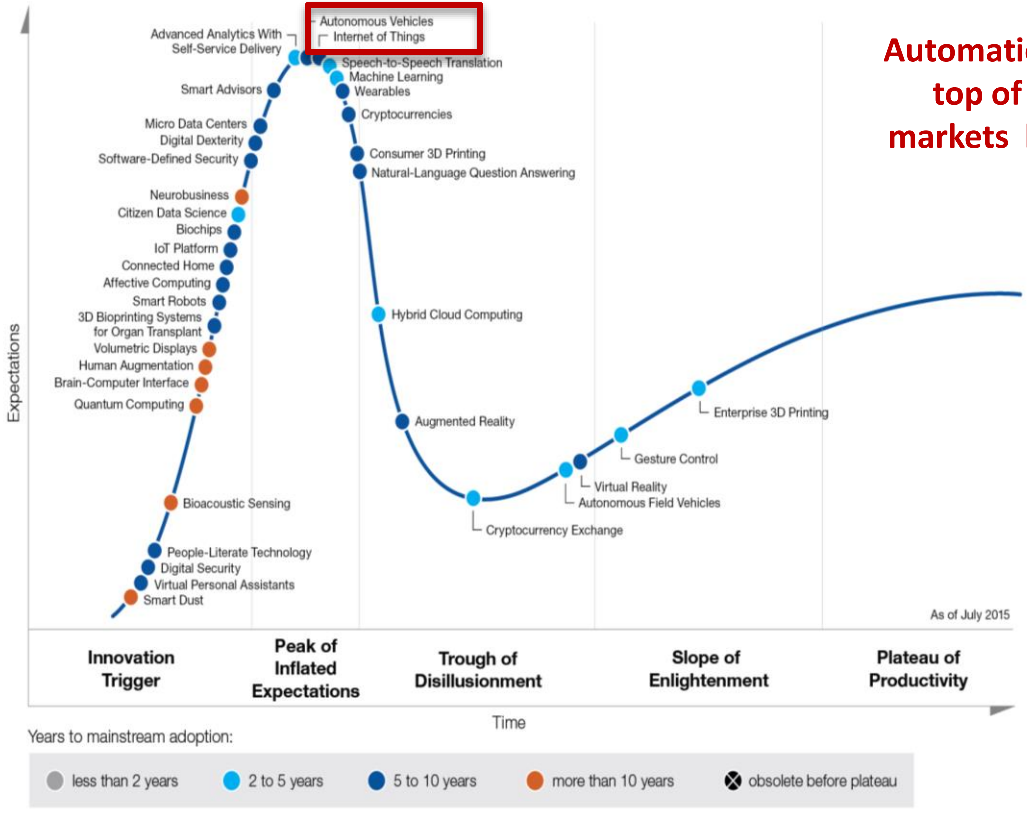
- How to understand the interaction between humans and automated vehicles (in-vehicle and outside vehicle) at different levels of automation?

- How to design the safe, intuitive interaction of automated vehicles with other road users?

- How to derive interaction design concepts for the automated vehicles so that both the human driver and other humans in the surrounding traffic sufficiently understand the capabilities and limitations of the vehicle?

Source: ERTRAC Automated Driving Roadmap, 2017

Automation: Market perspective



Automation & IoT is at the top of the emerging markets hype cycle, but…

Source: Gartner Hype Cycle for Emerging Technologies, 2015

Automation: User Acceptance

Users' feedback related to the usage of automated vehicles:

End-user expectations		
safety (33%)	more free time (20%)	fuel economy (18%)
lower insurance costs (11%)	less traffic congestions (7%)	lower CO_2 emissions (5%)
End-user concerns		
equipment failure (32%)	price of equipment (18%)	liability (12%)
learning to operate (8%)	data privacy (7%)	losing driving skills (6%)

Source: Goldman-Sachs (2015)

…safety is the highest priority for user acceptance and therefore deployment

Automation & Safety: Roadmap

- If maximum safety is indeed the goal…
  - **<u>Add</u>** the system's vigilance to the driver's vigilance instead of bypassing the driver's vigilance
  - Comprehensive hazard warnings plus some control assistance
- If the driver is out of the control loop (texting, sleeping, or not present), the system has to handle **<u>everything</u>**…
  - Unpredictable scenarios
  - Ethically untenable scenarios

Automated Driving: Safety impact

The safety impact of automated driving follows two patterns:

1. estimates based on consideration of how automation will resolve current factors in crashes
2. estimates based on early experiments with automated vehicles

- Automated vehicles will be 50% safer than non-automated ones, even with a market penetration as low as 10%

However, the first fatal crash with a Tesla automated vehicle took place in January, 2016 (China) and the second one May, 2016, (US) suggesting that automated driving does not necessarily result in a significant traffic accident reduction if it is not properly designed and implemented.

Automation and VRU Safety

- Vulnerable Road Users are more likely to get involved in fatal accidents or accidents with serious injuries due to the lack of added protection.
- While current vehicle autonomous systems have a considerable potential to save lives such as Autonomous Emergency Braking (AEB), the effectiveness is sensitive to restrictions on functionality as in darkness and high speeds.
- Mass and fast communication between ITS can drastically improve safety for all road users.

Source: Rosén, Erik. Autonomous Emergency Braking for Vulnerable Road Users. 2013

Cloud-based applications for detecting VRU-related critical situations

- Using a smartphone or similar device as a mobile sensor for active safety systems has shown that while the lateral deviations are too high to allow for lane-level localization, the longitudinal accuracy is good enough for many active safety applications already.
- All such applications can be easily embedded by an IoT Platform, combining vehicles' OBU and infrastructure's RSU to get the best possible outcomes.

Source: Active safety for vulnerable road users based on smartphone position data. Martin Liebner, Felix Klanner and Christoph Stiller. Gold Coast, Australia : Intelligent Vehicles Symposium (IV), 2013 IEEE, 2013

What is Collaborative Perception?

- Collaborative perception considers information exchange among road participants to enhance the usual perception capabilities of standalone users (vehicles and VRU).
- Particularly, the safety of VRUs can be improved by the collaborative perception since both vehicles and VRUs are collaborating (connected) and informed in case of a safety-critical situation.

Collaborative Perception aim

- Pedestrians and bicycles detection, interaction is an important security issue to allow automated vehicles on open roads.
- The aim of the Collaborative Perception to use other connected objects (vehicles, smartphones, traffic lights, cameras, etc.) to improve VRU detection through IoT technology.
- Collaborative Perception actual target is the safe coexistence of all road users in public roads.

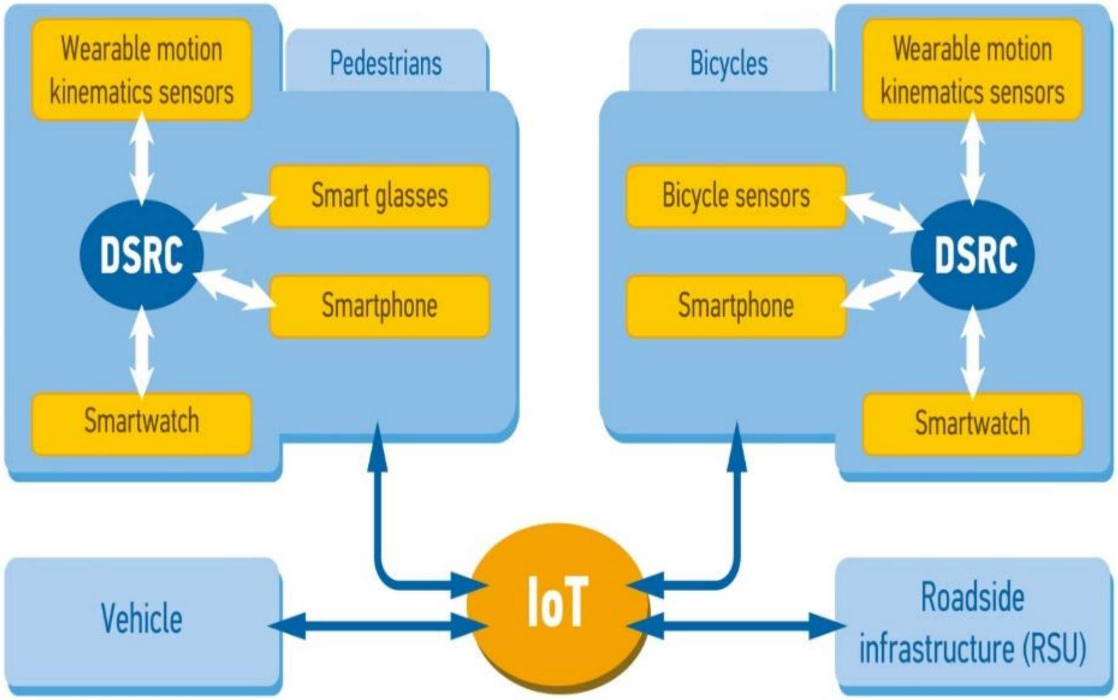
Collaborative Perception targets

- Augmenting the local perception of vehicles by fusing the information obtained from the communication (including IoT platform).
- Warning VRUs on a potential danger by using connected objects and dedicated services which analyse the collision risks with AD vehicles.
- Comfort and information services which can be provided to the pedestrians, such as the advertisement of autonomous driving vehicles, promotion of local shops, tourist guidance, etc.

Collaborative perception concept

Pedestrian's and bicycle's detection and communication via smart devices using an IoT-based platform

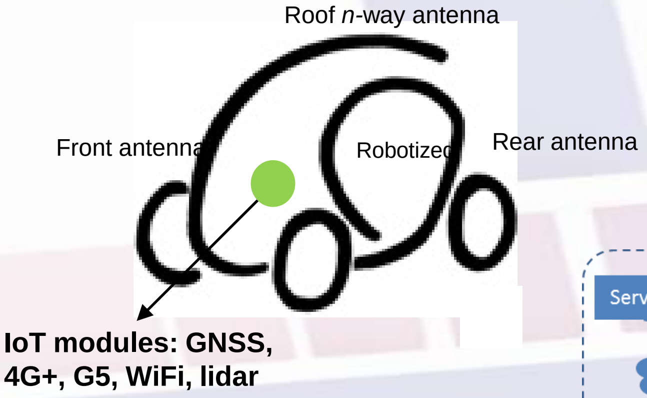
- Use of a combination of wearable, on board and roadside sensors , with short range and direct WiFi communication.
- Absolute position and intention detection estimated by a fusion of GPS, kinematics sensors and RSSI measurements, through an IoT cloud-based service.
- Open communication with automated vehicles and roadside infrastructure (access to vehicles CAN-bus, infrastructure input, etc.) and VRUs path and intentions.

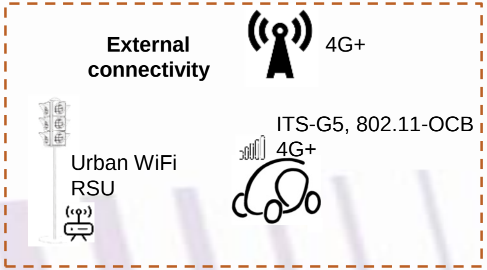


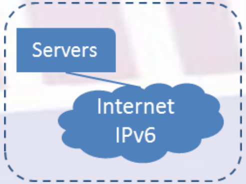
Source: Nikolaou S. Gragopoulos I., 2017

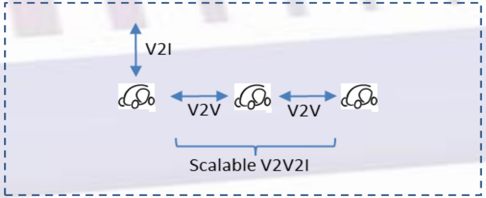
AUTOPILOT

IoT and connectivity







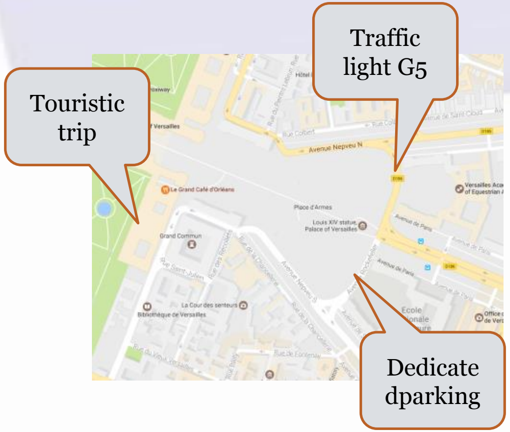


Touristic trip : L4 of AD in protected areas

Platooned touristic trip

L

Platooned re-balancing (no L)



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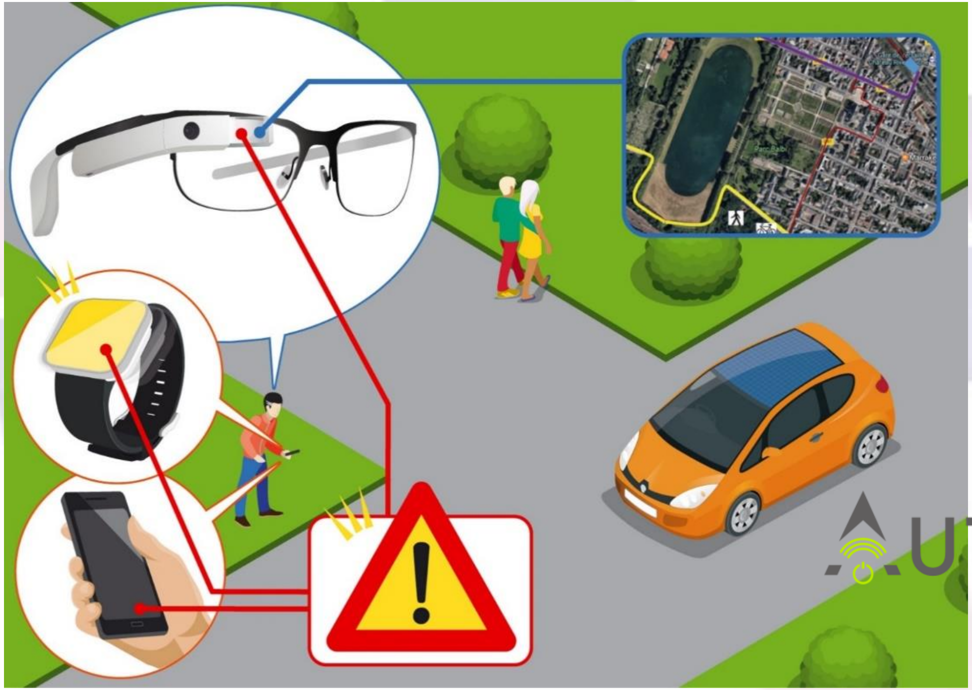
Source: VEDECOM, 2017

Enabling VRU communication through IoT – Pedestrian Concept Example



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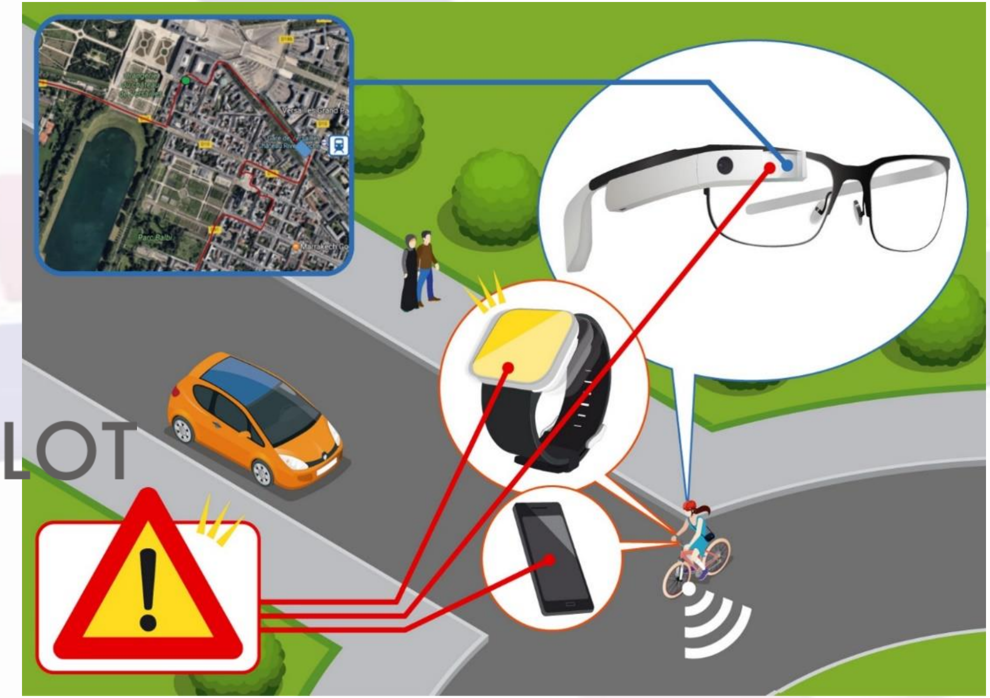
Source: Nikolaou S. Gragopoulos I., 2017

Enabling VRU communication through IoT – Cyclist Concept Example



Source: Nikolaou S. Gragopoulos I., 2017

IoT Collaborative Perception prototype

- CERTH/HIT ITS-G5 implementation is a combination of hardware and software modules.
  - Hardware is based on ARM-Cortex processors and is designed and developed completely in-house.
  - Software is based on Linux, where the necessary ITS-G5 protocol stack will be deployed. IEEE 802.11p is used for communications
  - The system can be used either as On-Board Unit (i.e. for cyclists) or as a Road Side Unit.
- Besides the ITS-G5 implementation, the system is equipped with cellular communications, GPS, WiFi, Bluetooth, CAN-bus, analog and digital inputs. LCD display can be connected for applications where HMI is required.

Future ‘Things’ to be connected: The case of motorcycles

Why Motorcycles a special case?

“Riding a motorcycle is more mentally and physically demanding than driving a car. Rest regularly on long trips”

State of the Road - CARRS-Q

Riding a motorcycle is more mentally and physically demanding than driving a car. Rest regularly on long trips.

REFERENCES

1. Bureau of Infrastructure, Transport, & Regional Economics (2011). *Road deaths Australia: Statistical summary 2010.* Canberra: Australian Department of Infrastructure & Transport.
2. International Traffic Safety Data and Analysis Group (2011). *Annual report 2010.* France: OECD/ITF.
3. Australian Department of Infrastructure, Transport, Regional Development and Local Government. (2008). *Fatal and serious road crashes involving motorcyclists, Monograph 20* (https://infrastructure.gov.au/roads/safety/publications/2008/pdf/mono20.pdf).
4. Queensland Transport and Main Roads. (2011). *2010 year in review road crash report: Road fatalities and hospitalised casualties.*
5. Australian Bureau of Statistics (2011). *Motor vehicle census.* Canberra.
6. Queensland Transport and Main Roads (2011). Vehicles on register in Queensland as at 30 June 1992 to 2011.
7. Broadley, C., & Hawkins, A. (2011). Older motorcycle rider safety in Queensland. *In proceedings of the Australasian Road Safety Research, Policing, & Education Conference.* Perth.
8. Blackman, R. (2011). The increased popularity of mopeds and motor scooters: Exploring usage patterns and safety outcomes. *Doctoral thesis, Queensland University of Technology* (https://eprints.qut.edu.au/52685/).
9. Haworth, N. and Mulvihill, C. (2005). Review of motorcycle licensing and training (Report #240). Melbourne: Monash University Accident Research Centre (https://www.monash.edu/__data/assets/pdf_file/0003/217254/muarc240.pdf).
10. FORS. *Risk taking by intoxicated drivers and riders. Monograph 15.* Federal Office of Road Safety, 1997 (https://infrastructure.gov.au/roads/safety/publications/1997/pdf/Alc_Risk.pdf).
11. Australian Transport Council, *National Road Safety Strategy 2011 to 2020.*
12. Queensland Government, *Queensland Motorcycle Safety Strategy 2009-2012.*
13. Queensland Government, *Queensland Road Safety Action Plan 2010-2011.*

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Factsheet current as at May 2012

Automation for MCs

- **Long range attentive touring with motorbike**

  During long-range motorbike touring, environmental conditions combined with rider fatigue, can affect the rider's state and lead to high-risk situations.

- **Rider faint**

  The focus here is to prevent crashes due to rider fainting (or other extreme psychophysical conditions).

Source: DUCATI, 2017

Systems vs. Scenarios

- Assist (inform/warn) in case of:
  - Tiredness (like extremes of temperatures and muscular fatigue)
  - Inattention
  - Stress

- Intervene if the rider state is critical:
  - Tiredness (see above)
  - Inattention
  - Stress

- If the situation is safety-critical, automation can actually stop the motorcycle

Source: DUCATI, 2017

Connecting MCs to Collaborative Perception

- A future challenge due to:
  - Motorcycle small size and complex dynamics
  - Connection to IoT platform how to achieve small size and cheap OBUs development
  - Involvement and adoption by the MC industry
  - User Acceptance

Source: Nikolaou S., Bekiaris E. & Anund A. (2017)

Questions?

To err is human

Lucius Annaeus Seneca

Exercise – Split in 4 groups

- Design the safety HMI for a) Pedestrian b) Cyclist
  - Failure of AD sensors - pedestrians in the area
  - Unexpected route of cyclist during AD operation
- Design the HMI for emerging business cases
  - Promoting availability of AD services - urban mobility
  - Promoting local community shops, services, etc.