Explaining Future Urban Mobility Mechanisms Using System's Thinking – A Case Study of Munich and Singapore

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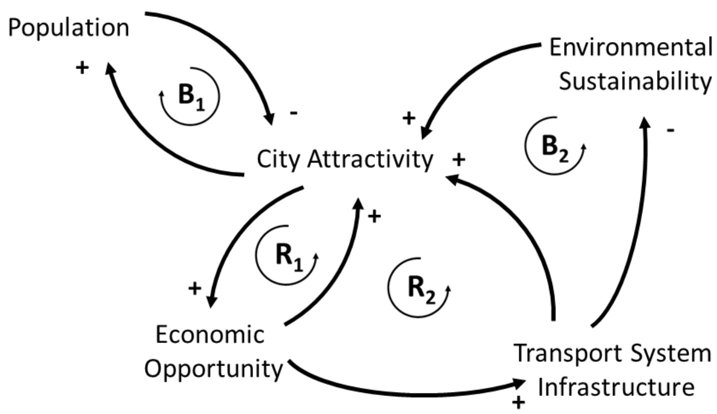
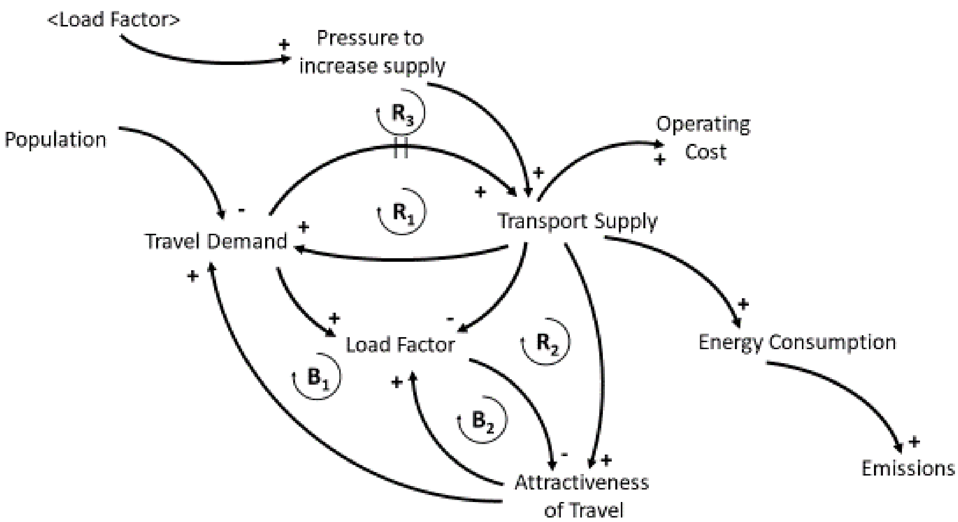
Extended Abstract: Shared mobility is growing among urban commuters around the world with increasing digitization of transportation systems. The further development to shared mobility including public transport is shaped by multiple factors such as city size, population, affordability, mode choices etc. This study attempts to explain the mechanism of an urban transportation system by modeling a high-level system's view as shown in figure below. System's Thinking or System Dynamics (SD) approach is taken showing basic factors that interact with each other with respect to attractiveness of a city, its transportation infrastructure, economy, and environment.



It shows a cause-and-effect diagram or Causal Loop Diagram (CLD) explaining relationships and interactions of the attractivity of a city using positive and negative polarities. The transportation system plays an important role in a city's economic prosperity and environmental sustainability. This inter-relationship seems fit for most of the cities around the world, if not all. Furthermore, it is dynamic and characterized by several other actors such as stakeholders (policymakers, operators, and users) and socio-economic and environmental desires.

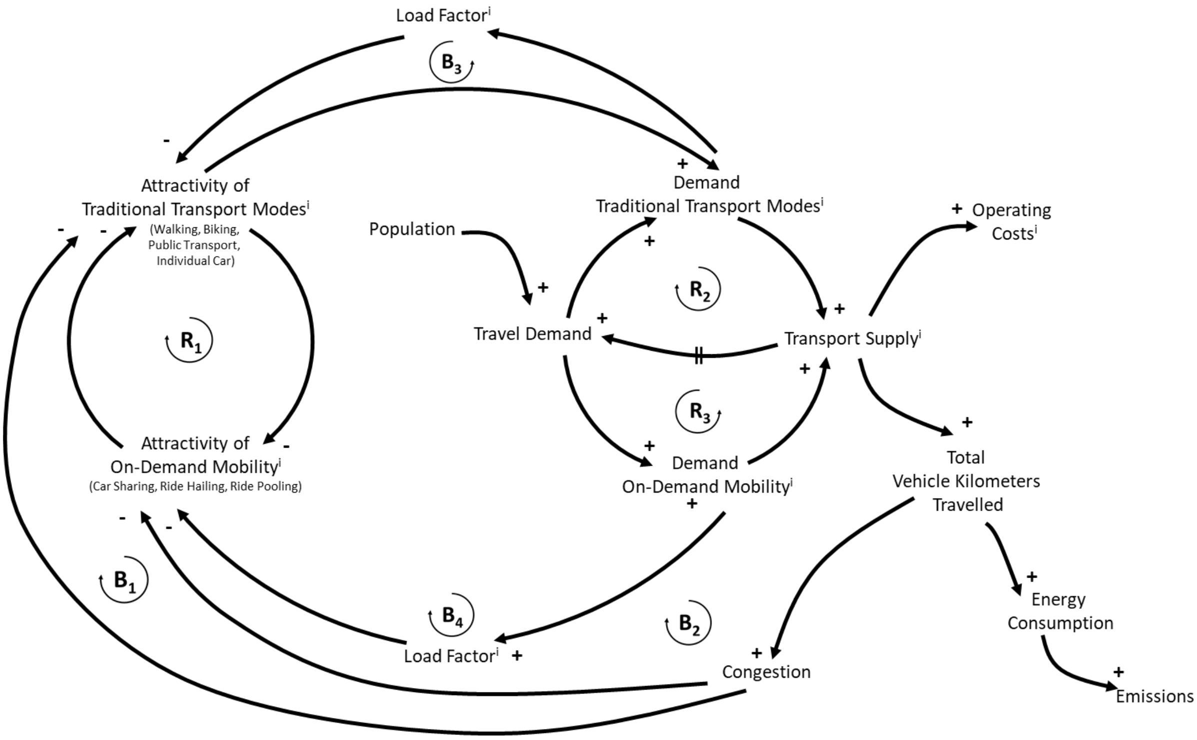


The model is further expanded for the cities of Munich and Singapore with futuristic scenarios in different use-cases of shared mobility: On-Demand Mobility (ODM) in Munich and Dynamic Autonomous Road Transit (DART) in Singapore. SD approach is taken using components or basic variables that constitutes an urban mobility system. For example: population, travel demand, mode choices, vehicle population, etc. are the variables that define characteristics of urban mobility. Similarly, energy consumption and emissions are the variables that indicates performance of the system with respect to sustainability goals set by the local authorities.

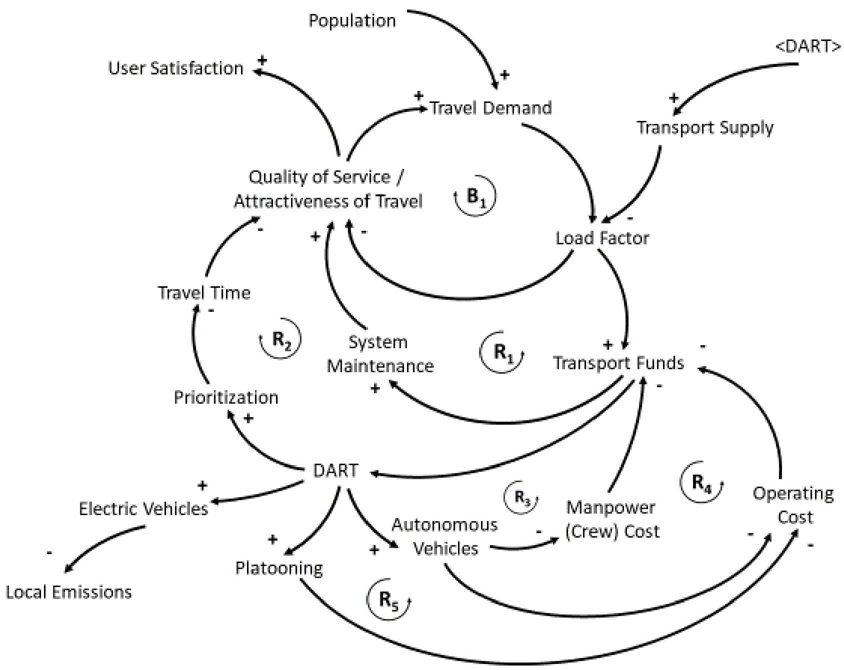
ODM in Munich: The case study of Munich is concentrating on the interaction between new mobility services and traditional transport modes. It analyses qualitative levels, the cause and effect on the modal split of transport modes and provides information about the development of indicators such as congestion, emission, and transport costs. In this study, ODM is classified as follows:

On-Demand Mobility Service	Ride Hailing	Ride Pooling	Car Pooling	Car Sharing	Car Renting
Service Type	Be driven	Be driven	Be driven	Drive yourself	Drive yourself
Level of Individuality	High	Low	Middle	High	High
Price	Middle – High	Low	Low	Low	Low – Middle
Service Examples	FreeNow (mytaxi) Uber	IsarTiger MOIA Clevershuttle	BlaBlaCar Ridebee	ShareNow (DriveNow, Car2go) Flinkster	Sixt, Europcar, Hertz

The model also considers potential side effects like congestion, energy consumption, emissions, and the total cost of transport for the operator. However, all those variables are derivatives of the transport supply in the study area. While congestion is having a direct impact on the attractivity of using individual motorized transport; ODM services or different forms of public transport like the bus, emissions and the total cost of transport do not result in a feedback to the model.



DART System in Singapore: The DART system is expected to have a capacity lower than the Mass Rapid Transit but higher than the bus system. The two main features of the operation are the module platooning and prioritization using the virtual right of way. The platooning allows combining positive aspects from the bus system and the MRT system with the help of which, it is possible to create high demand corridors (higher than bus). Further, prioritization methods can be implemented, and the street infrastructure can be redesigned for a faster public transport ride. The CLD below highlights the main features of DART and its potential impacts on the overall system.



This paper uses a holistic system approach to identify mobility mechanisms in urban areas. Based on a simple high-level CLD (see Figure 2), the basics between Population, Travel Demand, Transport Supply, Load Factor and Attractiveness of Travel are been explained and impacts on major transport externalities like Cost, Energy Consumption and Emissions had been discussed. A key finding which can be derived from the High-Level CLD is the balancing loop between the Load Factor and the Attractiveness of Travel. The Load Factor, which stands for the occupancy and the capacity of the system, is the main limiting variable that keeps the system in balance.

The two case-studies: Munich and Singapore, had been selected to explore two futuristic mobility scenarios like an increased use of on-demand mobility services in Munich, or the implementation of DART in Singapore. Although both corresponding CLDs mainly focus on the specific futuristic scenario, the basic mechanisms analysed in the high level CLD can be found again in both models. Whereas the Munich CLD has a strong focus on the attractivity of a transport mode and the resulting demand, the Singapore model rather focuses on the side effects of the implementation of a DART concept.

Even if the CLDs represents a highly complex transportation system, it can be used as a simplified illustration that shows relevant cause and effect relations. Of course, this simplistic view is limited to a small number of variables and has consequently clear system boundaries and limitations.