Innovation capability of Finnish Road Weather and Maintenance Network – challenges and maturity level

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1. Introduction

Myriad and rapid development of technology has already happened and driven many changes in many sectors of everyday life. One of the most evident advancement that has seen during the last decades is in the information and communication technologies (ICT). The fast growing ICT has led to the adoption or increase of the use of digital or computer technology by an organization, industry, country, etc. that is called as digitalization in a broad range of practices. Digitalization has widely brought convergence of various sectors of social life, including infrastructural, terminal, functional and rhetorical, and market convergence.

Due the digitalization the pace of innovation cycles become more intense. The process of generating new concepts to converting into marketable ideas or usable products and services are now expected to be refined in a relatively short time. The last years, the road management and maintenance have been under heavy restructuring caused by the digitalization (i.e. Intelligent Transport System, ITS). At the same time, the privatization of many functions of road management and maintenance has made the operation environment more fragmented. To some extent, it can be assumed that the fragmentation sets challenges for the implementation of ITS solutions which are mainly based on interoperable and complementary solutions, which more than once are also quite an innovative as well.

This study analyses the innovation capability of the Finnish Road Weather and Maintenance Network (FIRWE) and its current challenges for advancing the innovation potential of the network. These research objectives will be achieved by studying the position of FIRWE in innovation typologies among several known collaboration concepts and identifying the maturity of it in the innovation complexity scale.

Therefore, the research questions of this study can be distinguished as follow: *1) What does the Finnish Road Weather and Maintenance Network comprises and how are the stakeholders interacting with each other? and 2) How is the network positioned among collaboration concepts and how could innovativeness in the network be increased and supported*?

2. Innovations and collaboration in Road Weather and Maintenance Business

As a Nordic country, Finland's transport systems are most likely affected by the extreme weather events such as s, blizzard, hail, thunderstorm wind gusts, low temperatures, rainfall, fog, freezing rain and frost. Those abovementioned climate characteristics can cause a number of possible extreme weather events that evidently give a wide range of impacts on the Finnish transport systems, particularly in winter, which require a well-managed traffic management system accordingly.

To manage the traffic and transport system effectively and efficiently, the recent advanced technologies are needed. Several ITS products and services are relevant to that direction, e.g. Road Weather Information System (RWIS). RWIS is a combination of technologies and decision-making techniques that use detailed, historical and real-time road and weather information to improve the efficiency of highway maintenance operations and distribute real-time information to travellers (Castle Rock Consultants, 1998). By mitigating the impacts on transport systems caused by the extreme weather events, the road weather solutions can provide significant societal benefits. According to Pilli-Sihvola et al. (2012), for example, benefits impacts comprise improved driver information, increased maintenance efficiency, reduced environmental negative impacts, improved safety, improved service quality, and more convenience travellers' experience.

When it comes to the innovations, it is the introduction of something new: idea, method, device, service or product. This newness can emerge because of an individual flash of wit, because of identified urge or need or very slowly progressing towards the solution of a problem. Not only has the innovation process transformed in time, but also have the networks of creating innovations. Inter-firm collaboration has always been a natural part of the evolvement and diffusion of innovations. Majava et al. (2013) listed six different collaboration concepts where innovations may arise. The listed concepts are an *innovation hub, business cluster, business network, business ecosystem, triple helix and keiretsu*. In this paper, Keiretsu is carefully excluded as it occurs almost exclusively in Japan.

Innovation hub thinking bases on the recent changes and trends in the business environments where companies operate. Instead of dominance by a single company, systems consisting of a nodal network

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(regional) of firms, individual consumers, and consumer communities work together to create value. Knowledge is distributed among many players, and companies are encouraged to take advantage of the available information, use the others' ideas, and even allow others to use theirs (Chesbrough, 2003). Local uncoordinated innovation activities, regional programs, and technology parks have been claimed to be evolving towards global innovation hubs (Launonen and Viitanen, 2011).

Business clusters are geographical concentrations of interconnected firms and institutions in a certain field, and the idea of clusters suggests that regions should identify and develop their existing regional competitive advantage (Porter, 1998). A business cluster, also known as an industry or competitive cluster, can enhance regional economic growth and income, increase company productivity, drive innovation, and stimulate new businesses (Porter, 1990). Clusters may extend downstream to customers and channels, and laterally to producers of complementarities.

The logic in ***business ecosystem*** thinking is that companies must proactively develop mutually beneficial relationships with customers, suppliers, and competitors (Iansiti and Levien, 2004). A business ecosystem is "an economic community supported by a foundation of interacting organisations (even competitors) and individuals—the organisms of the business world" (Moore, 1996). The companies co-evolve capabilities around an innovation: they cooperate and compete to support new products, satisfy customer needs, and finally build succeeding innovations.

In a ***business network***, a company (or participant) is dependent on resources controlled by others, and access to resources is achieved by forming relationships with other actors, creating interdependency between the actors and their relationships in the network (Håkansson and Snehota, 1989). In recent years, business networks have expanded due to industrial restructurings, vertical disaggregation, outsourcing, and a strategic drive to focus on core competencies (Batt and Purchase, 2004). ***Triple Helix*** is much like a business network, but the collaboration is driven and steered by the government and the network always includes, in addition to government, participants from educational institutes and industrial sectors. Resulting from the governmental steering and research-industry collaboration, triple helixes are strongly connected to and influenced by the national innovation systems. Most countries and regions are striving to boost innovations through a long-term collaboration between companies, government laboratories, and academic research groups.

3. The Finnish Road Weather and Maintenance Network (FIRWE)

The current FIRWE structure consists of five different layers of the supply chain (Figure 1): 1) equipment manufacturers, 2) observations' data providers, 3) road and weather information providers, 4) winter road maintenance service providers, and 5) information service providers. As for the demand side, there are public sector (road authorities) and road users (private, commercial, other societal professionals), which together form the winter traffic and mobility market. What comes evident from the FIRWE structure model is the decisive role of the road authority that in the end finances the entire network.

There has been shifting on the road authorities' roles from the last two decades, which consequently lead to the change more or less on the structure (see Figure 1). The functions of the network have remained essentially the same, but unbundling of the government (public) activities have led to a need to increase the role of the private sector. As the authority stands now, a minimal amount of operational activities remains with it. Only long-term planning and procurement represent the authority's task in addition to infrastructure ownership and representation of the public. This political shift has created a whole new game environment for the road authority. What used to be publicly justified function is now increasingly relying on market players' capabilities and skills. Managing the new game and market's functioning then has changed the procurement as well and will keep changing it in the foreseeable future. The "public good" and "socio-economic" logic is more dependent on market's logic.

Based on the defined collaboration concepts our analysis positions the FIRWE currently between innovation hub (Zone 1) and business network or even Triple Helix (Zone 4), as it contains shared features from both collaboration concepts. The rationale of our analysis is following:

- Even though FIRWE's demand-side is mainly steered by the public authorities, it is put in practice by a set of companies, and the loose collaboration network features tend to be found (heterogeneous).
- FIRWE participants have the mutual objective in general.
- FIRWE has integrated coordination, but the public authorities set the rules. FIRWE also has public funding.

- Innovations are mainly incremental and company-specific. However, they can also come from public authorities sector and market side. Also, radical innovations are not likely expected.
- Relationships are formed to achieved objectives and create value, but the primary purpose is not yet to build global competitiveness.
- FIRWE is more or less focused on local and regional development activities.

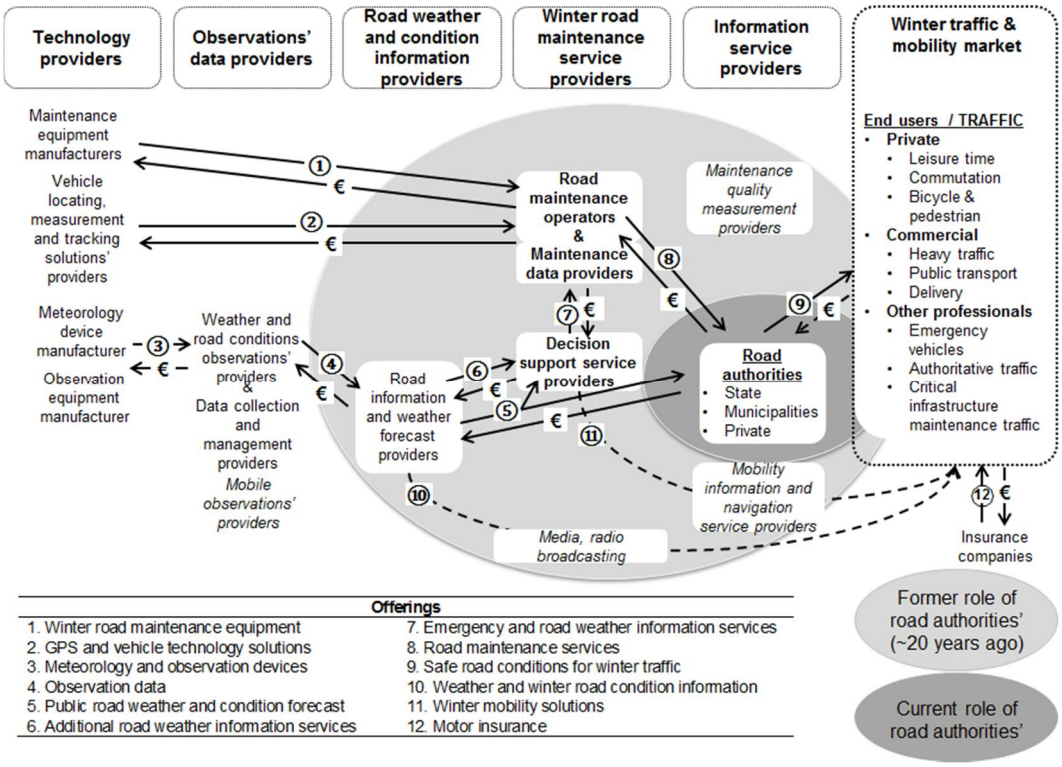

Figure 1. *The Finnish Road Weather and Maintenance Network (modified from Pilli-Sihvola et al., 2015)*

In the current FIRWE network, instead of the radical type of innovation, incremental innovations, small improvements to an existing product or product line to maintain or improve competitiveness, are more likely expected. In the context of FIRWE, incremental innovations could be shaped into several forms, e.g. in co-creating service offerings, experimenting innovative procurement models, and increasing end-customer requirements and involvement.

Another possible example of incremental innovation in FIRWE could also be the enhancing collaboration by involving new stakeholders (e.g. research institutes and public authorities). By that, the stakeholders can develop procedures that enable more efficient use and development of existing technology. For example, performance improvement by utilising ICT more efficiently (e.g., collection and utilisation of real-time information.

Moreover, public authorities are the enablers because the funding mainly comes from them. Research institutes, for instance, can provide an independent impact assessment of the system to propose some recommendations for the policy makers and business owners. These features (i.e. proactive involvement of government and research institutes) found in FIRWE can be a signal which shows that the current position is closely associated with the Triple Helix-type of collaboration network. Furthermore, in term of the organisations heterogeneity, the current FIRWE tends to have medium-to-high heterogeneous organisations, which contains deeper and more complex collaboration networks. Figure 2 shows the current position of FIRWE among the collaboration concepts and innovation typologies.

However, to make the circumstances for a better co-development, in the future, the position of FIRWE could be shifted toward business ecosystems somewhere between Zone 3 and Zone 4. The innovation will be slightly more radical in the future, in a sense that providing more space for private sectors to take their roles, drive the cooperation and competition mechanism, and gain competitive advantages within the ecosystem. Leviäkangas and Hietajärvi (2010) state that in the future, services are going to be more produced or driven by the private sectors. However, we argue that the development still has to be enabled and supported (e.g. funded) by the public authorities. Moreover, the future collaboration networks will likely expand into more complex and heterogeneous organisations.

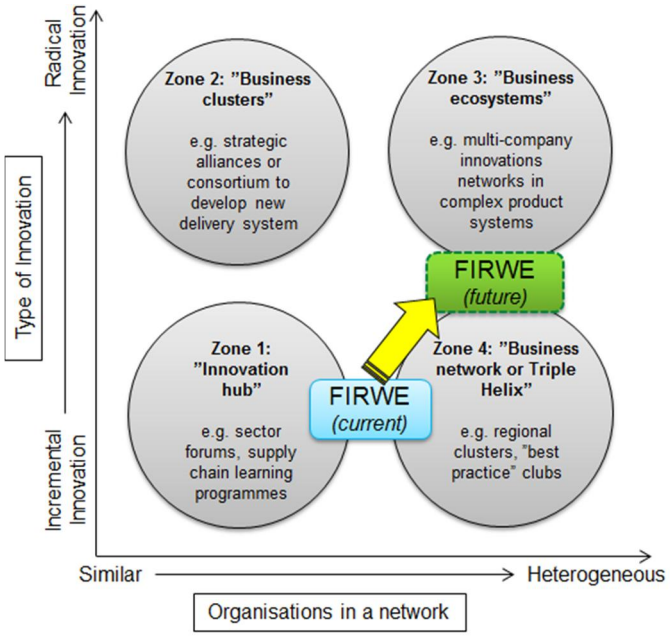

Figure 2. *The position of FIRWE among the collaboration concepts.*

4. Discussion and conclusions

At least, there are four interconnected themes of challenges that can be found in term of the innovativeness in the Finnish Road Weather and Maintenance Network (FIRWE). They include: 1) personification and vague roles in authority side, 2) short term view and preferences, 3) public-private procurement practices and traditions, and 4) network governance issues due to a multifold role in the network. Although every single challenge can hinder innovativeness by its own, however when they are combined, they can create an even more complicated and multi-dimensional set of challenges (see Table 1).

Besides addressing the identified challenges, taking those mentioned recommendations into account also can enable at least three different aspects, which is promising to bring a real potential for the better performance and innovativeness. The first aspect is the creation of an ecosystem where the service providers, road authorities, research institutions, funding agencies and end-users can collaborate. Secondly, FIRWE could attain an extensive service provider network that enables competitive supply of services and gives room for innovations. Third, FIRWE may rely on the existence of system integrator that facilitates better interoperability through its resources, and hence it ties together users, services, applications and hardware.

Ecosystem as a new collaboration paradigm will open business and market opportunities and even to some extent can enhance service export possibilities. Although the collaboration between road authorities and private service providers (including among them) appears to be problematic at present, however in the future, when the ecosystem has been matured as the risk-revenue model has been mutually settled, the stakeholders can gain competitive advantages through the ecosystem.

A wide service provider network to enables competitive supply of services may take part in value co-creation within the ecosystem, but on the other hand, every service provider will be still competing through innovations in their products or services to maximise their profit. In a business ecosystem, this phenomenon is known as the *coopetition*. In the long run, this will develop and expand the ecosystem, which means the potential advantage that can be gained by the ecosystem stakeholders will also be growing.

Third, FIRWE could benefit from the existence of the system integrator that facilitates better interoperability. SMEs in FIRWE expect some larger companies to act as a system integrator which integrates the offerings of stakeholders into their services or platforms. The reason for the large company leadership is understandable as they have resources and capability to manage the service network, especially when considering international markets. The views reflected, however, that the risk-revenue model should be designed in a way that the leader company cannot alone set the rules and every stakeholder gets their share.

Furthermore, to change the current position of FIRWE, it requires the engagement of public road authorities. Applying innovative procurement models would allow the deeper collaboration, value co-creation and service co-development between FIRWE network and road authorities. The reason is simple: winter road maintenance or maintenance, in general, can be considered as a complex product system where every stakeholder has their role and function. The road authorities must understand that based on their central

role, they are the drivers of the requirements, which should be in creating cost-effective state-of-the-art winter road maintenance and ultimately safe and reliable mobility system.

Table 1. FIRWE innovation challenges and recommendations

FIRWE innovation challenges	Recommendations/ Solutions
Personification and vague roles • Limited resources of authorities • Lack of monetary, human resources and technical competencies • Vagueness of the authorities' roles	• Funding agencies should provide funding and support to enable innovative ways of working (e.g. procurement methods) • The authorities must recognise their role as a central player in the network • Precise rules for collaboration to clarify the roles of each participant • Bringing all the views together and combining skills, services, and public interests in manner that deliver maximum benefit-cost ratio
Short-term view and preferences • Maintenance procurement is based on almost the price alone, not on the capabilities of service providers (fragmented supply chain) • No genuine desire to do the innovation in an authority side (the lack of resources, strategy and competencies)	• Supporting service and offering co-development (new business and export possibilities) • Building an ecosystem around a leading company (i.e., system integrator) • Research institutes as spreaders publicly beneficial information (making use of scientific networks in marketing) • Testing and piloting as a part of operational activities (road authorities as enablers (i.e., assisting companies to validate their innovations) • Impact assessments and evaluations supporting systematic development
Procurement methods and traditions • Procurement of maintenance and requirements setting is done by road authorities (state funded) • Operative maintenance is outsourced to private companies • Sub-optimization caused by the competitive tendering • No (monetary) incentives to develop maintenance systems	• Applying new procurement and delivery methods by road authorities to foster innovativeness and connecting the supply side (service providers) and demand side (road users) • Risk and revenue sharing; i.e. winning or losing together, to ensure commitment, collaboration and mutual goals. • Emphasizing competencies, capabilities and skills in supplier selection and procurement
Network governance issues due to the multifold role of the authorities in the network • An end-user (i.e. set requirements) for the supply side • A customer for the maintenance service providers • Public and road authorities serve the society and road users	• Customer requirements as a link between the supply and demand sides (i.e., maximizing socio-economic benefits) o Road users are not experts of road maintenance, thus the focal role of the road authorities as a maintenance expert between the service providers and end-customers is required. • Road authorities must collaborate with multiple stakeholders in this complex system • Road authorities are the drivers of the ultimate requirements

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