Trafi Finnish Transport Safety Agency

Human adaptation to automated road traffic

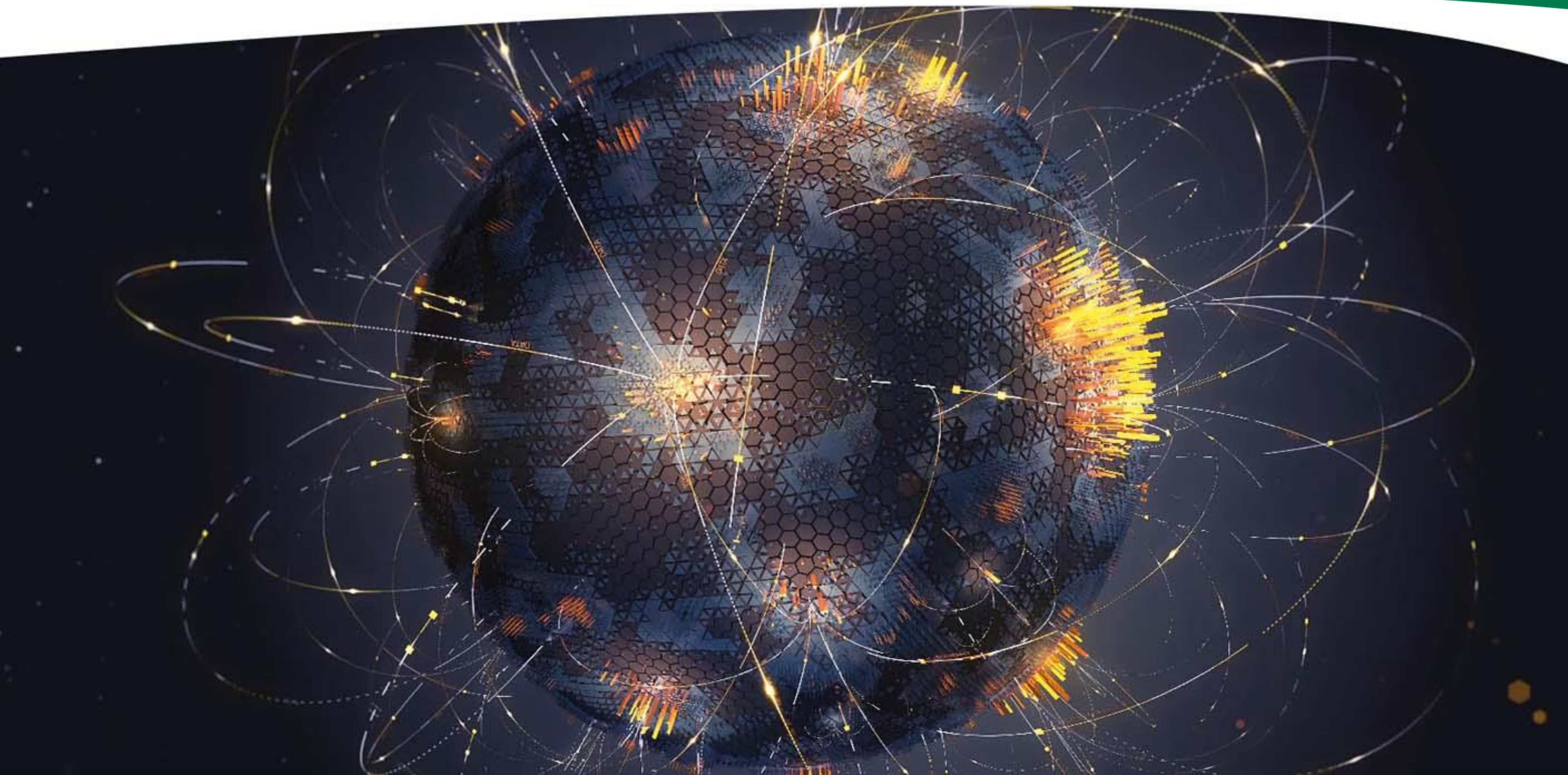
Autonomous transport systems and safety

Nordisk Trafiksikkerhedsforum 2017
Hanna Strömmer, 27.9.2017

Responsible traffic.

Courage and co-operation.

Automated traffic – where do we stand?



Road transport automation road map in Finland

- The Ministry of Transport and Communication (MTC) has emphasised that Finland is in the forefront in preparing for and utilising automated traffic
- “Road transport automation road map and action plan 2016–2020” prepared in 2016
- A summary of global research on technology, driver behaviour, acceptability and ethics, effects on transport system and legal aspects
- Altogether 49 action cards were prepared on five domains: infrastructure, road surface and equipment, in-vehicle systems, services and functions, and driver
- During 2016–2017 a total of 114 individual measures should be launched

Road transport automation road map in Finland – measures

- It has been acknowledged that the development is largely in the hands of private industry
- Examples of ways in which the Finnish road traffic administration enables automation (levels 3–5)
  - Co-ordinating areas for testing technology and impact assessment
  - Addressing legal issues such as privacy, data protection and data ownership
  - Information technology and communication, geoinformation, real time data – requirements for infrastructure and systems
  - Requirements for the fleet and periodic inspections
  - Driver licensing, education and examinations
  - Requirements for traffic modelling and analysis

Trafi and road traffic automation

- Trafi’s activities in research and development
  - Robots on land, in water and in the air. Promoting intelligent automation in transport services, Ministry of Transport and Communications, 2014
  - Impacts of increasing automation in road traffic, system level study, Trafi research reports, 01/2015
  - Requirements for driver’s in goods transportation, Trafi research reports 6/2017
  - **Identification of Issues from Human Actor Perspective – Three Driver and Operator Behaviour Models**
  - In 2017: interaction between the human actor and automated transport system (including other modes)
  - National co-operation in developing conditions for autonomous vehicles

Issues from Human Actor Perspective

Starting points for the study

- Interaction between automated vehicles of varying SAE levels and human actors thus far poorly understood
  - → a systematic approach to identify human issues related to increased automation in car driving
  - → three theoretical approaches of human behaviour
  - → scenario analysis: automation levels 2 and 4, urban and motorway driving, various sub-tasks, situations and conditions (e.g. traffic and weather)
  - → list of issues and suggestions on handling them in further research and development

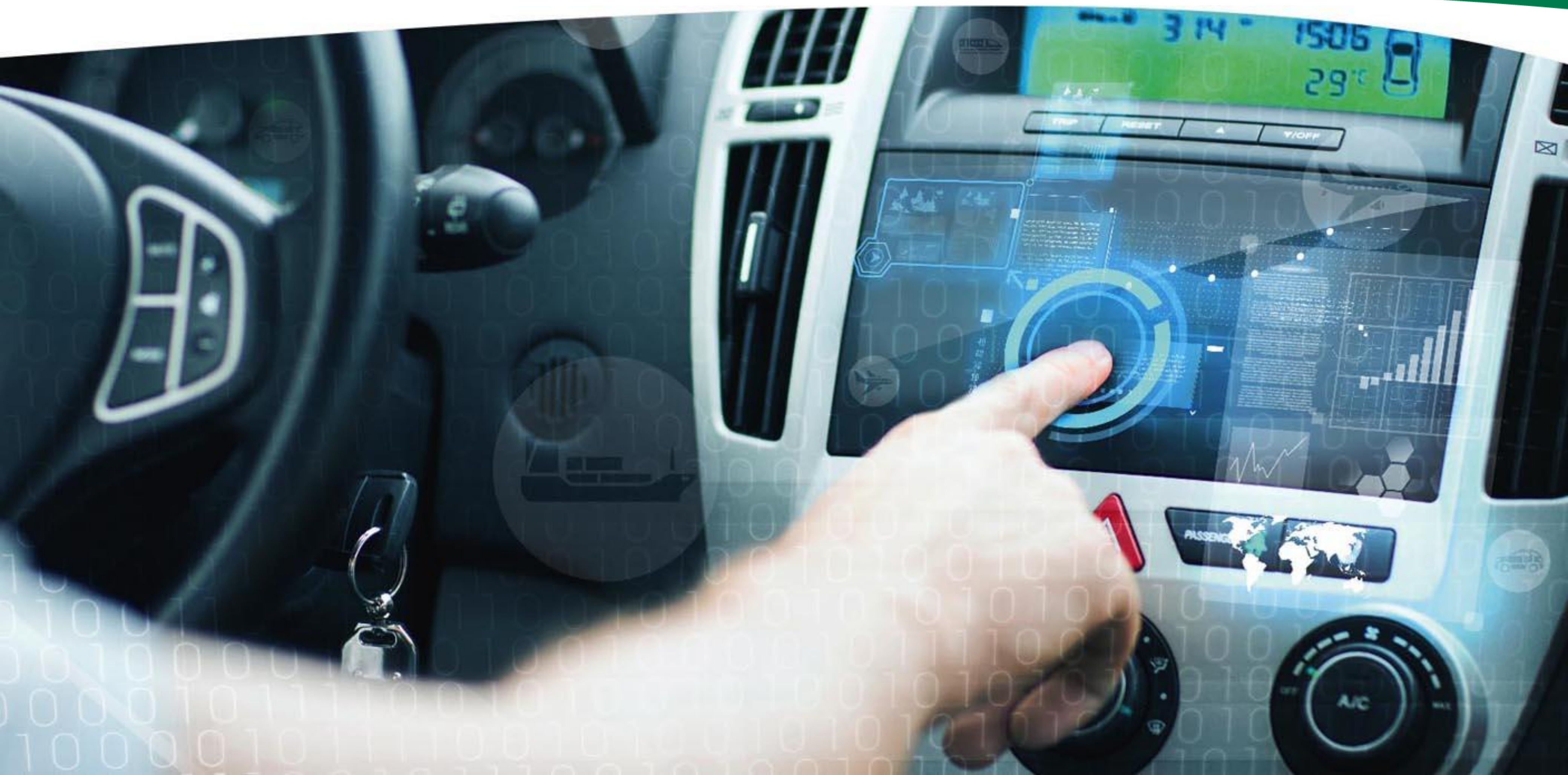
Theoretical approaches of human behaviour

- Motivational theories
  - Based on driver's conflicting motives of arriving at destination and maintaining desired level of risk (zero or 'target level')
  - Places importance on long-term behaviour adaptation such as risk compensation or other unintended consequences of changes in the road traffic system
- Information processing models
  - Modelling the processing of sensory information to form situation awareness and enabling response execution
  - With experience drivers form and apply mental models which enable routine driving – attention resources are still limited
- Core task analysis
  - Generalizing complex activity beyond individual actions
  - Analysing core tasks where human actors apply their resources (skill, knowledge and collaboration) to manage the dynamicity, uncertainty or complexity of the environment

Scenario analysis

- Three theories
- 'Basic case': driving in car following situation, only cars, wide road, no traffic lights, no incidents, normal weather and daylight
- Urban environment
  - sub-tasks: planning the trip, parking, driving on a link, driving at intersections, navigation
  - contexts applied upon basic case: congested flow, pedestrians and cyclists, narrow street, traffic lights, sudden/anticipated incidents, adverse weather, night time
- Motorway environment
  - sub-tasks: mode choice, timing, route choice, merging, driving on a link, leaving the motorway, navigation
  - contexts applied upon basic case: congested flow, quiet roads/busy roads, sudden/anticipated incidents, adverse weather, night time

Results of analysis



Planning and navigation

- Automation support – low
  - Car provides flexibility and freedom from timetables, automation support reduces workload and uncertainty
  - → Slight increase in private car's modal share
- Automation support – high
  - Automation reduces workload and uncertainty, vehicle in control most of the time
  - → Increased possibility for secondary tasks adds to comfort and thus modal share of private car
  - → Decreased joy from driving, could decrease modal share if level of service for public transport is high
  - Navigation optimizes fluent routes

Merging into traffic flow

- Automation support – low
  - Merging into traffic is not assisted due to complexity and dynamicity of the task, automation doesn’t support gap acceptance or monitoring other road users

  → Increased demand for monitoring and manual driving skills, added information (dead angle cameras) may add to workload
- Automation support – high
  - Park-assistance can merge into traffic

  → Driver’s observation of the environment and skills for manual driving are reduced
  - Upon merging into a motorway the driver still needs to take responsibility for gap acceptance, timing and steering

  → The need for interaction with the automation adds to driver workload, skills for manual driving required

Driving on a road section (1/2)

- Automation support – low
  - Speed adaptation, distance and lane keeping are assisted, demands for visual perception remain
  - In urban environment, complexity and dynamicity cause frequent shifting between automated and manual mode

  → Need for constant alertness on driver's part, risk of confusion
  - On motorways, automated driving largely preferred

  → Monotonous driving and lack of physical driving tasks risk maintaining focus and shift attention to secondary tasks

Driving on a road section (2/2)

- Automation support – high
  - Automation is in control most of the time
  - → Monitoring traffic becomes secondary task instead of being the primary task
  - System alerts the driver for manual driving
  - → The change becomes more demanding and workload higher
  - Automatic speed and lane control reduces speeding but shortens driving distance
  - → Increased risk when fast reactions are required

Driving at intersections

- Automation support – low
  - Driver takes manual control for turning, braking, yielding and interaction with other road users, situation awareness is high as a change is expected at intersection

  → Demands for manual driving, monitoring and interaction with other road users
- Automation support – high
  - Automation in control of movements, in exceptional conditions driver may switch to manual control

  → Driver is expected to monitor the environment for pedestrians and cyclists which the automation cannot reliably interpret, manual driving skills required

Leaving the motorway

- Automation support – low
  - Leaving the motorway is not assisted, only emergency braking is in use
  - → Switching off assistance may cause disruption and added workload upon driver due to change in complexity and dynamicity of the task
- Automation support – high
  - Similarly as in merging the driver is required to interfere in the driving task (gap acceptance, timing, steering)
  - In order to take control the driver must switch back from the momentarily primary task to the now secondary task of driving
  - → Early alert from the system is essential
  - → Driver’s awareness of the level and functioning of assistance is critical especially as the task requires interaction with the automation

Contexts: traffic flow (1/5)

- Free flow
  - Mean driving speeds may increase and distances decrease at least for low automation as driver chooses the maintained level of speed
- Congested traffic
  - Driving speeds in general are lower, which reduces dynamicity of driving situation

  → Drivers may become impatient or irritated by continuous automation responses (AEB) and shift to manual drive

  → Communication with other vehicles crucial in order to gain information on their intentions. In low automation or low penetration rate this might prove to be challenging
  - Merging into and out of the motorway remains the most challenging task for automation due to demands for communication with other vehicles

  → Manual driving probably required in high as well as low automation

Contexts: pedestrians and cyclists (2/5)

- Detection and anticipating the behaviour of pedestrians and cyclists is difficult for the automated vehicle. In complex situations, such as leaving on street parking or driving at intersections, the vehicle’s monitoring capacity is directed at observing other cars.
- Especial risk is involved with on street cycling. An automated vehicle may make sudden moves for instance when leaving on street parking or changing lane. Avoiding collision will, also, be difficult for the cyclist.
- Other street users pose challenge especially for low automation in urban surroundings due to simultaneous requirements for monitoring surroundings and frequent demands to manual driving. Driver’s workload is increased also in high automation due to monitoring needs and the need for quick switch to manual driving.

Contexts: incidents (3/5)

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- In low automation, only emergency braking is automatic. The driver is responsible for maneuvering the vehicle.
- In high automation, the driver may be involved in another task than driving and monitoring. This poses various risks:
  - Automation cannot identify all hazards – thus the driver should maintain situation awareness.
  - At the time of the actual incident, driver's awareness and ability to take over control should be raised before the incident happens. In sudden incidents there's little time for changeover and it's more probable that the vehicle cannot handle the situation.
  - In the long term, driver's overall ability to take control and handle situations might be reduced due to less driving experience.

Contexts: weather and lighting (4/5)

- Adverse weather and darkness in general increase uncertainty for automated vehicles, too.
  - In low automation, switching to manual drive may increase uncertainty especially if the driver has less driving experience. Observing hazardous slippery conditions is not assisted. In darkness monitoring capacity of both is reduced.
  - In high automation, driver may need to take control in heavy snow, rain or on icy roads. Driver's workload is increased and manual drive may be demanding due to less driving experience in adverse conditions.
  - In high automation, driver's understanding of the functioning of the automation is crucial. Misinterpretation of when and how the system works in adverse conditions may increase risk when switching between automated and manual drive.

Context: road width and traffic lights (5/5)

- Narrow streets
  - In low automation, narrow streets are one among many factors increasing complexity of urban driving and use of manual driving.
  - In high automation, park assist is better able to handle merging into traffic due to accuracy.
- Traffic lights
  - No specific challenge in low automation as traffic lights are expected and easily observed and change to manual drive is probable in intersection anyway.
  - In high automation, considering pedestrians and cyclists is the most demanding task which may require shifting to manual drive.

Conclusions

Human related issues in road traffic automation

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- Comfort and ease of driving probably increase private car's modal share.
- Parking will be more fluent – monitoring the environment crucial to safety, possibility for added information (dead angles).
- Merging into and out of the traffic flow is a demanding task for automation and would require all vehicles be connected. Until then the driver must be responsible for timing and gap acceptance. Risk from sudden change in the driver's workload.
- Mean driving speed may increase at least with low automation. Following distances will be shorter.
- In adverse conditions uncertainty is increased and abilities of observation are reduced for both vehicle and the driver – high requirements for understanding the assisted features functioning.
- Importance of vehicle to vehicle communication increases with congested traffic flow.
- Automated detection of pedestrians and cyclists and anticipation of their actions is a difficult task. On street cycling especially difficult to detect. At intersections driver's attention is required to monitor the environment and in low automation also for maneuvering.

Human related issues in road traffic automation

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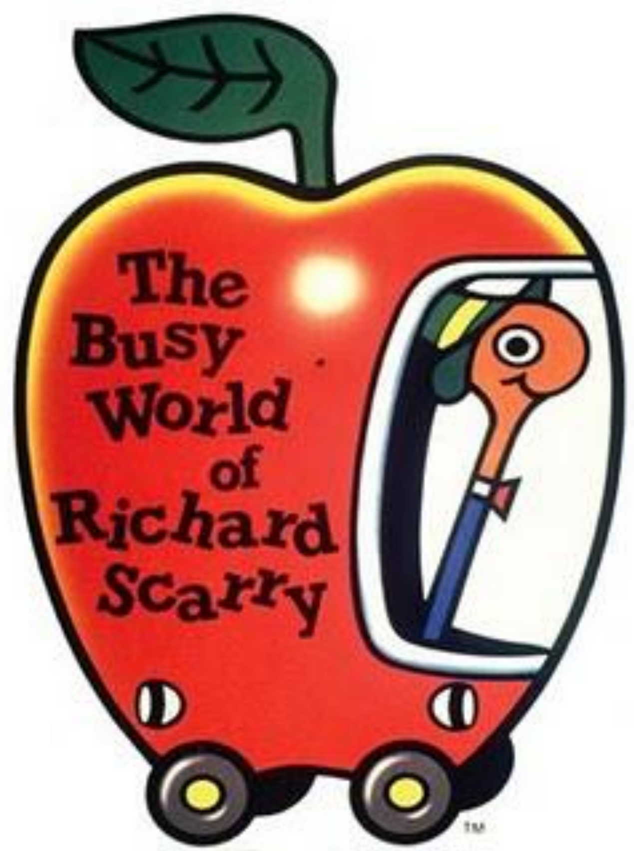
- Reduction in workload in automated vehicles increases possibility for added information as the risk of distraction is lowered. The information should support detection and anticipation.
- Trust in assisting systems: in low automation, frequent changes in automated and manual features may be confusing and reduce use of those systems. As trust develops with experience, any major accident will seriously damage it.
- In high automation, comfort and monotonous driving shift attention to secondary tasks, which become primary tasks making driving and monitoring traffic secondary. Driver's situation awareness and alertness will be compromised thus decreasing ability to act when required.
- Increasing automation eventually erodes manual driving skills, which poses a risk as the driver will mostly be alerted in complex environments and for demanding tasks. Situation awareness and understanding the functioning of the assisting systems is of primary importance.

Food for thought

- How do pedestrians and cyclists adapt? How can we know which vehicles are automated and on which level?
- Limitations of artificial intelligence do exist – monitoring, interpreting, time needed for calculations
- Is the safety benefit exaggerated? Possibility of error will not disappear.
- Is the human computer really inferior?

THANK YOU!



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