TRAIL Research Program 2013-2018

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I Introduction

This document is the input for the TRAIL research program 2013-2017. It firstly explains the changing context for research, and secondly it provides an overview of the themes per program and expected topics relevant for the coming five years / new research program.

II General changes and the relevance for the TRAIL research program

This section describes general trends and changes relevant for TRAIL in general. Trends that apply to the three research teams individually are presented in section III.

1. Changing context

The context for PhD research and acquisition is changing, in several respects:

1. The Graduate Schools are increasingly implemented at most universities
2. Maybe three year PhD programs will be introduced in the future
3. Dutch funding opportunities in the areas of Transport and Infrastructure are decreasing (but probably not in the area of logistics)

Ad 1 and 2

As a result of the first two points the time available for PhD research might decrease: the time needed for PhD education is expected to increase, and maybe the overall time for PhD research will decrease. This might lead to lowering the standards of PhD theses, at least their quantity, preferably not the quality. For example, currently in the domain of Transport, Infrastructure and Logistics, paper based PhD theses normally are based on at least four journal papers. This might reduce to three (a number that is common in other research areas in the Netherlands, for example in the area of psychology, as well as in the TIL domain internationally, e.g. at MIT).

Ad 3

In recent years Dutch funding opportunities in the area of Transport and Infrastructure have decreased. There is no new so-called BSIK program, budgets for NWO are decreasing, and remaining NWO budgets are increasingly earmarked to a specific list of topics (‘topsectoren’). Logistics is one of them, but transport and infrastructure are not. Consequently, either the number of PhD students in the areas of Transport and Infrastructure will decrease (a trend that has occurred in the last year) or researchers should try to find other sources of funding. Several researchers have already started to explore options for funding by the EU and other non-national organizations.

2. Changing research focus

In western countries the research focus related to Transport, Infrastructure, and Logistics will change, for several reasons, such as:

- Demographic changes: population growth is diminishing in several countries, and even declining in many regions. Consequently there will be a shift from large scale new urbanization to redesigning current urban areas. And the share of the working population in total population will decrease, reducing the pressure on the peak hours. The share of the elderly in the population will increase, and they will be increasingly mobile.
- Economic changes: economic growth is not distributed equally around the globe. The share of upcoming economies, such as the BRIC countries (Brazil, Russia, India, China), will increase, changing overall patterns in trade flows.

- Growing impact of ICT on society: increasingly people can work at other places than the traditional workplace, via ICT, e.g. at home or while traveling by train. Consequently options to avoid peak hour travel will increase, reducing pressure on networks. In addition, new technologies might reduce barriers to implement advanced forms of road pricing.
- Big and open data: the availability of data will strongly increase, as will the type of data (e.g. automatically generated data as opposed to data collected via questionnaires). This will change research opportunities, both in the area of freight/logistics, as in the area of passenger transport.
- Increasing impact of ICT, e.g. on travel behaviour, Transport Systems (ITS)
- Energy transition, the environment and resource efficiency: concerns related to climate change and the use of non renewable resources (including oil) might lead to an energy transition. But the outcomes are unknown, certainly in the area of transport. It is unclear of electric vehicles will become dominant. Depending on technological breakthroughs options for the future energy provision of the transport system can include electric vehicles, hydrogen, biofuels, or very efficient ICE vehicles, or a combination of these technologies.
- Wellbeing and health, especially linked with all kinds of factors that have an impact on wellbeing. There are growing bodies of literature linking transport to wellbeing on the one hand, and health on the other hand.
- Urban developments, harbours, airports. Changes in the TIL-system are increasingly interwoven with urban and other spatial developments. Within the theme of urbanization a shift from new urban developments to redevelopment of existing urban areas can be expected. Harbours and airports are increasingly seen as more than locations to change mode – several (air)ports become urban areas in themselves, and are increasingly interwoven with surrounding urban environments.
- Maybe increasing attention paid to security.
- In addition to these more topic related there could be a shift to more (policy) objectives related research.

3. Implications for the research agenda and ambitions

These trends probably have major implications for the research agenda relevant for the TRAIL domain. Ideally TRAIL would enjoy directly changing the research agenda. But TRAIL does not own resources to fund research. Consequently TRAIL can only indirectly try to influence research agendas of institutions financing research relevant for the TIL domain. This is addressed below.

4. Implications for TRAIL management

As explained TRAIL does not have its own funding for research – TRAIL members are in the lead for acquiring funding. So TRAIL cannot top-down program research activities. And even TRAIL members increasingly rely on external funding. Therefore the research program mainly reflects the focus of TRAIL research and ambitions, and the way TRAIL plans to register output.

What do these developments mean for TRAIL management?

1. Fora: TRAIL will support our members by organizing meetings discussing options for research funding.

2. Agenda setting: TRAIL will be active in pre-competitive acquisition aiming to stimulated organizations to fund research in the TIL domain. A dominant trend seems to be that dedicated programs in the area of transport and infrastructure are decreasing in importance. Other programs, in which transport can play a role, are expected to become more dominant. Examples of topics include urban developments, energy, critical infrastructures, security and health..

3. Providing information: TRAIL will distribute amongst staff members calls for proposals in other areas that might be relevant for the TIL-domain. To avoid overlap of work and increase efficiency we will discuss with other parties, such as the Transport Institute as well as the Valorisation Centre of DUT who will do what, and how we will keep each other informed.

The recent collaboration with the Dutch Ministry of Infrastructure and the Environment will provide us interesting opportunities to explore upcoming research themes, and for pre-competitive acquisition.

We realize we could do even more to increase research funding options, but this would also cost more time and money. Examples include: develop a course 'how to write a research proposal?', develop a PhD program for external PhDs, and make agreements with major clients (e.g. Rijkswaterstaat). For the time being we limit ourselves to the three activities described above.

The current focus and expected trends of the subprograms below do not explicitly reflect the impact of this dominant trend. Depending on opportunities that become available additional trends are possible, e.g. a stronger focus on health logistics, the link between travel behaviour and health, or the impact of the transport system on urban dynamics and livable cities.

TRAIL will not *as an organization* build consortia for research, because such consortia can never include all TRAIL groups, and selection might lead to problems with groups that are not selected. Individual TRAIL members can of course take such inivitatives.

III. Focus, robust themes and trends per sub-program

The TRAIL research program has three sub-programs:

A Transport and mobility
B Infrastructure
C Logistics and transport organization

Many interactions between these subprograms exist. Consequently a adequate way to illustrate the links between the sub-programs is visualized in Figure 1.

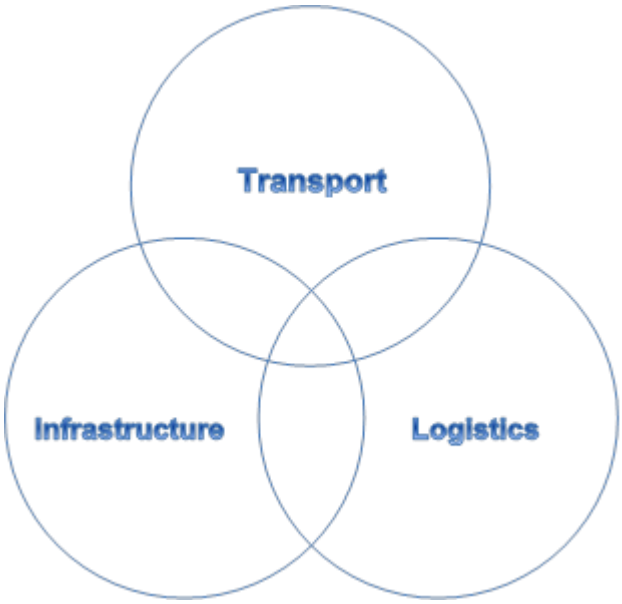

Figure 1: links between sub-programs

Table 1 gives an overview of the scope of each sub-program, robust research topics, and new themes that (probably become relevant in the coming 5 years.

	A Transport and mobility	B Infrastructure	C Logistics and transport organization
General description	Mobility patterns, impacts of transport on society, evaluation methods	Design and utilization of surface road infrastructure and networks for all transport modes	Design, analysis, control, and organization of logistics processes, in particular transport networks
Robust topics	• Changes in mobility patterns • Effects of policies on mobility • Effects of transport on societal relevant impacts • Evaluation methods	• geometric and network design • traffic and public transit operations, traffic safety • human factors • traffic management and information systems • dynamics rail management • crowd management • driver support systems • intelligent transportation systems • cooperative systems	• Logistics and supply chain management • Transportation organization • Terminal operations • Public/private logistic systems
New themes	• The impact of ICT on transport and mobility • Integration of modeling • Integration of behavioral insights into travel demand models • Changing mobility trends • Energy transition • Broadening the scope of ex ante evaluations	• Transition to multi-actor decentralized traffic management • The role of behavior in improving utilization of infrastructure • Multi-scale network simulation for a transportation system in transition • Network-wide optimization and anticipatory control • Cooperative systems and automated driving • State-of-the-art simulation for geometric design and safety assessment research	• Agent based models for city logistics • Optimization of multimodal transport infrastructure networks • Global container flow forecasting • Environmental regulation and fleet renewal • Sustainable supply chains and pricing

As mentioned above, many interactions between the sub-programs exist. For example, goods transport, very relevant for logistics and transport organization, relies heavily on infrastructure networks, and the performance of such networks is heavily influenced by the organization of logistics. Comparable interactions exist between travel behaviour and infrastructure networks. All these interactions between infrastructure networks on the one hand and travel behaviour and logistics organization on the other hand, are highly relevant for policy relevant impacts of the transport system. And evaluation issues play a major role in decision making on infrastructure networks, and decisions in the area of goods transport and logistics.

Therefore there are no strict boundaries between the three sub-programs, and also at the program board level there is much interaction between the themes.

Because of the shift away from research focusing on either Transport, or Infrastructure of Logistics, to themes that need the combination of expertise in these three areas (see section 2 – examples include ICT, energy health, urbanism) we expect a further merge of the three sub-programs in the coming decade.

Appendix A: Research program A (Transport and mobility)
Prof Dr. Caspar Chorus (TUD) (Prof Bert van Wee (interim)), Prof Harry Timmermans (TUE), Dr. Karel Martens (RU)

A general description of the theme

The effectiveness, efficiency and fairness of transport systems and policies – including but not limited to infrastructure investments, land-use changes and travel demand management – crucially depends on an accurate assessment of the expected impact of developments in the transport system and related policies on aggregate mobility patterns and associated metrics such as vehicle miles traveled, CO_2 emissions, etc. These aggregate mobility patterns themselves can only be properly understood as a function of impacts on i) mobility behavior of individual travelers, and ii) demand-supply interactions on transport networks. TRAIL research in theme A aims at gaining an increased understanding of these two phenomena.

Building on these gained insights, theme A furthermore analyzes and designs methods and institutional arrangements to (ex ante as well as ex post) evaluate developments in the transport system and transport policies in terms of their effectiveness, efficiency and fairness. Special attention is paid to studying cost-benefit analysis as a decision-making tool, but also other tools are taken into account, such as multi-criteria analysis and decision-making based on ethical considerations.

Research in this theme focuses on research challenges of a substantive (theoretical and empirical) as well as a methodological (e.g., model building) nature. The theme is intrinsically interdisciplinary, as it integrates methods and findings from fields as diverse as psychology, econom(etr)ics, management sciences, public policy and applied philosophy (ethics).

Recent trends / topics relevant for the next TRAIL research program

In addition we expect next research topics to become increasingly relevant for TRAIL:

The impact of ICT on transport and mobility. ICT will increasingly have an impact on activity patterns and travel behavior, as well as on (perceived) accessibility, both physical and electronic, and both will become increasingly mutually dependent.

Integration of modeling. Modeling travel behavior will increasingly be interwoven with modeling activities. In addition transport networks and their impacts on activity patterns and travel behavior will be modeled comprehensively (‘super networks’).

Integration of behavioral insights into travel demand models. Increasingly, and backed by ever more empirical evidence, researchers from the fields of psychology and (behavioral) economics question the validity of the behavioral assumptions underlying traditional travel demand models. A major research challenge is increase the behavioral realism of travel demand models, without compromising their theoretical and operational tractability and elegance

Changing mobility trends. Models assume that behavior of homogeneous groups of people in constant context, is constant. However, recent research shows that this might not be valid anymore. In particular young adults seem to be less car oriented. We expect an increase in research in the area of mobility trends.

Energy transition: we expect an increase in research into options for the energy provision of the transport system (electric vehicles, hydrogen, biofuels, very efficient ICE vehicles) and their pros and cons, and related transition paths.

Broadening the scope of ex ante evaluations: we expect ethically relevant issues such as distribution effects, social exclusion, and intergenerational justice, to become increasingly important. These might impact Cost-Benefit Analysis (CBA) , and might increase the impact of Multi Criteria Analysis (MCA) or hybrid methodologies (CBA and MCA).

Appendix B: II. Research program B (Infrastructure)
Prof. Serge Hoogendoorn (TUD), Prof. Eric van Berkum (UT), Prof. Karel Brookhuis (RUG)

A general description of the theme

This theme deals with the design and utilization of surface road infrastructure and networks for all transport modes (e.g. car, train, public transport, pedestrians), with the overall objective to ensure efficient, reliable, clean and safe network traffic operations, for both recurrent and non-recurrent conditions (events, incidents, etc.).
The theme includes, but is not restricted to, topics such as geometric and network design, traffic and public transit operations, traffic safety, human factors, traffic management and information systems, dynamics rail management, crowd management, as well as driver support systems, intelligent transportation systems, and cooperative systems. Specific attention is paid to the issues safety and security, vulnerability, network resilience, and reliability.
The scientific methods involved include empirical and experimental research, theory building, mathematical modeling, simulation, optimization and operation research, and computer aided design methods, borrowing from scientific fields like mathematics, physics, control engineering, psychology, and civil engineering..

Recent trends / topics relevant for the next TRAIL research program

In addition we expect next research topics to become increasingly relevant for TRAIL:

Transition to multi-actor decentralized traffic management. Road traffic management is in a transition phase, where we are moving from a predominantly centralized roadside measure based system, towards a more decentralized approach in which roadside traffic management and control systems (such as ramp-meters, traffic lights, etc.) co-exist with in-car (information and guidance) systems and technology (e.g. navigation systems, traffic information applications on smartphones). Currently, these systems are not deployed in a coherent way, despite the potential for large synergetic opportunities for data fusion, and system actuation. Research in this topic needs to focus on developing approaches to integrate these approaches, and to design a robust system that optimally deploys both type of methods and technologies, looking at aspects such as throughput, livability, reliability and robustness, as well as costs.

Role of behavior in improving utilization of infrastructure. Behavior and improving the system's performance by means of influencing behavior is gaining a lot of attention, under the premises that behavioral changes and adaptation (at different levels) would improve the infrastructure utilization. A strong and coherent scientific basis for these assumptions is however lacking, and needs substantial attention in years to come.

Network-wide optimization and anticipatory control. A continuing subject of interest in the network-wide and coordinated optimization of traffic control and management. In particular with the increased role of traffic information and other in-car services, the user-response to traffic control and management interventions will become more direct. This may have benefits, but it may also have unforeseen negative impacts, stressing the need to anticipate on these behavioral changes.

Cooperative systems and automated driving. The introduction of cooperative systems and automated driving systems is expected to lead to major improvements in traffic flow efficiency, comfort, safety, and reliability of travel. Focus so far has been mainly on the technical side of the system design, and had not extensively looked at the impacts and design of such systems from a traffic engineering and management point of view. In line with recent research outcomes, it is expected that the traffic flow characteristics (at the arterial and network level) will fundamentally change, which may have unexpected impacts in terms of the aforementioned impacts. Dealing with these in the system design, control approaches, and impact assessment is deemed essential.

State-of-the-art simulation for geometric design and safety assessment research. Predicting safety impacts of new measures, future technology, etc., in a painstaking task. Existing scientific approaches based on relating surrogate safety measures to outcomes of traffic simulation models fall short because of numerous reasons, one of which being the fact that microscopic simulation models are not

design to correctly reproduce the behavior of individual vehicles. Microscopic models focusing more on explaining behavior of the individual driver are becoming available, due to the increased availability of detailed datasets. This not only broadens up the application area of these models (e.g. geometric design), but it is also expected that this will improve the predictive validity of these models.

Network design. The costs of area wide infrastructure maintenance are expected to grow substantially the coming years. Given regional demographic developments, the current economic situation, but also developments in the technology of cars, a reorientation of the existing transport network may become necessary. This may involve a multi objective approach to the (re)design of the current multimodal transport network, where cost, level of service and externalities are included.

Uncertainty and reliability of traffic and transport networks. Over the past years, the issue of uncertainty has been addressed by many academics. However, characterization of its main sources, in particular relevant for this research theme, has only been addressed in a limited way. Furthermore, inclusion of uncertainty in modeling (both for operational and more strategic goals) has not matured sufficiently, also because the traveler response to uncertainty is still not fully clear (strong connection with TRAIL research theme A). As a consequence, the overall impact of uncertainty in operations and behavior needs to be addressed further, and needs rigorous analyses. Note that this topic also touches upon the issue of network reliability and resilience, i.e. how the network can cope with disturbances of different magnitude.

Safety and security for transportation networks. The issue of safety and security in transport networks is receiving more and more attention. On the one hand, this is because of the fact that transportation systems are often seen as easy soft targets causing major disruption and societal upset. One the other hand, this is caused by the fact that the transport system itself plays a key role during the different phases of a calamity (during an evacuation, in the rescue phase, during the recoil phase, etc.), while at the same time being under severe pressure.

Multi-scale network simulation for a transportation system in transition. Traffic and transportation modeling is in a transitional phase. Not only because of increased impacts of ICT on traffic and travel, gradual introduction of driver support systems, automated driving, cooperative systems, in-car information systems, social media, etc., but also because of the changing needs for coherency of traffic and transportation models.

Appendix C: Research Theme C:Logistics and Transport Organization
Prof. René de Koster (EUR), Prof. Gabriel Lodewijks (TUD), Prof. Lori Tavasszy (TUD))

A general description of the theme

This theme deals with design, analysis, control, and organization of logistics processes, in particular transport networks. Logistics focuses on meeting customer requirements, while organizing the processes efficiently and effectively. Logistics and transport organization are important to the Netherlands. Due to its natural geographical location, the Netherlands and in particular Rotterdam serve as a gateway to a large market in Western-Europe. Rotterdam hosts the biggest sea port in Europe. A large part of American and Asian multinational companies' distribution centres in Western-Europe are located in the Netherlands[3]. The trend of outsourcing and off-shoring production to the Far East has strengthened the position of the Netherlands, and Rotterdam in particular as the logistics gateway to Europe. The logistics sector employs over 750,000 people and is adding about €40B to the Dutch gross domestic product. In realizing this turnover, logistics' knowledge is increasingly important and our research aims to provide it.

In our research, we focus on four subthemes. In all subthemes, multiple scientific methods are used, in particular, empirical and experimental research, mathematical modeling, simulation, optimization and operation research, and computer aided design methods.

1. Logistics and Supply Chain Management

The research in this theme aims at decision making at various levels in the supply chain (including multiple chain actors with multiple objectives), with the objective of improving company and supply chain performance. Decisions at strategic, or design, level include logistics network design and optimization, new demands for safety and security (e.g. for food and hazardous goods), return flows, and interweaving service demands with processes. At operational level, decisions have to be taken in balancing inventories, capacities, and time or information to meet customer service objectives. In all these processes, the role of ICT is important; ICT applications not only may enhance the efficiency of chains, they also enable the provision of additional services and aid in providing process flexibility. Particular attention is also given to human aspects. Despite all systems, people make decisions, at various levels, and they are key in achieving performance. The subtheme also studies people and systems in interaction and how performance can be enhanced.

2. Transportation organization

The goal of this subtheme is to improve and optimize the performance of passenger and cargo transportation systems, by focusing on infrastructures and transport modes. Some particular research challenges that are addressed in this theme include:

- Optimization in the design of logistics and passenger transport scheduled services;
- Optimization approaches and methods of coordination and cooperation (for example: centralized, decentralized, or self-organized);
- Optimization of the operational aspects of the services, e.g. to increase reliability and/or to boost efficiency.

Applications can be adopted in air transport, road transport, rail (passenger and freight) transport, waterways, intermodal transport services, and hub-and-spoke services.

3. Terminal optimization

This research focuses on optimization of warehouses, port terminals (e.g. container and dry bulk), airport passenger terminals, railway stations, intermodal (road/rail), and intramodal transhipment terminals, with related material handling and ICT systems.
Specific research topics include:

- Design and operation of terminals and their processes to ensure efficient flows of goods and passengers;
- Designing efficient handling systems as well as intra-terminal transport facilities;
- Innovations in continuous transport infrastructure, like conveyor belts;
- Automated driving and automated transport systems;

4. Public/private logistic systems

This theme deals with research on freight transport systems where public policies influence their design, deployment or operation. Examples of such systems include urban freight transport, customs and safety/security authorities, dedicated freight infrastructures, public freight operators and disaster management. Public involvement can come in different guises, e.g. asset ownership, market

regulation, pricing or operation. The objective of the research is to understand how public policies affect logistics processes, to predict aggregate societal impacts of logistics processes and to improve the designs of public/private logistics systems. There is a strong emphasis on quantitative modeling.
Specific research topics include:

- Agent based models for city logistics
- Optimization of multimodal transport infrastructure networks
- Global container flow forecasting
- Environmental regulation and fleet renewal
- Sustainable supply chains and pricing

Recent trends / topics relevant for the next TRAIL research program
Within the subthemes several new trends emerge, which are of particular importance for the next TRAIL research program.
Role of behavior in improving logistics performance. Behavioral operations are important for several reasons. It has become clear that, in order to achieve logistic performance, not only systems and controls are important, but particularly how people interact with these systems and controls. People's behavior is not always rational and understanding how decisions are taken, depending on which drivers is a topic that requires research attention. In addition, it may be possible to exploit differences between people to obtain better system performance. In order to explore this area further, substantial attention in the years to come is needed.

Developing modular, distributed controls for large-scale material handling systems. New material handling systems, such as the Kiva system, or AVS/R systems, use large numbers of vehicles. It is difficult to control these in a robust manner. Distributed, autonomous control may bring advantages. At the same time achieving and guaranteeing performance is difficult. This area will require substantial attention in the coming years.

Compact storage systems. Space is getting short for many types of facilities: container terminals, warehouses, and cross-docks. Examples of compact systems are new container terminal concepts where containers are stacked higher than five levels, parking garages where cranes and shuttles store the cars, or compact shuttle-based warehouse systems. Using space more efficient while maintaining performance is an important topic for the coming years.

Sustainable supply chains. Next to delivering the right service to customers and focusing on efficiency and response, supply chains have to become more sustainable. An increase in sustainability can be achieved in different ways, looking at the life-cycle impact of logistics processes and systems:

- By increasing the sustainability of the way equipment used is being produced and scrapped
- By reducing the energy consumption and emissions of the equipment used in logistic systems
- By optimizing the control of existing logistic systems in such a way that for example unnecessary transport movements are prevented
- By developing new logistic processes with the focus on sustainability

Sustainability has become an important area where companies can distinguish themselves. Investigating trade-offs between logistics performance and sustainability is an important new topic.
Personalized logistic services. The general public expects logistic service providers to deliver more and more personalized services. For example, instead of having to pick up luggage on a carousel at airports there is a development towards a personalized pick-up service where you can pick up your suitcase in a locker which is secure. Instead of having to wait at home for half a day to accept the delivery of a parcel, people expect sms-based services where you can either provide alternative delivery locations on the spot or a much narrower time slot with allows the receiver to minimize waiting time. The organization of the logistic processes that allow for an increased personalized service level are an intriguing research area for the coming years.