



VTT

**HELLO, MY NAME IS SMARTTRAM,
HUMAN FACTORS IS ON BOARD,
ENJOY THE RIDE!
DEVELOPING A HUMAN FACTORS
PROGRAM FOR AUTOMATIC TRAMS**

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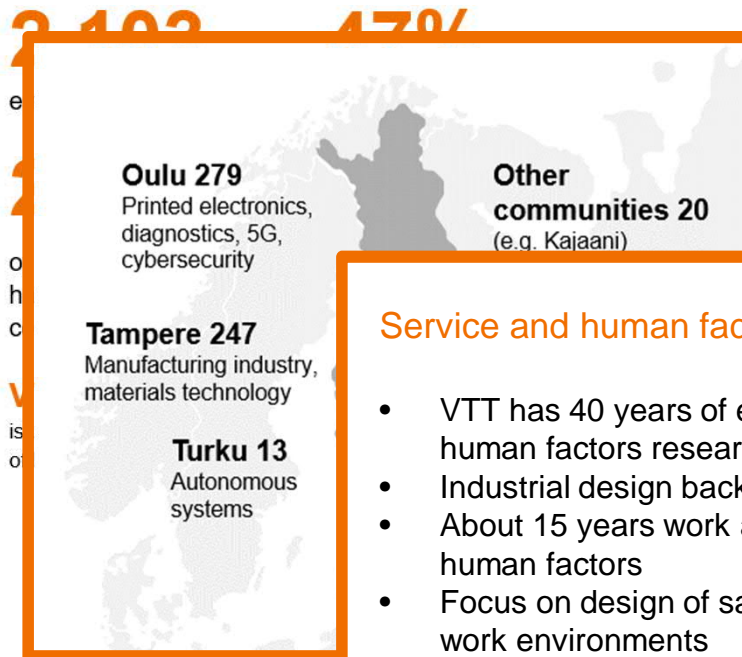
VTT Technical Research Centre of Finland Ltd

30/09/2021 VTT – beyond the obvious

VTT Technical Research Centre of Finland



147 M€ Turnover (parent 147 M€)
9 M€ Other operating income
89 M€ Government grant



Service and human factors engineering – team

- VTT has 40 years of experience on human factors research
- Industrial design background
- About 15 years work at VTT and human factors
- Focus on design of safety-critical work environments



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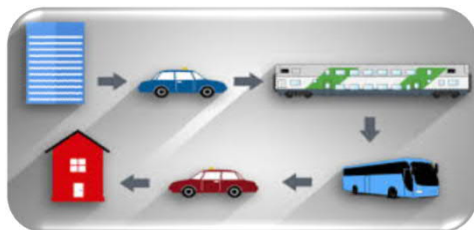
Introduction

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SmartTram project

- The project is part of SmartTram living lab activity in Finland that aims at building more sustainable and user friendly public transportation solutions
- Research-oriented project that supports industry projects and collect together different parties and facilitate the ecosystem build around the smart tram concept
- The research project combines knowledge areas of 1) transportation service chain and users, 2) connectivity and automation, and 3) low-carbon and energy efficient solutions



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Project organization view

- Part of Simulation of autonomous system - work package
- Under the task Verification and validation process for autonomous systems

Research ambition view

- There is a worldwide initiative to increase use of automation solutions in transport systems and enable new kind of mobility services that are in the center of the smart city concepts
- The higher levels of automation is not visioned only to be future in cars but also in other forms of transportation (e.g., public transportation and cargo)
- In this project, the focus is on developing automatic solutions for trams (not many reference cases can be found)
- The design task, i.e., the development of automatic tram, is challenging because the tram needs to operate in an open infrastructure (i.e., urban city environment with other vehicles and road users)

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Human Factors view

- The automatic tram will change the tram driver's work substantially
- From the passengers' point of view, the automatic tram is a notable change, as well (e.g., trust and interaction issues)
- Several other user groups such as technicians and traffic controllers
- Thus, driving a tram and interaction with automated tram will remain as an important human factors issue to be taken under careful investigation

In this paper

- We introduce the human factors engineering (HFE) program including the iterative evaluation framework that have been developed for the SmartTram project in order to acknowledge appropriately the human and social aspect in the design of the automatic tram

Human factors engineering in safety-critical design projects

Human factors engineering in safety-critical design projects

Motivation

- There is a lot of evidence that complex engineering projects do not always proceed as has been planned
 - They do not meet their deadlines, cost estimates and other expectations

HFE activities in the engineering design of control room systems

| | | |
|----------------------------------|--|--------------------------------------|
| Screening | Task analysis | Design of maintenance activities |
| Management and planning | Human reliability analysis | Procedure design |
| Operating experience review | Manning | Training design |
| Development of ConOps | Personnel selection and qualifications | Verification and Validation |
| Function allocation and analysis | System design and development | Commissioning and in-time monitoring |

Human factors engineering in safety-critical design projects

- To really have an impact and appropriately address all the activities that needs human factors attention
 - A more integrated and holistic approach to HFE is called for

Solution

- We propose that a HFE program within which all the HFE activities, their deliverables and main interactions with the other design parties are described may be an effective cure for carrying out successful design projects
- The HFE program should cover all the phases of the design process from the initial clarification and analysis phase to the final implementation of the system



Human factors engineering in safety-critical design projects

| Input | Design process | Output |
|---|--|--|
| <ul style="list-style-type: none">• Need for change (e.g., growing amount of passengers, sustainable and environmentally friendly public transport solutions)• Existing concepts (e.g., proofs of concept, level of automation)• Operational experience (other automated traffic solutions e.g., automatic metro) | <p>Initial clarification and analysis</p> <p>Impact, needs and constraints</p> <p>HFE goals</p> | <ul style="list-style-type: none">• Human factors input to project plan• HFE program/ activities (i.e., tasks and responsible persons, schedule and resources)• Preliminary evaluation schema (i.e., Systems Usability Case based evaluation of concept, subsystems and integrated system) |
| <ul style="list-style-type: none">• Operating environment description• User and safety requirements• Standards | <p>Requirements and concept design</p> <p>Concept of Operation (ConOps)</p> <p>Task analysis</p> <p>User requirements</p> | <ul style="list-style-type: none">• SmartTram concept (documentation of ConOps, level of automation, user interactions)• Project requirement set• HSI style guide (e.g., main design principles, HSI guidance on layout, navigation, color-coding, alarms etc.) |
| <ul style="list-style-type: none">• I&C architectures• Standards | <p>Detail/integrated design</p> <p>User interface, training design</p> | <ul style="list-style-type: none">• Tram interior and user interface design solution |
| <ul style="list-style-type: none">• V&V plan (e.g., users groups, scenarios, acceptance criteria)• Standards | <p>Verification & validation (V&V)</p> <p>Simulations</p> <p>Validation tests</p> | <ul style="list-style-type: none">• V&V record (e.g., identified human engineering discrepancies and design feedback, decisions on further design iterations) |
| | <p>Implementation & commissioning</p> | <ul style="list-style-type: none">• Accumulated evaluation record (careful documentation of implantation and early operating experiences) |

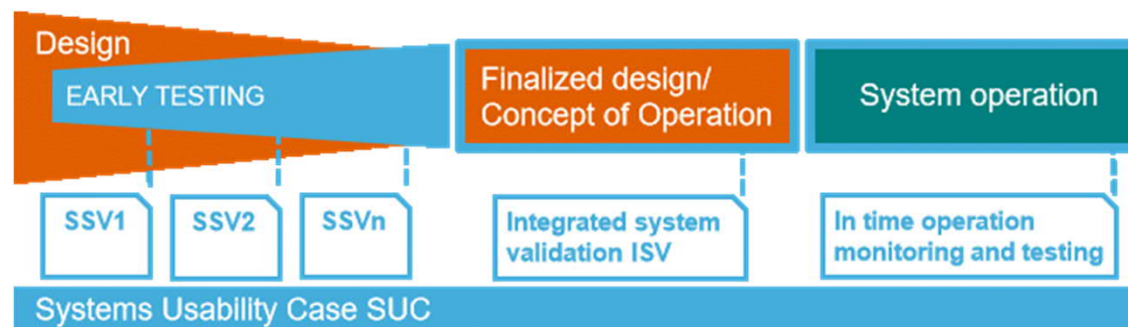
Human factors engineering in SmartTram project

Human factors engineering program

- The project is in its initial clarification and analysis phase
 - Identification and analysis of relevant user groups (e.g., interviews with conventional tram drivers)
 - Benchmarking on human-system interaction concepts in tram driving
 - Operating experiences of similar systems (other automatic transport and machinery may offer relevant background information, e.g., automatic metro or crane operation)
- Above information serves as an input for 1) planning the SmartTram project and 2) drafting the specified HFE program and 3) the preliminary evaluation schema (i.e., V&V plan)

Verification and validation plan

- Iterative evaluation and testing is an integral part of designing complex safety-critical systems and the continuous engineering paradigm that promote improvements throughout the product life cycle
 - A concept of subsystem validation (SSV)
 - An integrated system validation (ISV)
 - Operating experiences are systematically collected



- System Usability Case (SUC) is used as a methodical starting point for managing and organizing the SmartTram evaluation

SmartTram simulator facility for user testing

- One useful approach to be applied during an HFE program in a safety-critical system design is virtual reality (VR) based models and simulators
 - By using VR simulators, it is possible to immerse users to their future operating tasks in a safe environment (e.g., concept testing and training)
- In the SmartTram project, a virtual environment was created for the SmartTram system
 - 3D models of a tram and a city
 - Road event visualizations (other trams, cars, pedestrians, etc.)
 - Variety of weather conditions (e.g. heavy rain, winter frost)
 - Data recording functionalities



Conclusions and future work

Conclusions and future work

- In the modern smart city environments, many technologically advanced mobility services and solutions are expected to be in place
- Thus, increasing levels of automation is central in developing the public transportation
- In this presentation the development efforts to introduce automatic tram has been described including the HFE program and V&V evaluation framework

Future work

- In the following phases of SmartTram project, the most critical HFE activities are to
 - set the user requirements and
 - design an initial concept of operation
 - construct a first version of Systems Usability Case documentation

Thank you!
Questions?

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