Obstructions in becoming completely connected: A case study of the fibre broadband expansion in Sweden

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***Abstract*—For countries like Sweden, sparsely populated and with ambitions of staying ahead regarding digitalisation, the government plays an extra important role in providing the fundamental infrastructure. In 2016, an ambitious strategy for nationwide connection to high-speed broadband was presented, where three strategic areas of importance was highlighted.**

This study has intended to contribute to the understanding of the dynamics of the Swedish broadband infrasystem. It was conducted as a qualitative single-case study by applying systems thinking, and more specifically the Multi-Level System Diagnosis framework, upon the case of fibre broadband expansion in Sweden over the last four years, with focus on rural areas. The empirical data mainly consisted of public inquiries, complemented with some commercial text sources. Internal and external tensions of the system were identified and categorised after how they have affected the implementation of the strategy. The study identified several tensions, such as delaying juridical processes regarding access to land, malfunctioning cooperation between actors and misdirected governmental support. The tensions were found to obstruct the system in all of the government's highlighted areas.

***Index Terms*—Systems thinking, fibre broadband, telecommunications, rural Sweden, digitalisation, policy.**

I. Introduction

For countries like Sweden, sparsely populated and with ambitions of staying ahead regarding digitalisation, the government plays an extra important role in assuring that fundamental infrastructure is equal throughout the country (Government Offices of Sweden, 2016, 2017). The demand for nationwide, high-speed broadband is highlighted during the ongoing COVID-19 pandemic, as development towards a more digital society is accelerating. Travel is discouraged and, if possible, working from home is recommended in order to limit the spread of the virus (Public health agency of Sweden, 2020). Luckily, digital solutions are already here, meetings can be moved to be held online and required data can safely be accessed from remote via VPN-connections. But the uneven access to high-speed broadband divides the population and the companies of the country, denying many households and business in peripheral areas to take part of the digital solutions and the advantages of working from home (Government Offices of Sweden, 2016; Swedish Post and Telecom Authority, 2019b).

In the Swedish strategy for broadband expansion, 'A Completely Connected Sweden by 2025', the short term goal was set to providing high-speed broadband (above 100 Mbit/s) for 95 percent of households and companies by 2020, and for 99.9 percent by 2025 (Government Offices of Sweden, 2016). The latter goal includes access to broadband speeds of at least 1 Gbit/s for 98 percent of the population, speeds that as of today mainly can be reached by fibre. On top of speed, the society's and the market's increasing requirements and demands for robustness, security, sustainability and cost efficiency fits well with the characteristics of fibre, making it the most central source of connection as of today and in the near future (Forzati and Li, 2019; Government Offices of Sweden, 2016; IP-Only, 2019). In the strategy, three strategic areas were pointed out as extra important going forward: (1) *Roles and rules*, (2) *Cost-efficient expansion* and (3) *Infrastructure and services for everyone* (Government Offices of Sweden, 2016).

The ambitious goals, being part of the Swedish government's ambitions to be world leaders in terms of utilising the opportunities of digitalisation, are first and foremost supposed to be achieved through a well functioning market, and the role of the government is hence mainly to ensure that the market is working properly, as well as to support areas where the market lacks commercial ground for expansion (Swedish National Audit Office, 2017; Government Offices of Sweden, 2017). Historical investments in telecommunications, railways, post, and road infrastructure in Sweden expose a distinct characteristic of the state substituting for the market in incentive lacking areas (Palm and Wihlborg, 2006). We are now approaching the first due of the goals, but Swedish Post and Telecom Authority (2019d) predicts that most of the goals will not be accomplished. Moreover, delayed and aborted projects have caused numerous filings against infrastructure building companies, and media reports of disappointed inhabitants of rural areas due to delayed or aborted projects (SVT, 2019; IP-Only, 2019; Land, 2019). But why has the path towards a completely connected Sweden been paved with disappointment and goals predicted to remain unaccomplished? The following study investigates the matter further, digging deeper into why the digging for optical fibre in Sweden has been such a bumpy road.

The study is conducted as a qualitative single-case study, applying systems thinking and more specifically the framework of *Multi-Level System Diagnosis* (MLSD). The framework was introduced by Blomkvist and Johansson (2016), and is an extension of Hughes's well renowned framework of *Large Technical Systems* (LTS), often used in order to better understand changes in infrastructural systems (Hughes, 1983; Kaijser, 1994).

Initially, the purpose and research question of the study is presented, followed by a review of related literature. The

LTS and MLSD frameworks are then explained, followed by a methodological description of the study. Finally, the theoretical framework is applied to the case in order to identify and analyse tensions of the broadband expansion. The study may be interesting for someone interested in the dynamics of a system under heavy influence of regulation and policies, as well as for someone interested in the rural broadband expansion in Sweden.

A. Research question and purpose

The purpose of this study is to contribute to the understanding of the dynamics of the broadband expansion in Sweden. The point of departure of the study is the governmental broadband strategy from 2016, and the intention is to identify and analyse how tensions on different levels in the system have affected the progress towards the strategic goals. The broadband strategy is aimed towards reducing friction between actors affecting the expansion, directly or indirectly, such as public authorities on different levels, external actors, infrastructure-building firms, and clients (businesses and households). It lays focus on high-speed broadband expansion by fibre in rural areas (Government Offices of Sweden, 2016), which will be the focus of this study as well. Thus, the following research question is formulated:

- *How can tensions between actors of the rural fibre broadband expansion be explained to have obstructed the progress towards achieving the goals of the Swedish broadband strategy?*

B. Previous work

There are plenty of research of interest for this study. Both in the field of telecommunications development in Sweden as well as of infrastructure from a systems thinking perspective. There seems to be a consensus regarding that well integrated ICT infrastructure generates positive effects on society, and the socio-technical perspective has often helped explaining the dynamics of infrasystems.

In 'The extension of sophisticated broadband and regional competitiveness', Lorentzon (2010) studies the effect of wired broadband access for businesses in peripheral locations of Västra Götaland, concerning regional competitiveness. He claims that the expansion of ICT, like previously integrated infrastructure such as railroads and the electric net, has followed the common process of diffusion from big cities to the periphery. But as ICT are continuously upgraded, the countryside keeps lagging behind, and big city regions are favoured. Furthermore, as rural areas mainly are populated by elderly, this increases the already strong digital divide between old and young people. The other way around, Lorentzon identifies the demography as a stressing factor for equalising broadband access between centre and periphery. Notable is that Lorentzon's study was conducted at a time when xDSL was the dominating technique for broadband in Sweden, enabling speeds of around 2 Mbit/s.

The OECD report 'Development of high speed networks and the role of municipal networks' (Mölleryd, 2015) describes experiences of broadband network in a number of OECD countries, including Sweden. It determines that the municipal networks are important factors for Sweden's highly expanded fibre network (15 subscriptions per 100 inhabitants and only beaten by Japan and Korea in 2014). Two thirds of Swedish municipalities were covered by a municipal network by the time, and all together they were responsible for 23 percent of broadband investments during 2014. The municipal networks typically own and provide basic infrastructure without a commercial purpose, open for operators on equal terms, enabling connection for consumers and businesses. The report feature three examples of how high-speed broadband, and particularly by municipal networks, can be beneficial for society, both socially and economically, e.g. by utilisation of e-services and development of advanced services creating new jobs.

In 'Innovation in Large Technical Systems', Davies (1996) presents a case study of the telecommunications system, applying systems thinking and the LTS framework in combination with economic forces affecting innovation, i.e. economies of scale, scope, and system. The latter refers to increased utilisation of already installed network capacity. The trajectory of an LTS can in general only be reversed by such radical innovation that makes it economically feasible to disregard the previous financial commitments. But as for hierarchically structured telecommunications, the author claims, the system favours development along the same trajectory despite rationally preferable alternatives. He means that there are too powerful interest holders committed to the existing system, and that the common involvement of the state makes the system resilient to radical changes. However, if the radical innovation do have the support of the government, it may be able to transform the network into an open and decentralised system - but the technical, economic, and political momentum of the current regime has to be broken (Davies, 1996).

'Bridging the critical interface' by Blomkvist et al. (2020) investigates the actions of regime actors of the water provision system in low-income areas of Nairobi, Kenya. It is a system in need of change in order to meet the heavily increasing demand of clean water in the upcoming years. As the largest provider of water fails to deliver to low-income inhabitants - the majority of the population - the informal water market is strong. It is a complex social web consisting of individual entrepreneurs, community organisations, illegal organisations, and corrupt officials. The theoretical framework applied is a variant of the MLSD, implemented to identify internal misalignments between innovation and contextual factors at a micro, meso and macro level, and thus emphasised the importance of avoiding technical and institutional mismatch in the system. The interface between these levels is critical and it was also here the majority of the misalignments was identified - in the crossing of the water provision company's technology, routines, and staff versus the users, their organisations, and their physical space, the authors mean. Other misalignment is found around the collision of established processes in the company and innovation activity. Furthermore, as Nairobi is under constant shortage of water, prioritisation of informal areas would decline supply to high-income premium customers, which is an important factor preventing actions - handling one misalignment may produce other problems. The authors also

identify tensions within the regime actor's innovation strategy, trying to both keep efficiency in daily management of the existing network, and attempting to adapt its services to the landscape in the informal areas.

II. Theoretical framework

The following section intends to unify the reader and the authors regarding the theoretical framework of the study. The theoretical foundation applied was the MLSD, which builds on the LTS framework combined with elements from the Multi-Level Perspective (MLP) framework.

A. Large Technical Systems

The concept of LTS, introduced by Hughes, builds on the notion of systems thinking - the understanding of a complex whole, i.e. a system, through its interconnected components (Blomkvist and Johansson, 2016; Hughes, 1983). Hughes stressed that the dynamics of deeply embedded technological systems, such as electricity systems, railways and telecommunications, contain a *"rich texture of technical matters, scientific laws, economic principles, political forces and social concerns"* (Hughes, 1983, 1). He further acknowledged that there had been substantial interest in the impact of technology on society, but that the impact of society on technology had been practically neglected. To try and comprehend the complex and multifaceted relations of such systems, and to provide a holistic perspective, Hughes developed the concept of LTS. LTS are both socially constructed and society shaping, containing *"messy, complex and problem-solving components"* (Hughes et al., 1987, 51). These components are technical artefacts (e.g. transformers and transmission lines), institutions (formal, e.g. regulatory laws, and informal, e.g. technical and social norms), and actors (e.g. professional, commercial, scientific organisations) (Hughes et al., 1987; Blomkvist and Johansson, 2016). The basic point of departure is consequently that an LTS is not only technical but also socio-technical in its nature (Kaijser, 2005; Blomkvist and Johansson, 2016). This means that an LTS should be analysed by addressing all parts of it by viewing it as a seamless web of political, economic, cultural, institutional and technical components (Hughes, 1986; Blomkvist and Johansson, 2016). Thus, not only technical components should be taken into account when analysing it, but also the people and organisations that build, operate and use the components, as well as the institutional and regulatory framework in which the activities of the system are carried out (Kaijser, 2005).

However, Hughes did not make it entirely clear how an LTS should be separated from one that is not. One proposed delineation of LTS is that of Joerges, who singles out technical systems that are indisputably large as: "those complex and heterogeneous systems of physical structures and complex machineries which (1) are materially integrated, or "coupled" over large spans of space and time, quite irrespective of their particular cultural, political, economic and corporate make-up and (2) support or sustain the functioning of very large numbers of other technical systems, whose organisations they thereby link" (Mayntz and Hughes, 1988, 24).

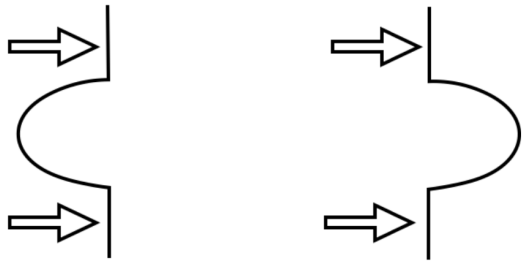

Fig. 1. Reverse salient lagging behind (left) and salient moving ahead (right). Source: Blomkvist and Johansson (2016)

Hughes himself reasons that interconnected components of an LTS are often centrally controlled, and the limits of the system are thus established by the extent of this control exercised by artifactual and human operators (Hughes, 1983; Hughes et al., 1987). The controls themselves are in turn exercised in order to optimise the performance of the system, as well as to direct the system towards achieving certain goals (Hughes, 1983). Moreover, Mayntz and Hughes (1988) reflect upon the interconnected organisations in LTS, arguing that most are linked only technically to each other through the LTS, but that the social base can be enormous as many modern LTS *"guarantee the ongoing production, distribution, use and disposal of almost all goods in almost all organisations of a society"* (Mayntz and Hughes, 1988, 25).

Salients and reverse salients: A crucial function of actors in LTS is to complete the feedback loop between system performance and system goals, and by this mean correct errors in system performance. Change, expansion and system errors themselves, according to the terminology of Hughes, takes the form of reverse salients or salients (Hughes, 1983; Hughes et al., 1987). These concepts are central when trying to understand the dynamics of an LTS, and thus also for this study. Reverse salients arise in systems because of technical or organisational anomalies that result in uneven growth of its components, making some components out of phase with the others and consequently prevents the entire system from developing and achieving its goals. The expression itself is borrowed from the military, and explains an advancing front that have fallen behind (reverse salients) or moved ahead (salients). Since an advancing military front exhibits many irregularities and anomalies, Hughes argue, the metaphor suits an evolving complex and multifaceted technological system (Hughes, 1983; Hughes et al., 1987). Until the lagging components are altered, they remain reverse salients and hinders system growth (Hughes et al., 1987). In LTS, central actors and organisations with interests try and correct the reverse salients so that the system can function optimally and better fulfil its goals (Hughes, 1983). However, a reverse salient is not always easy to identify for actors using perspectives from inside the system, as it is not a dormant failing component suddenly breaking, and because it prevails with the current system logic (Blomkvist and Johansson, 2016). Thus, a reverse salient is, to some extent, a social construction that is in the eye of the beholder.

B. Multi-Level System Diagnosis

MLSD, introduced by Blomkvist and Johansson (2016), is based on Hughes's LTS framework. In MLSD, the focus is on the system actors' point of view, and on finding reverse salients, in order to identify and explain misalignment between system components and their environment. The framework divides the investigated LTS into three levels of analysis - micro, meso and macro - with the purpose of illustrating alignments and locate reverse salients within and between the different levels that potentially slows down the system expansion. The three different levels are derived from the MLP by Geels (2002), in which alignment is explained as the level of "fitness" between the societal environment (macro) referred to as *landscape*, the regime level (meso) and local innovation activites (micro), called the *niche* level (Blomkvist et al., 2020; Geels, 2002). While MLP is focused on explaining and analysing innovation, MLSD rather combines LTS with the system division used in MLP to provide an overview of the dynamics of the investigated system. The landscape level constitutes the environment of the regime and niche levels, and thus influence these through factors they cannot control, such as rules that shape market development (Blomkvist and Johansson, 2016). Hughes and the LTS equivalent of the landscape level is referred to as the societal context of the system (Hughes, 1983). On the macro level of MLSD the external factors, organisations, systems and institutions in society (concrete, not general or abstract ones) causing direct friction with the LTS are thus taken into account and focuses on the friction between the two lower levels in the LTS and their environment (Blomkvist and Johansson, 2016). The regime level consists of three dimensions: (1) the network of actors and social groups, (2) formal and informal institutions and (3) physical and technical elements, while the niche level concern components on a more local and concrete level.

III. Methodology

A. Research design and delimitations

The study has been performed as a qualitative single-case study. It is a method examining a single case, or a clearly delimited event or phenomenon (Johannessen and Tufte, 2003, 56). Yin (2007) claims that case studies are suitable for research questions searching "how" or "why" about something, and particularly if that something is of a complex nature. The research question of the study was a "how"-question regarding the fibre broadband expansion in Sweden, which notably can be concerned as a complicated manner, and thus the case study was a suitable research design. Moreover, the design of a case study ensures that the findings stay relevant and in touch with reality, and provides a ground for more persuasive arguments about causal forces vis-à-vis broader empirical research (Siggelkow, 2007). As the findings of the study might interest readers not only being academics, the case study design was considered appropriate.

Yin (2007) means that the more cases, the better, but according to Siggelkow (2007), a single case can be a very powerful example. The case investigated in this study was defined as the wired broadband expansion in rural Sweden, that is, the physical expansion of the optical fibre cable network in peripheral areas, and all activities in direct and concrete relation to dito. As with the conceptual framework used, MLSD, the study focused on aspects of the involved actors on different levels. The case was further delimited in time to concern the interval between the Swedish broadband strategy presentation (Government Offices of Sweden, 2016), until the time of when the study was performed, i.e. from 2016 to April 2020.

The study was conducted by a systematic review of the data, where tensions, or reverse salients according to the theoretical framework, affecting the dynamics of the case were identified and analysed. The ambiguities, dilemmas and frictions caused by these tensions has been the focus of this paper. In order to respond to the research question and evaluate how these tensions have obstructed the goals of the national broadband strategy, they were categorised according to which of the three strategic areas of the strategy they have affected. These areas, i.e. *roles and rules*, *cost-efficient expansion*, and *infrastructure and services for everyone*, are defined and explained in *Chapter IV*. The areas were not considered mutually exclusive, i.e. a reverse salient was categorised to *all* areas of effect.

B. Empirical data

The empirical material used in this study has exclusively been of written form, collected by qualitative text analysis. A qualitative approach, in relation to a quantitative one, tends to better explain underlying motives, intentions, goals, and plans of activities (Johannessen and Tufte, 2003). The purpose of the study was to increase the understanding of the challenging broadband situation in rural Sweden, and a qualitative approach was thus preferable. The public sources of data were the Swedish Goverment Offices, Post and Telecom Authority (PTS), Broadband Forum (Bredbandsforum), Byanätsforum (forum for local initiatives for broadband), Board of Agriculture (Jordbruksverket) and National Audit Office (NAO) as well as the Organisation for Economic Co-operation and Development (OECD). Two private sources of data were used, i.e. the Swedish IT and Telecom Industries (ITT), and the infrastructure builder and owner IP-Only. The study was conducted via so called triangulation, i.e. by determining the reliability of certain data by correlating it against data from other sources (Jensen and Sandström, 2016).

As many of the sources used are stakeholders in the matter, the risk for undermined data has been extra important to consider (Denscombe, 2009). Thus, all data from such sources was reviewed with extra caution of its freedom of tendency. Furthermore, the framework for qualitative text analysis sometimes require personal assessments. It is important that such analysis is performed objectively in order to not decrease the reliability of the results (Johannessen and Tufte, 2003), which have been considered throughout the data collection process.

IV. The Swedish governmental broadband strategy - Sweden Completely Connected 2025

This section presents a joint description of the national broadband strategy from 2016 with emphasis on explaining the three strategic areas.

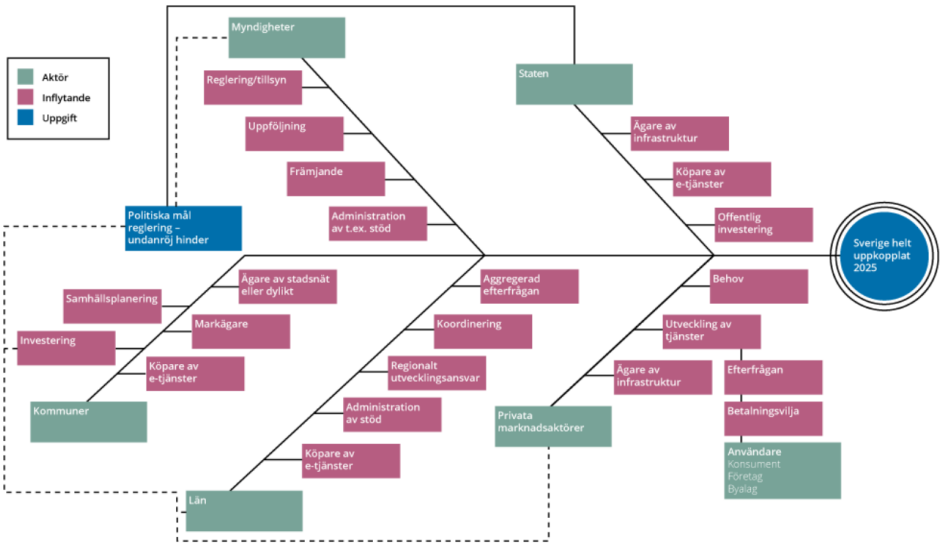

Fig. 2. The Swedish government's overview of national, regional and local level operators on the broadband market. Source: Government Offices of Sweden (2016)

The Swedish government's vision is that of a "completely connected Sweden" (Government Offices of Sweden, 2016). In the broadband strategy from 2016, it was acknowledged that access to broadband is becoming a prerequisite for innovation and growth, and for access to basic public services such as healthcare and education. Ambitious goals were thus set up for equal access to broadband in the entire country, with extra emphasis on the improvements needed in rural areas lagging behind in terms of faster broadband speeds. The goals entailed that by 2020, 95 percent of all households and companies should have access to broadband of at least 100 Mbit/s. Furthermore, by 2025 the goal was set to 98 percent of households and companies to have access to broadband of 1 Gbit/s in their proximity, 1.9 percent of 100 Mbit/s and the remaining 0.1 percent of 30 Mbit/s.

The point of departure to reach these goals has been a market driven expansion, complemented with the responsibilities of public authorities, such as regional councils, municipalities, county councils and the Swedish Association of Local Authorities and Regions (SKR), to provide people with public services and fair opportunities through equal access (Government Offices of Sweden, 2016). The role of the government has hence been to formulate political goals and to eliminate development obstacles in a way that does not intrude on market competition, as well as to utilise public infrastructure and direct public efforts to areas where the market have lacked commercial ground for expansion. Private investments and competition should shape the market and not be hindered, while being balanced with complementary public intervention for the greater good of the public, as well as to ensure an efficient use of and impartial access to publicly owned broadband infrastructure. In sparsely populated and peripheral areas, where commercial grounds for expansion are missing, public support should be available. In the report from Mölleryd (2015) on the role of high speed networks and the role of municipal networks, aspects of such balance was brought up. It was pointed out that combinations of private and public investments could be beneficial, and that municipal networks could play an important role with the increasing demands of connectivity, as well as to foster competition. However, there were also tendencies showing that such networks could rather compete with the private market as public interests were put beforehand, and thus hinder private investments and fair competition.

In the strategy, three main strategic areas were identified in order to reach the defined goals:

(1) *Roles and rules*: The roles, rules, responsibilities, relationships and cooperation between private and public actors on the complex broadband arena needed to become clearer in order to create incentives for further investments. The dialogue them between thus needed to be enhanced through the cooperation of a handful of public and private organisations, communities and political roles that have been appointed and created for this purpose alone, such as, to name a few, Bredbandsforum, Byanätsforum, and regional broadband coordinators appointed by region councils (Swedish Broadband Forum, 2020; Swedish Post and Telecom Authority, 2019c).

(2) *Cost-efficient expansion*: Aspects of the broadband expansion, such as terms and incentives, also needed to be clarified and more transparent to create better conditions for an increased cost efficiency through faster administration and processes. The purpose was to decrease the entrance barriers of the market. This included e.g. the terms, requirements and processes to be granted land access and electricity permissions, areas including many operators both within and beyond the broadband system, such as the Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet), the Transport Administration (Trafikverket) and property owners (Swedish Post and Telecom Authority, 2020b; Government Offices of Sweden, 2016).

(3) *Infrastructure and services for everyone:* Conditions needed to be created for broadband to reach people regardless of their location - urban, rural, and everywhere in between. An increased robustness, capacity and quality was seen as an important part of this. Moreover, the efficiency of governmental support was identified as needed to be overlooked, but was still identified as necessary. The financial support set aside for the period 2014 to 2020 was thus increased from 3.25 to 4.25 billion SEK, distributed through the Rural Development Programme (RDP) (Government Offices of Sweden, 2016; Swedish Post and Telecom Authority, 2019d). The support has been given for broadband expansion projects lacking commercial ground, in rural areas exclusively, which is defined as all settlements with less than 200 inhabitants with no more than 150 meters between the households (Swedish Board of Agriculture, 2020a). Jordbruksverket, the Swedish Agency for Economic and Regional Growth (Tillväxtverket) and regional councils has been assigned the responsibility to design the rules of and manage and administrate such support. Furthermore, PTS was given the responsibility to follow up the broadband situation, evaluate and analyse the strategy, as well as to communicate and coordinate the public authorities involved (Government Offices of Sweden, 2016).

A map of how the government intended the different roles on the market to be on a national, regional and local level can be seen in *Figure 2*.

V. Analysis

This section presents the analysis of the study. The case is divided into the three levels of the conceptual framework in order to identify and analyse reverse salients. Finally, the results of the study is presented.

A. The macro level

On the macro level, we observe how external and neighbouring factors align with the system of interest. That is, how activities and phenomenons from the outside, create tensions within the system. The rural broadband LTS is dependent on financial support from the government, and as even the government has financial limitations, other systems competing for financial support might misalign with the current system. Peripheral fibre expansion also includes the crossing of land where other interests, such as environmental, might misalign with the digging for fibre.

1) Competition for governmental support: In December 2019, the government announced an extension of the broadband support for 2020 by nearly 200 million SEK, also assigned to be distributed through the RDP. Nilsson, the Minister for Rural Affairs, stated in the announcement that *"Having access to broadband in the entire country is fundamental for a growing Sweden. It is a prioritised question for the government which is why we now assign this mission to increase the pace of the payouts"* (Government Offices of Sweden, 2019). However in April 2020, only months after the announcement, Jordbruksverket, the authority governing the RDP, announced that the broadband programme will be stopped completely for the rest of the year in favour of environmental support.

Fig. 3. A warning sign for cable is better suited along the road than on a field or in the forest. Source: Government Offices of Sweden (2009).

Jordbruksverket estimates the total decrease of the broadband support to 200 million SEK (Swedish Board of Agriculture, 2020b). The extended governmental support for the, according to Nilsson, prioritised broadband question was thus erased. This external misalignment changes the formal rules of the regime level, completely removing the state's efforts in substituting for the lacking market incentives. In the end, the direct effect of this reverse salient is that businesses and households of rural areas which have not yet been granted support, will miss out, and thus the *third strategic area* is obstructed.

2) Land permissions: Another reverse salient causing landscape misalignment can be identified as laws and customs regarding land permissions, of which one important factor is the road infrastructure. Often, as stated by e.g. Swedish Post and Telecom Authority (2018), Swedish IT and Telecom Industries (2019) and IP-Only (2019), constructing fibre along roads in rural areas is the only reasonable option in terms of time and cost efficiency, as the constructors in such cases will not have to cross tough terrain. Moreover, permissions regarding construction along roads can easier be obtained, as the roads have already impacted nature and cultural environments. Additionally, placing wires along roads, rather than in disconnected pieces of land, decreases the risk of the wire being cut by other digging activities.

Laws affecting the construction of fibre along roads, however, has become a problem, as the construction of wiring in road system requires special permission from Trafikverket. The strict rules for these permission obstructs the broadband expansion in rural areas, since the roads in such areas often do not meet certain requirements. Moreover, the administration processes are complicated and time consuming (Swedish Post and Telecom Authority, 2018; Swedish IT and Telecom Industries, 2019; IP-Only, 2019). As the broadband expansion has been pushed further to the periphery, the number of applications for such permissions has increased drastically, and Trafikverket have had to put a substantial amount of resources into dealing with them (Swedish Post and Telecom Authority,

2018). The turnaround time for handling the applications has risen and often exceeded the statutory time of four months, something that has created frustration for both private actors doing the constructing, as well as for e.g. public authorities administrating broadband support to rural areas. Thus there is misalignment with the *first strategic area*. The costs of constructing broadband in rural areas also have, for the same reasons, increased in a market that is already financially pressured, affecting the *second strategic area*. Additionally, this reverse salient, arisen from the bureaucracy of road-related regulations, leads to further delays in the broadband expansion. Extensively, as roads are often the most reasonable route for the wires, especially for peripheral connections, the commercial incentives for such areas is further decreased, and also the *third strategic area* is obstructed.

B. The meso level

The analysis of the meso level concerns tension within the socio-technical regime of the system. From a socio-technical perspective in general, this includes the network of actors, the formal and informal institutions, and the physical and technical elements. However, from the MLSD framework, focus lays upon the actor perspective (Blomkvist and Johansson, 2016). The expansion of broadband in rural areas includes many actors, and it relies on their mutual cooperation. Misalignment can be expected to arise between actors of such complex actor webs. Moreover, the high level of governmental involvement can be expected to somehow cause misalignment towards the market.

1) Ambigious roles and malfunctioning cooperation: In 2017, the broadband strategy from 2016 was investigated by the Swedish NAO (Swedish National Audit Office, 2017). The investigation emphasised the challenges of bridging the divides of access to broadband between urban and rural areas. Amongst other reasons, the varying interests, strategies and goals of different involved actors was highlighted, such as those for municipalities and private actors, where one is acting for the greater good of the area, while the other is governed by commercial interests. Interviews conducted by the Swedish NAO showed that private actors found the power balance to be asymmetric, as municipalities, perhaps with other interests, make many decisions that the private actors are dependent upon in order to dig for fibre (Swedish National Audit Office, 2017). This goes well in hand with the findings of Mölleryd (2015), entailing that the interests of municipals could intervene with private interests. How the government in their broadband strategy formulated the division of roles and responsibilities between different private, municipal and public actors was further identified as a major reason for these ambiguous roles (Swedish National Audit Office, 2017). The view of malfunctioning cooperation and unclear roles is also a view shared by public and private actors being both independent and dependent, such as OECD, the ITT, PTS and IP-Only (OECD, 2018; Swedish IT and Telecom Industries, 2019; Swedish Post and Telecom Authority, 2019d; IP-Only, 2019). Actors and organisations appointed and created for the purpose of coordination and cooperation alone, such as Bredbandsforum, Byanätsforum and regional broadband coordinators also show clear tendencies of agreeing to this view (Swedish Broadband Forum, 2017; Forum, 2018; Ulfbecker et al., 2015). Consequently, the cooperation and coordination between different actors on all levels - national, regional and local - can be identified as a clear reverse salient on a meso level, prohibiting the *first strategic area*.

2) Misdirected support programmes: Another tension can be found in the visions and goals of the governmental broadband strategy versus how the ambitions are actually supported by the government. While the broadband strategy emphasised the importance of reaching peripheral areas, the investigative report from Swedish National Audit Office (2017) showed that there was a risk that governmental support intended for broadband expansion in rural areas, had rather been issued to commercially attractive areas partly because the supports had been difficult to administrate and coordinate because of ambiguous regulatory frameworks (Swedish National Audit Office, 2017). Swedish Post and Telecom Authority (2017) and Swedish Broadband Forum (2017) agreed on this view, pointing out the need for a stricter, more regionally adapted and more centrally guided support program to direct support to the areas really needing it, rather than the current application-controlled program. Such a support program was proposed by Swedish Post and Telecom Authority (2020a), in which it was suggested that support could be directed by region councils to especially important areas. The limited support budget however, also leads to propositions entailing that support should be prioritised to where it is most cost efficient, i.e. where the support can enable the highest number of connections and can reach the highest number of people (Swedish Post and Telecom Authority, 2020a). As the rules for support are clearly ambigious, and because it affects peripheral areas, this reverse salient inhibits the *the first and third strategic areas.*

Swedish IT and Telecom Industries (2019) pointed out that to reach the goal of 95 percent of households and companies having access to broadband speeds of at least 100 Mbit/s by 2020, merely 46 percent of rural areas would have to have access if the corresponding number for urban areas was 100 percent. Further, the details of the goal of 98 percent of households and companies having access to broadband speeds of at least 1 Gbit/s by 2025 was discussed. They meant that this goal was misleading as its access specifications only concern so called home passed access, i.e. access by the property boundary or its very proximity but not necessarily by the property itself, a detail greatly disfavouring the countryside where the distance from the household to the property boundary can be long (and thus expensive).

In some sense, this reverse salient can be seen to undermine the bespoken focus on decreasing the gap between urban and rural areas, both in terms of how the goals are formulated, as well as to where the support is directed. This illustrates that the ambitions of reaching the defined national goals overrides the intended purpose of the goal itself, which is a further contradiction to the *third strategic area*.

3) Undersized support programmes: Many of the private actors applying for support to be able to build in peripheral areas have, in conjunction with financial investigations from

PTS themselves, mentioned the need for more governmental support in order for the national goals to be reached (Swedish Post and Telecom Authority, 2019d; Swedish IT and Telecom Industries, 2019; IP-Only, 2019). Swedish Post and Telecom Authority (2019d) estimated that fibre investments of 22 billion SEK, on top of the expected investments of commercial actors and already set aside governmental support, would be needed in order to reach the goals set up until 2025, which can be put in relation to the 650 million extra actually set aside by the government for the years 2020 to 2022. Furthermore, Swedish Post and Telecom Authority (2019a) showed that commercial investments in the broadband expansion are actually decreasing, mostly because of the increasing immediacy of supplying sparsely populated and thus less commercially interesting areas with broadband, combined with the need for more governmental support. Lastly, Swedish Post and Telecom Authority (2019d) prognosticated that the strategy's defined goals would not be reached. This could arguably be an incentive for the government to supply the broadband expansion with larger investments, but could also be a stress factor, yet again misaligning support to more densely populated areas rather than to areas needing it the most, challenging the *third strategic area*.

4) Undermined public interests: One of the major purposes of the governmental broadband strategy striving for a nationwide fibre net is to strengthen the international competitiveness and increase growth (Government Offices of Sweden, 2016). In 2019, 85 percent of businesses and households had access to high-speed broadband by fibre (Swedish Post and Telecom Authority, 2019b). As this percentage increases, so do the competitive and growth related advantages of the society, and so does the misalignment towards the purpose of the strategy. Most of the competitive advantages of a fully connected Sweden is probably already met at an 85 percent reach, and even more at 90 percent. This reverse salient can be seen as undermining the government's and other public authorities' interest to achieve the set goals, if most of the purpose already has been accomplished. In addition to this, as the broadband expansion follows the common process of diffusion - from the centre to the periphery - (Lorentzon, 2010), the last 15 percent are probably the most peripheral connections. The longer and further away, the more expensive is the roll-out, but the most peripheral households and businesses are often the ones with the most gain (Forum, 2018; Swedish Broadband Forum, 2017; Swedish IT and Telecom Industries, 2019; IP-Only, 2019). That the most expensive connections remain, while the most of the government's purpose is already fulfilled, can be a heavy factor stressing the *third strategic area*.

5) Lower demand in rural areas: What controls the market is, in general and by the book, supply and demand (Dornbusch et al., 2008). The government's financial support for rural broadband expansion creates an artificial supply where there otherwise would not be any. But for the government to reach their goals of a fully connected Sweden, the demand also needs to be sufficient. In order for both commercial and non-commercial projects to launch, enough end-users in the area needs to be contracted. Otherwise, the cost per user becomes too high. Despite the support, the households pay a significant fee, and the broadband strategy points out that the customers' willingness to pay needs to be high (Government Offices of Sweden, 2016). The population is in general older in the countryside than in the cities (Swedish Board of Agriculture, 2013), and older people more often perceive the digital world as complicated (Findahl, 2014). The demand for high-speed internet can thus be expected to be lower amongst the older part of the population than amongst the younger, and accordingly as lower in rural areas than in cities. A lower demand for high-speed broadband in rural areas is misaligned with the governmental goals and efforts within the *third strategic area*. This reverse salient of lower demand in rural areas obstructs the progress towards the strategic goals as projects fails to get enough interest to be feasible, leading to delays.

C. The micro level

Analysis of the micro level includes misalignments between local actors and components of the system. Local projects for fibre broadband has no way of standardisation and are surrounded by many different actors. In some cases there are Byanät or municipal authorities driving the expansion, and in some cases commercial companies. The net often needs to cross ground of whose owner is unrelated to the project, where misalignments can arise.

1) Conflicts between infrastructure companies and land owners: IP-Only is a major actor in building and owning fibre broadband in peripheral Sweden (Swedish Post and Telecom Authority, 2019a). The company lays and owns the physical fibre cables of networks. IP-Only has been given much critique for not living up to promises given to the customer[1]. In their own report, they claim that the main reason for the delays are conflicts with private land owners over whose property the fibre needs to cross. According to IP-Only, the processes can take more than a year due to long juridical processes in order to get the right to dig without permission of the land owner (IP-Only, 2019). However, in many cases the digging have been delayed for much longer, and the minister of public administration Shekarabi is worried for the rural population and wants IP-Only to act (Shekarabi, 2019). The conflicts between the land owners and commercial actors are reverse salients on the micro level. By leading to costly delays and even aborted projects, they obstruct the path to fulfilment of the government's goals in the area of the *second and third strategic area*. The delays can further lead to conflicts between the customers affected by the delay, and in some cases the customers withdraw their project involvement. In such sense, the *first strategic area* is obstructed by lacking regulations of how the processes should be conducted. For IP-Only's investments in an area to be profitable, enough households in the area must be contracted (IP-Only, 2019). As customers withdraw from a project, its profitability, and thus also the commercial interest in fulfilling the project, decrease. In that way, the land owner conflicts can strengthen other reverse salients, further delaying the broadband expansion.

[1]For conflicts involving IP-Only, see e.g. (Land, 2019; IP-Only, 2019; SVT, 2019; Uppsala Nya Tidning, 2018)

TABLE I
REVERSE SALIENTS OF THE RURAL BROADBAND EXPANSION
(1) ROLES AND RULES, (2) COST-EFFICIENT EXPANSION, (3) INFRASTRUCTURE AND SERVICES FOR EVERYONE

Level	Reverse salient	Strategic area(s) 1	2	3
Macro	Competition for governmental support			X
	Land permissions	X	X	X
Meso	Ambiguous roles and malfunctioning cooperation	X		
	Misdirected support programmes	X		X
	Undersized support programmes			X
	Undermined public interests			X
	Lower demand in rural areas			X
Micro	Conflicts between infrastructure companies and land owners	X	X	X
	Market protection		X	X

2) Market protection: Another reverse salient, is the market protective actions of the two major commercial actors IP-Only and Telia. When signing with customers, the companies force exclusiveness of the right to build broadband on the premises in question (Forzati et al., 2017; Nilsson, 2019). In order to leave the contract, the customers face considerable fees. This creates a local monopoly, forcing the customers to stick with what they signed up for - even if there are substantial delays or conflicts. Thus, this reverse salient is not only leading to local delays in the expansion, but also decreasing the private actor's incitement to avoid conflicts and to deliver their product before or on time. It can be seen as obstructing both the *second strategic area*, as it inhibits the open market, and the *third strategic area*, as it extensively leads to delays in the nationwide diffusion.

D. Results

The identified reverse salients and which strategic area they have affected are summarised by label in *Table 1*. The tensions regarded in the study was mainly found in the meso level, containing five of the reverse salients, whereas the macro and micro level included two each.

VI. DISCUSSION AND CONCLUSION

The study has, by applying the MLSD framework, identified tensions in different levels of the rural broadband expansion. By analysing how these tensions affect the government's strategic plan for a nationwide broadband reach, the study has contributed to the understanding of the dynamics of the system. Thus, the purpose of the study can be seen as fulfilled. Furthermore, the study has provided an example of how the MLSD framework can be applied to the case of broadband expansion in rural Sweden.

Central in the study has been how tensions regarding the investigated LTS of the Swedish broadband expansion have obstructed the progress of following the governmental broadband strategy. That most of the tensions were observed in the meso level, could be expected, as the governmental involvement in large infrastructures is high. Amongst the analysed reversed salients, most were in the third strategic area. However, this must not mean that this is where most of the tensions exist, as the focus of this study was laid upon the *rural* broadband expansion which is most coupled to the third area. Nevertheless, the results provide evidence of reverse salients affecting all three areas in the government's action plan, on all three levels of the system - i.e. the reverse salients inhibits the governments goals in various ways, on all areas highlighted as strategically important by the government. Beyond this conclusion, a number of interesting aspects were identified, presented in the following paragraphs.

The study analysed each level in isolation, but as have been observed, the three levels are all interconnected, and so are the tensions within. For example, the micro level reverse salient arising from conflicts between land owners and the infrastructure companies is strengthened by the long juridical processes, where the latter is an external factor and thus a reverse salient on the macro level. Another example is how the meso level reverse salient of undermined governmental interests, correlates with the macro level reverse salient of Jordbruksverket hitting the breaks on the broadband support programme, in favour of other programmes.

The government should, according to the strategy, merely ensure well functioning conditions for the market to operate on (Government Offices of Sweden, 2016). While it is positive that actors on all levels have identified the reverse salient of ambiguous roles and malfunctioning cooperation, even more ambiguities and confusion arise when support programs are misdirected and undersized - consequently making the market rely on and put responsibility on the government, while the government put responsibility on the market, highlighting a clear contradiction.

Another aspect observed during the study, is whether the government really prioritise the rural broadband expansion. During the period 2014-2020, the government budgeted 4.25 billion SEK for the broadband support programme, and an additional 650 million between 2020-2022, numbers that can be put in relation to the 700 billion SEK put aside for the road, railway, aviation and shipping infrastructures between 2018-2029, as well as to the estimated extra need of 22 billion to reach the broadband goals set up for 2025 (Government Offices of Sweden, 2018, 2016; Swedish Post and Telecom Authority, 2019d). Not least during the current Corona pandemic, the importance of digitalisation-enabling infrastructure is increased, whereas the usage of transportation infrastructure is decreased. To what extent high-speed broadband can

substitute for the latter, even after the pandemic, is currently being explored as we are forced to speed up the utilisation of digitalisation. Perhaps will we see a slight shift in the focus of financial support.

VII. Suggestions for further studies

No evidence of which strategic area has been the most affected, neither from which of the system levels the tensions arise, was provided by the study. It was outside the scope, but is noted as an interesting approach for further studies.

As the static infrastructure changes, and in some sense becomes more interconnected, the role of concerned public authorities, according to the findings of the study, seem to shift. Take for instance the pinpointed case of how the road and fibre broadband systems have intertwined and where Trafikverket has suddenly become an important part in the fibre broadband expansion puzzle. Analysing how new connections between different infrasystems affect the roles of the authorities managing them, would be an interesting direction for further studies. Will and should these changed dynamics fundamentally change the authorities' purposes and responsibilities? Will perhaps mergers, or institution of new authorities, be necessary?

The origins of data in this study have mainly been public authorities and the reports from private companies, and, unfortunately, suitable sources of the end-users' (the companies and households affected by the delays) perspective have not been found for the study. Continuing research in the area could thus be suggested to further address the client perspective. Other methods for data collections would perhaps be necessary, and a study built on, e.g., client interviews would be highly interesting.

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