Research Article

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Reimagining the future of transport and forever open road program

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Highlights

- Intermodal transportation
- Forever Open Infrastructure Across all Transport Modes Program
- Forever Open Road Program

Abstract

Transportation has a very wide effects either economic or social on human life. Millions of people are also working directly or indirectly for this industry. So, it is a mandatory for governments to evaluate their aspects on transportation construction, management, control and maintenance by increasing mobility. Also new technological developments and researches caused some changes in the expectations at many fields by new design and management approaches. The European Commission have supported some researches within Horizon 2020 program for new innovations to develop a highly efficient and effective cross modal transportation. In this paper recent developments at FOX (Forever Open Infrastructure Across all Transport Modes) program seeks to develop general methods for all transport modes and FOR (Forever Open Roads) program have reviewed. There are also benefits of FOR program that developed by Forum of European National Highway Research Laboratories (FEHRL) have mentioned and the outcome elements as automated, autonomous and resilient roads of the program have described.

Information

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1. Introduction

Sustainable transportation is mandatory for any economy to constitute a proper and reliable supply chain. The correct operation of markets, especially the European Market, is impossible without effective transportation networks. Investments in transportation infrastructure foster wealth creation, economic growth, and improvements to trade, accessibility, and human mobility [1]. A vital prerequisite for the connection of people and commodities in Europe as well as the foundation for economic growth, competitiveness, and territorial cohesion is an effective and high-quality transportation infrastructure [2].

The FOR program was started by FEHRL in 2010 with the purpose of reimagining a new vision for designing, constructing, operating, and maintaining the roads in the future. When addressing global concerns, other modes of transportation, particularly rail, suffer many of the same difficulties. At TRA2018(Transport Research Arena), FEHRL unveiled the Intermodal FORx4 (Forever Open Roads, Rails, Runways, and Rivers) initiative to address these problems. In 2013, the organization also produced a "Point of View" document outlining areas to consider and introduce a technological concept for transportation infrastructure, governance, and most importantly shared customers in different transportation modes as shown in Figure 1 [3].

In 2014, FEHRL presented two Next Generation Transport Infrastructure concepts to H2020. The fundamental concepts in these recommendations call for resource-efficient, wiser, and safer solutions to some of the major FORx4 construction, user, and governance-related issues [4]. As a result of these studies, a thorough research roadmap was created, highlighting the important study areas on which cross-modal transportation should concentrate [5].

The FORx4 program's precursor, FOR, which is where the MG-8.1 and MG-8.2 initiatives have linkages to existing multimodality projects that have already been created inside FOR. To achieve the goals outlined by the National

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Road Administrations and the European Union, FOR was created [6].

The mission of FOX is to create an environment and culture for cross-modal research and development that is highly effective and efficient and that satisfies the stringent requirements for the connectivity and transportation of people and goods. The FOX project creates a network of scholars and practitioners from many modes and establishes the goals for advancing cross-modal research development innovation as well as for demonstrating and putting the findings into practice [7,8]. The FOX project's other objective is to find common problems and creative solutions for building, inspecting, maintaining, repairing, and recycling transportation infrastructure as in Figure 2 [9].

In Fox researches, six research areas have shown the highest potential. These areas were;

- Life cycle modelling
- Network assessment through asset management including Building Information Modelling (BIM)
- Techniques and materials for fast maintenance measures
- Durable and energy-efficient materials
- Analysis and optimization of the process chain
- Maintenance by design & Life Cycle Costs [8]

In 2017, new research prospects, such as the integrated information system, have taken on increased significance in addition to using ground penetrating radar and ultrasonic data. This technology gives operators access to current data resources to ensure good decision-making. Additionally, multipurpose inspection tools are more effective in gathering information from roadways under ongoing traffic flow situations. The use of robots for inspection and maintenance work, which is considerably safer for the workers who may encounter hazardous situations on the job and utilizing intelligent materials, such as self-powered wireless sensors. fleet probing and remote sensing, heavily rely on the acquisition and analysis of sensor data are some of these new developments [10].

Figure 1. FORX4 intermodal transportation [3]

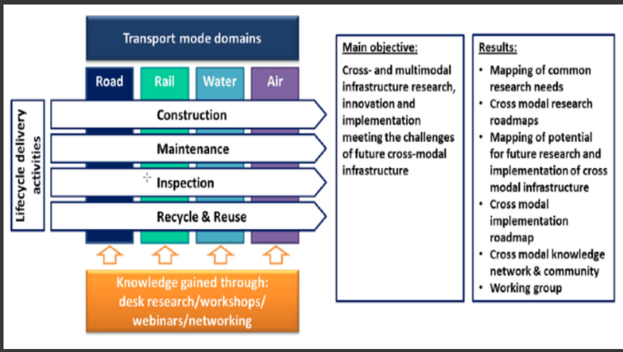

Figure 2. FOX Approach [7]

According to USE-iT (Users, Safety, Security and Energy in Transport Infrastructure) report over 70 potential technologies have examined, such as Vision Zero approach, Intermodal Emergency response service, Automatic Train Supervision, Integrated Vessel Traffic Control System, vehicle to vehicle and road side sensors to improve road safety [11].

In response to the FOR, a number of FEHRL institutes have been established, while additional institutions have some similar research interests [12]. These are;

- IFSTTAR's (French Institute of Science and Technology for Transport) R5G project that aims to propose innovative road solutions in the fields of vehicle-infrastructure energy, new pavement technology and climate resilient infrastructure [12-14].
- Roads in the 21st Century - R21C in Germany [15,16]
- Ferry Free E39 in Norway
- Exploratory Advanced Research (AER) in USA Rijkswaterstaat Corporate Innovation Programme in Netherlands [16].

2. The Need For The FOR

The movement of people and products through an efficient and effective transportation infrastructure increases economic efficiency, but its influence is more significant. It has a significant effect on communities and the environment. Additionally, there are scientific fields have connections to transportation applications, either directly or indirectly [17].

However, society pays a price for the construction, maintenance, and use of the road systems, as well as the traffic that uses them, including both financial and environmental costs. Additionally, the cost of congestion, which runs into the tens of billions of euros, is a key problem in the majority of national and European economic and transportation policy. In light of this, it is evident that efforts to simultaneously address societal challenges related to decarbonization, journey time reliability, energy reduction, and safety will necessitate new approaches to developing, operating, and maintaining our road infrastructure within the larger European transportation system [18, 19].

According to this view, in line with the EU's "Forever Open Road" program, a strategy has developed to create a successful national innovation system for considering climate change by integrating highways into a flexible, progressive and autonomous system of mobility [20].

The creation of a next-generation road—one that is ICT (Information and Communications Technology)-integrated, ecologically friendly, adaptive to changing user and societal requirements, and comes at a lower cost and risk—would have significant long-term benefits for the European economy, environment, and society. Efforts to increase the energy-efficiency of road transport through cooperative vehicle-to-highway systems, dynamic traffic management, and the integration of energy harvesting and generation within the infrastructure will deliver the economic benefits of lessened congestion and the associated improvement in travel time reliability [19].

3. The FOR Project

By offering the greatest levels of globally available, maintainable, safe, secure, healthy, and livable transportation at the lowest possible cost, the FOR program intends to reassess the design, building, operation, and maintenance of the future roadways [6,21].

FOR will help to meet societies goals such as:

- Safe and secure
- Sustainable, cleaner, quieter and more energy efficient
- Supported by innovative and competitive industry and private sector
- Provide reliable mobility based on user needs and expectations
- Based on the need to take into account the shrinking public-sector budgets [22].

The FOR program, which was started by FEHRL, aims to create the next generation of economical, high-tech roads that can be used for both maintaining the current network and creating new ones. Because of this, road operators will be able to embrace cutting-edge technology while overcoming growing capacity, sustainability, reliability, and integration restrictions. Additionally, FOR will have a significant impact on how the road transportation industry responds to societal issues [23].

For roadways, the "Forever Open" Concept was initially developed. It aims to make sure that roads can handle upcoming global difficulties including climate change, carbon reduction, energy generation, and the global financial crisis [24]. It will interact with automobiles and enable automated driving [25].

The following three components must be included in the upcoming road system in order to attain this goal:

- Adaptability: emphasizing methods to enable road operators to react quickly to changes in users' needs and limitations,
- Resilience: ensuring that service levels are maintained under difficult operating situations.
- Automation: emphasizing the complete integration of ICT applications between the user, the vehicle, traffic control services, and operation [24].

Through integration with current road infrastructure and adaptation to various locations, including urban and rural ones, the FOR concept seeks to create techniques and systems that will function across Europe's diverse transport network. The idea would be applicable to both the upkeep and renewal of current roads as well as the construction of new roads, and it would be able to meet demands for safety in freight transportation as well as the highest levels of traffic intensities in Europe, as well as goals to reduce the number of fatalities and serious injuries from traffic accidents and to reduce greenhouse gas and noise emissions. The three key components will be developed in this program, together with their viability, benefits, and applicability [18,26].

3.1. The adaptable road

The design, building, and management of the transportation infrastructure must be made more adaptable and flexible to accommodate change. The ability to adjust the infrastructure cost-effectively to accommodate changing needs, such as changes in policy, environmental variables, technology, and use, can be considered by new thinking on flexible and adaptable transport infrastructure and systems [27].

The Adaptable Road has important components that offer a quick and affordable approach of designing and maintaining roads, such as:

- Creating new methods for building roads, such as prefabrication with integrated service delivery, to cut costs;
- Enabling quick and efficient maintenance to diminish on delays;
- using automated traffic management and road maintenance techniques to increase safety;
- Creating adaptable drainage systems to handle storms;
- Using harvested solar energy to control road temperature and lessen the need for winter maintenance;
- Using harvested solar energy to power roadside lighting and signage, and perhaps even the vehicles themselves;
- Low noise and low spray pavements; cost-effective, low energy integrated lighting systems; building and

maintaining with low carbon and low energy materials and procedures (Figure 3) [18].

The main objectives in the Adaptable Road aspect are:

Decarbonization > The Adaptable Road will be made from materials with minimal embodied carbon and/or recycled content, be tough, and thanks to self-healing technology, it will have a longer lifespan and require less upkeep and replacement than current systems.

Reliability > The supply of stronger, longer-lasting structures that may self-repair or be rapidly and readily replaced, when necessary, would increase reliability.

Safety and Security > Through forgiving road design and the implementation of systems and technology from the Automated Road Element concerned with traffic management and control, the Adaptable Road will contribute to safety.

Livability > By using electric vehicles to transport people and goods, air quality will be improved. At the same time, low-noise road surfaces will be created. Additionally, in order to lessen the amount of carbon and pollutants produced by driving, the Adaptable Road would try to use roadside vegetation.

Cost > Cost reductions can be achieved through lowering the requirement for maintenance, optimizing and decreasing material use, standardizing processes to spend less time providing services, and improving reliability [26].

3.2. The automated road

The effects of automation on infrastructure development—roadway and traffic signage, electronic vehicle-to-infrastructure communication, liability in the event of infrastructure failure, and consequences on infrastructure maintenance—are a major source of concern for highway authorities [28].

Key aspects of this road type are as below:

- An extensive communications network that connects the driver, vehicle, road, and operator.
- Integrated sensors and systems to assess and track the performance and condition of the road.
- Making it possible for future vehicles to control their speed and direction on highways.
- Using in-road vehicle guidance to manage traffic and modify lane usage.
- Using solar energy and highway power to run autos.
- Tracking vehicle performance, traffic, and road conditions to increase dependability and efficiency.
- Automated response systems and incident monitoring to cut down on delays.

Ensuring efficient road tolling and pricing to increase efficacy (Figure 4) [18].

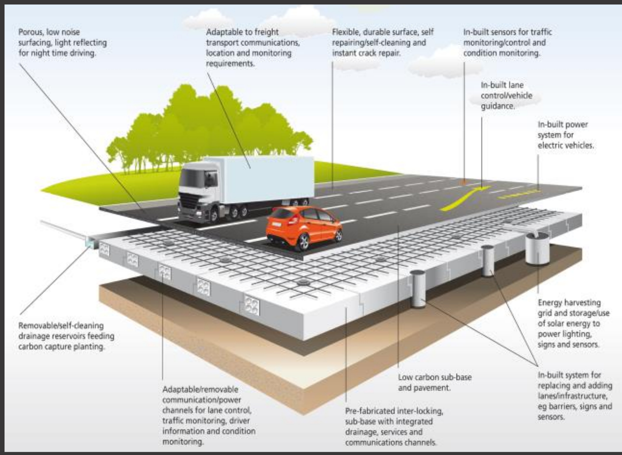

Figure 3. The Adaptable Road [26]

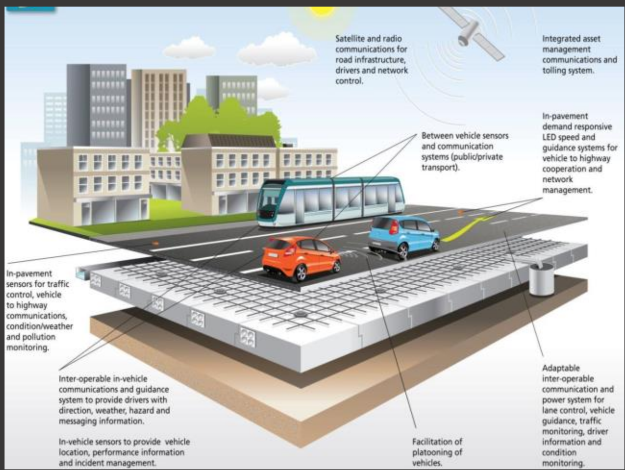

Figure 4. The Automated Road [29]

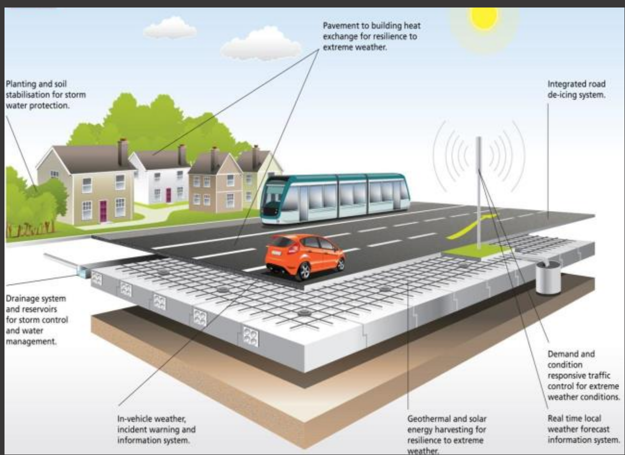

Figure 5. The Resilient Road [29]

The main goals of the Automated Road component include assisting in overcoming difficulties related to decarbonization, reliability, safety & security, livability, and costs.

Decarbonization > The Automated Road is anticipated to promote the effective use of road capacity by improving traffic efficiency through effective network management.

Reliability > Road network reliability will increase thanks to advanced infrastructure communication systems and intelligent traffic management techniques.

Safety and Security > To insert "intelligence into traffic," Intelligent Traffic Management Strategies and Advanced Infrastructure Communication will be created.

Cost > Implementing an open architecture for systems, open standard interfaces, lower energy consumption from decreased consumption, maintenance, and operations, as well as enhanced user journey times, network management optimization, and incident management from decreased congestion, incidents, and accidents, are all ways to reduce costs [27].

3.3. The resilient road

Keeping the road network open in severe weather conditions is the goal of the resilient road innovation. The adaptation of road operations and control of the effects of extreme weather (flooding, snow, ice, storm, drought, heat) will be addressed within this road type innovation topics in order to guarantee acceptable service levels. Improved materials, soil fortification and rock stabilization, improved water management, early warning systems based on local weather forecasts, and specialized weather proofing systems are just a few of the resilient solutions that can be developed to address the challenge of ensuring the availability of mobility. This requires suitable behavioral modifications and the consideration of climate change risk while making decisions [30].

The main features will be as below:

- Methods for managing with severe weather conditions; e.g., storms, wind, heat and cold
- Integrating the road with its surroundings to use water, energy, and planting effectively (Figure 5) [18].

It is significant to note that early maintenance of pavement is far more successful than waiting until serious issues arise when it comes to road pavement maintenance and adaption procedures. When pavements are already deteriorated, maintenance expenses might multiply by four or five. Pavement maintenance is becoming more challenging by climate change since it necessitates more frequent maintenance cycles. The ability to develop a resilient road through prevention and/or modification of machinery and materials that will be able to account for the effects of climate change without compromising safety and comfort depends on gathering enough data about pavement maintenance cycles [31].

4. Conclusion

Some of the goals set up for this work touch upon the following aspects:

- The transport modes will more effectively combined in future transportation
- New Approach to FOX and USE-iT Projects is assisted in the choice of a more efficient journey
- Presented technologies contribute to improved productivity in future transport
- Safer and more reliable environment for passengers and products
- Transportation infrastructure that meets users' expectations
- User information management can increase safety and
- Decarbonization by a longer lifespan and less maintenance requirement
- More reliable transport by self-repair or be rapidly and readily replaced pavements
- Using electric vehicles will increase livability, reduce noise pollution and carbon emissions
- Cost reductions can be achieved by constructing more adaptable, automated and resilient roads

At the end of these projects new technological developments have been reached, new aspects have been evaluated and many recommendations of European commissions have been fulfilled.

Declaration of Interest Statement

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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