Finnish adaptive road management for 2050:Toward a low-impact mobility system

1.0 Introduction

The following research scenario for the Finnish National Road Authority, concerning climate change adaptation measures for road maintenance on the national road network, has been prepared for internal use to assist in the long range planning needs for the Road Authority. Abackcastingscenario was developed which built upon a set of normative assumptions.These normative assumptionsare intended toestablish a pathway for Finnish society to achieve a low-impact mobility system. The scenarios are designed for use internally within the Finnish Transport Agency to assist in long-range planning and strategic investment, explicitly grounded in adaptive management principles of multiple loop learning and innovation.

The original remit was to analyze the projected climate change impacts on the projected needs for road maintenance on Finnish national road network while maintaining existing levels of service. However, in light of the need to radically reduce transport sector GHG emissions in order to keep average global warming under a 2 degree threshold (IPCC, 2007), it was decided to broaden the remit to include both mitigation and adaptation measures across the broad range of transport systems.

Expected main climate effects for Finland in relation to the national road network: 1) Wetter winters with lower snowfall and more rain, 2) increase in freeze/thaw cycles in winter in the southern parts of Finland, 3) higher frequency and severity of storms, 4) hotter summers, leading to melting permafrost in the northern part of Finland, resulting in more frequent buckling of roadways, 5) increases in spring flooding and riparian flooding and 6) coastal sea level rise and erosion (Jaroszweski, Chapman, & Petts, 2010).

Key uncertainties: 1) epistemic uncertainties- regionally down-scaled projected impacts, road usage patterns, road safety data, cost data, CBA data from project evaluation, 2) model uncertainties-structural uncertainties (aerosols, wind, ocean, bio-physical, land use). The AOGCM circulation model resolutions are still coarse, therefore the range and severity of projected regional impacts are also very simplified, 3) qualitative uncertainties- location decision for residential and commercial development, road pattern usage, ethical and cultural norms, consumer behavior, policy response and conflicts, and 4) recognized ignorance/unrecognized ignorance: socio-technological shifts, disruptive events (war, disease, belief shifts,aka. the Four Horsemen of the Apocalypse)

Key drivers with respect to climate change: 1) demographic development (population, household composition, age, etc.), 2) affluence level, 3) energy mix, 4) mobility patterns, technological development, 5) equitable distribution of social goods, ethical dynamics

Background information and knowledge gaps: 1) time scale-what is the consensus view of when are the CC impacts projected to begin to be felt, 2) spatial scale-where are the impacts expected to occur, 3) vulnerability assessments of differential capacity to adapt to CC impacts (both human and non-human), 4) magnitude-what are the magnitudes of impact that are expected to occur, 5) ignorance-what don't we know and are which areas are reducible through better/more knowledge and which are inherently unknowable and 6) range of impacts-what are the upper and lower boundary ranges of the projected impacts.

2.0 Scoping

Problem context: Table 1 below highlights some of the potential key impacts from future climate change in relation to road systems.

Table 1; Jaroszweski, Chapman, Petts (2010)

Table 1
The effects of climate change on transport (based upon Peterson et al., 2008).

Increased numbers of hot days	1. Increased thermal loading on road pavements a. Melting tarmac b. Roadway buckling c. Expansion/buckling of bridges d. Increased numbers of tyre blow-outs 2. Increased railway buckling 3. Increased heat exhaustion of maintenance and operations staff 4. Effects of higher density altitudes on aviation a. Reduced engine combustion efficiency b. Increased runway lengths required
Decreased numbers of cold days	1. Reduced winter maintenance costs for road and rail 2. Improved working conditions for personnel in cold environments 3. Permafrost problems: a. Unable to rely on 'frozen roads' b. Infrastructure problems caused due to settlement when permafrost thaws c. Increased subsidence and landslides on slopes and embankments 4. Positive effects on marine transportation: a. Less de-icing required and freezing fog b. Less icebreaking required c. Potential opening of new sea passages in polar regions
Increased heavy precipitation	1. Road submersion and underpass flooding 2. Increased landslides and undercutting 3. Poor visibility 4. Exceedance of existing 100 year flood
Seasonal changes	1. Longer summers/shorter winters will mean changes in timing of a. Leaf-fall for railways b. Winter maintenance regimes c. Shift in ice/snow belts 2. Reduction in frozen precipitation–significant improvements in road safety
Drought	1. Navigation problems on inland waterways
Sea level change	1. Locations of ports may be inappropriate 2. Other infrastructure–many airports are built 10 m> of sea level 3. Localised problems, e.g. storm surges
Extreme events	1. Increased numbers of tropical storms? 2. Increased lightning effects on aviation No clear projections are available for wind

Intended users: 1) the Finnish Road Agency, 2) the Finnish Transport Administration, 3) the Ministry of Finance, 4) members of parliamentary committee for transportation investment and policy, 5) infrastructure planning and construction companies

Outputs: There are two primary outputs from this scenario exercise. Firstly, we articulated a low-impact mobility and transition pathway for Finland in the year 2050 built upon a series of assumptions and projections using regional and global drivers. Indeed, these drivers of climate change at global scale were derived from a cognitive mapping exercise. The main goals of this low-impact mobility system aims to: 1) lower environmental infrastructure impact, 2) provide equal access to mobility, 3) ensure safety, 4) be adaptive, and 5) support increases in societal well-being (4Es: environment, economy, equity and ethics).

Secondly, a scenario was developed within the normative frame, but rooted in existing conventional regimes, practices and policies found within the Finnish Road Authority. One of the key innovative features of this approach is the integration of a scaled (single/double/triple) helical learning model that embeds adaptive management principles. This creates the potential for the evolution of institutions to respond to changing socio-technical regimes. (Jaroszweski, Chapman, & Petts, 2010)

Finally, a set of robust policy measures and strategies for adaptive management of the road maintenance sector were created with the inherent design logic to be robust over different temporal, spatial and governance scales. The main assessment criteria for road maintenance in relation to climate adaptation that have been identified are: 1) safer roads, 2) better asset management, 3) lower frequency of maintenance, 4) use of lower impact materials, and 5) intelligent roads (ITS).

Temporal scale: The rationale for choosing 2050 as a starting point for the backcast is twofold: 1) 2100 is too far into the future, resulting in high levels of epistemic and ontologic uncertainty (time, values, knowledge, etc.), 2) road transportation investment lifetimes typically encompass 30-40 year spans.

3.0 Scenarios

3.1 Background

Brief: Prior to initiating this research, there has been signed a memorandum of understanding between the Ministry of Finance and the Finnish Transport Administration, outlining the administrative, legal and regulatory framework that will guide transport policy planning and investment toward low-impact, adaptable forms of mobility in Finland. Approved strategies and policies will be incorporated into the long-term strategic investment plan and coordinated with strategic guidance from the EU concerning transport policies and plans. The policy objectives set within relevant EU directives will play an integral part within Finnish long range planning processes, as EU directives allow member states flexibility to implement various measures according to national conditions. An essential requirement has been the buy-in of the relevant stakeholders into the scenario development process, not necessarily the specific normative vision.

3.2 Assumptions and key drivers

Transport planning has recently undergone significant structural reform in Finland, with a new emphasis upon integrated planning and delivery of mobility services. The shift from primary materials extraction to services within the Finnish economy is likely to accelerate in the coming decades.

Assumptions: For the purposes of this exercise, we assumed the A2 SRES scenario as the baseline scenario for global GHG emission. This scenario is at the upper bound of expected GHG emission levels and projects the highest consequent radiative forcing. This will ensure that the range of proposed climate adaptation measures will be stress-tested against the worst of the foreseen possible impacts.

Drivers: Within the backcast, the changes in key climate change drivers that are projected toaffect road maintenance in 2050 include:

1. Decrease in long-term economic growth potential
2. Decrease in demographic expansion combined with ageing distribution of population.
3. Continued urbanization, leading to denser land use and transport networks in the south and depopulation of rural areas. Also, facilitates modal shift for commuting
4. Decreases in Vehicle Kilometers Traveled (VKT), leading to lower overall traffic volumes.
5. Increase in Public-Private Partnerships (PPP) and Private Finance Initiatives (PFI)
6. Long term decline in oil reserves, implying a need to develop non-petroleum sources for road construction and maintenance.
7. Path dependency, meaning that roads will likely continue to exist even if the underlying need for them decreases.
8. Social shifts, personal ownership of cars no longer seen as necessary. Car-sharing becomes part of a suite of mobility options within the collective transportation system.
9. Behavioral shifts, mobility no longer dominant variable in daily life. Focus
10. Rising carbon prices, putting price pressure on carbon-intensive inputs in the road sector, including concrete, asphalt and bitumen.
11. Shorter logistics chains driven by shifts toward service consumption rather than goods consumption, reducing Heavy Goods Vehicle traffic
12. Shift to biological primary resource inputs, reducing the need for mining, metallurgy and other primary resource extraction.

Scenario milestones and objectives

2012 Institutionalized ex-post project evaluation systems and creation of technical niches
2020 Integrated mobility planning and delivery-Finnish Ministry of Mobility

2025 Intelligent Transport Systems fully deployed on the national road networks
2030 Hypercar is the dominant vehicle on the road (lightweight, 100km/l, multi-fuel mix); new long-term investment strategy prioritizing low- or zero-net carbon forms of mobility
2040 Modal shift in logistics chains, especially within heavy industry.

3.3 Backcasting scenario narrative

Low-Impact Mobility Project Evaluation (LIMPE)

Climate change is occurring. Is it natural or anthropogenic? It doesn't matter. Even though the future is inherently uncertain, one certainty is that the future transport system will have to adapt. In 2012, transport planners adopted a pro-active approach to the future, seeking to embrace uncertainty to enable society to move toward a low-impact mobility system. "*What happens tomorrow depends less on prevailing trends and more on individual and collective decisions taken in the face of these trends*" (Godet, 2005, p. 9). The creation of adaptive management capacity is a fundamental requirement in order to establish such a trajectory.

In order to realize this future, a proto-Ministry of Mobility was created in mid-2012 using existing institutional structures but premised on a different conception of a future transport regime. By 2015, political support for the creation of a formal Ministry of Mobility was confirmed by Parliamentary approval. Key to the establishment of achieving the future goals of low-impact mobility, namely: 1) low environmental infrastructure impact, 2) equal access to mobility, 3) safe, 4) adaptive, and 5) supportive of increases in societal well being (4Es: environment, economy, equity and ethics) was the institutionalization of an integrated adaptive management within planning and policy cycles with integrated helical learning cycles. Meanwhile, in order to deal with the increasing severity and frequency of winter rainfall (which once was snow) has led to large increases in funding for experimental road surfaces; the embryone of a new type of biological road construction system.

Due to fossil fuel depletion and consequent doubling of oil prices, the imposition of a global carbon tax, and need for equal access to mobility, lightweight, alternative fuel vehicles became the dominant mode of personal transport in Finland.

3.4 Road maintenance scenarios:

1) Climate skeptic (Reactive/Engineered). Main strategies include no long term planning that includes climate change impacts, research and development focused on continued investment and expansion of the road network with no major technical alterations in personal mobility, continued provision of standard levels of service and capacity expansion goals. No significant focus on creating more adaptive management processes within the Road Authority.

Pros: few institutional/cultural changes required, cost savings from avoiding new infrastructure to accommodate CC impacts.
Cons: potentially significant exposure to higher immediate and distributed costs in case CC impacts occur, long lead times to gain the necessary knowledge to respond, leading to significant policy lags, exposure to political risk if the government moves to implement significant CO2 reduction targets that generate lower overall traffic volumes.

2) Reactive/Autonomous. Main strategies include some inclusion of possible impacts of CC, mainly pertaining to flooding and storm drainage, increasing elements of passive storm water management, porous road surfaces, occasional evaluation of potential vulnerabilities within the road network, but no significant investment in new types of road surfaces or realignments based upon identified weaknesses within the network.

3) Proactive/Engineered. Main strategies include significant investment in creating more adaptive infrastructure, using full life cycle costing of road maintenance/construction methods, relying on traditional engineering approaches using resource intensive materials to build resistance to climate change impacts. Periodic reviews of network vulnerabilities and

4.0 Reflections on the scenario

Critical assumptions

Assume bounded rationality, cultural biases (mobility as human right, anthropocentrism), institutional and public policy acceptance

Positioning of the scenarios in the planning process

Target group: long term strategic planning teams in the ministerial and sub-ministerial level within the Finnish Transport Administration with commitment from Ministry of Finance and the Finnish Transport Administration. Legal basis for evaluation of strategic mobility planning,

Credibility and impact evaluation

To ensure the credibility of the scenarios systematic evaluation of measures, goals, indicators and strategies will be necessary. Using a fact-based frame for the initial conditions of the scenario, with a decadal evaluation of the drivers and indicators, it is recommended that planners and policy focuson targeted indicators.

Indeed, the normativity of the scenariosmay be undermined from many vantage points and ‘cities of legitimacy’ (for example, primary extractive industries, commuters, rural/urban citizens, logistics companies, effected ministries).