Leena Parkkila • Piia Ailinpieti • Marko Lehtosaari

B

Railway Operations, Maintenance and Repair Practices in Northern Finland

Turnout as a Critical Asset

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1. Introduction

This publication 'Railway Operations, Maintenance and Repair Practices in Northern Finland' is a mapping report. The project is called KO 2011 Arctic Railway Infrastructure in Kolarctic II – ARINKA. The project is financed through the Kolarctic CBC 2014 – 2020 Programme with co-financing by the EU, Finland, Norway, the Russian Federation and Sweden. The main objective of the ARINKA II project is to increase railway capacity in the Kolarctic region and to contribute to making railway network, operations and maintenance smarter, more sustainable and climate-proof.

The aim of the project is to develop a cross-border railway research and development collaboration between the parties from different countries in the Kolarctic region. Another aim is to exchange railway technical know-how and best-practice solutions and to make the Kolarctic railway more reliable through robust infrastructure solutions, to obtain more cost-effective maintenance and repair operations, and to develop railway infrastructure monitoring and measurements through advanced sensor technology solutions.

The project is divided into the following five work packages:

WP 1 – Management & Coordination
WP 2 – Competence Building and Cross-border Experience Transfer
WP 3 – Railway Infrastructure (Track Components & Sub Structure)
WP 4 – Railway Operation, Maintenance and Repair Practices
WP 5 – Railway Monitoring and Sensor Technology

This technical report is part of the work package 4: Railway Operations, Maintenance and Repair practices. The report provides an overview of railway operations, maintenance and repair practices in northern Finland. This report presents also a description of a turnout as a critical asset and related maintenance.

The gradually increasing demand for transport capacity of both freight and passenger loads involve increasing wear of the railway track infrastructure. Due to the situation the Kolarctic region provides extremely challenging conditions for railway operation and maintenance.

This publication provides a brief overview of the railway operations, maintenance and repair practices in northern Finland. The safety and availability of the railway infrastructure are an essential part of maintenance. The maintenance level of the track is determined by the need of traffic, track superstructure and maximum speed. The Finnish Transport Infrastructure Agency (FTIA) acts as the infrastructure manager of the state-owned railway network and it is the responsible organization for maintenance. Maintenance follows the rules of the safety instructions in track maintenance, 'Radanpidon turvallisuusohjeet (TURO)' and the Railway Engineering Guidelines (RATO) which contain the technical instructions for railway tracks. RATO includes basic information on development, inspection and maintenance of a track and its equipment.

The ARINKA project is involved in SINTEF Narvik, Luleå University of Technology, Lapland University of Applied Sciences, Emperor Alexander I, St. Petersburg State Transport University and Kola Science Center of the Russian Academy of Sciences. The project is also involved in the Railway Companies in each partner country Bane NOR, Trafikverket, Finnish Transport Infrastructure Agency (FTIA) and October Railway.

2. General Description of the Railway Maintenance Organization

In Finland railway infrastructure is owned by the state. The Finnish Transport Infrastructure Agency (FTIA) operates in the administrative branch of the Ministry of Transport and Communications. The FTIA is the Finnish railway infrastructure manager of the national railway network. The FTIA is also responsible for the maintenance and development of the Finnish transport infrastructure. (Finnish Transport Agency 2019.)

The agencies and companies in the administrative sector of the Ministry of Transport and Communications are shown in the figure 1. In the figure the ownership and steering relationships of the different agencies and companies can be seen. The Agency's activities are aimed at maintaining the operating condition of the rail network in order to ensure its safe and efficient use. FTIA purchases construction and maintenance work related to the infrastructure property as well as regional property management services from private sector service providers. (Finnish Transport Agency 2019.)

The Finnish Transport and Communications Agency (Traficom) is the responsible authority for permits, licensing, registrations and approvals. They promote traffic safety and the smooth functioning of the transport system. They also ensure that everyone in Finland has access to high-quality and secure communications connections and services. (Finnish Transport and Communications Agency Traficom 2019.) Traficom is a central government agency that operates under the administrative branch of the Ministry of Transport and Communications (Finnish Transport Agency 2019).

The Finnish Rail Regulatory Body monitors the competitive situation of the rail market. It ensures the fair and non-discriminatory treatment of all operators in the railway sector. The regulatory body operates within the Traficom. (Finnish Rail Regulatory Body 2019.)

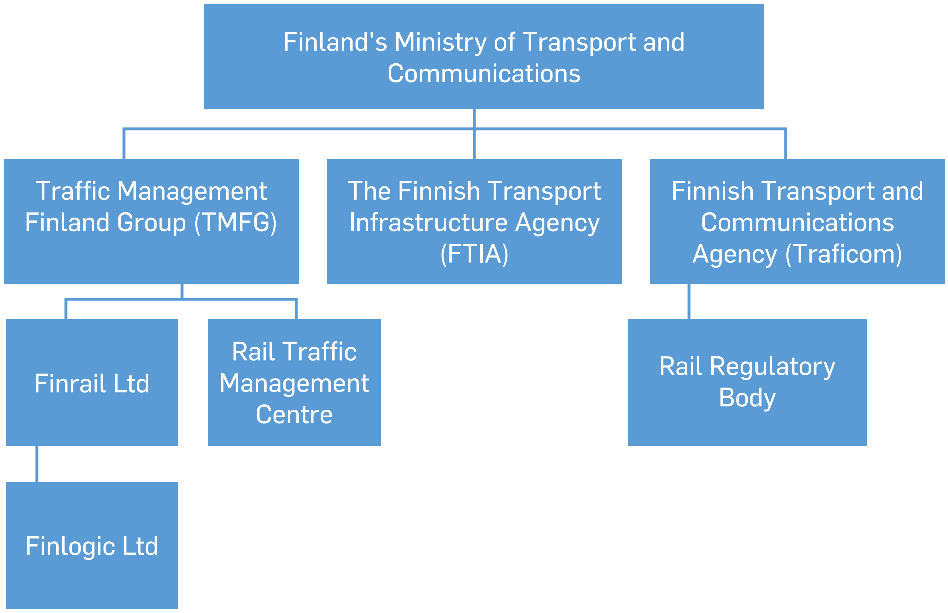

Figure 1. Ownership and steering relationships (Finnish Transport Agency 2019; modified by Parkkila.)

Traffic Management Finland Group (TMFG) provides and develops traffic control and management services for all modes of transport. TMFG ensures traffic safety and fluency in a responsible manner around the clock, every day of the year. (Traffic Management Finland 2019d.) Finrail Ltd is part of the Traffic Management Finland Group. Finrail Ltd provides services including the traffic control and safety of the railways, traffic planning, and operating centre operations and also services related to the passenger information services to rail travel. (Traffic Management Finland 2019a.)

Finrail Ltd is responsible for the safe and smooth travel of more than 500,000 trains and 80 million rail passengers on an annual basis. The FTIA purchases traffic control, passenger information and traffic planning services from Finrail Ltd. Finlogic Ltd is a subsidiary of Finrail Ltd. Traficom also purchases the operating centre services for the electric track from Finlogic Ltd. (Traffic Management Finland 2019b.)

The Rail Traffic Management Centre monitors traffic on the railway network. The task is to ensure the smooth flow of traffic on the railway network. The Rail Traffic Management Centre is part of TMFG. Finrail's Rail Traffic Management Centre is responsible for the national overall management of rail traffic. (VR Group 2019c; Traffic Management Finland 2019c.)

The Finnish railway network is divided into twelve track and signalling system maintenance areas. The Finnish railway network is divided into 4 administrative districts: southern, eastern, western and northern Finland, which are in turn divided into 12 maintenance areas for track and signals (see figure 2). Each district is run by a district manager. The district managers have their own budgets and are responsible for overseeing maintenance and construction work, licensing of infrastructure management, preparation of investment contracts, land use issues and preparation of tenders for work. (Väylä 2019d, 39; Väylä 2019b.)

The maintenance service providers operate in accordance with the maintenance area contract and the guidelines of the FTIA (including the RATO instruction set), which are part of the contract package. FTIA monitors compliance with the agreement at separate contract monitoring meetings. (Väylä 2019d, 39.)

Figure 2. Maintenance areas and administrative districts of FTIA (Liikennevirasto, 2017.)

Southern, eastern, western and northern Finland (track management areas) administrative districts are divided into two or more maintenance areas, the maintenance of whose periodically goes through a competitive tendering process. Several companies carry out maintenance on the Finnish rail network. (Liikennevirasto 2018c.)

FTIA procures maintenance services through competitive bidding. As a rule, five-year basic maintenance contracts, with an option of two additional years, are entered for these twelve maintenance areas. These contracts include also winter maintenance (Väylä 2018c). Maintenance is procured for:

- track superstructure and signalling and control equipment
- overhead line and high voltage systems
- communication systems
- station and platform areas
- signalling and control buildings HVAC (heating, water and air conditioning)
- special systems (wayside inspection equipment). (Väylä 2018a.)

The largest actors in the track maintenance and construction were NRC Group Finland Oy and Destia in 2019. NRC Group Finland Oy is the largest rail infrastructure company in the Nordic countries. (Väylä 2019c, 11.) At the beginning of 2019, Destia were responsible for 50 % of Finland's 12 railway network maintenance areas. Destia maintenance areas are 3, 5, 6, 8, 9, 11 and 12. Destia's railway network services cover the entire life cycle of the track maintenance throughout Finland. Destia is in charge of the maintenance of northern Finland's track areas 9: Ostrobothnian railway line (yellow) and Area 12: (Oulu) - Lapland (blue), since 1st of January 2019, see figure 2. (Destia 2019.) Welado Ltd. is responsible for northern Finland administrative district track maintenance supervision (Väylä 2019a).

Main railway company is VR Group. The VR Group primarily operates in Finland, but it also has operations abroad, especially in Russia. It employs 6,300 professionals, with annual net sales of approximately one billion euros. The purpose of the VR Group's operations is to transport people and freight using customer-oriented solutions which are smooth, safe and environmentally friendly. (VR Group 2019e.)

In addition, Fenniarail Ltd operates in northern Finland which is a privately held freight rail operator. They provide industry the transportation of raw materials, refined goods and end products on the Finnish rail network. (Fenniarail 2020.) They do not run trains every week, but they do run on a regular schedule (Lane 2020).

The railway system consists of track infrastructure and rolling stock, and all of its operation. The characteristics of the Finnish network that differ from those of other European rail networks are: broad gauge (1524 mm), large proportion of single-track rail lines on the rail network (over 90 %) and combined use of almost all tracks for both passenger and freight services. In Finland there are three types of heavy electric locomotives (Sr1, Sr2 and Sr3) and four diesel locomotive types (Dv12, Dr14, Dr16 and Dr18). Both are used in non-electrified sections of track and railway yard shunting. (VR Transpoint 2019; Lane 2020.)

VR Group's business operations serve consumers and corporate customers. VR Group's passenger services offer public transport services in long-distance and commuter traffic with trains and buses. VR Transpoint offers logistics services in rail and road logistics. VR FleetCare (formerly VR Maintenance Oy) is a subsidiary of the Finnish rail operator VR Group. VR FleetCare maintains, repairs and manufactures rolling stock and provides expert services related to rolling stock technology. They having also maintenance lifecycle services. VR Group's property unit takes care of property development and rental operations. VR Group's businesses operate mainly on the Finnish and Russian markets. The business operations are supported by train operations and corporate services. (VR Group 2019a; VR Group 2019d; VR Group 2019b.)

3. Description of the Turnout as a Critical Asset

The Finnish rail network has about 5,500 turnouts whose safety and reliability are prerequisites for efficient traffic. The turnout is subject to a large number of technical requirements. Turnouts are always a major investment. Life-cycle economics of turnouts set requirements for long life-time and minimization of maintenance needs. (Varis 2017.)

In Finland, turnouts are divided into two categories: main line track turnouts and secondary tracks turnouts. A main line track turnout is a turnout which has a rail that is connected to the main line track. A secondary track and siding turnout is a turnout where none of the rails is connected to the main line track. A turnout is a crossing point at the railway track where traffic can be routed from one set of rails to another. There are four different turnout models in use in Finland: (Liikennevirasto 2016b.)

- single turnouts
- double turnouts
- single and double junction turnouts
- railway junction (Kemppainen 2018, 3.)

Figure 3 shows the main parts of single turnouts, which can be divided into three sections: switch panel, closure panel and crossing panel. Furthermore, the turnout contains point machine(s) and check rail sections. This division is repeated when a new turnout is installed, all turnouts are delivered and installed in three elements. (Kemppainen 2018, 4.) The turnout types available in Finland are 60E1 and 54E1 (Liikennevirasto 2012). The turnout unit is divided into the following parts below:

A = stock rails
B = switch (point) blades
C = running rails
D = check rails (guard rails)
E = wing rails
F = point rails
M = mathematical centre of the turnout
H = mathematical centre of the crossing
α = angle of the turnout (normally it is expressed as a crossing ratio e.g. 1:9)

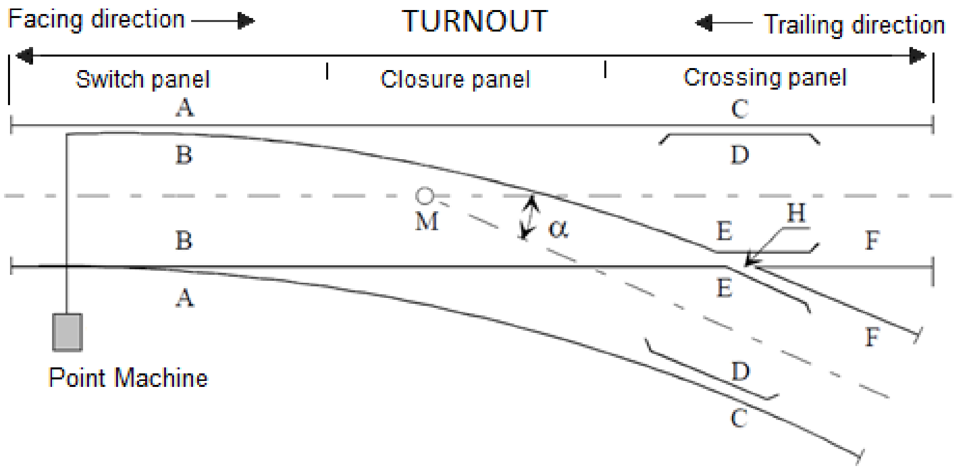

Figure 3. Turnout parts (Liikennevirasto 2012 modified by Seppälä 2020 and Parkkila L.)

According to the traffic register maintained by the Finnish Transport Agency, in 2016 there were 5,315 state-owned railway network turnouts and approximately 2,000 private-owned industrial railway yard turnouts in Finland. Approximately 92 % of the turnouts in the state network are single turnouts and 83.8 % of the tracks are with either 54E1 or 60E1 track profiles. 73.6 % of the available turnouts were installed between 1995 and 2016. (Kemppainen 2018, 11.) Table 1 below summarizes the number of the turnouts in the different regions of Finnish Lapland.

Table 1. Quantity of turnouts in maintenance areas 9 and 12 in 2016
(Kemppainen, 2018; modified by Ailinpieti)

	Single turnouts	**Double turnouts**	**Single and double junction turnouts**	**Railway junction**
AREA 9	304	5	12	2
AREA 12	247	5	8	1

The turnouts are of different lengths and the turnout type is determined by the traffic needs. The speed used on the track determines the type of the turnout used. The maximum permitted speed on a non-standard track is 40 km/h for short turnouts. For long turnouts the maximum speed is 60 - 160 km/h. (Liikennevirasto 2012, 22.)

The switch point machines and safety equipment used in Finland are described below. The switch point machines are: Siemens Bsg 9; models 783, 546 and 691, Siemens S700, Alcatel SEL L710H and LM Eriksson JEA 722170. The end position detectors which are mounted next on the track on existing railway sleepers in use are Siemens ELP 319, Alcatel SEL and Peverk D500. E.g. the Peverk D500 inspection and maintenance interval is every six months. (Peverk 2016.)

Point locks monitors the position of a switch and assist the switching point machine. The point lock models in use are Railex 102, 202, 122 and Jousivippe (figure 4). Other safety devices of switching point machines are

- switch connecting rods
- backup lock
- wedge lock
- joint lock
- switch point lock (Liikennevirasto 2016a.)

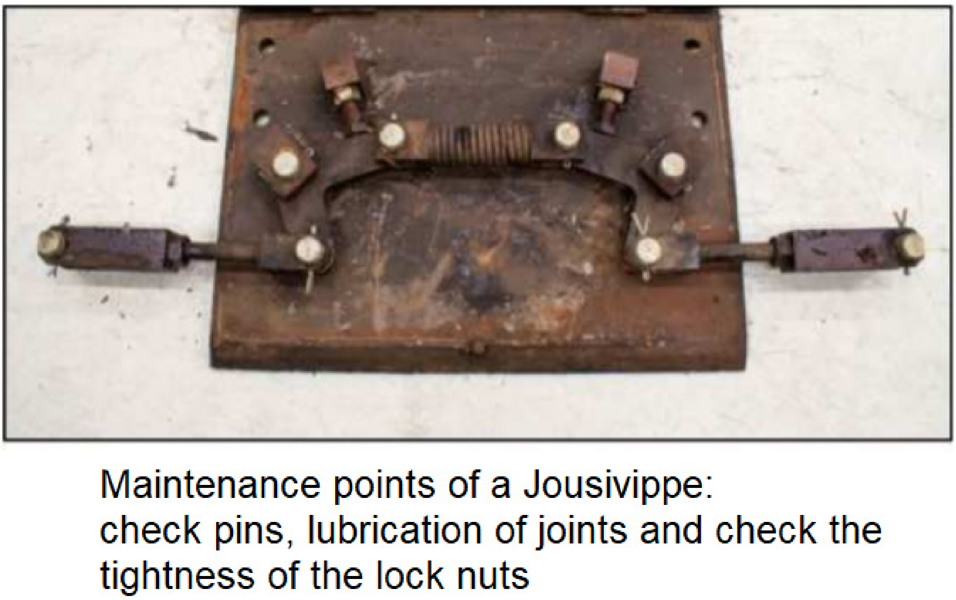

Figure 4. Jousivippe point lock (Liikennevirasto 2016a.)

The maintenance of the switching point machine will be done according to the FTIA's handbook – Turnout maintenance instructions https://julkaisut.vayla.fi/pdf8/lo_2016-23_vaihdekasikirja_web.pdf. This handbook includes essential maintenance instructions, which are primarily intended for the maintenance contractor's personnel who are responsible for the turnout service, adjustments and other turnout maintenance related work. (Liikennevirasto 2016a.)

4. Maintenance Strategies

The Finnish railway network is constantly open to traffic. This requires also constant maintenance. Maintenance services include inspections, periodic servicing and repairs, as well as snow removal in winter. To ensure proper operating conditions, the various parts of the railway network are maintained throughout their lifecycle. Maintenance is conducted on superstructures (rails, sleepers, turnouts and ballast), substructures, level crossings, bridges, traffic control and safety equipment, electrification and power current equipment, and land areas. (Väylä 2018b.)

The rules and regulations relating to the safety of rail transport set a high standard for the functionality and condition of the rail track infrastructure (Äijö & Virtala 2011, 9). The Finnish Transport Agency has provided comprehensive guidelines for track work and safety compliance. The Finnish Rail Agency's 'Ratatekniset ohjeet' (RATO) consists of 21 sections, which contain requirements and guidelines for different railway system entities. The 21 sections of the RATOs are listed in 'Ratatekniset ohjeet (RATO) osa 1 Yleiset perusteet' (Railway Engineering Guidelines (RATO) Section 1 General instructions), which can be found at: https://julkaisut.vayla.fi/pdf8/lo_2018-31_rato1_web.pdf. (Liikennevirasto, 2018b, 13.) Here are some guidelines for safety:

- 'Rautatietoimintojen turvallisuusjohtamisjärjestelmä, Käsikirja' (2019), www-address: https://julkaisut.vayla.fi/pdf8/rtjj_kasikirja_web.pdf. (Väylä 2019d)
- 'Radanpidon turvallisuusohjeet (TURO)' (2018), Safety instructions in track maintenance (TURO) (2018) www-address: https://julkaisut.vayla.fi/pdf8/lo_2018-07_turo_web.pdf. (Liikennevirasto 2018a)
- 'Turvallisuusmenettelyjen käsikirja rautatietoiminnoissa', (2018), www-address: https://julkaisut.vayla.fi/pdf8/ohje_2018_turvallisuusmenettelyjen_kasikirja_web.pdf (Liikennevirasto 2018d.)

The track service providers act as safety coordinators in their hosting area / administrative district. The Finnish Transport Infrastructure Agency's maintenance manager nominates the safety coordinators. The role of the Safety Coordinator is described in the track management agreements. The Security Coordinator is responsible for the developer / client's safety-related tasks during the maintenance project. (Liikennevirasto 2018d, 22.)

The aging of the track, the increased traffic speeds and the heavy axle loads of freight traffic cause uneven wear to the existing railway network and, above all, to the track structure. This results in higher maintenance costs and over the years, repair debt will only increase. According to a 2011 study, the overhaul debt for track superstructure is estimated at about € 500 million and the total at around € 1,000 million. A maintenance technician inspects and reports the condition of the superstructure. The reports act as a tool for a condition evaluation of the superstructure life cycle. (Kalliokoski, Junes, Kansoinen & Eerikäinen 2012, 24; Hyvärinen 2013, 42; Äijö & Virtala 2011, 11.)

According to Poussu (2014), the strategic goal of track management is to ensure the functionality and structural condition of the railway track network. The goal is guided by traffic service levels and prioritised customer needs. The maintenance department and the track maintenance unit describe their activities in the action plans. The railway track maintenance strategy has not been specifically developed and the focus is on maintaining the existing railway track network. The aim is to make target investments as precisely as possible. (Poussu 2014, 37, 39.)

According to the study by Kalliokoski and partners (2012), the track classification should serve the planning and guidance of maintenance on a strategic level. Service level classifications for passenger and freight transport are used to monitor the achievement of budget targets, but neither is well established for use in maintenance planning and management. (Kalliokoski 2012, 24, 50.)

FUNCTIONAL CLASSIFICATION OF THE RAILWAY INFRASTRUCTURE

The Finnish railway network is functionally divided into a main railway network, i.e. high-speed passenger and heavy freight railway track lines, and the rest of the network, i.e. other lines of national importance and other lines (figure 5). (Liikennevirasto 2019a; Kalliokoski 2012.)

There are different criteria for designing a railway infrastructure asset and determining the level of service. Such classification criteria are functional, service level and technical classifications (see table 2). The functional classification depends on the importance of the railway track and its position in the railway track network. The functional classification is based on the use of the railway track line; passenger lane, freight lane or both. The technical classification of the infrastructure is related to the maintenance level specifications. The rating determines the level of maintenance on the railway track. Technical classifications are, for example, those related to traffic volumes or the structure of a railway infrastructure and generally serve as a basis for the geometry and structure of the railway infrastructure. (Äijö & Virtala, 2011, 16-17; Kalliokoski 2012, 11-12.)

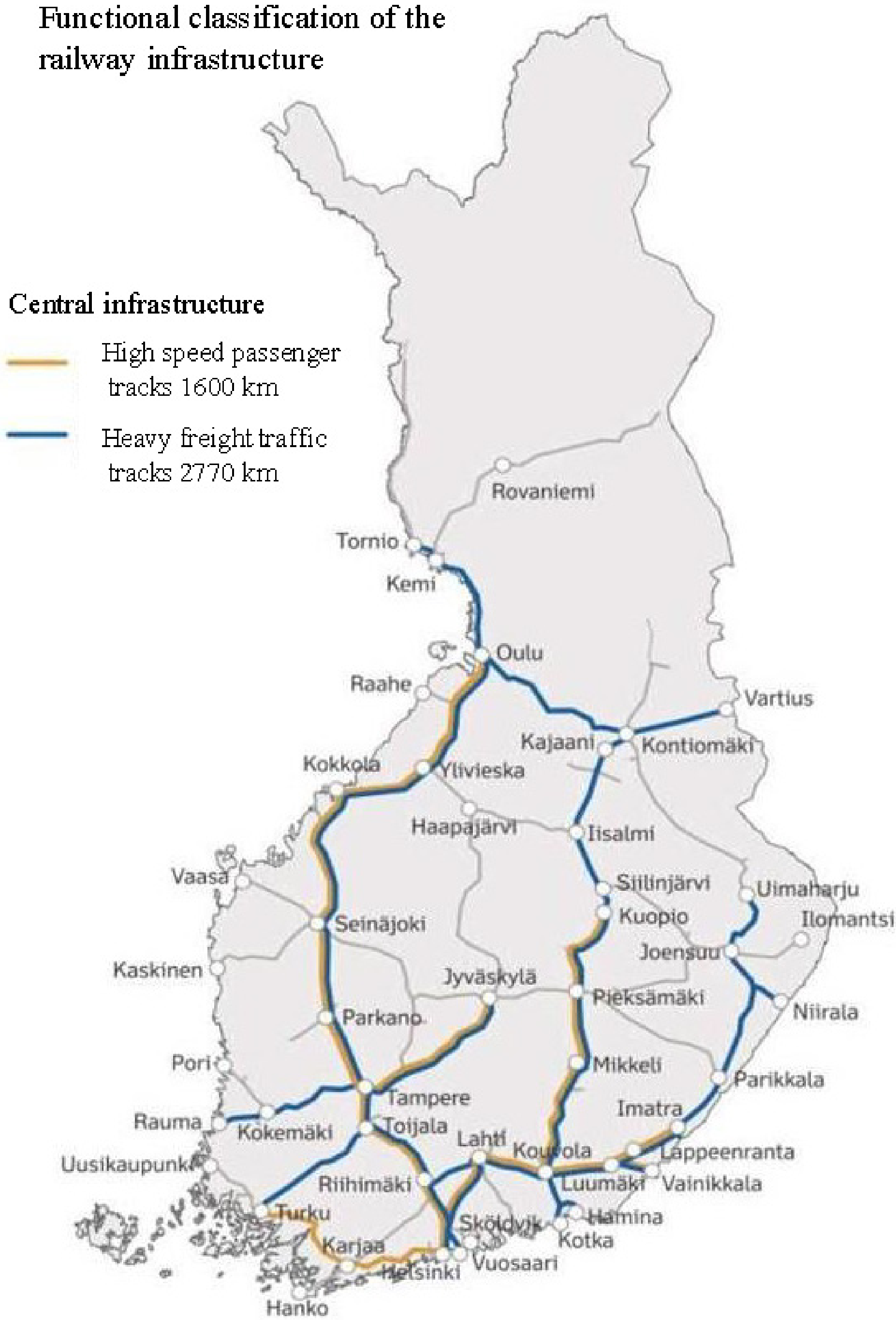

Figure 5. Functional classification of the railway infrastructure (Liikennevirasto 2019a.)

Table 2. Tracks categories criterion (Kalliokoski 2012, 11.)

Grouping by criterion	Tracks
Functional categories / classification	Passenger traffic Freight traffic
Service level	Categories / classification of passenger traffic Passenger traffic (H1–H6) Freight traffic categories (T1–T6)
Technical categories / classification	Maintenance level

RAILWAY NETWORK SERVICE LEVEL

There is a passenger traffic service level classification for the railways (H1 to H5) based on the maximum speed of a railway section and a service level classification for freight services (T1 to T4) based on the maximum allowed axle load. Both are used to monitor the achievement of budget goals, but neither is well established for use in maintenance planning and management, see table 3. (Kalliokoski 2012, 24.)

Table 3. Railway network service levels (accepted speed and axle load) (Äijö & Virtala 2011, 17.)

Service level category / classification (passenger)	Passenger traffic	Service level category / classification (freight)	Freight traffic
H1	Speed over 140 km/h	T1	25 tn and 60-100 km/h
H2	Speed over 140 km/h	T2	22.5 tn and 100 km/h
H3	Speed over 140 km/h	T3	22.5 tn and 50-80 km/h
H4	Speed over 140 km/h	T4	20 tn and 40 km/h
H5	No regular passenger traffic		

In passenger transport, the service level of the railway is defined by the traffic speed. The main service levels are H1, over 140 km/h and H2, 130-140 km/h. All major passenger railway line sections fall into categories H1 and H2 and their total length in 2010 was approximately 2,550 km. The largest passenger flows in Finland are between Helsinki and Turku, Helsinki and Oulu, and Helsinki and Kouvola. The train density of passenger trains on these lines is also high. (Kalliokoski 2012, 26-27; Äijö & Virtala 2011, 16-17.)

In freight transport, the service level of the railway line is based on the maximum allowed axle load, the main service levels being T1, which allows 25 t axle load at 60-100 km/h and T2, which allows 25 t axle load at 100 km/h, see table 3. Almost all major freight railway line sections fall within the categories T1 and T2 and have a total length of approximately 3,800 km. (Kalliokoski 2012, 28.)

Maintaining the current level of service in the railway track network is mainly achieved through maintenance and replacement investments. The development of the railway track network is aimed at raising the service level of the railway track network. The aging of the railway track network is one of the major challenges for the track management, which will require significant replacement investments. (Ratahallintokeskus 2001, 34-39.)

MAINTENANCE LEVELS OF THE RAILWAY TRACK

The maintenance levels of the track are determined according to the need of traffic, superstructure of track and maximum speed. Traffic needs are based on the annual gross tonnage transported and the volume of passenger traffic. The quality of the track superstructure is considered in terms of the support layer, the rail profile and the track length. Within a track section the level of maintenance may vary locally from the track base level due to lower speed limits, due to small radii of curvature, temporary site construction, bypass track, ground features, etc. These deviations from the overall maintenance level of the track line section will be determined separately by the FTIA. (Ratahallintokeskus 2006.)

Maintenance levels 1AA ... 3 apply to main line tracks and maintenance levels 4 ... 6 apply to both to main line tracks and to secondary tracks and sidings. During the inspections of the secondary tracks and sidings done with the inspection wagon, neither loading dock rails nor stabling rails will be inspected unless specifically agreed upon with the FTIA. (Ratahallintokeskus 2006.)

The maintenance levels of the main line track lines are shown in the figure 6. The maintenance levels are the basis for the maintenance of the track lines. The levels are determined by the importance of the traffic and the composition of the traffic. For example, high-speed passenger traffic places special demands on maintenance performance. (Liikennevirasto 2018c, 53.)

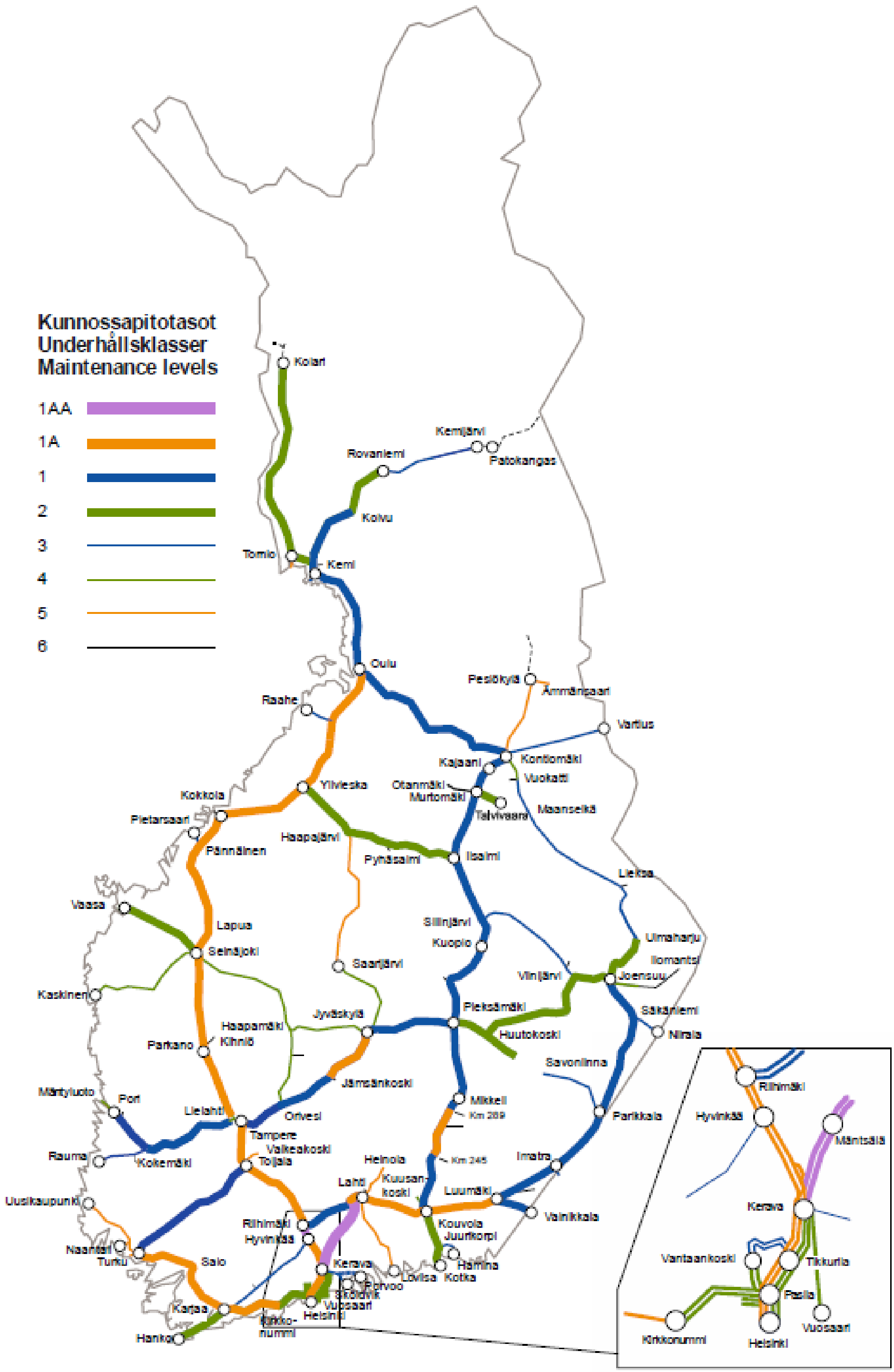

Figure 6. Maintenance levels in the Finnish railway network (Liikennevirasto 2019b.)

Main line tracks and secondary tracks and sidings maintenance levels are shown in table 4. Northern Finland Destia's track maintenance area 9 is Ostrobothnian Line (Figure 2) and its maintenance levels of tracks and turnouts are 1A and 1, see table 4 (yellow line). Track area 12: (Oulu) - Lapland and its maintenance levels of tracks and turnouts are 1 and 2, see table 4 (red line).

Table 4. Main line track and secondary tracks and sidings maintenance levels (Ratahallintokeskus 2006, 17.)

Maintenance level	**Maximum speed, V_{max} [km/h], equivalent axle load P [kN] [1)2)], tracks**	**Rail profile (at least)**	**Sleepers (at least)**	**Ballast (at least)**
1AA	V_{max} ≤ 220, P ≤ 185	60E1	Concrete	Railway ballast
1A	V_{max} ≤ 200, P ≤ 185	54E1	Concrete 1987 or newer	Railway ballast
	V_{max} ≤ 180, P ≤ 185	54E1	Concrete 1986 or newer	Railway ballast
	V_{max} ≤ 160, P ≤ 185	54E1	Concrete/ Wooden	Railway ballast
	Maximum allowed speed 160 track change points	60E1	Concrete	Railway ballast
1	V ≤ 140, P ≤ 185	54E1	Concrete/ Wooden	Railway ballast
	Maximum allowed speed 140 track change points			
2	V ≤ 120	54E1	Concrete/ Wooden	Railway ballast
	Maximum allowed speed 110 track change points			
3	V ≤ 110	K43	Wooden/ Concrete	Railway ballast
4	70 < V ≤100 main line tracks	K43	Wooden/ Concrete	Gravel
	70 < V ≤100 secondary tracks and sidings			
	Maximum allowed speed 80 track change points			
5	50 < V ≤ 70 main line tracks	K30	Wooden	Gravel
	50 < V ≤ 70 secondary tracks and sidings			
	Maximum allowed speed 35 track change points			
6	V ≤ 50 main line tracks	K30	Wooden	Gravel
	V ≤ 50 secondary tracks and sidings			
	Loading and standing tracks			

Track maintenance is carried out according to a specific annual plan, see figure 7. Significant savings in the life cycle costs of railway track management can be achieved by timely and correct maintenance and efficient procurement processes.

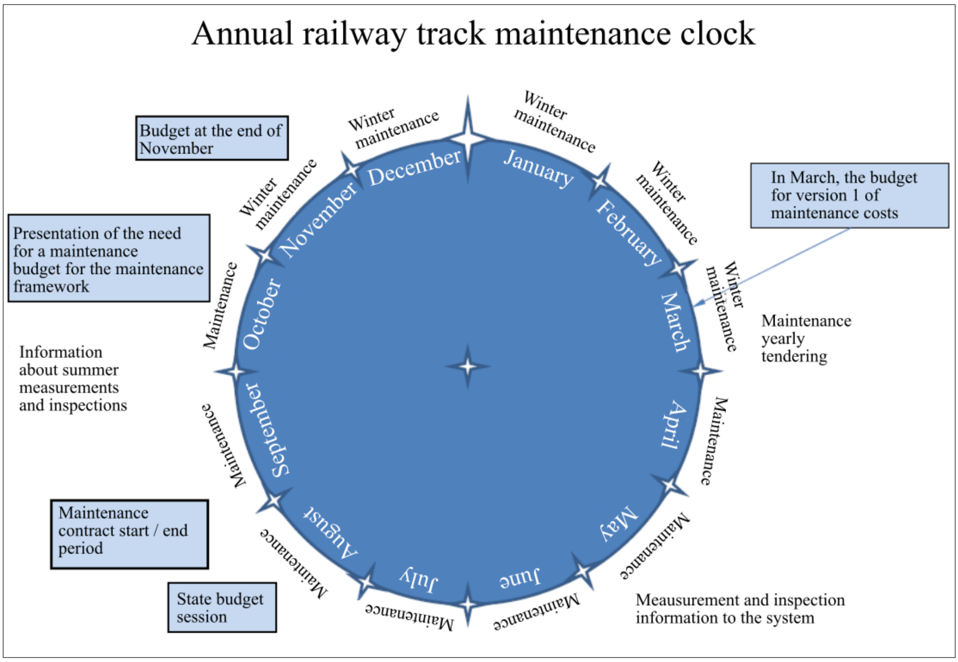

Figure 7. Annual railway track maintenance clock (Kalliokoski 2012.)

Figure 7 is suggestive because of the variety of railway track types and methods, timing and maintenance terms. However, it is important to note that maintenance is an ongoing process that continuously gathers information on the state of the network and on planning and acquiring maintenance operations. (Kalliokoski 2012.)

RAILWAY WORK PREPLANNING

The traffic capacity for the planned track work should be reserved from the traffic planner, by drafting a preliminary plan and delivering it to the traffic planner for approval. The preliminary plan for the planned track work will be done in the JETI system and the traffic planner will issue a notification into the JETI system. (Liikennevirasto 2018a, 56.)

The preliminary plan shall be prepared at least seven days before the scheduled railway track work. In other cases, a maintenance worker must contact the traffic planner. Any work that requires a power shutdown should be preceded by a preliminary plan before the power shutdown request. For railway works, which is requiring transport arrangements (changes in timetables, substitute transport), must be in contact with the traffic planning:

- a maintenance work, at least 2 months before
- at least three months before construction work
- at least 4 months before the commencement of work, in the case of work affecting passenger traffic between Finland and Russia.
  (Liikennevirasto 2018a, 56.)

4.1 Corrective Maintenance

Corrective maintenance is performed as needed by the maintenance contractor. The service center (Finrail Ltd.) makes a service alarm to the traffic control, based e.g. on the observations by the train drivers. For example, if the traffic control cannot turn the switch, Finrail's operator will alert the maintenance contractor. The maintenance contractor will repair the fault and report the work to the computerised maintenance management system.

Corrective maintenance activities mainly focus on turnouts and the various safety device system components, but also on other superstructures such as rails. Corrective maintenance is done in the form of immediate maintenance and delayed maintenance, always aiming at ensuring the smooth flow of traffic and making corrective actions when the traffic permits. Corrective maintenance is to be avoided, because almost always a failure causes train service delays.

4.2 Preventive Maintenance

Turnout maintenance is primarily preventive maintenance. The basic maintenance is based on the demands of technical requirements, availability and traffic safety. More detailed information on the basic turnout maintenance work is provided in the Väylä's RATO Guide 14 "Inspection and maintenance of the Turnouts". (Liikennevirasto 2016b; Vahtera 2019.)

Basic maintenance of turnout includes:

- maintenance inspection
- maintenance of turnout geometry
- maintenance of switch blade parts
- maintenance of turnout sleepers
- maintenance of fastening parts
- maintenance of point machines and locks
- maintenance of ballast beds
- lubrication, cleaning and washing of turnouts
- winter maintenance (Liikennevirasto 2016b.)

The special maintenance of the switch unit includes i.a. the replacement of the switch unit, switch element or switch blade parts, and switch point heating. In addition, the service technician must carry out a separate maintenance inspection before starting work. The results of the mechanical track inspection shall be considered when planning the maintenance of the turnouts. More detailed work on the turnout maintenance is given in the Finnish Rail Administration's RATO Guide 14 "Inspection and maintenance of the turnouts". (Liikennevirasto 2016b.) The inspection of turnouts is described in chapter 4.3.1 of this document.

The geometry of the turnout is assessed yearly with the "Emma" track inspection wagon. Track inspections shall be carried out according to a schedule in accordance with the maintenance levels of the track. Emma records all errors in geometry in its database. This gives the technician the best knowledge of geometry errors. Turnout geometry should also be visually inspected. (Kosonen 2011, 44.)

The maintenance of the steel parts of the turnout unit means the maintenance of the set of switch point area, crossing, check rails and closure rails (Vahtera 2019).

The maintenance of turnout sleepers is also part of the basic turnout maintenance. In the case of continuous rail (jointless track) main line track turnout, the number of defective turnout sleepers shall not exceed 5 %. For other main and side turnouts the percentage shall not exceed 10 %. The secondary tracks and sidings may have 20 % of poorly conditioned turnout sleepers. Two poor condition sleepers cannot exist consecutively in one turnout. Also, the turnout sleepers must not be in poor condition. (Vahtera 2019.)

The maintenance work on the fasteners involves checking the condition and tightness of the fasteners on the turnout unit. Bolted joints and loose screws are fastened and damaged spring rings and springs are replaced. Specific torques are specified for the rail slide chair screws. (Vahtera 2019.)

The basic maintenance of turnouts includes the maintenance of point machines and switch locks. These include the maintenance of the switching machine, electric switch machine and contacts and switch adjusters. (Vahtera 2019.)

Turnouts are generally on a ballast bed. The condition of the ballast is monitored and, if required, the ballast layer is cleaned or replaced. When the turnout is supported, ballast replenishment is performed if deemed necessary. After the ballast replenishment, the ballast is levelled and the turnout is cleaned. (Vahtera 2019.)

Lubrication and cleaning of turnouts is one of the most important tasks in the maintenance of turnouts. The turnouts are mechanically cleaned of dirt often enough to avoid interruptions caused by dirt or debris. Cleaning is also important so that switch lubrication and other maintenance work can be done. Lubrication should be done at a sufficient frequency; however, excessive lubrication should be avoided. (Vahtera 2019; Liikennevirasto 2016b.)

WINTER MAINTENANCE OF TURNOUT

During winter time, winter maintenance is done for the turnouts, which includes preparatory work for the winter season. In preparation for the winter season, snow shields are installed and snow guides, snow defrost resistors, snow protection brushes, snow sensors, pressure air blowers, and other equipment functions are checked. If necessary, such equipment shall be repaired and adjusted. The inspection also examines the locking of the snow shields on the switch rods and the covers of the switch shields of switch units, the cotter pins and the seals on the housing covers. (Vahtera 2019.)

Snow and ice must not be left between the snow shields and their supporting surfaces. Snow should be removed from the moving part area of the switch blades and the flange grooves of the junction and stock rails. Snow removal is very important, because even small ice lumps can prevent the switch from locking. At the cross over switch the switch blades must be clean of snow and ice in order for the switch to turn. (Vahtera 2019.)

Salt or other saline based substances should not be used for thawing snow on the turnouts. If snow removal is done with a brush machine or similar, the turnout should be inspected after snow removal. The inspection shall verify that the snow shields, snow shield brushes, attachments and fasteners, as well as defrost resistors and wires, are in good condition. There must be enough space left next to the turnout for the removed snow from the turnout. Snow ploughing is always prohibited between the front and rear joints of the turnout unit i.e. in the turnout area. (Vahtera 2019, 19-20.)

4.2.1 Predetermined Maintenance

The maintenance level guides the inspection of the track: the frequency the inspection of the rolling stock and the inspection by foot increase along with the maintenance level, see table 5. The track sections of the Maintenance Level 1AA and 1A are inspected with track inspection vehicles 6 times a year. The maintenance levels also define the allowed error limits for the track geometry on the track section, the higher the level the less errors are accepted. (Kalliokoski 2012, 24-25.)

Table 5. Inspection frequency needs of main line track and secondary tracks and sidings (Peltokangas & Nurmikolu 2015, 16.)

Maintenance level	Tracks	Measuring with track inspection wagon, Times / year	Inspection from rolling stock, Times / year	Walking inspection Times / year	Turnout inspection Times / year
1AA		6, interval ≤ 3 months	6, middle of track inspection	2-3	4
1A		6, interval ≤ 3 months	6, middle of track inspection	2	4
1		3	6, middle of track inspection	1-2	4
2		2	6, interval ≤ 2 months	1-2	2-4
3		2	6, interval ≤ 2 months	1-2	2-4
4	Main line tracks	2	3, at least 6 months interval	1-2	2-4
	Secondary tracks and sidings	1	1, with measuring wagon or equal		
	Maximum allowed speed 80 double cross over				
5	Main line tracks	2	2, according to need at least every 6 months from the locomotive	1-2	1
	Secondary tracks and sidings	1 times / 3 year	1, with measuring wagon or equal		
	Maximum allowed speed 35 double cross-over				
6	Main line tracks	2	2, according to need at least every 6 months from the locomotive	1-2	1
	Secondary tracks and sidings	1 times / 3 year	1, with measuring wagon or equal		
	Loading and standing tracks	will be agreed separately			

Inspections at track site: Working on the track site influences the track structure, the inspection shall be carried out before the track is released to traffic to ensure the safe movement of the rolling stock. The inspections are described more in detail in RATO (Part 13) Track Inspection. (Liikennevirasto 2018a.)

TURNOUT REPLACEMENTS 2016-2021

urnout maintenance is carried out on the basis of inspections. The turnout inspections are presented in detail in chapter 4.3.1 Inspection and Condition Monitoring. The inspections of railway turnouts are scheduled 2-4 times per year depending on the track. In Finland, 180 turnouts should be replaced each year to maintain the condition of the turnouts required for the current traffic. About 60 turnouts are overhauled each year. The need for new turnouts is around 120 units per year. The financing requirement is approximately EUR 19.9 million per year. (Liikennevirasto 2018e.)

In the service area 9, 14 turnouts have been proposed for annual replacement. These replacements are likely to be concentrated at Oulu, Raahe and Ylivieska traffic locations. About 10 turnouts should be replaced per year. (Liikennevirasto 2018e.)

In the service area 12, the Oulu-Lapland track, replacement has been proposed for a total of 21 turnouts. Fifteen of these turnouts are located at Kemi and Kemi Ajos traffic locations. 8-10 turnouts should be replaced annually. (Liikennevirasto 2018e.)

Figure 8 shows the need for the turnout replacements in 2016-2021. In the northern region, mainly the 54E1 and 60E1 turnouts require replacement. In northern Finland, the need for replacement is around 30 turnouts by 2021. The total need in Finland is estimated at 286 units during this period. (Liikennevirasto 2018e.)

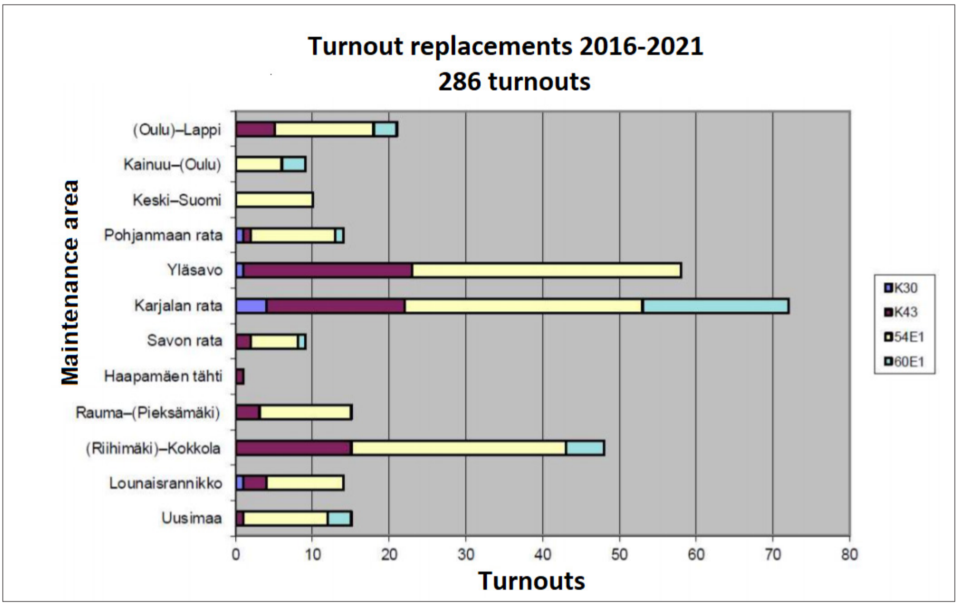

Figure 8. Planned replacements of turnouts (Liikennevirasto 2018e.)

4.3 PREDICTIVE MAINTENANCE

Predictive maintenance is being developed for the maintenance of the Finnish rail network. Digitalization experiments have attempted to predict, for example, the need for turnout maintenance using information from the safety device system. Predictive maintenance is still in its early stages in FTIA, but condition development prediction will increase in the near future.

4.3.1 Inspection and Condition Monitoring

The maintenance inspection determines the condition of the turnout unit, level of service and maintenance needs, and the timing of maintenance work. The maintenance inspections include the wear level inspections for the turnouts. At the same time, individual component replacement and welding maintenance work is planned and the need for individual component replacement is determined. The maintenance intervals for switching devices, such as the switch motor, must be determined. The turnout inspection is carried out according to the instructions of the RATO 14 Inspection and Maintenance of Turnouts. (Liikennevirasto 2016b.)

The turnout inspections are scheduled according to the use. Table 6 below shows the number of inspections on different turnouts. The main line track turnouts are inspected 4 times a year. For secondary tracks and sidings, the inspection is carried out every two years. An inspection record shall be drawn up on the inspection of the turnout unit and it shall be kept for at least two years. For the secondary and siding turnouts the report will be kept until the next inspection report. (Liikennevirasto 2016b.)

Table 6. Scheduling of inspections (Liikennevirasto 2016b.)

Turnouts	Inspections / year	Max inspection interval
Main line track turnouts	4	110 days
Additional main line track turnouts	Min 2	7 months
Secondary tracks and sidings turnouts	Every second year	26 months

The frequency of inspections needs to be increased if the turnout is under higher load than normal. FTIA will decide on the increase of the frequency of inspections. (Liikennevirasto 2016b.)

The turnout is subject to regular visual and ultrasonic inspections. Visual inspections shall be carried out in accordance with the RATO 13 Radan tarkastus (RATO 13 Railway Inspection) guide, which can be found at https://julkaisut.vayla.fi/pdf4/rato_13_radan_tarkastus.pdf. From the visual inspection, conducted while walking along the track, an inspection document shall be compiled and the observation site (km + m or/and track) and the observation time shall be logged in the document, see table 7. (Ratahallintokeskus 2016.)

Table 7. Inspection of turnouts (Ratahallintokeskus 2016.)

Subject of inspection	**Inspection area**
Turnout area	Vertical geometry
	Horizontal geometry
	Amount of ballast
	Condition of sleepers in turnout area
Turnout	Vertical geometry
	Horizontal geometry
	Amount of ballast
	Condition of sleepers in sequel area
Fasteners for rails and sleepers	Loose rail fastenings
	Missing rail fastenings
	Raised sleeper fastenings
	Missing sleeper fastenings
Rail joints	Condition of short rail joints
	Condition of insulation joints
Cables and equipment	Condition of thermal insulation
	Fastenings of conductor loops
	Switchboard height position
Switch cleaning and lubrication	Switch cleanliness
	Switch lubrication

Problems have been identified within the practice of visual inspections, including in the logging practices. Visual inspection records are only made for specific operations such as replacing parts or welding rails. If the turnout to be inspected does not require any action, the inspection is not recorded anywhere. As a result, inspections may reveal irregularities that are not anticipated in maintenance work. It has also been considered a problem that the maintenance officer records the deviations only in his or her personal notebook. (Vahtera 2019.)

The purpose of the ultrasound inspection is to detect cracks inside the rail. Ultrasound is a method of detection so that it detects only the first distortion from the surface. There may be other cracks near the surface, but they cannot be detected in this way. Ultrasonic inspection effectively enables the detection and tracking of individual track faults. It is very important to look into the internal cracks of the rail, for example a 5 mm crack detected in the switch blade may break the entire switch blade in half a year under continuous traffic. (Varis 2017, 35.)

Table 8 shows the scheduling of ultrasonic inspections of a turnout and its parts. The Railway Engineering Guidelines for track management define the acute limits. Traffic should be stopped if the acute limits are exceeded. (Ratahallintokeskus 2006.)

Table 8. Scheduling of ultrasonic inspection for the turnout parts (Ratahallintokeskus 2006, 31.)

Component	**Ultrasonic inspection**
Main line track turnouts	Annual inspection
Secondary tracks and sidings turnouts	During the periodic inspection in accordance with RAMO 14 or prior to welding refurbishing.
Facility refurbished turnout parts	Before installing parts
Welded joint	After welding
Insulated joints	Before repair
Turnout and other rail joint welding and cladding	At acceptance inspection

Ultrasonic inspections are analyzed and faults are classified on-site and faults afre reported to the Maintenance Information System. Turnout measurements are made with an electronic measuring device, from which the results are automatically transmitted to the maintenance information system. The track inspection results (track inspection wagon, EMMA wagon) are stored in their own system where they are available. Their fault logs will automatically go into the maintenance information system in the future.

CONDITION MONITORING OF TRACK INFRASTRUCTURE

The location and the status of the track position are checked during the track test wagon inspection. The mechanical adjustment of the track position and geometry is done based on the inspection wagon reports. The planned inspections and maintenance of the technical equipment and structures of the track are mainly based on periodical maintenance. Inspections and preventive maintenance, as well as repairs to detected faults, are conducted during periodical maintenance at a set time interval. (Saha 2017.)

Traffic disruptions occur occasionally and track infrastructure failures are not sufficiently predictable before the failure. Experts have determined preliminary inspection and maintenance periods and time intervals. These periods are based on available component life cycle estimates and maintenance experience. In the case of disruptions to traffic, the service provider will be alerted on a case-by-case basis to repair the faults. Corrective maintenance is mostly implemented as an emergency repair. (Saha 2017.)

In Finland, rail inspection is primarily based on visual and ultrasonic inspection. Visual inspection provides an overview of the condition of the track and ultrasonic inspection can be used to detect internal rail defects. However, the depth of cracks near the surface cannot be measured reliably with ultrasonic inspection. Eddy-current inspection is suitable for measuring cracks near the surface, making it a complementary method to ultrasonic inspection. Eddy-current inspection is based on detecting changes in the electromagnetic spectrum generated by the eddy-current sensor and the surface inspected. The most common variations detected with an eddy-current device result from a surface damage or changes in the sensor distance. (Rajamäki, Vilppola & Nurmikolu 2016.) Eddy-current inspection is not in use in Finland at the moment (Lane 2019).

4.3.2 Condition Based Maintenance

Track condition monitoring is mainly carried out by the Railway Inspection wagon (EMMA). The wagon measures e.g. track and turnout wear, track geometry, and electrical track contact wire position. A new track inspection wagon will be launched in 2020 in Finland, and the number of objects to be measured will increase significantly.

The maintenance contractor shall obtain a list of defects found with the track inspection wagon. The contractor will schedule the implementation of the maintenance based on the severity of the faults. The fault lists are delivered to the maintenance contractor mainly as different prints when thresholds are exceeded.

4.4 MAINTENANCE IN PRACTICE AND CRITERIA FOR STRATEGY SELECTION

In preventive maintenance, special emphasis is placed on reliability-critical items such as turnouts and signalling devices. Maintenance is carried out mainly outside of traffic periods and strictly on schedule, so that delayed repairs will not cause disruption to the traffic. (Mukula 2008, 81.)

Maintenance management strategies focus on performing maintenance tasks correctly and at the earliest possible stage. Maintenance of the switch control fault variables have been identified and compiled in the 6M's Ishikawa chart. (Saha 2017, 47.) The areas of repair are: Measurement, Material, Man (People), Mother Nature

(Environment), Methods and Machines. By examining the various stages, defects and their root causes can be identified, see figure 9.

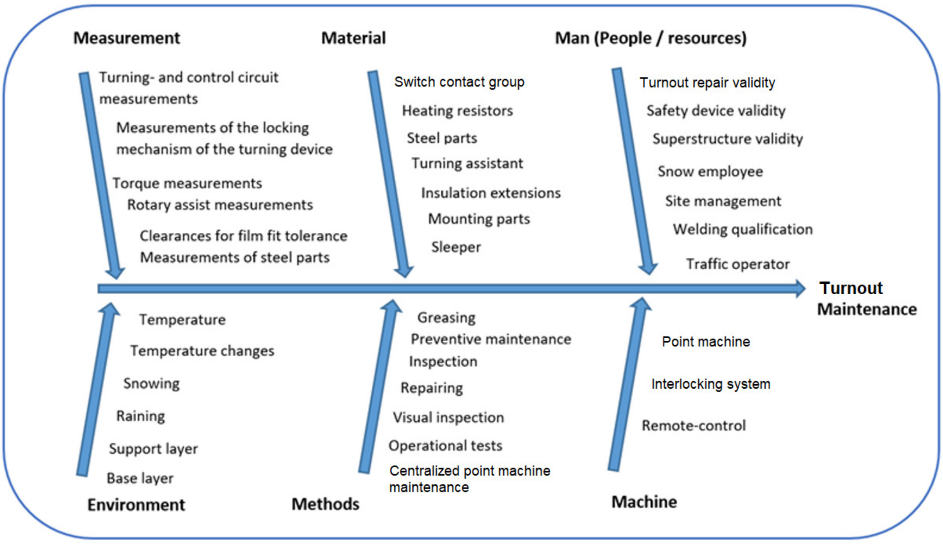

Figure 9. Elements of turnout repair shown in Ishikawa diagram (Saha 2017 translated by Parkkila L.)

The FTIA does not have reliable statistics on the relationship between different types of maintenance. Maintenance is governed by the RATO guidelines and the maintenance agreements based on them, with contractors.

5. Maintenance Work According to the Chosen Strategy

According to Poussu (2014) excessive number of the maintenance tasks are corrective maintenance actions. The maintenance work is performed only after the structures or equipment have failed. The Finnish Transport Infrastructure Agency's future goal is to develop operations more towards predictive and proactive maintenance, see figure 10. (Poussu 2014, 63.)

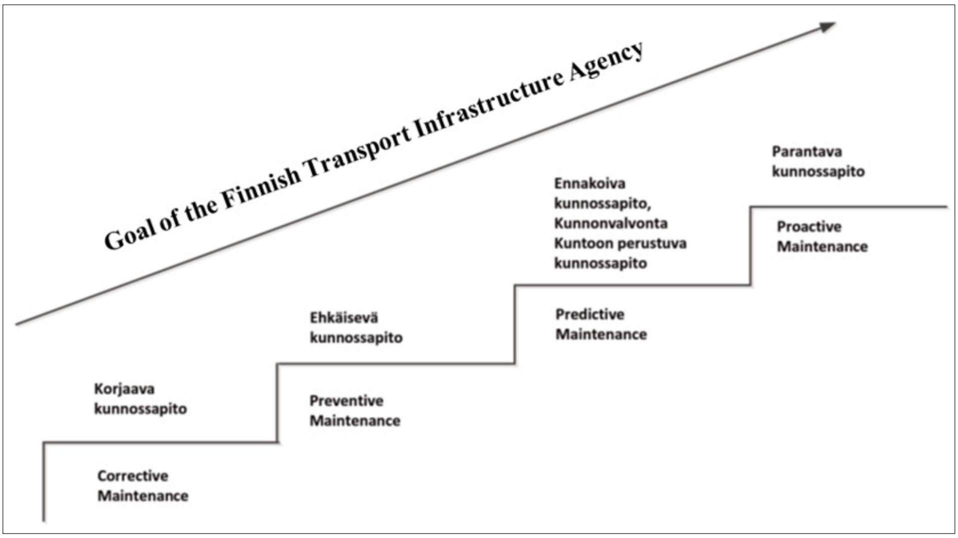

Figure 10. Target direction of the FTIA's rail maintenance (Poussu 2014, 63.)

Destia is in charge of the maintenance of the northern Finland's maintenance areas 9 and 12, see figure 2. Welado Ltd. is responsible of the northern Finland administrative district track maintenance supervision. (Destia 2019) Destia has about 20 people involved in daily maintenance in northern Lapland, maintenance area 12. In addition, experts in various fields of technology come to the area with the contribution of some man-years.

The maintenance contractor carries out the inspection activities but they do not have any condition monitoring systems. Presently, condition monitoring systems are rarely used in Finland, but a few development projects are in progress. They are designed to monitor the operation and condition of the switch machine. The inspection intervals are defined in the Railway Engineering Guidelines (RATO) and the final inspection schedule is defined by the maintenance contractors and the schedule is approved by the FTIA.

6. Conclusion

This publication relates to ARINKA project WP4 Railway Operations, Maintenance and Repair practices. The report provides an overview of the railway operations, maintenance and repair practices in northern Finland. The railway track infrastructure safety and availability are essential parts of maintenance.

Railway safety regulations set high standards for the functionality and condition of the railway infrastructure. The Railway Engineering Guidelines (RATO) contains requirements and guidelines for the various railway systems and their maintenance. The strategic goal of the railway management is to ensure the functionality and structural condition of the railway network. Maintenance focuses on maintaining the existing infrastructure.

The maintenance objective is guided by different classifications: functional, service and technical classifications. The technical classification determines the maintenance levels to the different areas in Finland. The maximum speed and axle load of the track also influences the maintenance level. This will determine the intervals at which railway components will be checked.

Railway classifications should serve maintenance planning and guidance. Functional and service rating classifications are used to monitor the achievement of budget goals. These have not been well established in the use of maintenance planning and control.

The turnout is a railway component which causes the most maintenance work in the Finnish railway sector and that is why it has been selected for this report. Turnout maintenance is mainly predictive/preventive maintenance. Turnout maintenance is divided into basic and separate maintenance. Turnout maintenance is carried out on the basis of visual and ultrasound inspections. Winter maintenance is an important part of basic maintenance because the winter season causes challenges for railway services.

References

Destia. 2019. Destian radan kunnossapitämät alueet 1.1.2019 lähtien. Accessed 9 September 2019 https://www.destia.fi/media/tiedostot/pdf-tiedostot/180803_3_destia_kunnossapitoalueet_kartta.pdf

Fenniarail 2020. Fenniarail Oy. Accessed 24 June 2020. https://www.fenniarail.fi/en/front-page/

Finnish Rail Regulatory Body. 2019. Rail Regulatory Body. Accessed 4 September 2019 https://www.saantelyelin.fi/en

Finnish Transport Agency. 2019. Finnish Railway Network Statement 2019. Helsinki: Finnish Transport Agency. Accessed 4 September 2019 https://julkaisut.vayla.fi/pdf8/lv_2017-03_vs2019eng_web.pdf

Finnish Transport and Communications Agency Traficom. 2019. Traficom. Accessed 4 September 2019 https://www.traficom.fi/en/traficom/about-us

Hyvärinen, J. 2013. Radan päällysrakenteen kunnonhallinnan kehittäminen. Riihimäki: Hämeen ammattikorkeakoulu. Accessed 24 September 2019 https://www.theseus.fi/bitstream/handle/10024/64249/Hyvarinen_Jakke.pdf

Kalliokoski, A. Junes, J. Kansoinen, J. & Eerikäinen, E. 2012. Väyläverkoston yhtenäinen luokittelu kunnossapidon suunnittelua varten. Helsinki. https://julkaisut.vayla.fi/pdf3/lts_2012-10_vaylaverkoston_yhtenainen_web.pdf

Kemppainen, P. 2018. Rautatievaihteiden ennakoiva kunnossapito. Kajaanin ammattikorkeakoulu. Rakennus- ja yhdyskuntatekniikka. Insinööri (AMK). https://www.theseus.fi/bitstream/handle/10024/146442/Kemppainen_Paavo.pdf?sequence=1&isAllowed=y

Kosonen, H. 2011. Vaihteiden kunnossapito Suomen rataverkolla. Oulun seudun ammattikorkeakoulu. Rakennustekniikka. Insinööri (AMK). https://www.theseus.fi/bitstream/handle/10024/28865/Kosonen_Henri.pdf?sequence=1&isAllowed=y

Lane, K. 2019. Sähköposti to jukka.leinonen@lapinamk.fi 23.10.2019.

Lane, K. 2020. Sähköposti to leena.parkkila@lapinamk.fi 23.6.2020.

Liikennevirasto. 2012. Ratatekniset ohjeet (RATO) osa 4 Vaihteet. Helsinki. https://julkaisut.vayla.fi/pdf3/lo_2012-22_rato_4_web.pdf

Liikennevirasto. 2016a. Vaihdekäsikirja Vaihteen huolto-ohjeet. Helsinki. https://julkaisut.vayla.fi/pdf8/lo_2016-23_vaihdekasikirja_web.pdf

Liikennevirasto. 2016b. Ratatekniset ohjeet (RATO) osa 14 Vaihteiden tarkastus ja kunnossapito. Helsinki: Liikennevirasto. https://julkaisut.vayla.fi/pdf8/lo_2016-14_rato14_web.pdf
Liikennevirasto. 2017. Liikenneviraston kunnossapito- ja isännöintialueet. Accessed 4 September 2019 https://vayla.fi/documents/20473/23405/E0076_Kunnossapitoaluekartta.pdf/8b5e1056-0350-4bff-aa2b-6fbba6ee1f35
Liikennevirasto. 2018a. Radanpidon turvallisuusohjeet (TURO). Helsinki. Accessed 12 August 2019 https://julkaisut.vayla.fi/pdf8/lo_2018-07_turo_web.pdf
Liikennevirasto. 2018b. Ratatekniset ohjeet (RATO) osa 1 - Yleiset perusteet. Liikenneviraston ohjeita 31/2018, Helsinki. https://julkaisut.vayla.fi/pdf8/lo_2018-31_rato1_web.pdf
Liikennevirasto. 2018c. Rataverkon kokonaiskuva - Lähtökohtia ja näkökulmia. Liikennevirasto tutkimuksia ja selvityksiä 37/2018. Accessed 4 September https://julkaisut.vayla.fi/pdf8/lts_2018-37_rataverkon_kokonaiskuva_web.pdf
Liikennevirasto. 2018d. Turvallisuusmenettelyjen käsikirja rautatietoiminnoissa. Helsinki. Accessed 3 October 2019 https://julkaisut.vayla.fi/pdf8/ohje_2018_turvallisuusmenettelyjen_kasikirja_web.pdf
Liikennevirasto. 2018e. Vaihteiden vaihtotarve vuosille 2016-2021. (Liikennevirasto) Toteutuksessa oleva hanke 2/2018. https://vayla.fi/documents/20473/441749/RATA_Vaihteiden_vaihtotarve_vuosille_2016-2021.pdf/4406d95b-402f-410f-822e-fb38f1053532
Liikennevirasto. 2019a. Rataverkon toiminnallinen luokitus. Loppuraportti syksy 2019.
Liikennevirasto. 2019b. Rautateiden verkkoselostus 2019. Updated 12 June 2019. Helsinki. https://julkaisut.vayla.fi/pdf8/lv_2017-02_rautateiden_verkkoselostus_2019_web.pdf
Mukula, M. 2008. Aikataulusuunnittelu ja rautatieliikenteen täsmällisyys. Ratahallintokeskus. Accessed 2 August 2019 https://julkaisut.vayla.fi/pdf4/rhk_2008-a1_aikataulusuunnittelu_ja_web.pdf
Peltokangas, O. & Nurmikolu, A. 2015. Raidegeometrian kunnossapito tukemalla ja tukemiskalusto Suomen rataverkolla. Helsinki. Accessed 3 October 2019 https://julkaisut.vayla.fi/pdf8/lts_2015-23_raidegeometrian_kunnossapito_web.pdf
Peverk Oy. 2016. Vaihteenkosketin D500 Asennus ja kunnossapito-ohjeet. https://julkaisut.vayla.fi/pdf9/ohje_peverk_vaihteenkosketin_d500_web.pdf
Poussu, T. 2014. Rautateiden kunnossapidon johtaminen. Kemi. Lapin ammattikorkeakoulu. Teollisuuden ja luonnonvarojen osaamisalan opinnäytetyö
Teknologiaosaamisen johtaminen. Insinööri (YAMK). Accessed 17 September 2019 https://www.theseus.fi/bitstream/handle/10024/83214/Poussu_Teemu.pdf?sequence=1&isAllowed=y
Rajamäki, J. Vilppola, M. & Nurmikolu, A. 2016. Pyörrevirtatarkastus kiskon kunnon valvonnassa. Helsinki. https://julkaisut.vayla.fi/pdf8/lts_2016-27_pyorrevirtatarkastus_kiskon_web.pdf
Ratahallintokeskus. 2001. Rataverkko 2020 –suunnitelma. Helsinki. Accessed 19 September 2019 https://core.ac.uk/download/pdf/132486475.pdf

Ratahallintokeskus. 2006. Ratatekniset määräykset ja ohjeet (RAMO): 13 Radan tarkastus. Helsinki. Accessed 16 September 2019 https://julkaisut.vayla.fi/pdf4/rato_13_radan_tarkastus.pdf

Saha, J. 2017. Liikennevirasto Radan kunnossapitoyksikön strategia ja operatiivisen toiminnan kehittäminen. Metropolia Ammattikorkeakoulu. https://www.theseus.fi/bitstream/handle/10024/124802/Saha_Jukka.pdf

Seppälä, H. 2020. Sähköposti 10.6.2020

Traffic Management Finland. 2019a. Finrail - Green Railway Traffic. Accessed 4 September 2019 https://tmfg.fi/en/finrail-0

Traffic Management Finland. 2019b. Finrail in brief. Accessed 4 September 2019 https://tmfg.fi/index.php/en/finrail/finrail-brief

Traffic Management Finland. 2019c. Traffic Control and Management. Accessed 4 September 2019 https://tmfg.fi/index.php/en/finrail/traffic-control-and-management

Traffic Management Finland. 2019d. Traffic Management Finland Group. Accessed 4 September 2019 https://tmfg.fi/en

Vahtera, R. 2019. Rautatievaihteiden ennakoiva kunnossapito. Turun ammattikorkeakoulu. Tuotantotalous. Insinööri (AMK) https://www.theseus.fi/bitstream/handle/10024/166653/Vahtera_Riika.pdf?sequence=2&isAllowed=y

Varis, R. 2017. Vaihderakenteiden pystysuuntaiseen jäykkyyteen liittyvät ongelmat ja niiden ratkaisuvaihtoehdot. Helsinki: Liikennevirasto. https://www.doria.fi/bitstream/handle/10024/133654/lts_2017-09_978-952-317-359-0.pdf?sequence=2

VR Group. 2019a. Business operations. https://www.vrgroup.fi/en/vrgroup/vr-group/business-operations/

VR Group. 2019b. VR FleetCare. Accessed 11 September 2019 https://www.vrgroup.fi/en/vrgroup/vr-group/business-operations/vr-fleetcare/

VR Group. 2019c. Rautatiealan keskeiset toimijat. Accessed 4 September 2019 https://www.vrgroup.fi/fi/vrgroup/toimintaymparisto/rautatiealan-keskeiset-toimijat/

VR Group. 2019d. VR FleetCare – incorporated rail equipment maintenance seeks new growth via name change. Press release. Accessed 11 September 2019 https://www.vrgroup.fi/en/vrgroup/newsroom/news/vr-fleetcare-incorporated-rail-equipment-maintenance-seeks-new-growth-via-name-change-040920191302/

VR Group. 2019e. VR Group as a company. Accessed 9 September 2019 https://www.vrgroup.fi/en/vrgroup/vr-group/

VR Transpoint. 2019. General information about rail transport. Accessed 9 September 2019 https://www.vrtranspoint.fi/en/vr-transpoint/customer-guide/general-information-about-rail-transport/

Väylä. 2018a. Radan kunnossapidon kilpailutus. Accessed 9 September 2019 https://vayla.fi/palveluntuottajat/hankinnat/rataurakat#.XXX3i-SP4Ud

Väylä. 2018b. Railway network maintenance. Accessed 18 September 2019 https://vayla.fi/web/en/railway-network/maintenance#.XYHI5eSP6KE

Väylä. 2018c. Winter maintenance in the railway network. Accessed 6 September 2019 https://vayla.fi/web/en/railway-network/maintenance/winter-maintenance-in-the-railway-network#.XXJD2OSP5dN

Väylä. 2019a. Pohjois-Suomi Rataisännöitsijät. Accessed 9 September 2019 https://vayla.fi/rataverkko/kunnossapito/tyonjako/pohjois-suomi#.XXZKIeSP4Ue

Väylä. 2019b. Ratojen kunnossapidon työnjako. Accessed 6 September 2019 https://vayla.fi/rataverkko/kunnossapito/tyonjako#.XRERtxaU8zQ

Väylä. 2019c. Rautatieliikenteen häiriökirjausten syykoodiston käyttökäsikirja. Accessed 9 September 2019 https://julkaisut.vayla.fi/pdf11/ohje_2019_rautatieliikenteen_hairiokirjausten_web.pdf

Väylä. 2019d. Rautatietoimintojen turvallisuusjohtamisjärjestelmä, Käsikirja. Säädösperusta. Accessed 6 September 2019 https://julkaisut.vayla.fi/pdf8/rtjj_kasikirja_web.pdf

Äijö, J. & Virtala, P. 2011. Liikenneväylien korjausvelka - Laskentamallin kehitys ja testaus. Helsinki: Liikennevirasto, väylänpito-osasto. Accessed 25 September 2019 https://julkaisut.vayla.fi/pdf3/lts_2011-42_liikennevaylien_korjausvelka_web.pdf

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This publication is part of the work package 4: Railway Operations, Maintenance and Repair Practices. Report provides an overview of railway operations, maintenance and repair practices in northern Finland and description of a turnout as a critical asset.

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