Rethinking mobility and transport

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The challenge of mobility and transport

Mobility of people and transport of goods is becoming increasingly more challenging in our modern world. Not only are we a lot more mobile than e.g. 100 years ago, the ease of communication has actually increased the need for mobility and transport. Combined with economic growth whereby Just-In-Time logistics are a must to remain competitive, a growing population and urbanisation are placing our mobility and transport systems under stress. At the same time, we need to reduce the energy consumption, partly to keep this evolution affordable, partly to reduce the stress on the environment in order to ensure its sustainability.

The lack of interconnectivity

So what can we do? Until now most solutions have been thought out in terms of improving our traditional means of transportation. Faster and more efficient airplanes, ships and trains have been developed and are continuously being researched. The same applies to road vehicles, often by going electric and using lightweight construction materials and methods. These are crucial and enabling factors. But has it really delivered?

An important element that is often overlooked is that current transport means do not provide for seamless interconnectivity. This is not only a technical issue but also an organisational one. It is, however, a factor that seriously affects the user and largely explains why public transport remains less popular than using private transport means such as cars. Even with traffic jams, using a car most often provides less travel time in much more comfortable circumstances.

The lack of scalability

When looking at the increasingly long traffic jams and people being killed or hurt on the road, it is clear that maintaining and increasing the quality of service of our transport systems will not be solved by only improving on the transport means as they are today. The current system has reached it limits in terms of scalability.

When looking at current road transport systems, we can see that they have reached a choking point. Stress it a bit further and the system can collapse, the Quality of Service offered already continuing to decrease, even if the vehicles individually taken become more comfortable, energy efficient and safer. Using normative criteria like ARRL (Assured reliability and Assurance Level) most ground based transport means are not fault-tolerant, they reach an ARRL-3, transitioning to a so-called fail-safe state, but often bringing the transport system in which they participate to halt, affecting sometimes 100000's of users in traffic jams and delays.

What we need is not only a fault tolerant transport system, but one that exhibits the property of anti-fragility, a term recently quoted by Prof. Taleb to describe a system that improves after failures have occurred. In ARRL terms, we need to reach ARRL-7.

The need for a holistic approach

A holistic approach is needed that regards transport and mobility as a system. Automation is a must to reduce the stress on its users but also to increase Efficiency, Safety and Quality of Service. Whoever says automation must also think system. A system that is complex and dynamic and includes its users as well as its operating environment. How can we characterise such a system?

1. Top level requirements:

- Maximise the throughput of people and cargo.
- Minimise the safety risks.
- Minimise the point-to-point travel time.
- Minimise the life cycle energy and material use.

2. Consequences:

- Automation requires standardisation.
- Automation requires scalability.
- Automation requires trustworthy modularity.
- Automation requires digitalisation.
- Automation requires connectivity.

From transport and mobility means to transport and mobility modes

Compared with our current transport and mobility systems, this requires a few important changes:

1. Transport (of cargo) and mobility (of people) must each become integrated for its users but separated as they cover different needs.
2. This cannot be achieved by only optimising specific and existing transport means.
3. We need standardised transport and mobility means that change "modes"
4. The vehicle becomes a component, hence it must be 100% trustworthy.
5. The transport infrastructure is an essential element in the system.

We propose a bottom-up approach, following the principles below:

1. Transport and mobility are separated in distinctive categories based on purpose (cargo vs. people) and usage pattern to facilitate constant speed and simpler automation in each category. For example bulk transport is separated largely from people transport.
2. In each category modular transport units are defined that can change mode by assembling together, which also allows more efficiency and QoS.
3. This will simplify the transport system as traffic is more homogenous which facilitates automation and will improve global energy efficiency. The latter is achieved when vehicles move at a constant speed.

Such an approach, even when automated, is not possible when staying with current transport means because this would not create scalable mobility units. The question is if the current transport means (such as cars and trucks) can be adapted without a major redesign to act as a trustworthy component. If so, we can as well rethink the whole approach. Which is challenging, as we also need to take into account a gradual transition.

Bottom-up scalability

Hence, we propose a different approach whereby a person's individual short range mobility is tackled first. This has several advantages.

The smallest mobility component is a one-person vehicle. It doesn't need to be a bicycle. On the contrary, it should be better. It should be safer, faster and allow a longer range for the average user. Consider it as a personal mobility pod.
It should take less space as traffic density is one of our issues. But it operates in "bicycle mode". Connect 2 together, or 4 and one gets a small car.
Connect even more together and one gets a small bus and when connecting busses, maybe we can scale it up to a train. When we scale it up, the resilience increases and actually the safety margins will increase as well. The speed can increase and the range can increase. But we also keep the flexibility of being able to leave and join such a group in bus or train mode, just like we can with normal cars.
For transport of cargo, a similar approach is aimed for. To some extent the transport industry has already taken steps in that direction by introducing standardised containers for transporting goods.

Challenges: the greater scheme

The idea might be simple, but it poses quite a number of engineering challenges. In addition, the approach should not just extrapolate the situation today but provide advances on several levels. The same applies for the mobility domain (people moving) and the transport domain (cargo moving). It should be noted that there are systems where similar principles are (partially) applied with great success. The aviation industry has adopted a coordinated approach with stringent certification requirements and a standardised infrastructure, yet is one of the safest, most fuel-efficient and cost-efficient means of transport in the world.

1. Life cycle energy efficiency for the unit and the system;
    a. Energy efficiency in operation
    b. Full lifecycle efficiency
    c. Light weight construction
    d. Toxicity levels and impact
2. Safety for the unit and the system:
    a. Trustworthiness and QoS
    b. Fault tolerance (ARRL-4 or 5)
        i. At unit level
        ii. At system level
    c. Resilience:
        i. Active adaptive behavior (ARRL-6)
        ii. Active feedback process (ARRL-7)

3. Standardisatian
    a. Inter vehicle interconnecting and communication
    b. Vehicle to road and infrastructure communication
    c. Traffic related information in real-time: map changes, roadworks, accidents, …
4. Usability and ergonomics
    a. Comfort and convenience
5. Infrastructure and urban planning
    a. Leveraging of existing infrastructures to ease transition and protect existing investments
    b. Develop new concepts for new investments.
6. Business models
    a. Ownership
    b. Shared ownership
    c. Pay per use models
7. Low cost produce-ability

Transport as a Service

What we really need is to fulfill societal needs and challenges. Mobility and transport should not be a car, truck or bus but a service. Regulate, but do not impose choices as technology will sooner or later come up with better solutions

Consortium needs

The following table list the domains of competence needed for executing the project.

Table 1

Domain	Clarification	Name of the candidate partner (fill in)
Principles	Orthogonality in competence and expertise	*
Holistic	By looking at problems in a holistic way	*
Academic	Formal approaches for trustworthiness	*
Engineering	Multidisciplinary teams, mechanical, chemical, electrical, electronics, software as well as systems engineering and project management	*
Safety engineering and certification	The safety engineering challenge is much higher than currently covered with automotive related standards like IEC-26262.	*
Production	Innovative production techniques and technologies to ensure cost effectiveness	*
Infrastructure	Formulating of relevant	*

	standards to ensure early standardisation of infrastructure requirements and capabilities	
Business models	Defining business models for all aspects of system lifecycle, production, re-selling, maintenance and repair, infrastructure service providers as well as ownership models etc.	*
Legal aspects	Allowing manufacturers to remain competitive by providing room for innovation and ensure protection of intellectual property	*
Human aspects	Acceptance barriers, usability aspects	*
Communication	How to spread the message best?	*
Public authorities	How to come to a partnership?	*
Economic aspects	Impact on the economy, growth	*
Sustainability	Impact on energy and resources consumption	*
Other		

*: select up to three domains and rank them 1 to 3 (1 is highest). Add comments if needed.

The project proposal is very wide. It would make sense to generate at least two or three proposals focused on a particular domain:

- Light and green vehicles
- Safe and sustainable transport (autonomous driving)
- ICT (Embedded Systems).

ARRL references:

1. http://www.altreonic.com/sites/default/files/Altreonic_ARRL_DRAFT_WIP011113.pdf
2. http://www.altreonic.com/sites/default/files/ANTIFRAGILE_02_EricVerhulst.pdf

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