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Scenario based analysis for intelligent transportation systems for road freight transport

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Abstract. The paper deals with a scenario analysis for intelligent transportation systems (ITS) for road freight transport in Germany. A positive and a negative scenario for the year 2030 are discussed. Impact areas as well as key factors and projections are presented. Further research implications are stated.

1 Problem background and research questions

How is road freight transport evolving in Germany? What are the key factors and what scenarios can be expected? These are the driving questions of this project.

In many cities, road infrastructure has reached its capacity limit. Especially in the early hours of the day on the way to work or in the evening rush hour, long waiting times on the streets due to traffic jams must be taken into calculation. Traffic jam statistics of TomTom or INRIX [1] document the costs that are due to crowded roads (e.g. 2013: 25,2 Billion €) and that every journey needs in average 35 minutes longer per day [2]. In addition, fossil fuels are wasted, as well as environmentally harmful carbon dioxide is emitted.

Reasons for the increase in traffic can be seen in the shift of production to system suppliers and manufacturers of semi-finished products resulting in necessary just-in-time deliveries, globalization, and growing E-Commerce. This all leads to an increased transport volume, respectively transport performance. As road networks cannot be endlessly expanded, and society needs to treat fossil resources responsibly, intelligent transport systems are getting more and more important [3].

However, the future perspective is lacking, which would enable today's innovators and decision-makers to adapt transport systems and processes to a possible situation in 10 years. On the one hand, the question arises which factors are influencing the area of intelligent transport systems (ITS) for road freight transport. And on the other hand, what scenarios could be conceived for ITS for road freight transport for the year 2030.

2 Method and results

Figure 1. shows the chronological sequence of the project, which led to the creation of two consistent scenarios. In a first stage the scenario field (= ITS for road freight transport) was identified and examined by an extensive literature review. As a result, ITS for road freight transport are focusing on the four sub-areas “Advanced Driver Assistance Systems”, “Fleet Management”, “Toll Systems” and “City Logistics” [4]. Next, impact areas, influencing factors and key factors were determined in two workshop sessions with 15 participants. This resulted in five impact areas as well as 22 influencing factors out of which twelve key factors were extracted (see Figure 2.). Afterwards, each key factor was assigned to at least one descriptive feature, which was the starting point for the creation of projections. Table 1 presents the twelve key factors and their descriptive features. For each key factor, positive and negative projections bundles were developed. These projections were then

analysed regarding their consistency for being able to create valid bundles of projections. For this step all projection bundles were validated by using independent evaluation matrices.

Finally, these results were used for setting up two consistent scenarios (a best case and worst case) following the methodological considerations suggested by [5] and using the scenario software INKA 3 [6] (see Tables 2 and 3). This selection of scenarios corresponds to a recommendation by [7].

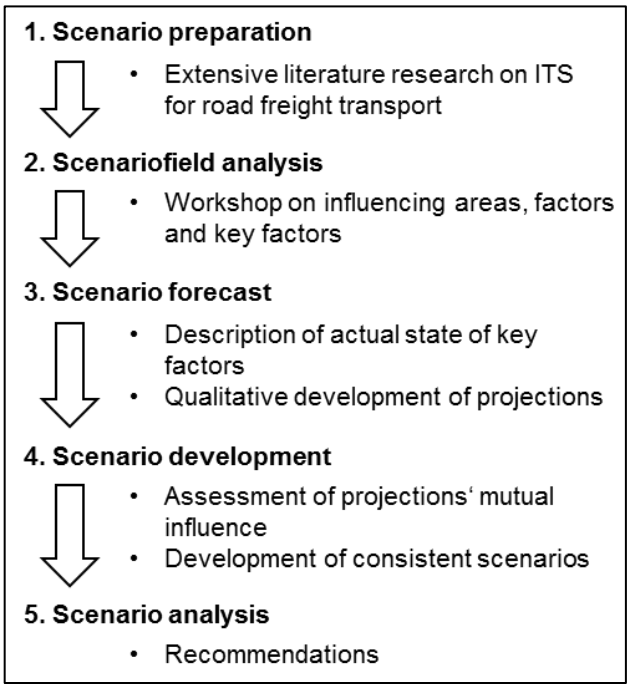

Figure 1. Methodological steps for scenario analysis on ITS

For identifying a best case scenario the bundle with the highest consistency value was selected. For identifying the worst case scenario the (consistent) bundle with the most deviating projections in contrast to the positive scenario was selected.

An interdependency analysis for the key factors provides information about the most active key factors. The three most active projections are "Germany is a patent oasis", "Galileo and LTE era" as well as "High confidence in policymakers" vice versa in the negative scenario "Technological standstill", "Unfulfilled expectations" and "Great Political upheaval". Based on these projections, the overall development in the positive scenario as well as in the negative scenario can also be explained

Table 1 Key factor characteristics

No.	Key factor	Characteristics
1	Willingness for information exchange	Relational Norms [8]
2	Technology acceptance	Technology Acceptance Model [9]
3	Cargo volume and product division	Data on cargo volume and product devision (data provided by [10]
4	Economic development	Gross Domestic Product (provided by [11]
5	E-Commerce	Annual data on E-commerce sales (data provided by [12]
6	Technological development	Amount of annual patent registration (data provided by [13]
7	System security	Cybercrime statistics (data provided by [14]
8	Traffic flow	Congestion hours (data provided by [15]
9	Condition of road infrastructure	Global Competitiveness Index: Quality of road infrastructure (data provided by [16]
10	Condition of technological infrastructure	Global Competitiveness Index: Technological readiness (data provided by [16])
11	Political framework	World Governance Indicator (data provided by [17])
12	Environmental factors	Fossil fuel reserves [18]

Table 2. Best Case Scenario for ITS

Impact area	Projection
	Open information culture
	Technologically driven life
	Steady increase of cargo volume in ton per kilometer
	Economical prosperity in Germany
	Home-Shopping
	Germany is a patent oasis
	Large-scale security updates
	Intelligent route guidance
	Big investments in road infrastructure
	Galileo and LTE-era
	High confidence in policy makers
	High environmental requirements

Table 3. Worst Case scenario for ITS

Impact area	Projection
	Turning away from open information culture
	Technology obverse society
	Steady increase of cargo volume in ton per kilometer
	Economical prosperity in Germany
	Shopping as leisure experience
	Technological standstill
	Cybercrime is flourishing
	Traffic gridlock
	Dilapidated infrastructure
	Unfullfilled expectations
	Great political upheavel
	Climate protection becomes a side issue

3 Discussion and conclusion

Our results show that the overall political situation appears to be an important driver for giving companies a high planning certainty in their use of ITS. This is due to high investment costs for new systems, which small and medium-sized enterprises often cannot cope with. Further supportive grants and clear legal requirements for the industry sector are often seen as the driving factors for the use of new systems. The second important influencing factor is the state of the technological infrastructure, especially information and communication technology. It is obvious that companies are ready to invest in the latest communication systems if adequate network coverage can be guaranteed. Here, the first scenario implication can be taken from the positive scenario by recommending the assurance of high network coverage in Germany the best functionality of the Galileo navigation satellite system. The third key factor, "Technological development", is, however, difficult to influence as investments in research and development do not assure new technological advances.

The importance of the physical infrastructure, here in terms of the general road condition, is for sure without controversy. Road condition is decisively influenced by the transport performance as well as current receipts by tolls for the usage for maintenance of the roads. However, this key factor should not be critical, since a reasonable road infrastructure is compulsory for road freight transports as well as for the attractiveness of a country. Therefore, the government should continue to undertake far-reaching infrastructure measures.

It is interesting that in both scenarios a steady increase in the area of transport performance is assumed. This in turn must be concluded from the economic development of Germany, which foresees an average increase for economically developed industries by 2030.

Both scenarios relate to comprehensible developments. Extreme scenarios are possible but have the disadvantage that they are to a large extent classified as untrustworthy and therefore not relevant. In the case of the scenarios, however, further analyzes are necessary in order to define a broader development spectrum.

As a criticism, the validity in the consistency analysis of the projections should be treated with caution. This is certainly due to the fact that the evaluators did not have the same projection background as the author and therefore chose different interdependencies as basis for their decisions.

Furthermore, it would be appropriate to draw up detailed projections on the different areas of ITS for road transport. In addition, the already existing projections could be confirmed or even better validated via an expert survey in the form of interviews or a Delphi-analysis. Plus, a cross-border analysis would be helpful for the future use of intelligent transport systems in order to be able to derive further implications for the European economic area and European policy area.

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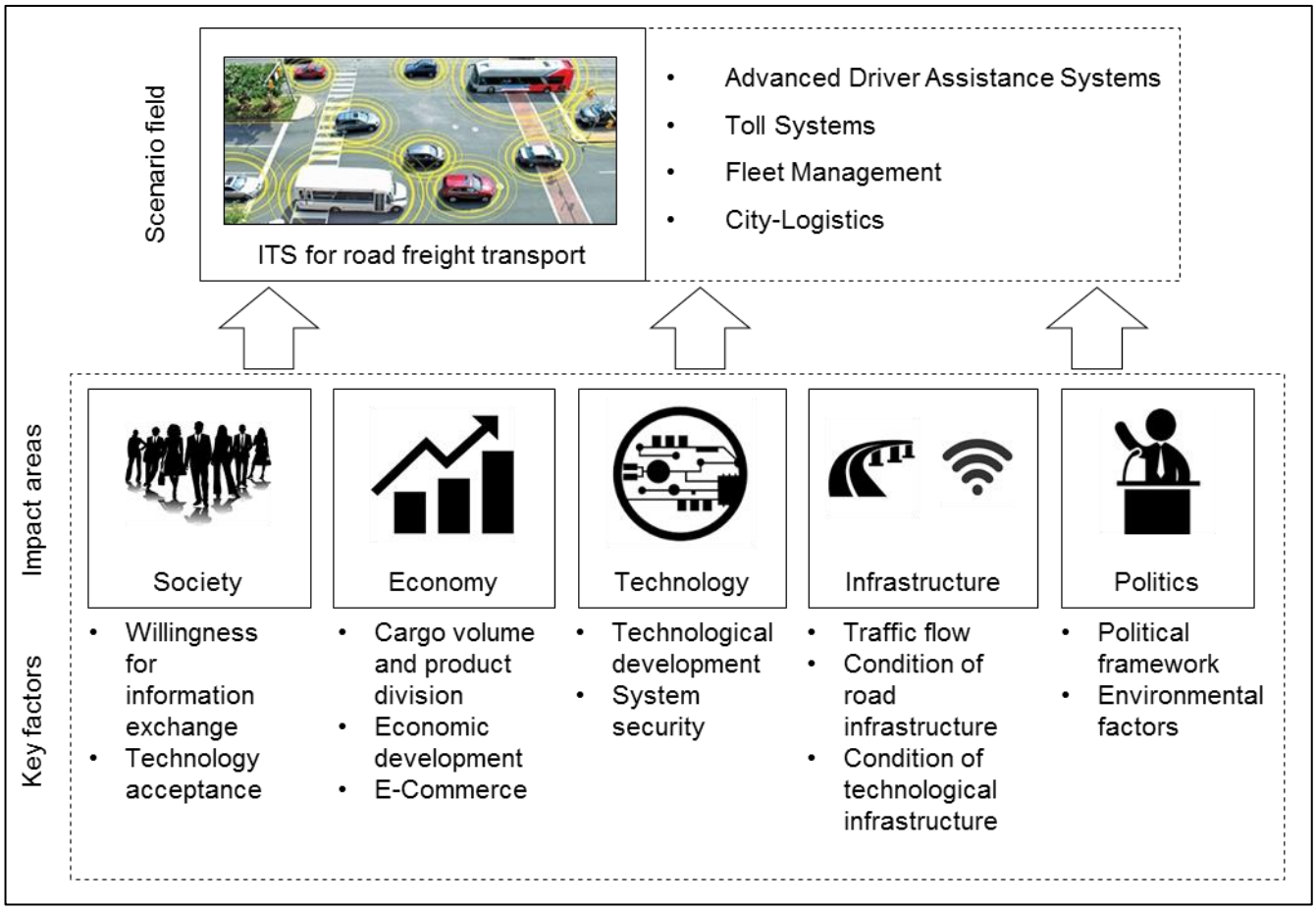

Figure 2. Scenario field's impact areas and key factors

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