VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

Three Human Behaviour Theories in the Context of Automated Driving – Identification of Issues from Human Actor Perspective

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Let me introduce myself…

- Colleague of Pirkko Rämä
- Industrial design, work psychology and management
- VTT Technological Research Centre of Finland LTD
- Human Factors, virtual and augmented reality team
- Focus on studying work practices and tools in context of complex safety-critical systems

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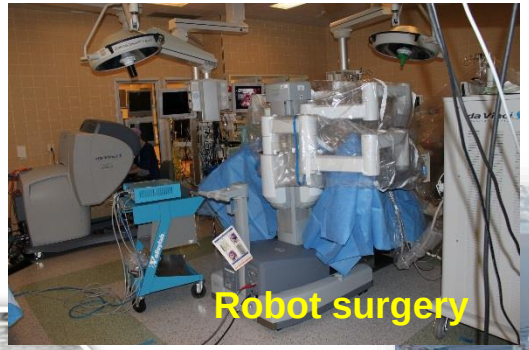


Picture © Rolls-Royce

Content of presentation

- Background

AIM
- Aim of the study

THEORIES
- Motivational driver behavior theories
- Human as information processor
- Practice theory approach - Core task analysis

LoA
- Low automation support scenario
- High automation support scenario

METHOD & MATERIALS
- Study setup
- Urban driving
  - Sub-tasks in urban driving
  - Example of the data
- Motorway driving
  - Sub-tasks in motorway driving
  - Example of the data

- Results and conclusions

Human issues in automated driving

https://www.google.fi/search?q=future+automated+cars&tbm=isch&tbs=rimg

Background

Human issues?

- How to perceive situation awareness (SA) of the driver?
- How to handle the shift from automated to manual driving (L3 - L4)?
- How to cope with mixed transport where automated and non-automated cars should interact with each other?
- How to handle interaction with VRUs?
- What would be the implications for fluency of traffic flow?
- Acceptance of automation: security, experience of control?
- …

How well are the issues and research questions covered?

Aim of the study

- ✓ Determine human issues related to automated driving
  - Create good coverage of relevant issues – to find new issues using a systematic approach
  - Better understanding of human issues and behavior mechanisms

- ✓ To study the descriptive power of human behavior theories for automated driving
  1. ‘traditional’ driver behavior theories – car driving
  2. general human information processing model applied in work environment and in other modes of transport
  3. Practice-theory approach and core task analysis developed in the context of safety-critical work systems

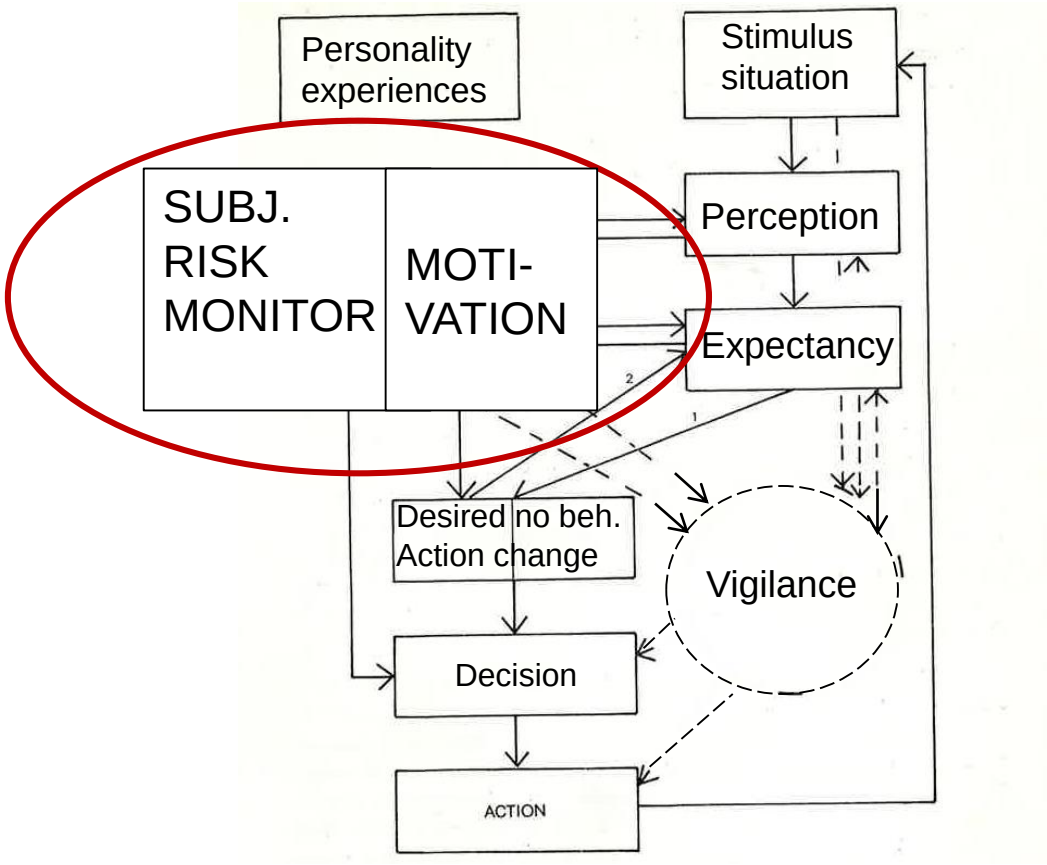
Theoretical approach to human behaviour 1/3

Motivational driver behavior theories

Wilde: The theory of risk homeostasis

Näätänen & Summala: The zero risk theory

Fûller: The threat avoidance theory

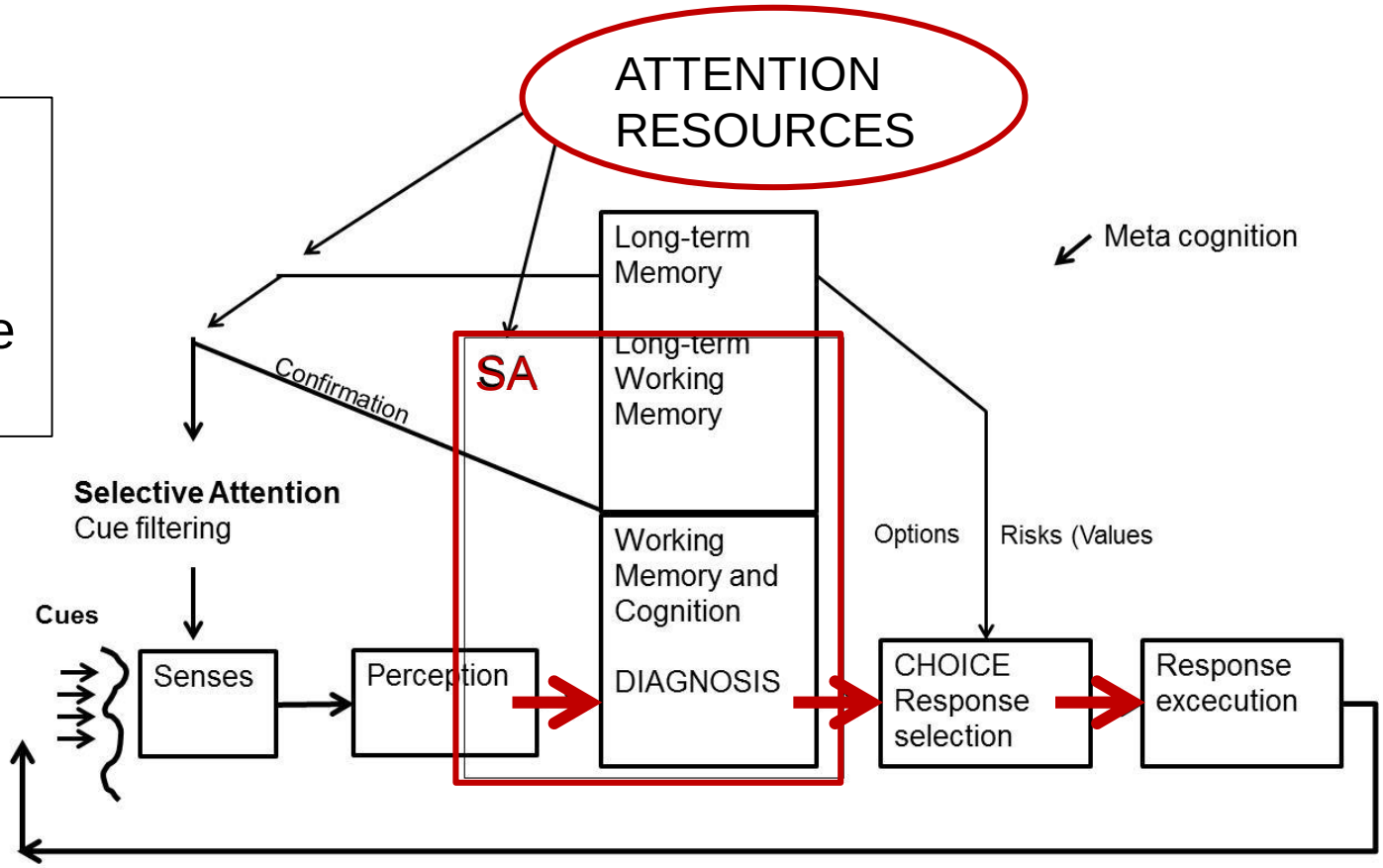


Näätänen & Summala 1976

Theoretical approach to human behaviour 2/3

Human as information processor

Applied in variety work environments and for example aviation

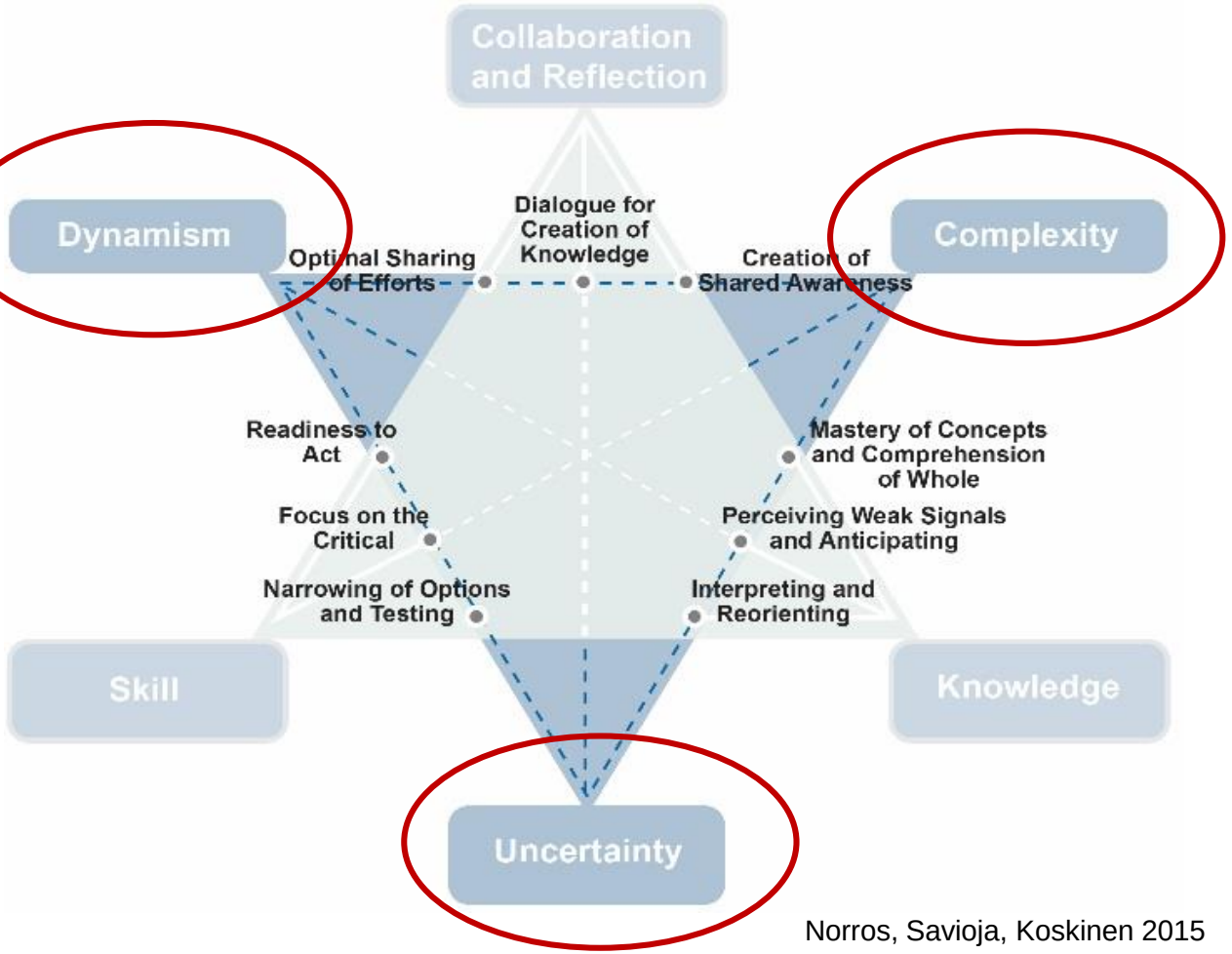


Wickens & Hollands 2000

Theoretical approach to human behaviour 3/3

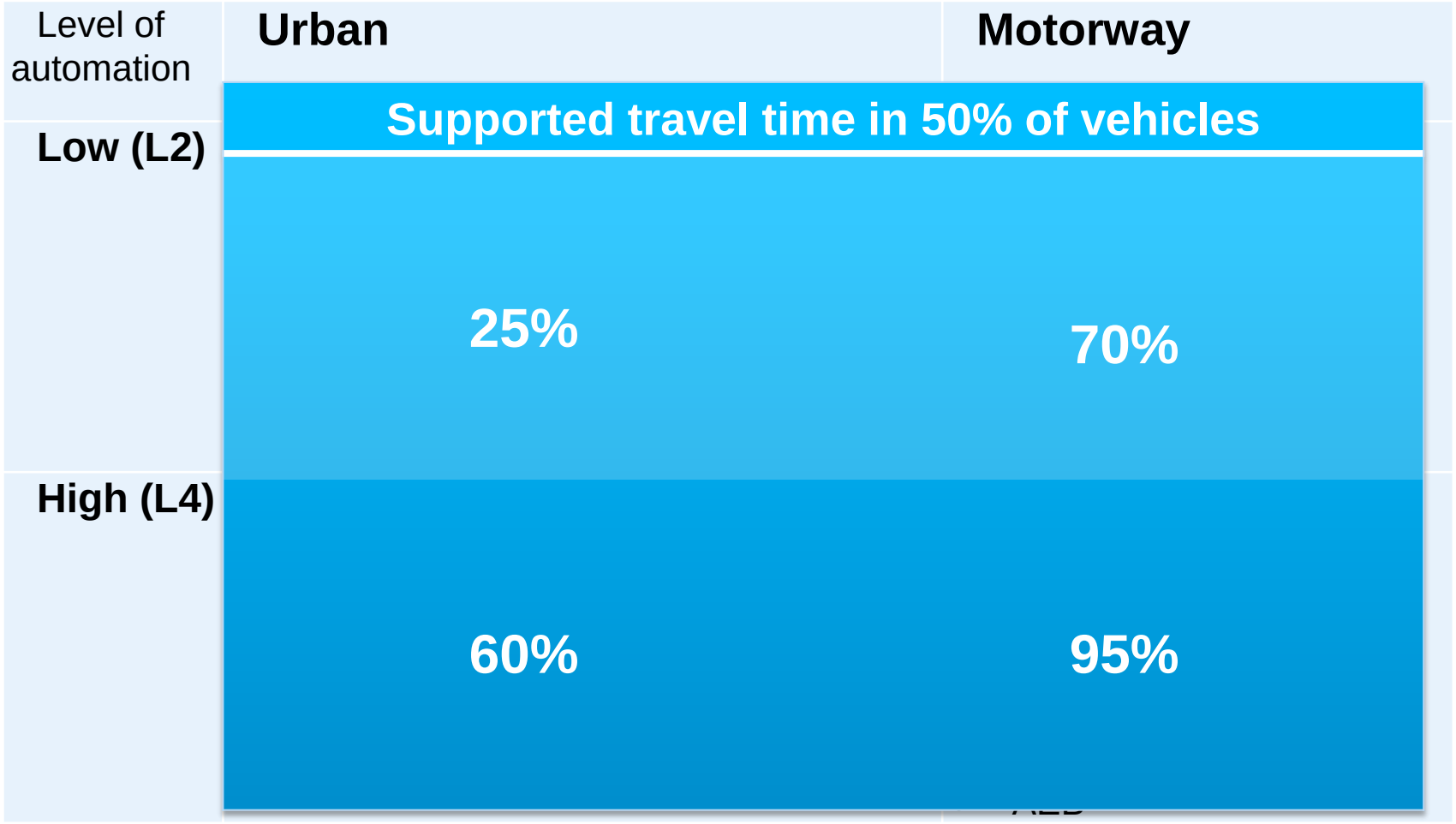
Practice- theory approach – Core task analysis

A contextually defined model for work activity



Norros, Savioja, Koskinen 2015

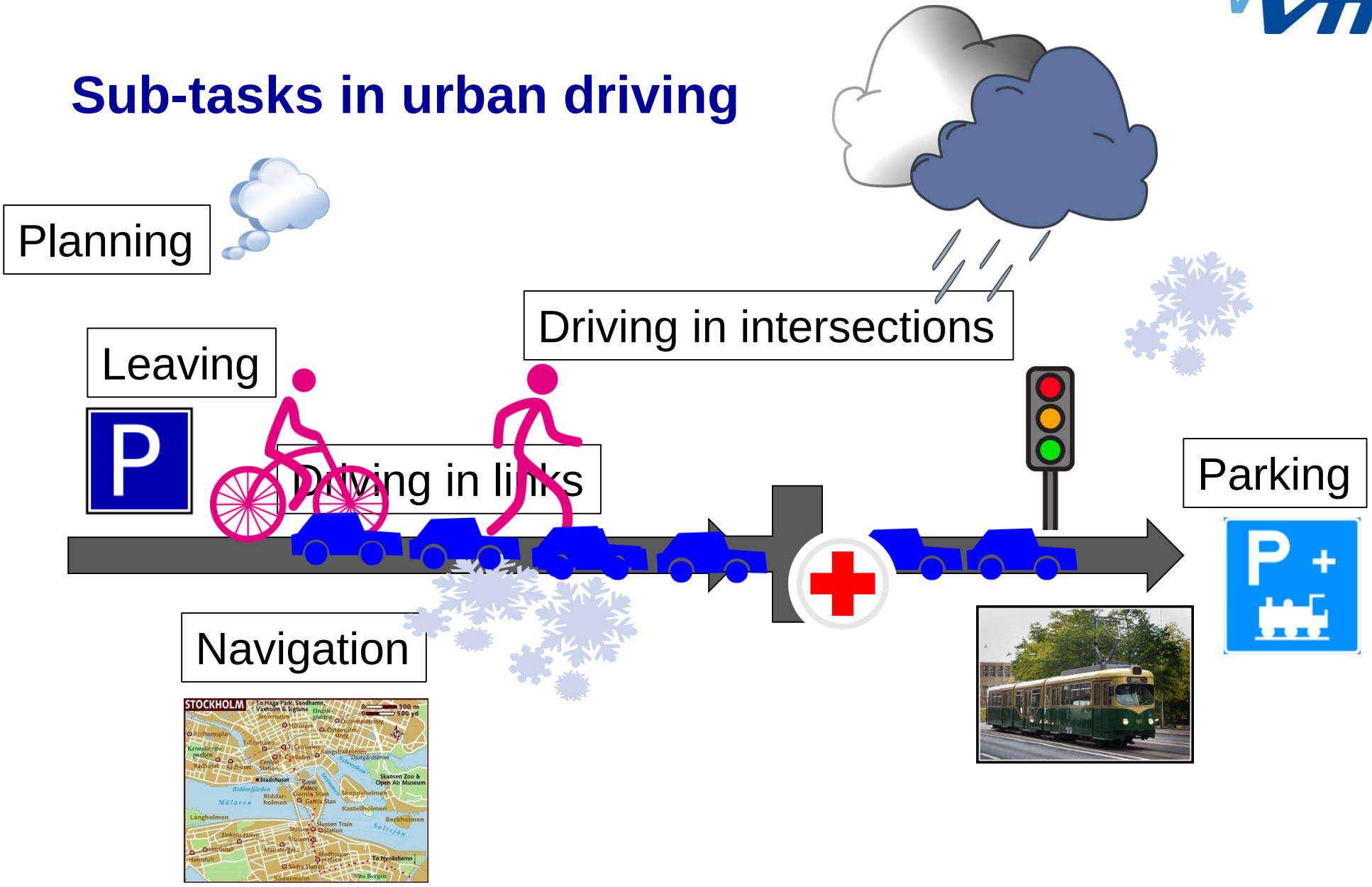
LoA – Automation support scenarios



Method and materials

- Expert assessment of automated driving utilizing three selected theoretical approaches or models – pair work, work shops
- Careful consideration of sub-tasks and contextual circumstances in urban and motorway driving
  - Break-down of the driver tasks in detailed level – not to forget something
  - Merging the tasks to entities on a reasonable level – to be comprehensible
- Definition of the basic case – add on contextual circumstances
- Qualitative data as outcome
- Content analysis to identify the human issues
- Assessment of the human issues in the light of relevant literature

Sub-tasks in urban driving



URBAN	Contextual circumstances											
Sub tasks	Basic case: Car following, only cars, wide road, day time	Traffic in front: Free flow	Traffic in front: Jam	Composition of traffic: Pedestrians	Composition of traffic: Cyclists	Composition of traffic: Trams	Width of the road: Narrow	Traffic lights: Yes	Weather: Hazardous	Lightning: Night time	Incident: Anticipated	Incident: Sudden
Leaving the parking place	**1 MOTIVATIONAL**	1		1	1	1	1	1	1	1	1	1
	2 INFORMATION PROCESSING											
	3 CORE TASK	3	3	3	3	3	3	3	3	3	3	3
Driving in the links	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3
Driving in the intersections	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3
Parking	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3
Navigation (during the trip)	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3
Planning an urban trip	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3	3	3	3

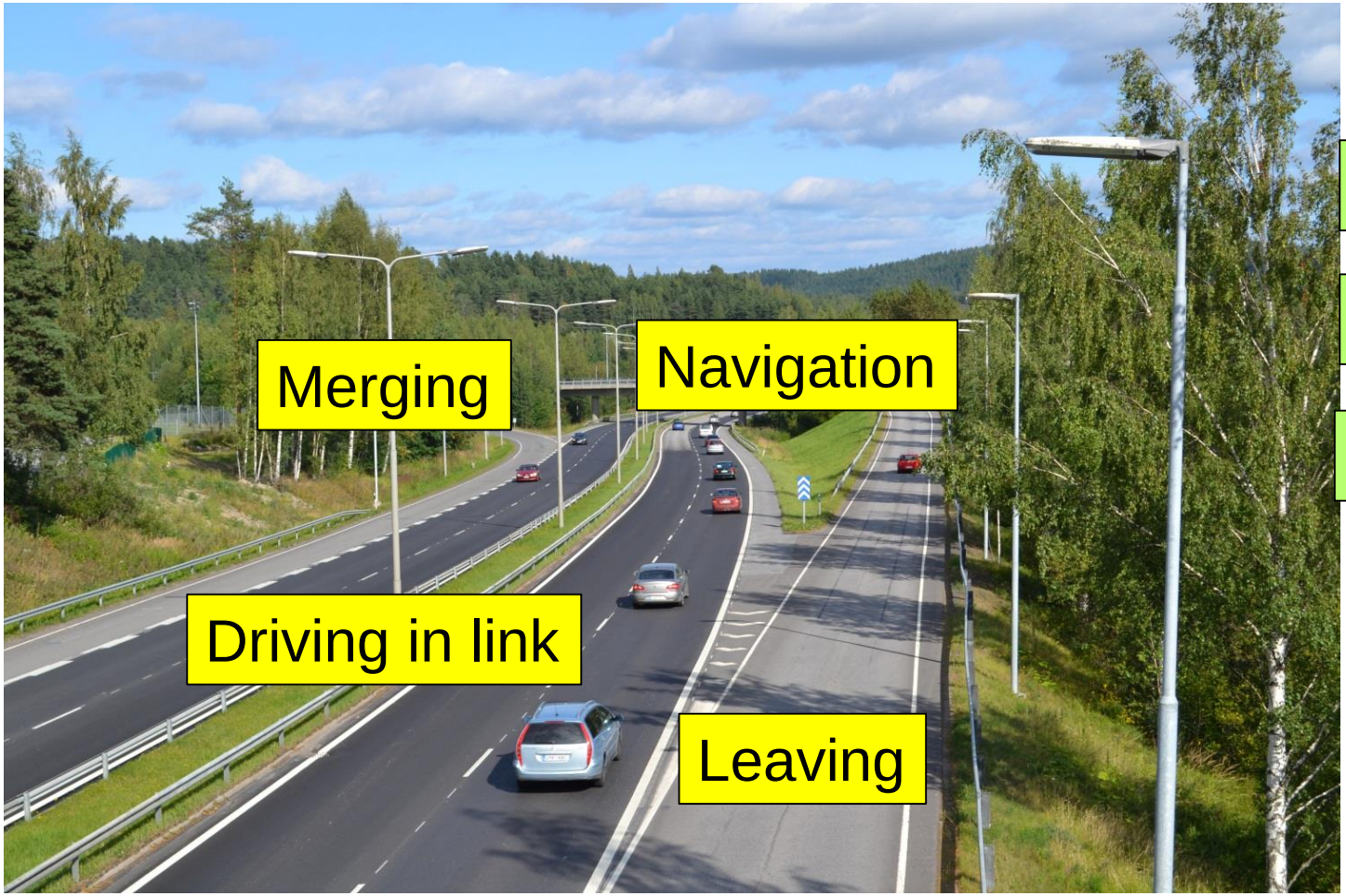
Example of the data – urban

Driving in link section:

L2: An increase in the **mean speed** of the traffic flow is expected (1). Doing secondary tasks is questionable, because visual demand remains, and the execution of most secondary tasks may demand the **same visual capacity and load the same channel** as the driving task (2). The **complexity** of the task may increase with automation, as the driver may need to shift from supported to non-supported mode quite frequently (3).

L4: **Speeding** no longer occurs, as the maximum speed is set by the automated system (1). With only few opportunities for manual control, the manual driving task becomes more difficult and the **workload** heavier (2).

Sub-tasks in motorway



Mode choice

Timing

Route choice

MOTORWAY	Contextual circumstances									
Sub tasks	Basic case: Car following, quiet roads, good weather day time,	Traffic in front: Free flow	Traffic in front: Jam	Type of environment: Busy roads	Weather: Visibility/ rain	Weather: Slippery/ icy	Lightning: Night time	Incident: Anticipated	Incident: Sudden
Merging	**1 MOTIVATIONAL**			1	1		1	1	1
	2 INFORMATION PROCESSING				2	2	2	2	2
	3 CORE TASK	3		3	3	3	3	3	3
Driving in link section	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3
Leaving	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3
Navigate	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3
Mode choice	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3
Timing	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3
Route choice	1	1	1	1	1		1	1	1
	2	2	2	2	2		2	2	2
	3	3	3	3	3		3	3	3

Example of the data – motorway

Leaving the motorway section:

L2: The driver may **try to delay** switching to manual driving as long as possible due to limited AD support in the leaving (1). In the leaving-the-motorway task, all models highlight transformation **from one driving mode to another** (1,2,3).

L4: The shift from secondary **back to primary** task is critical. The countdown is central to defining how quickly and well the driver comprehends the situation and may take the control (2). How well the driver **knows** the functionalities and the limits of the AD systems and how well they are **learned** to use in the driving task is critical (3). Slowing down to the **appropriate speed** may be challenging after driving at highway (1,2,3).

Results and conclusions – Human issues 1/2

Strategic decisions

- ✓ more car driving? Later less in adverse/demanding conditions.
- ✓ fastest routes → better considered route choices
- ✓ more cars in city centres? (P assist)
- ✓ limited support – use of automation; trust
- ✓ role of car in fulfilling extra motives?

Traffic safety

- ✓ crash risk in low automation – learned automatics no longer valid
- ✓ secondary tasks in low automation
- ✓ speed and following distances – factory installations
- ✓ willingness to give way to other participants

Results and conclusions – Human issues 2/2

Communication

- ✓ entering a queue – connectivity
- ✓ entering the flow – passing cyclists → new arrangements of city space
- ✓ design task: how to improve communication

Role of information

- ✓ more space for information
- ✓ real time to support detection and anticipation
- ✓ general guidance
- ✓ new mental models
- ✓ pertaining manual driving skills

Results and conclusions – Theories

Role of theories

- ✓ all three useful points of view
- ✓ driver behaviour models: direct link to speed and flow
- ✓ information processing and core task analysis: more topics

Issues not covered

- ✓ effects on exposure and consequences of a potential crash
- ✓ non users and other modes – in some degree
- ✓ efficiency and environment less

Further analysis and developing core task analysis approach in the context of automated driving

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Information about Traffic Safety 2025 is available at http://www.vtt.fi/sites/tl2025/en