



General technology strategy

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Foreword



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Jernbaneverket, the Norwegian National Rail Administration, is currently facing major technological challenges in conjunction with choosing the technical systems and facilities of tomorrow. This applies both when carrying out renewals and in the construction of new infrastructure. The challenges imply a need for a general technology strategy that clarifies goals and guides for technological choices. In this context, the central approaches to problems may include:

- *The choice of the technological platforms of the future and performance requirements for central facilities and systems*
- *Management of the ageing stock of facilities, in terms of maintenance, prioritisation and pace of renewal*
- *International standardisation and requirements for interoperability*
- *Accelerating development and use of ICT-based railway engineering facilities and systems*

The strategy has been drawn up primarily for internal use, and shall be used mainly as a basis for investigations and principal plans where alternative technological choices and solutions are to be evaluated, and in the procurement of technical systems and facilities. We assume that the strategy can also be useful in other contexts, such as in conjunction with technical discussions with railway undertakings, suppliers and railway administrations.

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Introduction

Technology strategy is a broad term, and initially it was necessary to limit and prioritise in order to make the scope manageable. In the introductory work, a synopsis was drawn up covering the most important principal technological challenges and choices that face the National Rail Administration in terms of infrastructure. In addition to the requirement for a general technological strategy, a particular requirement emerged for drawing up technological sub-strategies for electrotechnical facilities and systems. For a long time, an international superstructure and substructure project has been executed to harmonise railways. This means there is less need to draw up sub-strategies within these areas at the present time. Consequently, the natural thing has been to draw up sub-strategies

for signalling systems, energy supply and KVIKT (Kjørevei [Eng: track], Informasjon [Eng: information], Kommunikasjon [Eng: communication] and Trafikkstyring [Eng: traffic control]) in parallel with the formulation of a general technological strategy. The substrategies are presented in separate reports. When required, sub-strategies will be drawn up for more specialist areas.

In addition to formal strategy documents, technology strategy work also revolves, to a large extent, around attitudes. When drawing up the National Rail Administration's general technology strategy, great emphasis was therefore laid on good, broad interdisciplinary involvement cutting across organisational boundaries.

Strategy process

Technological action by the National Rail Administration will contribute to making Norwegian railways more competitive. Consequently, conscious targeted technological decisions must be taken based on customer and owner requirements, the National Rail Administration's business strategy and other central framework conditions (terms), and which take technological developments into account. However, it is important to undertake adjustments/updates to the

strategy in conjunction with rolling out the NTP (National Transport Plan) and action programmes. This work is being initiated by the department responsible for technology strategy. It is these conditions, together with experience gained from drawing up the technological sub-strategies that form the foundation for drawing up the National Rail Administration's general technology strategy. Figure 1 shows a schematic diagram of the interactions within the strategy.

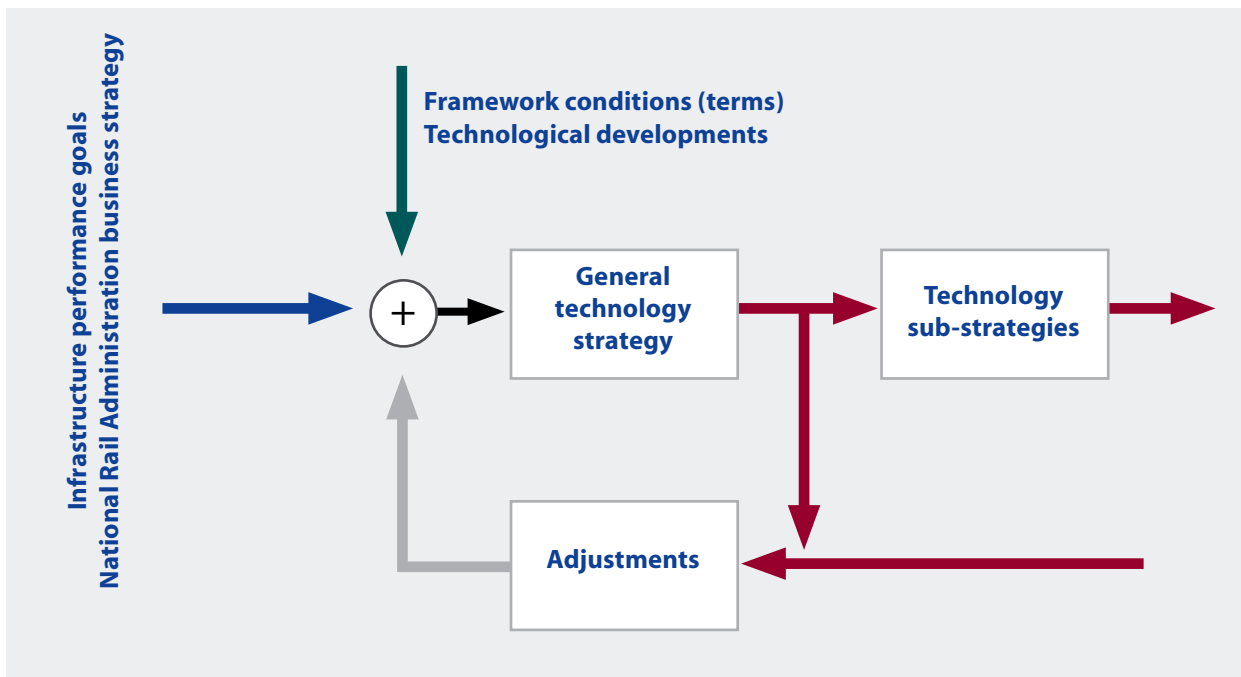


Figure 1 Schematic diagram of the interactions within the strategy.

The National Rail Administration business strategy

Vision: More by rail!

The National Rail Administration's starting point: The Norwegian State owns and holds responsibility for the scope and quality of the public railway network, stations and terminals, and regulates and controls traffic on the network. In exercising this responsibility, Norway's Ministry of Transport and Communications wishes to have its own national professional organisation (the National Rail Administra-

tion) which takes care of the need for independent Norwegian management, inspection and preparedness.

The National Rail Administration's purpose – transport policy objectives: The National Rail Administration shall offer a safe, functional railway network with an efficient, safe traffic system, and with good availability to railway undertakings, the travelling public and transport users.

AREAS OF FOCUS

PRINCIPAL OBJECTIVES

Competitive strength and social benefit

Stresses owner and customer requirements and expectations for the National Rail Administration – and the results that are to provide added value for society and the customers

- Prepare for more freight on the railways
- Contribute to increased market share for local traffic and medium-distance traffic
- Guarantee effective capacity and resource utilisation
- Act as a neutral and active infrastructure administrator and capacity distributor
- Improve the opinion of the National Rail Administration

Safety, punctuality and customer satisfaction

Stresses the three most important features of the National Rail Administration and delivery to the customer

- Maintain the established safety level for rail transportation, and guarantee that all changes produce development in a positive direction
- Ensure that all trains can adhere to the route schedule
- Guarantee good levels of availability and correct traffic information

Productivity and process quality

Stresses the correct use of resources and the quality of the internal work processes

- Improve productivity in all areas
- Strengthen and make more efficient the preparedness for fault correction
- Improve planning work

People and organisation

Stresses the input factors – people, competence, organisation and systems necessary for carrying out National Rail Administration duties

- Guarantee good, sufficient competence within the rail sector
- Improve leadership at all levels
- Take care of human needs during the transition
- Improve and simplify control and monitoring systems

Requirements and performance targets

To ensure that customers and owners are satisfied with the services delivered by the National Rail Administration, it is of

particular importance to be able to satisfy the requirements of both customers and owners within the following areas:

Customer requirements	Owner requirements
<ul style="list-style-type: none"> • Safety • Uptime • Efficient stations and terminals • Information • Training and maintenance of skills within the railway sector • Keeping promises 	<ul style="list-style-type: none"> • Safe transportation system • Eco-friendly transportation • Improved mobility within and between regions • Efficient transportation system • Availability for all

Figure 2. Customer and owner requirements Source: General plan for business operations 2007-2010

Of these requirements, there are special performance targets for

- Efficient transportation systems
- Uptime
- Safety
- Information

which impact on the formulation of the general technology strategy.

Important performance requirements for these areas are given below. In addition, please refer, among other things, to the National Rail Administration's business plan for 2007, the Safety Manual, the National Network Enquiry (More by Rail up to 2040), the National Rail Administration's business strategy and the National Rail Administration's strategy for public information for supplementary descriptions of relevant performance targets.

Efficient transportation systems

The National Rail Administration aims to reduce the costs of operating and maintaining the infrastructure, and of traffic control. In addition, the National Rail Administration wishes to contribute to reducing the railway undertakings' transportation costs. Important technical areas that could contribute to reducing overall transport costs include increases

in axle loads, speeds and free space profiles, increased terminal and passing track capacity, and sufficient capacity in the energy supply. The National Rail Administration has a goal of being able to effect a trebling of current freight volume on the main routes up to 2040, and increased frequency and running speeds for passenger trains.

The National Transport Plan (NTP) 2010-2019 will contain main targets and staged targets for the transport sector, plus indicators for each of the staged targets that state how much progress has been made in following these up.

Uptime

Today's requirement for maximum time loss due to slow moving is 1 minute per 100 km. In addition, the National Rail Administration has defined the following objectives for uptime with regard to punctuality for existing infrastructure:

$$\text{Uptime} = \frac{\text{Train times per year} - \text{hours' delayed per year}}{\text{Train hours per year}}$$

This requirement has been set at 99.4 (based on 600,000 train-km), to be fulfilled by 2009.



Centralized traffic control. Photo: Øystein Grue

Process standard EN-50126 shall be used in the procurement of components and in the project design of new facilities. This requires requirements to be drawn up for reliability, maintainability and safety for components and facilities, adapted to the requirements of the route concerned. It is expected that infrastructure uptime will be increased further through this work.

Safety

Rail transportation shall not lead to any loss of human life or any serious injury to persons, environment or materiel ("vision zero"). The National Rail Administration's general objective for rail safety has been formulated as: "The established safety level for rail transportation in Norway shall be maintained. All changes shall ensure development in a positive direction."

Information

Performance requirements in the National Rail Administration's strategy for public information include:

- The general public shall be content with information from the National Rail Administration
- The National Rail Administration's information at stations shall be standardised and easily recognisable
- The National Rail Administration's information base shall be accessible, correct and unambiguous
- An important factor for success will be the supply of correct and relevant information from the railway undertakings at the correct time

Technological trends and development features

Weighing up technological /strategic choices and solutions for the National Rail Administration will contribute to supporting the National Rail Administration's business strategy, but at the same time, this will have to take into consideration the technological trends and development features that we are seeing. Thorough knowledge and an active attitude to the technological development will mean that we can be at the leading edge in evaluating technological choices and solutions, and form an opinion about the consequences of these for the National Rail Administration and the railway undertakings (opportunities and threats). In particular, the following trends and development features are those that will affect the technological choices and developments of the National Rail Administration:

- International standardisation (interoperability etc.)
- International collaboration on R&D and purchasing
- Environmental awareness and development of green technology
- Accelerating developments within ICT-based facilities and systems
- Shorter working life and increased frequency of replacement
- Centralisation
- Requirements for universal design
- Developments in rolling stock
- Competition for resources

International standardisation (interoperability etc.)

Each country in Europe has built up its own national engineering systems and the traffic regulations associated with those. These systems possess characteristics that constitute both a technical and operational barrier to trains being able to operate across national boundaries. In particular, this situation has been brought about through defence considerations and the protection of national industries. In contrast to rail, other forms of transportation, such as traffic by road, sea and air, have already facilitated interna-

tional transportation and technical and operational standardisation. To arrange for the free movement of traffic over national boundaries, thereby reinforcing the competitive strength of the railways, a historic comprehensive standardisation programme is currently underway within the EU.

EU directives have been drawn up including requirements for interoperability, and, as far as Norway is concerned, these have been implemented in Norwegian Law by means of the Interoperability Regulations [Samtrafikkforskriften]. In accordance with the directives, technical specifications for interoperability (TSIs) within the trans-European railway system are to be drawn up. Such TSIs will gradually be drawn up for a number of districts, systems and subsystems both for infrastructure and rolling stock.

The Interoperability Regulations set requirements for interoperability for the Norwegian part of the conventional trans-European railway system. The regulations apply to the track and its operation, traffic control and traffic operations, including rolling stock. It may be expected that all of our routes will gradually be included in the conventional trans-European railway system. The High Speed Regulations specify requirements for interoperability for the trans-European railway system for high-speed trains, and, for the National Rail Administration, will be used in potential project design and the building of high-speed lines.

The EU Commission's vision for further work on interoperability includes consolidation and amalgamation of the interoperability directives for European railways. This may mean an amalgamation of the TSIs for the high-speed network and the conventional railway network. Important purposes of this type of amalgamation are that rolling stock for high-speed services is able to operate on conventional track, and that rolling stock designed for conventional track is

able to operate on high-speed track. In addition to practical considerations, this type of arrangement will also better facilitate cross-acceptance of rolling stock.

Apart from being able to operate the trains across national boundaries, free from any obstacles, an increase in international technical standardisation will contribute to increased competition for development, production and delivery of railway engineering facilities and systems. One important objective is to facilitate the most open competition possible as far as deliveries are concerned, thereby keeping monopoly situations in check. International standardisation, and the removal of special national characteristics, will prepare the ground for more use of cross-acceptance, thereby streamlining today's resource-intensive and expensive processes for technical type approval.

In conjunction with the international TSI work, the formal procedures for change management are being drawn up. Procedures such as this shall, among other things, ensure that software and hardware equipment upgrades should be backward compatible.

An important factor for success in the continuing European standardisation project is succeeding in developing a standardised safety system, known as Euro-Interlocking. Work on this is still ongoing

International collaboration on R&D and purchasing

The choice of technological solutions based on technical standardisation (TSIs and other relevant standards and agreements) means that the National Rail Administration and other countries' railway administrations (such as Banverket, the Swedish Rail Administration) will, in many cases, choose the same technological platform. This opens up good opportunities for R&D collaboration, such as the joint development of interfaces between new technology and existing infrastructure. Cf. the collaboration on the development/procurement of STM (Specific Transmission Module)

and the ERTMS onboard equipment (ERTMS: European Rail Traffic Management System) and the intent to enter into joint framework agreements.

The choice of international standardised technological solutions, and therefore increased opportunities for international collaboration on joint technology platforms and interfaces, will be of benefit in many ways to the National Rail Administration. In addition to the formal collaborative venture, valuable synergistic effects will be achieved by being able to build good personal professional networks, and exchanging reports, investigations and experience within one another's areas of interest. The good technical collaboration that exists between Norway's National Rail Administration and the Swedish Rail Administration on joint technological developments and trialling can continue in the form of several joint R&D projects, and with a greater scope of joint procurements and framework agreements.

Environmental awareness and development of green technology

In future, increasingly strict requirements for environmental respect are going to be set. Both nationally and globally, there is currently a great deal of interest in developing new technology that can contribute to more eco-friendly solutions. Within the railway, such new solutions could result in the development of locomotives and multiple units based on fuel cell technology, and new railway engineering solutions in the infrastructure that produce fewer emissions and noise. The development of more intelligent control systems will make it possible to economise further on energy in facilities and systems, driver support on trains for reduced energy consumption etc.

Accelerating developments within ICT-based facilities and systems

Accelerating technological developments within ICT means an increasingly rapid accomplishment of new, useful solutions. The rapid development is a challenge for the National Rail



Part of safety installation. Photo: Jernbaneverket

Administration and other railways which traditionally have a renewal cycle of 30 to 40 years or more for the “heaviest duty” facilities.

In future, the National Rail Administration will be able to bring new solutions to fruition within intermodal intelligent transport systems and services (cf. the work with Arktrans and the National Rail Administration’s participation in ITS Norway). Within traffic control also, we will be able to benefit from these technological developments by bringing into use more effective systems with increased intelligence for decision-making support for the train controllers. An example of this type of support might be assistance with assigning priorities between freight and passenger trains in exceptional situations.

The train undertakings’ requirements for access to real-time information will increase in the years to come, and this will specify requirements for the National Rail Administration as infrastructure administrator.

We can expect an increase in the use of wireless communication, and therefore increased use of the GSM-R network for purposes other than train radio, emergency communication and ERTMS.

Shorter working life and increased frequency of replacement

With developments leading in the direction of a greater use of electronics- and

ICT-based solutions, the working life of facilities and equipment has reduced. For example, the expected working life for older relay-based safety systems is approx 40-50 years, while expected working life for newer computer-based safety systems is approx 30 years. We have an equivalent situation within track power supply in which the oldest rotating converter stations have a working life of approx 60 years, while the more recent static converters are assumed to have a working life of approx 40 years.

We see examples of life-extending measures being a major challenge, both technical and financial, for facilities and systems with strong supplier ties and where the National Rail Administration gradually will become the only user. The challenge may be highlighted by what now happens within today’s ATC equipment (ATC: Automatic Train Control). The National Rail Administration has had to carry out a final order for the specifically Norwegian ATC codes because these are going out of production. New European legislation forbids further production of the decoders based on respect for the environment, and it will be extremely expensive to undertake necessary reconstructions and conversions of the production process for relatively small-scale supplies to the National Rail Administration. The National Rail Administration has received notification from relevant suppliers that the current ATC will gradually be phased out. In general, we see a development in which the supplier market within signalling systems prioritises the



Overhead contact line installation. Photo: Øystein Grue

development and sales of ERTMS ahead of life-extending measures in older technological solutions. The National Rail Administration "as a small-scale" railway administration will be "forced" to change technological platform.

The speed of ICT developments will mean a more frequent need to upgrade software for facilities and systems. This type of development, with which the National Rail Administration is familiar from its administrative ICT systems, will also gradually manifest itself within more of the National Rail Administration's basic engineering areas. An important consideration with upgrades such as this must, however, be that facilities and systems thereby provide a higher cost-benefit to rail traffic and users. The National Rail Administration will have to carry out some updates in order to maintain continued product support from the suppliers.

New technology will have to be introduced at a rate of progress which means that the technology will not be "out-of-date" before the implementation has been completed. Increased international standardisation will contribute to a reduced requirement for special Norwegian solutions. By using standardised facilities and systems as much as possible, for example, there will be several railways sharing the costs linked to technological developments. This ought to mean that the costs of the systems will be lower to compensate for the shorter working life.

It is particularly important to manage increasingly rapid technological developments, and the increasing scope of electronics and ICT in such a way as to ensure that operating and maintenance costs are kept at an acceptable level in relation to the cost-benefit of the facilities and systems. When choosing new technology and carrying out progress planning, efforts must be made to find the optimum cost option, by measures such as cost/benefit analyses and LCC analyses (analyses of lifecycle costs).

Centralisation

Increased technical centralisation is currently in focus within many businesses and, in future, technological developments will provide additional opportunities for streamlining by means of appropriate centralisation.

In particular, this will provide the National Rail Administration with new options concerning the centralisation of systems for control and monitoring.

With a development in which computers are becoming increasingly more powerful, while at the same time requiring less physical space, they will be assigned larger and more complex tasks. The National Rail Administration has centralised all remote control of the transformer stations within the track power supply. Monitoring and inspection of the National Rail Administration's GSM-R network is also centralised on a national basis.

Developments can make it possible to work with bodies such as the Swedish

Rail Administration on joint central equipment and operator locations. This is a situation which the National Rail Administration will gradually have to take a stand on. Community safety and preparedness must be included in any evaluations of solutions of this type.

With centralisation, the number of components and the scope of the stock of facilities could be reduced, to ensure increased reliability (fewer fault sources). One major risk of increased centralisation is that this may lead to major negative consequences for the railway undertakings in the event of any failure of vital components and in the event of major interruptions which involve downtime (resulting from fire, flood, sabotage etc.) in rail operations.

To avoid this type of situation, technology and performance must be chosen to guarantee the maintenance of rail operations in exceptional situations. Thorough assessments must be carried out (RAMS, LCC, redundancy criteria etc) to make the correct choice of technology and necessary additional equipment for alternative forms of operation (standby systems, duplication of facilities and systems, possibly geographically separate duplication and other backup solutions) in the event of any deviation. It will also be important to improve the degree of automatic monitoring to ensure that a warning is issued at as early a stage as possible of any danger of component and system failure. Careful planning/ coordination must also be undertaken in relation to planned maintenance and upgrades, and formal duty arrangements.

Requirements for universal design

In the period ahead there will be an increased focus on the universal design of stations and station areas to ensure that all user groups and travellers, including passengers with reduced mobility, can use the public transport services offered. Gradually, many opportunities will become available as modern information technology is developed. But, here too, there are some pitfalls in the form of expensive technological solutions and special adaptations.

Developments in rolling stock

With the exception of the IORE locomotives on the ore trains on the Ofotbanen line, Hector Rail's converted E15 and CargoNet's newest diesel locomotives (CD 66) on the Nordlandsbanen line, to date universal locomotives have been used (for example CargoNet's E14 and E16, GreenCargo's RC4, and OBA's E13 and Di3) for moving freight trains on the Norwegian railway network. Future developments will be moving in the direction of greater use of standard freight locomotives with increased performance. To ensure that the tractive power of the freight locomotives can be used to the full, this must be taken care of by dimensioning the energy supply of the future, and by capacity increasing measures such as passing-tracks and measures taken in super- and substructures etc.

Developments will be moving in the direction of more "intelligent trains" which will involve major sections of infrastructure systems being moved

onboard the trains (such as ERTMS). We will also see a development in which efforts are made to use lighter rolling stock, perhaps especially within the area of passenger traffic.

Access to the railway enterprises' strategies for procuring and phasing out existing rolling stock, in so far as these are available to the National Rail Administration, will provide useful information about important circumstances that affect infrastructure development.

Competition for resources

We are in a period of strong competition for resources such as engineering manpower. This trend will probably continue. It is consequently important to focus on ensuring that the National Rail Administration is given the necessary access to technical resources and continuity of knowledge and competence. It might be noted that it takes approx 2 years before a recently qualified employee is capable of planning overhead lines and signal systems. It can be problematic to recruit and maintain good technical skills within "yesterday's" technology. New graduates want to work with new technology.



Framework conditions for choosing technology

In addition to supporting the National Rail Administration's business strategy and paying attention to technological trends and development characteristics, the general technology strategy must also take as a starting point, and provide support for, a number of central framework conditions (terms):

- Functionality
- Financial framework, technical resources and R&D
- Adaptations for the Norwegian railway network and Norwegian operating conditions
- Principles for facility renewals
- Norway's Act relating to Protective Security Services [Sikkerhetsloven]
- Railway safety regulations [Sikkerhetsforskriften]
- Technical regulations
- Environmental consideration
- Promoting supplier independence and competition for supplies
- Socio-economic profitability

Refer to the business strategy for information on taking care of safety and punctuality.

Functionality

The technical facilities/systems in the infrastructure shall each, in co-existence with one another and with the railway undertakings' rolling stock, satisfy the functionality and quality requirements that are necessary in order to meet the infrastructure performance targets.

When choosing technology, solutions must be selected that are robust and reliable with a view to operating environment, operating conditions and co-existence with the rest of the infrastructure and rolling stock.

Improvements to technical co-existence will be an important contribution in enabling the National Rail Administration to achieve performance requirements for

uptime. For example, a transition to train detection based on axle counters will be less vulnerable than today's track circuits to earthing problems and return current from the overhead power system.

Financial framework, technical resources and R&D

We have to relate to the fact that Norwegian railways are regarded as "small" in a European context. In comparison with the larger railways (such as those in Sweden, Germany and France), the Norwegian Rail Administration and Norwegian railway undertakings have considerably smaller budgets and technical resources at their disposal for technological R&D. Consequently, the conditions permit market-oriented (user-oriented) development of infrastructure based on a moderate level and scope of technological R&D, ahead of a technology-oriented focus with large research departments and R&D budgets.

This means that the National Rail Administration ought to base development of the infrastructure on familiar, established and tested technology. A principle such as this, on the choice of technology, will involve relatively moderate financial and technical risk, and therefore a good level of predictability taking into consideration technical approval, planning (implementation, progress etc) and budgeting of investments, renewals and maintenance.

This does not mean, however, that no investment should be made in technical R&D activities in National Rail Administration in the time ahead. The National Rail Administration's infrastructure consists of a number of complex technical facilities and systems. Consequently, it is important that within the field of market-oriented technological development the focus is also on finding new, useful and cost-effective techno-



Discussion of technical solution. Photo: Gunalf Bækkelø



GSM-R terminal. Photo: Øystein Grue

logical solutions that can contribute to increased competitive strength. Even without any ambitions to be at the forefront of technology internationally, considerable R&D investment would be required to produce the desired results with a market-oriented strategy.

Among other things, the degree of technical and financial uncertainty in R&D projects will be dependent on the type of facility/system, areas of use, the complexity of the interface, the technology that is selected in the larger railway administrations, when a final decision ought to be taken about the transition to a new technology platform, the time for the first implementation, and the rate of implementation. For cases in which the use of familiar, established and tested technology will not lead to the desired performance targets, the matter must be dealt with separately.

It is crucial to the development of the infrastructure that the National Rail Administration, in consultation with the railway enterprises, should be in the forefront with evaluations of new and useful technology. That will allow sufficient time to be gained for undertaking the necessary investigations, obtaining experience and other relevant decision base information.

The choice of technology and technical solutions in the National Rail Administration will be based principally on technology that has already been brought into use by the major European railways.

Information about development features and experience gained by other railways will best be obtained by the continuation of good international commitment, for example the technical collaboration through NIM (Nordic Infrastructure Managers), EIM (European Rail Infrastructure Managers), ERA (European Railway Agency) and UIC (Union Internationale de Chemins de fer). The close, intimate collaboration with the Swedish Rail Administration on joint solutions and R&D is particularly important.

Adaptations for the Norwegian railway network and Norwegian operating conditions

When implementing new international standardised technological solutions in the Norwegian railway network, adaptations for specifically Norwegian technical solutions and operational stipulations ought to be avoided as far as possible. However, consideration must be given to circumstances/factors such as:

- Weather conditions, such as snow, icing, cold and ever increasing extreme weather
- The National Rail Administration has a large extent of single-track operations and a star-shaped railway network
- The traffic load on the network varies greatly between different routes and the various parts of the network
- The National Rail Administration's routes are used mainly by mixed traffic, and the facilities must consequently be dimensioned for both passenger and freight trains



Leivoll substation for frequency conversion. Photo: Bane Energi



Assembly of GSM-R. Photo: Øystein Grue

- Coordination with the Swedish Rail Administration
- Appropriate differentiation of requirements for the performance of the facilities and systems on the basis of traffic volume and the line's importance (line priority)

The purpose of pilot facilities and observed routes at the National Rail Administration will mainly be the acquisition of competence and experience to enable adaptation of the further implementation with a view to scope, progress, technical details, resource requirements etc, and to a lesser extent technical trials.

A technological development with moderate technological and financial risk would also be a natural choice based on the National Rail Administration's large extent of single-track operation and star-shaped railway network. This type of track structure could involve major negative consequences for railway operations (and the railway undertakings) in the event of any outflow of facilities and systems as a result of technical risks being too great in connection with trialling and establishing new technology.

Principles for facility renewals

General technology strategy is largely a matter of which technological principles the National Rail Administration will use as a basis for renewals.

The term renewal means replacement of facilities where it is no longer economic or possible to maintain a required function by means of preventive or corrective maintenance, or improvement of larger components to avoid accelerated degradation.

The facilities in the infrastructure and the railway undertakings' rolling stock have a long working life. For example, the overhead power line systems currently may reach an age of 65 before they are renewed, and CargoNet's EL14 locomotives approach 40 years. As a rule, new and modern rolling stock (locomotives and wagons) will have to run on infrastructure that has different types of facilities varying in age, technology and quality. The National Rail Administration has many years of solid experience linked to analyses, evaluations and procedures for establishing optimum technological and financial working lives for the infrastructure's stock of facilities, and prioritisations for renewals (cost-driven maintenance).

The current high level of corrective maintenance is linked to the fact that systematic preventive maintenance will only have been focused on individual facility components, particularly those that were safety critical. Budgetary conditions have led to the down-prioritisation of preventive maintenance (and renewal) because there is a necessity to carry out fault correction and emergency preparedness in

order to maintain security and punctuality in railway traffic. In other words, the maintenance philosophy has had to be organised towards increasing functional competence in the facilities and maximising the length of the facilities' working life before they are renewed. This means more component replacements and less simultaneousness in renewing different types of facility.

The main challenge for maintenance in the period ahead is not just maintaining the standard of the railway network. The maintenance must be organised so that the standard and performance of the facilities are improved where this is required as a result of stricter performance requirements. Good coordination between investments and renewals will be of crucial significance to this work.

An important approach to this is to gain uniform renewal based on routes (as opposed to spots) where this is necessary to achieve/harmonise the performance targets for the infrastructure. The optimum length of a "route" would depend on several circumstances, such as the type of subfacility/subsystem, the status of existing plant, performance requirements and facility quantities.

Important advances of a rotation of this type will be that longer routes will get a standard improvement and a homogeneous stock of facilities with regard to traffic control, train movement regulations, technology, age, performance and rolling stock. For example, renewals based on ERTMS and overhead power line systems with autotransformers will require, at the outset, a route-by-route implementation. Some of the TSIs that are currently being drawn up, such as the TSI for Energy and its potential requirements that the overhead power line systems should be designed for the use of Euro-pantographs, will also mean route-by-route renewals before the full effect of the action will be achieved. By coordinating renewals of several specialist areas, the National Rail Administration will achieve improved use of the time made available for track work.

To be able to harmonise, on a route-by-route basis, the performance requirements, it may be appropriate to replace facilities, systems and individual components before they reach the end of their technical working life. This applies in particular to older facilities that limit the benefit of investments, and for facilities that will form an obstacle to interoperability. Other elements may be the acquisition of synergistic effects from co-locating technical central equipment for several specialist areas, or technological developments resulting in greater integration of control and monitoring systems. Decisions such as this on enforced maintenance must be dealt with separately and evaluated in conjunction with other prioritised measures.

For a long time to come, the infrastructure will have to live with a mixture of old and new types of facilities and systems. For routes in which ERTMS is to be implemented far in the future, development of new parcels (investments) and necessary spot renewals of safety systems (for example due to age and the risk of collapse) will have to be carried out using today's conventional technology (not ERTMS). Such facilities will have to be replaced later when ERTMS is implemented on the route. Dismantled facilities with some remaining residual life could be used elsewhere or as spare parts. Within the energy supply, the National Rail Administration will have routes with conventional overhead power line systems and routes based on autotransformers.

To facilitate increased safety and more flexible attention to operations, fault correction and maintenance, module-based systems shall be used with the fewest possible and clearly defined interfaces with existing facilities.

Norway's Act relating to Protective Security Services [Sikkerhetsloven]

The purpose of this legislation is to facilitate efficient counteraction of threats to the country's independence and safety and other vital national security interests. The Act applies to admin-



Train for renewal and installation. Photo: Njål Svingheim

istrative agencies. Government or local authority agencies are included under the term "administrative agencies". The Act also applies to every legal entity that is not an administration agency and which is a supplier of goods or services to an administration agency in conjunction with a security-graded procurement procedure. The National Rail Administration coordinates emergency preparedness work for infrastructure, traffic control and railway traffic. Technological choices must fall within the stipulations of the Act relating to Protective Security Services.

Railway safety regulations [Sikkerhetsforskriften]

The requirements in the safety regulations will form the basis for technological choices. The safety regulation requires the RAMS standard (EN50126) to be used, and the National Rail Administration has drawn up guidelines for this.

(RAMS is a process standard that is intended to take care of the rail system's Reliability, Availability, Maintainability and Safety throughout the working life of the entire system. In a railway context, RAMS encompasses railway rolling stock, infrastructure and the interaction between rolling stock and infrastructure).

Technical regulations

The National Rail Administration's technical regulations provide space for an appropriate differentiation of requirements for the performance of

facilities and systems. Important factors for evaluations such as this will often include requirements for performance and implementation related to track priority. Necessary permits for deviating from technical regulations will have to be obtained from the regulatory authority prior to any decision.

Environmental consideration

The National Rail Administration shall reinforce the railway's environmental advantage. The environment is one of the railway's most important advantages, and is therefore one of the areas regarded as being most important to be successful in. The National Rail Administration's general environment policy is intended to ensure that statutory and in-house requirements are included as a natural part of the operation, renewal and development of the railway network. Environmental assessments shall be carried out in conjunction with all processes (cf. the National Rail Administration's environment manual).

Promoting supplier independence and competition for supplies

Basing technological development on the use of international standards (TSIs etc) and agreements, will better facilitate greater competition on supplying the Norwegian railways. In general, technological choices ought as far as possible to minimise those parts of facilities and systems that are supplier-dependent. Necessary interfaces (such as interfaces

between remote control systems, safety systems and drive machinery) must be clearly defined.

The use of interdisciplinary teams is often appropriate in conjunction with drawing up specifications and procurement strategies. That guarantees effective use of the market. It is important to prepare high quality specifications and procurement strategies which guarantee that the National Rail Administration behaves like a professional purchaser. Functionality, reliability (R), availability (A), maintainability (M), safety and vulnerability (S) and supply strategy must be subject to a full evaluation. In addition, LCC assessments shall be used as the foundation for making decisions on signing contracts with suppliers.

Future contracts shall principally be based on framework agreements. At the same time as entering into framework agreements, the National Rail Administration shall establish contracts for operations and maintenance. The scope of operations and maintenance, for which the supplier is assigned responsibility, shall be assessed before any supply contract is entered into. In such cases, strategic assessments must also be made with regard to supplier-specific conditions.

There are complex reasons for some technological systems in the National Rail Administration being tied to supplies from one or a few suppliers. One of the explanations for this is the tradition of establishing special Norwegian operating regulations and technical solutions (such as signalling and interlocking in the safety systems), something that has made the market too small to generate the desired amount of competition and supplier independence. Other causes of

supplier-dependence may be that the National Rail Administration was early at bringing out new systems and that there were therefore few suppliers to choose from. This was the case for GSM-R, for which until now there have only been two relevant suppliers, worldwide. Other systems with supplier-dependence would include the Vicos remote control system, and supplies of "telecommunications transport" over the telecommunications network.

Complete supplier-independence will scarcely be achievable in practice. Within standardised systems we will have supplier-dependence in future also. In particular, this relates to computer-based facilities and systems (such as remote control and ERTMS). The reason is that the software-based systems provide a reduced opportunity for customer insight in relation, for example, into existing relay-based signalling systems.

Interfaces between new standardised technology and existing facilities and systems must, to a large extent, be "tailor-made" in order to allow adaptation for the railways' various existing technical solutions.

Socio-economic profitability

Investments and renewals of facilities in the infrastructure are measures that make huge demands of resources, time and costs. In addition to technical evaluations, technological choices must also be based on socio-economic analyses and evaluations throughout the entire working life (RAMS, LCC) of the relevant alternatives. One goal will always be to be able to choose the most cost-effective total solution for the National Rail Administration and the railway undertakings.



General technology strategy

On the basis of the aforementioned circumstances and discussions, the National Rail Administration's general technology strategy is as follows.

Goal

Any choice of new technology, including its development and use, shall contribute to achieving all of the infrastructure's performance targets in a cost-effective manner while also attending to the needs of the customers.

Guides for choosing technology

When transferring to a new technological platform, the primary choice must be known, established technology that has been tried out on other railways before implementation/development is initiated by the National Rail Administration.

- Before new facilities and new systems are brought into ordinary operations, there must be proof that they will function satisfactorily for the National Rail Administration and the railway undertakings.
- If trialling is to be carried out at the National Rail Administration (pilot system/observed route), it must be possible to do this without any major inconvenience to railway traffic.

Technological choices must facilitate safe, user-oriented, environmentally friendly developments, which are adapted to:

- An acceptable level of safety
- The Norwegian railway network (extent of single-track and star-shaped network etc)
- Norwegian operating conditions (mixed traffic, climatic conditions etc)
- Market and users (external and internal)
- The infrastructure's performance targets

To reduce costs, technology shall be chosen with regard to international standards and agreements, to ensure that the National Rail Administration:

- Promotes supplier-independence
- Is only able to use standardised and open interfaces

Technology must be chosen that can be implemented, repaired and maintained to ensure that inconvenience to ordinary train operations falls within what is acceptable, by:

- Facilitating flexible safeguarding of operations, fault correction and maintenance
- Using standardised module-based systems with the fewest possible interfaces
- Improving the degree of automatic monitoring in order to identify faults and impending faults at as early a stage as possible, to ensure that necessary measures can be implemented at a sufficiently early stage to prevent any halt to rail traffic operations.
- Ensuring that necessary interfaces are clearly defined
- Choosing an appropriate differentiation of requirements for the performance of the facilities and systems on the basis of traffic volume and the line's importance (line priority)



Photo: Njål Svingheim



Photo: Njål Svingheim

Any risk relating to technology, finance or progress shall be identified, clarified and reduced through systematic work on:

- RAMS (LCC analyses, cost/benefit analyses, safety analyses)
- Effective processes and decisions concerning technological approvals (cross-acceptance etc)
- R&D collaboration with the Swedish Rail Administration and other rail administrations
- International collaboration (NIM, EIM, ERA, UIC)
- Collaboration with railway undertakings
- Removal of special Norwegian and often expensive solutions (technical and operational)

Guarantee the supply of relevant interdisciplinary skills for making the correct technological choices by systematically working on:

- Recruitment
- Skills development (skills sharing)
- Continuity in knowledge and skills
- Investigations into technological choices

Uniform route-by-route renewal shall be endeavoured where necessary for achieving/harmonising the performance targets for the infrastructure by implementing:

- Route-by-route coordination of major renewals such as signalling and power supply systems
- Good coordination between investments and maintenance. This can involve enforced renewals if older facilities and systems are limiting the benefit of investments, possibly postponing investments while awaiting the renewal.

Endeavours shall be made to make maximum use of working life for existing technical facilities and systems by carrying out:

- Systematic corrective and preventive maintenance. This involves lengthening the working life of individual facilities and systems where this is appropriate in anticipation of route-by-route renewal.



Firm links with the National Rail Administration's focus areas

The figures indicated in the National Rail Administration's focus areas show which points in the general technology strategy underpin the focus area.

AREAS OF FOCUS

Competitive strength and social benefit

1, 2, 3, 4, 5, 7, 8

Safety, punctuality and customer satisfaction

1, 2, 3, 7

Productivity and process quality

1, 2, 3, 7

People and organisation

2, 6

GENERAL TECHNOLOGY STRATEGY

1. When transferring to a new technological platform, the primary choice must be known, established technology that has been tried out on other railways before implementation/development is initiated by the National Rail Administration.
2. Technological choices must facilitate safe, user-oriented, environmentally friendly developments
3. To reduce costs, technology shall be chosen with regard to international standards and agreements
4. Technology must be chosen that can be implemented, repaired and maintained to ensure that any disadvantages to ordinary railway operations are within acceptable limits
5. Any risk relating to technology, finance or progress shall be identified, clarified and reduced
6. Guarantee the supply of relevant interdisciplinary skills for making the correct technological choices
7. Uniform route-by-route renewal shall be endeavoured where necessary for achieving/harmonising the infrastructure performance targets
8. Endeavours shall be made to make maximum use of working life for existing technical facilities and systems

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