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Center for Sustainable
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Research Issues for the Sustainable Operation of Railways and other Mobility Systems

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1 Introduction

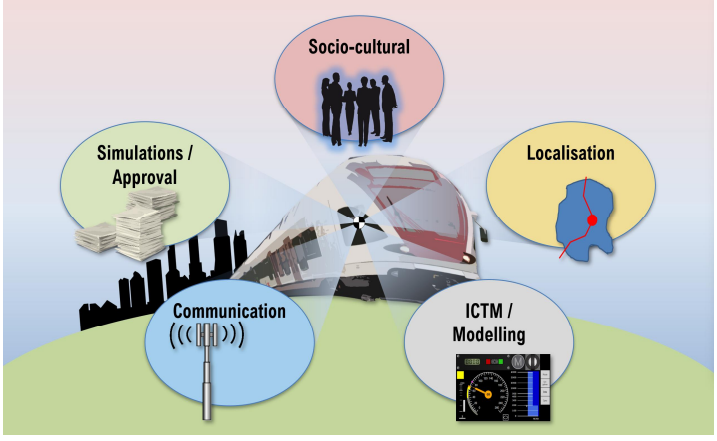
The current urgency of a new, circular economy which protects our planet's resources better induces the need of new, more sustained solutions for mobility. This concerns all mobility systems, be it track, road, air or water, be it private, public, passenger or freight transportation.

2 Historical Context

- Railway is in itself a modern, ecological system. It can be called the forefather of all kind of electric mobility.
- In the area of steam locomotives, railway was originally a technically complicated challenge, but organizationally simple. The train driver controlled the technology of the locomotive and the stoker made sure that the signals of the dispatcher were observed correctly. The roles and instances were clearly separated by onboard and trackside systems as well as rules and regulations.

3 Statement, Claim

- The requirements for modern mobility systems are many magnitudes more demanding: Higher capacity in conjunction with higher speeds but smaller headways are called for. More technology, more subsystems, more interaction, more interoperability, more complexity induce much more difficulties.
- The well-known insight known from optimization theory that the search for local optima doesn't necessarily lead to the global optimum is certainly true for this kind of conglomerate of systems.
- There are five thematic areas identified, in which substantial progress is required, in order to approach the global optimum of a sustainable mobility system.
- These areas have been identified by specifically considering the railway system. However, it became clear later, that they apply to each mobility system, at least to a large extent.



4 Rationale and Discussion

Socio-cultural

The socio-cultural consciousness correlates with the values of society. The protection of the environment and the careful handling of resources become the new, over-essential importance. This transformation in society must have consequences for the design of mobility. Hence, isolated development of subsystems must be replaced by a systematic overall approach based on the analysis of the real causalities. *This requires a new form of collaborative, integral and interdisciplinary view*.

Localization

Future intermodal real-time optimization systems require cost-effective, fast, safe and secure localization of all moving objects: roughly estimated requirements are: +/- 10^{-1} m accuracy, update interval 10^{-1} s, MTBF for safety-related failures in the order of 10^{-8} y. *The current systems are far from delivering such a performance.*

ICTM and SW Modelling

Railway ICT and other mobility systems are a kaleidoscope of proprietary subsystems based on governmental regulations. Safety-relevant systems have mostly been developed according to the paradigms of the last century in an industrial level 2.0 and 3.0. *The mobility industry must organizationally renew itself and apply methods and technology of industrial levels 4.0 to 5.0.*

Communication

Any kind of automation is based on the correct process image of all involved subsystems. The degree of the automation is directly dependent on the efficiency of the *communication systems* between the subsystems involved. *The current systems cannot do this.*

Simulation and Approval

The true safety level of a complete system cannot be accurately deduced by separately inferring the safety levels of the subsystems. This is a lesson learned in the approval of the signaling system ERTMS/ETCS. All railroad projects – and mobility projects in general – are based on an n-dimensional matrix of a hypercomplex organization behaviors[3]. *Without an accurate digital simulation of an adequate number of test scenarios and the complete digitalization of support processes, the tsunami of information is not manageable.* Today's methods don't achieve this.

5 Conclusion and expected impact

- By improving the understanding of the proposed areas, humanity will approach the global optimum of a sustainable mobility system.
- The respective ecologically best can solution only be found, if all systems are abstracted in a similar way, based on a common syntax and method. An end-to-end perspective is required, living in an open META-data cloud, leading to open standard systems.

References

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3. See. Ulrich, Hans; Probst, Gilbert (2001): Anleitung zum ganzheitlichen Denken und Handeln., S 109 ff.; See also. Koch, Hans Peter; Bolli, Markus (2016): KOBO - die integrale Intelligenz - Der Weg zur nachhaltig erfolgreichen Unternehmung, S. 28 ff.

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