International Benchmark 2014-2018

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Summary

- In 2019, NS conducted an international benchmark study with a number of European railway operators; DSB, Greater Anglia, NMBS, SBB and West Midlands Trains. This benchmark focuses on the development of the performance during 2014-2018.
- NS' performance is above the average of the peer group on the following aspects: attractive product, quality of the railway services and capacity of the railway system.
- NS' punctuality has improved over the past years and is above the average of the peer group, while the Dutch network has the highest utilization of the peer group. Utilization has increased even further during 2014-2018.
- NS' rolling stock has a relatively low age and only uses electrical traction. By using energy from renewable resources, the CO_2 emission decreased to negligible levels.
- The overall custom satisfaction has increased by 11 percent point, which is the highest increase in the peer group, putting NS above average in the peer group. An improved and extended train service, higher punctuality, better service and modernized trains and stations all contributed to the increased customer satisfaction.
- High utilization of rolling stock and stations leads to a high productivity and a relatively low cost level compared to the peer group.

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1. Introduction, context and methodology

1.1 Introduction and objectives

1.2 Context, data and analysis process

1.3 Methodology and explanations

This chapter gives a short introduction on the history of the benchmark study, the context of the current benchmark study and the objective of the study which aims to identify realistic and potential improvements to NS performance (1.1).
It also provides a short overview of the participants in the benchmark, which is elaborated in chapter 2 - the peer group description.
The process of data collection and analysis (1.2) is followed by an overview of the methodology and considerations on the interpretation of the information and data represented (1.3).
Appendix C provides more information on the methodology.

1.1 Introduction and objectives

Objectives: identify opportunities for improvement of the performance of NS

- Every three years NS carries out a benchmark project, in accordance with its 2015-2025 Transportation Contract (art. 26), to monitor its performance and to pursue continuous improvement. The peer group consists of at least four comparable operators. Topics cover the key performance areas of the Transportation Contract and the development of productivity.

- The benchmark encompasses data over a period of 5 years, to provide insight in trends and developments and to offer an overlapping continuity between the subsequent benchmarks.

- Results will be used to identify a realistic potential for improvement and best practices to contribute to NS' performance. Where applicable this will be input for NS' annual Transportation Plan.

- The study encompasses a comparison between five European operators (DSB, GreaterAnglia, NMBS, SBB, West Midlands Trains) and includes subjects like punctuality, safety, costs, sustainability and productivity.

- There are confidentiality arrangements with the participating operators.
  - All confidential information in this benchmark will be presented anonymously and ranked per comparison. Therefore the operator codes change per comparison to prevent identification of individual operators.
  - All confidential information will be presented as indices (not absolute numbers), with 100 as the average for data from 2018. Where available data for 2018 is incomplete, the average of 2017 will be used for the index (this will be stated where applicable).

1.2 Context, data and analysis process

Challenging process to collect, compare and analyze international rail data

- The peer group consists of train operators from Belgium, Denmark, Switzerland and the United Kingdom. The peer group is largely the same as the peer groups of earlier benchmarks of NS to ensure continuity and a longer term perspective.

- NS used multiple sources for this benchmarking study:

  1. Publicly available information (annual reports, internet, statistical bureaus, sector reports, etc.);
  2. Data from international benchmark platforms and working groups that NS participates in;
  3. Bilaterally exchanged information from the peers (covering 2014 - 2018).

- The data collection and analysis process has proven to be quite challenging: not all peers have all requested data for the requested years available, or use different definitions. This results in a number of analyses with data missing for a number of peers or years. In cases where comparisons require caution, because of differences in definitions, this is mentioned in the texts.

- All companies were consulted to verify and complete the data, evaluate trends and exchange best practices.

- Financial data is harmonized for exchange rates and purchasing power parity levels (PPP).

- This benchmark study is reviewed by the Kennisinstituut voor Mobiliteitsbeleid (KiM).

1.3 Methodology and explanations

Other remarks

- The definitions used for the analyses are chosen for comparability with the indicators of the peer operators. Therefore the KPIs in this report do not always match the definitions of the KPI's that NS uses in their dashboards and in the reports for the Ministry of Infrastructure and Water Management.
- The scope for the NS data include all trains running as part of the main rail concession. Therefore trains on the high speed line (IC Direct, IC Brussels) are included starting in the 2015-2018 numbers. Trains from regional contracts are excluded.

- Punctuality scores of the train operators and customer satisfaction scores are harmonized using the methodology described in Appendix B. There is a certain amount of uncertainty in the comparability. The figures are not harmonized for differences in measurement methodology (e.g. survey method for customer satisfaction and end station vs. entire route for punctuality).
- All financial numbers are excluding VAT and harmonized using the OECD purchasing power parity indices* (see Appendix B).
- Graphs represent time series (typically 2014-2018) or comparisons for 2018, unless stated otherwise.
- The numeric convention of this report is the Dutch; a period (.) is used to separate groups of thousands. A comma (,) is used to indicate the decimal point.

- Based on the results of the 2016 benchmark study, this 2019 study dedicates some extra attention to customer satisfaction and train cancellations.

- Apart from this benchmark study NS engages in a number of benchmarking initiatives to improve performance. Examples include the International Mainline Rail Benchmark Group, a joint NS-ProRail weather preparation benchmark, bilateral contacts with other railways on timetable development, punctuality improvement, customer satisfaction, passenger information, etc.

* source: https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm

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2. Peer group

2.1 Criteria and choice

2.2 Organization and market regime

2.3 Characteristics and key figures

2.4 Rolling stock fleet

This second chapter provides more detailed information on the peer group operators which are included in this benchmark study.
A summary of the criteria on which the operators in the peer group are selected (2.1) is followed by an overview of the different organizations, roles and market regimes (2.2). The chapter concludes with some overall key characteristics and figures of the operators in the peer group such as passenger kilometers, average trip length and system speed (2.3) and a description of the rolling stock fleet used within the peer group (2.4). Appendix B provides some more information on the peers.

2.1 Criteria and choice

The peer group consists of operators that run medium-sized, high density operations

Criteria

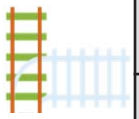
1. As many participants as possible from previous international benchmarking studies by NS to establish a longer term perspective with time series
2. Trade off between comparability and learning potential:
   a. Operations: commuter / regional transport, travel distance, traffic density, average speed, size
   b. Infrastructure: network lay-out, potential weather / winter influences, intensive use of network; multiple operators on network
3. Cooperation of peer group / availability of data:
   a. Willingness to participate (market / competition issues, confidentiality conditions)
   b. Existing cooperation in other international working groups and/or benchmarking platforms

	Train operators
	NS
	NMBS
	DSB
	Greater Anglia West Midlands Trains
	SBB

2.1 Criteria and choice

Some key figures of peer group

The table summarizes some structural characteristics of operating environment of the peers[1]. Differences in these parameters have significant impact on the performance of the peers.

	Passenger operator(s) in peer group	NS	DSB	GA, WMT[2]	SBB	NMBS
	**Infrastructure manager**	ProRail	Bane-danmark	Network Rail	SBB	Infrabel
	Network (routekm) – Total	3.075	3.476	16.837	5.690	3.592
	Network (routekm) – IM peer	3.075	1.896	15.804	3.090	3.568
	Network (trackkm) – IM peer	5.370	3.076	31.091	6.239	5.379
	**Area – land (km²)[1]**	33.893	42.434	241.910	39.997	30.278
	Population (mln)[1]	17,28	5,9	65,8	8,4	11.72
	Population density (inh./km[1])	502	132	266	204	387
Rail ratio's	**Routekm / 1000 km² land**	90,7	81,9	69,6	142,3	118,6
	Inhabitants / km network	5620	1697	3908	1476	3263
	Passengerkm (train) / km²	578	146	288	464	347
	Pass.km (train) / inhabitant	1.134	1.048	1.059	2.212	896

Most countries have one infrastructure manager. In case there are multiple infrastructure managers the total network length of the country differs from that of the peer.
All passengerkm numbers are national (Eurostat / KiM), except in the cases of SBB and NMBS, where the passengerkm of only that operator are given.

1 Source: https://www.cia.gov/library/publications/the-world-factbook
2 GA = Greater Anglia; WMT = West Midland Trains

2.2 Organization and market regime

Peer group: a mix of operators with tendered and directly awarded transportation contracts

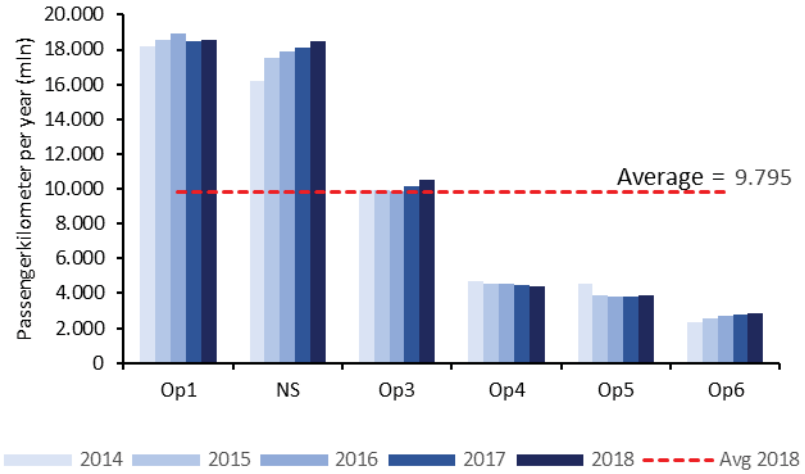
- The peers operate in different market environments. Main difference: DSB, NMBS, NS and SBB have directly awarded transportation contracts while Greater Anglia and West Midlands Trains operate tendered contracts. Open access operation may be formally applicable, but is very limited or absent in practice.
- Greater Anglia and West Midlands trains share a significant part of the network with other operators, introducing more coordination with multiple other passenger operators. The operation of the other peers involves less interaction with other operators .
- The operators in the peer group are also responsible for station management. The exact implementation differs with the network, station and market characteristics.
- SBB has a holding organization with both infrastructure management and operations. All other peers have full separation between infrastructure management and operations.

Market segment					
HS passengers	Open access	Open access	Open access	Open access	Open access
IC passengers	PSC direct award	PSC direct award	PSC direct award	PSC tendered	PSC direct award
Commuter trains	PSC direct award	PSC direct award	PSC direct award	PSC tendered	PSC direct award
Regional passengers	PSC tendered	PSC direct award	PSC direct award & tendered	PSC tendered	PSC direct award
Freight	Open access	Open access	Open access	Open access	Open access

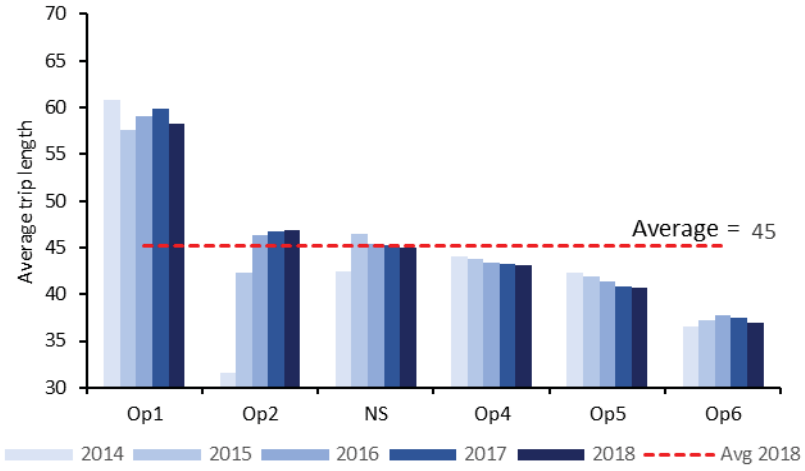
PSC: public service contract

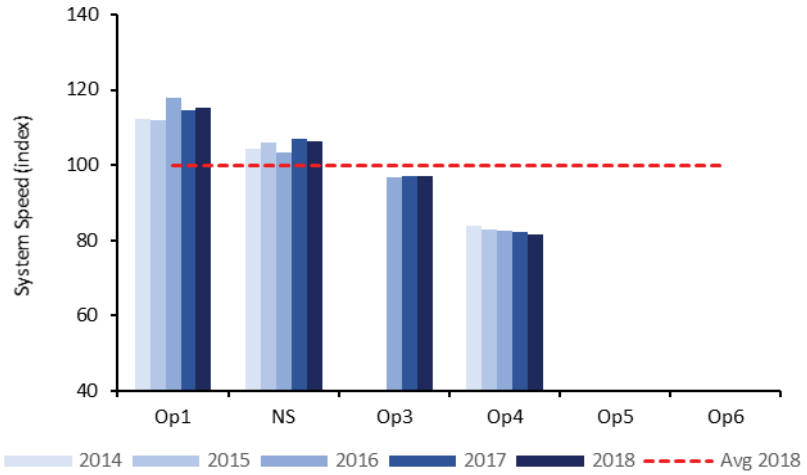
2.3 Characteristics and key figures

Passenger kilometers are consistently growing, trip length is average, system speed is above average



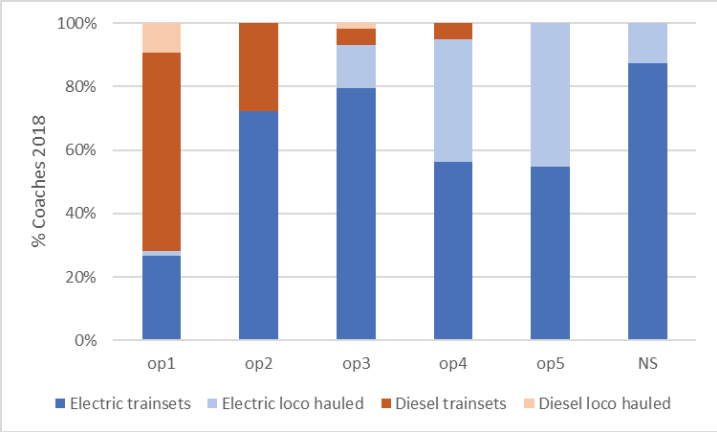
- The total volume of passengerkm per year has been consistently rising for NS, and is now almost twice the average of the peer group. Most peers expect a rise of passengerkm in the near future.
- The average trip length of NS remains stable around the average of the peer group.
- NS' system speed (km/h) is above average for the peer group. System speed is a main driver for travel speed and productivity.
- Geographical characteristics (see p.54,55) and economies of scale contribute to high efficiency.

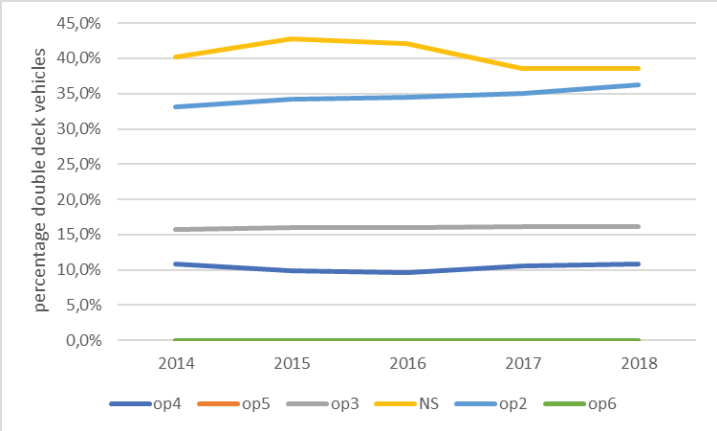




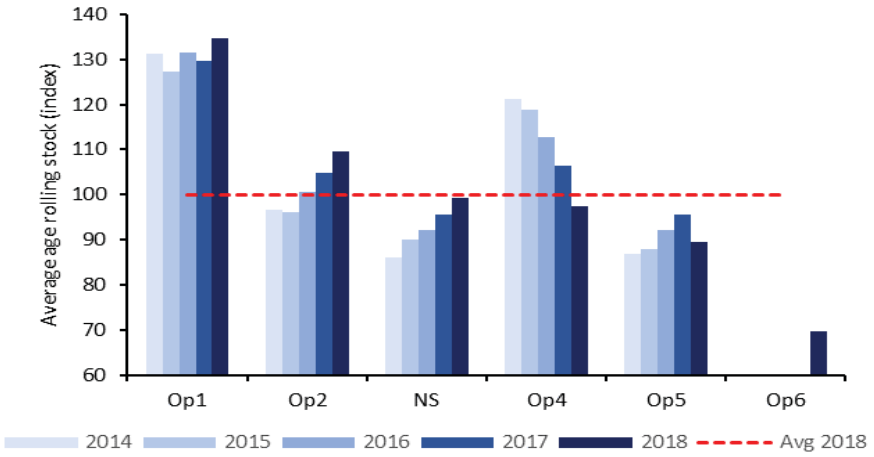
2.4 Rolling stock fleet

NS operates mainly electric trainsets, allowing for a higher operational flexibility





- NS operates mainly electric multiple units (last diesel trainset was put out of service in 2017). NS has the highest proportion of electric multiple units of the peer group.
- NS has the highest proportion of double deck rolling stock of the peer group (operator 5 and 6 do not use double deck units).
- The average age of the fleet of NS is below the average of the peer group.
- During 2014-2018 this average age was rising due to recommissioning of reserve fleet. Since then NS has procured new rolling stock.



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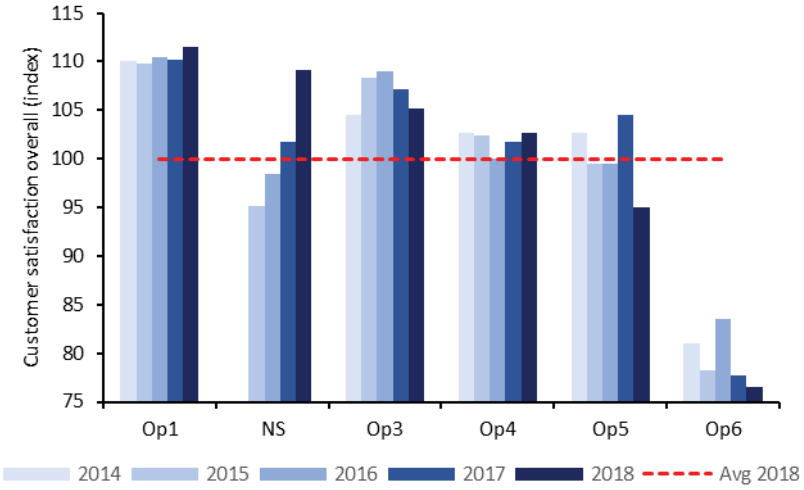
3. Attractive product for passengers

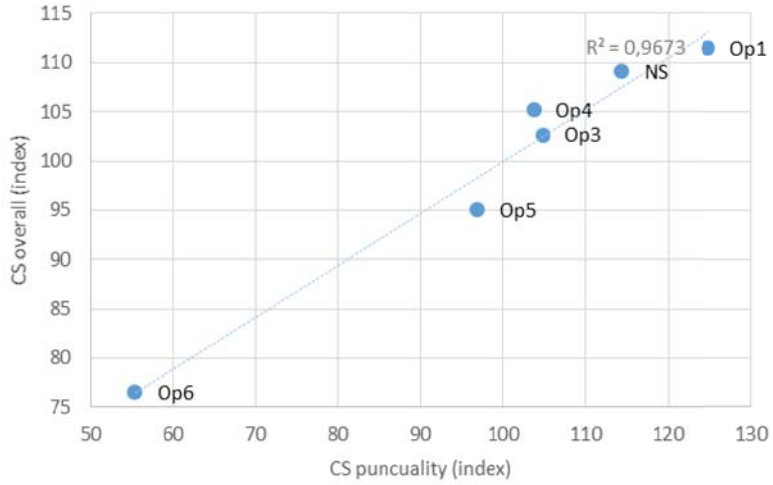
- 3.1 Customer Satisfaction
- 3.2 Complaints
- 3.3 Sustainability
- 3.4 Trends, insights and best practices

A comparison of customer satisfaction trends and other relevant factors provides an overview of the attractiveness of the product.
The chapter contains a comparison of the overall customer satisfaction and the satisfaction on underlying aspects (punctuality, passenger information, cleanliness, stations, connections and frequency (3.1). Other aspects of attractiveness are the development of the complaint ratio (3.2); sustainability, energy efficiency and CO_2 emissions are presented in (3.3). The chapter concludes with other trends, insights and best practices of the peer group (3.4).

3.1 Customer Satisfaction - *Overall*

NS' customer satisfaction is above average and rising significantly





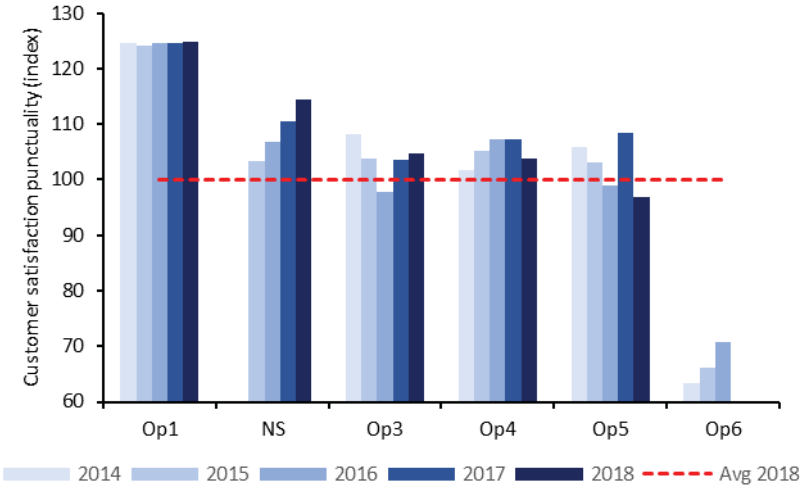
NS' overall customer satisfaction is 9% above the average of the peer group and shows a significant and continuous increase during the benchmarking period.

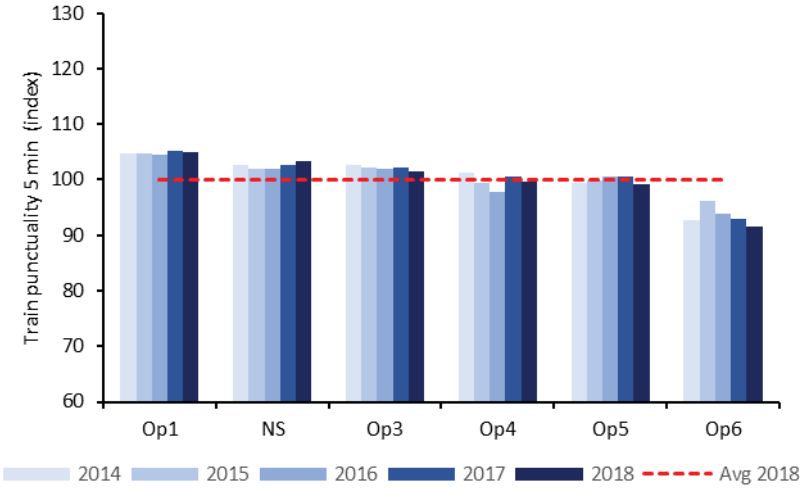
- All peers attribute increasing customer satisfaction to a goal-oriented focus on improving performance and punctuality, increasing cross-functional collaboration.
- Overall customer satisfaction is strongly correlated to customer satisfaction on punctuality.
- Operator 5 attributes the declining customer satisfaction in 2018 mainly to holding the customer satisfaction survey immediately after a winter with extreme negative impact on performance.

- NS recognizes a positive impact of:
  - Introduction of newly designed timetable with higher frequencies
  - Introduction of new and modernized rolling stock
  - Innovations in personalized passenger information
  - Improvement of service quality level of staff
  - Station improvement (major overhaul of stations, "station living room", retail, etc.)

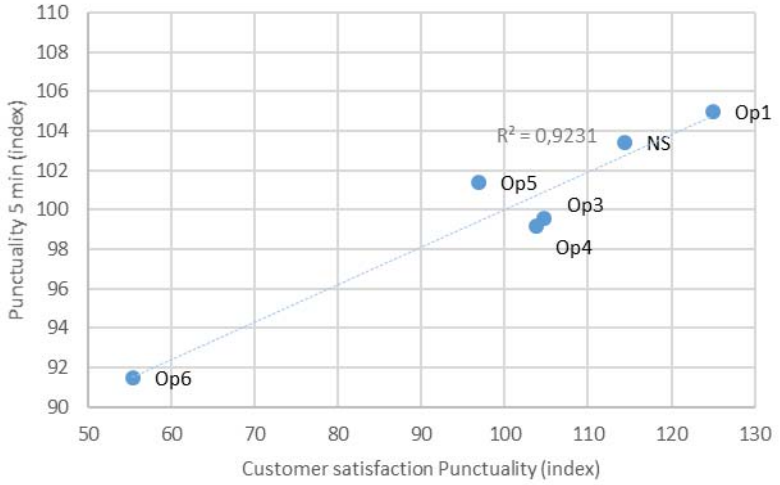
3.1 Customer Satisfaction - *Punctuality*

Customer satisfaction on punctuality is high and shows correlation to actual performance



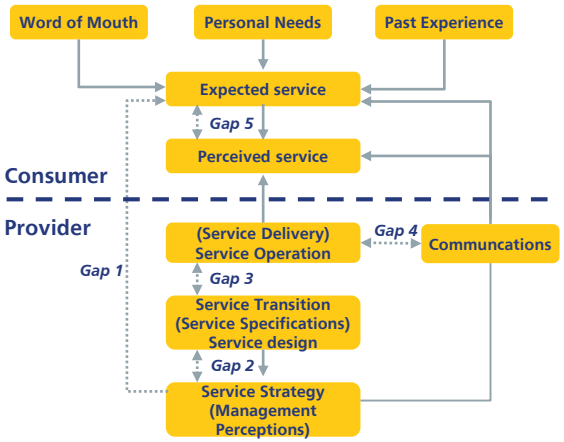


- Customer satisfaction on punctuality shows some correlation to the actual punctuality, but it is far more volatile than measured (actual) punctuality.
- Peers attribute this volatility of the customer satisfaction to the impact of extreme weather conditions, construction works and major changes in the timetable.

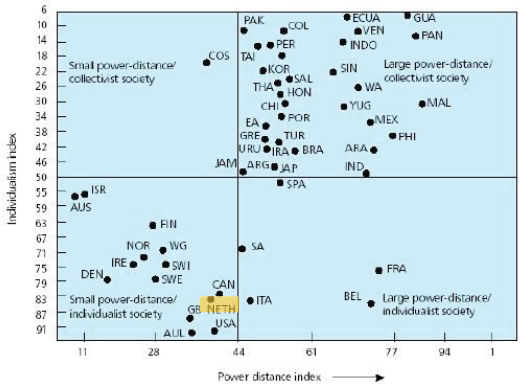


3.1 Customer satisfaction – *Differences between peers*

CS depends on perception vs. expectation. Cultural factors have major impact on response style.



POWER DISTANCE/INDIVIDUALISM DIMENSIONS ACROSS CULTURES



Source: Hofstede (2003)

- The *International Benchmark 2011-2015* found only a weak correlation between customer satisfaction and actual performance. Other factors seem to have a higher impact. The auditors recommended to give this some extra attention.
- There are two models that provide some insight in differences in customer satisfaction and response style.
- The standard model for customer satisfaction (fig. 1, EN13816 or SERVQUAL) focusses on the difference between perception and expectation.
  - This model implies that a higher performance leads to higher expectations. Therefore the operator has to improve performance even further, and/or focus more on satisfiers, such as comfort, ease of use, experiential performance, etc.
  - Higher performing peers seem to invest more in "intangible performance" and managing expectations.
- Other research* shows that the response style correlates with cultural factors, such as the power distance and level of individualism.
  - Hofstede (2003) maps countries on these dimensions (fig. 2). The Netherlands rank as a relatively individualistic culture with a medium power distance. This may lead to a less positive and more middle (less extreme positive) response style than average.

- A.W. Hartzig; 2006; Response Styles in Cross-national Survey Research, A 26-country Study; International Journal of Cross Cultural Management Vol 6(2): 243–266

3.1 Customer satisfaction – *Trends*

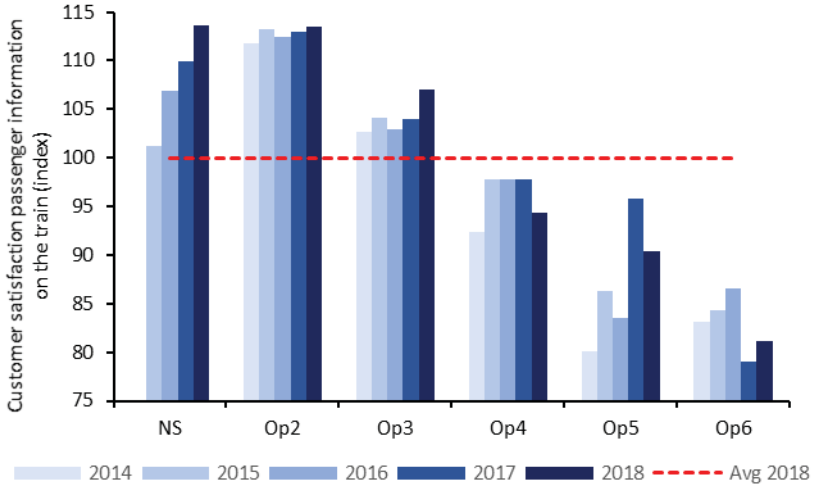
Customer satisfaction is influenced by a large number of factors, including overall public opinion

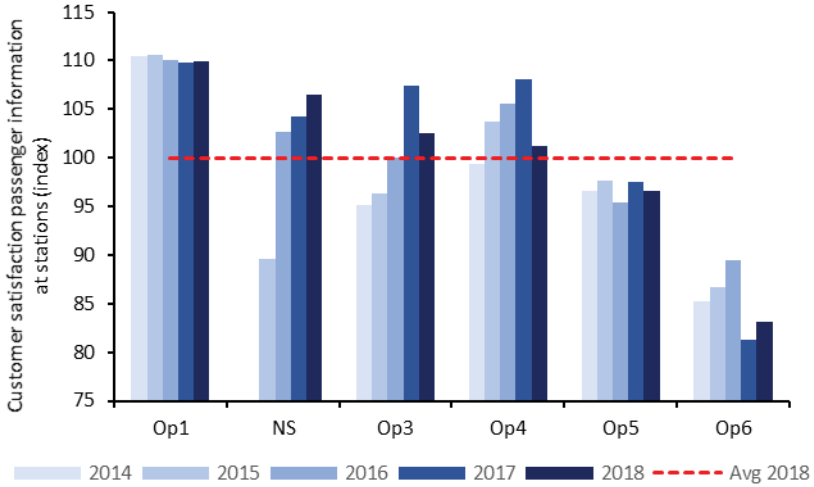
Customer satisfaction on different aspects of a trip shows a high correlation between these aspects. A lower performance on one aspect can influence the evaluation of other aspects of the trip.

- A number of peers attribute part of the variation of customer satisfaction to overall public opinion about the performance and/or the reputation of the operator. Empirical evidence for this notion across the peer group is limited as the practices of reputation measurement vary.
- Some of the peers, including NS, design questionnaires to focus on the evaluation of the actual trip and minimize bias due to variations in public opinion.
- NS has redesigned its methodology accordingly in 2015. To ensure consistency and comparability this benchmark only includes 2016-2018 customer satisfaction measurement from NS.
- NS has dedicated a considerable effort to understanding the entire travel experience of its customers and improving the experience during key moments of the trip.
- NS invests in providing clear information before and during the trip (e.g. adding new functionality to the Reisplanner Xtra app) and managing expectations about the trip (e.g. seasonal communication campaigns).

3.1 Customer satisfaction - *Passenger information*

Customer satisfaction on passenger information shows significant increase

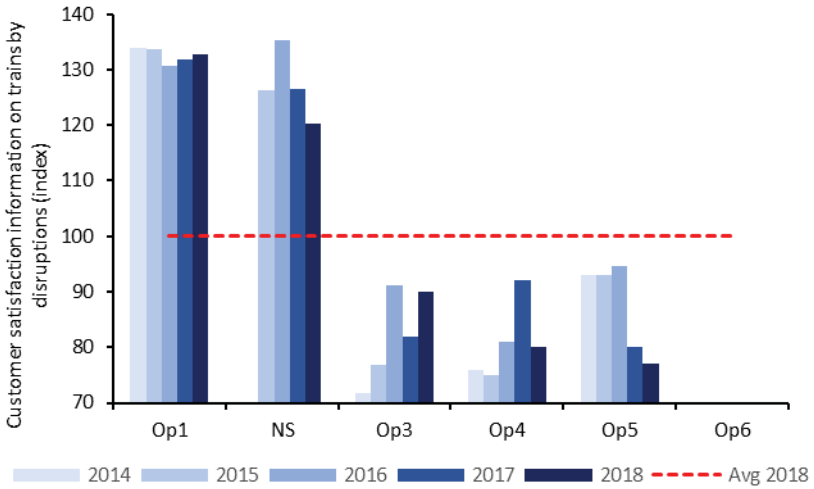


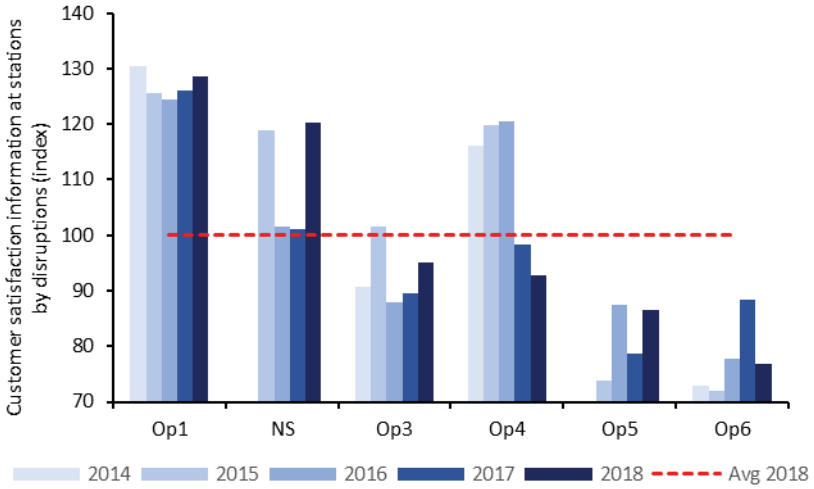


- Customer satisfaction about passenger information at NS has risen consistently and is now above average for the peer group.
- New developments, e.g. functionality of the passenger information app ("Reisplanner Xtra") and the higher punctuality are significant contributors to the increasing customer satisfaction.
- Customer satisfaction about passenger information is rather volatile for some operators. Peers confirm correlation with punctuality and the impact of the moment of measurement of passenger satisfaction (e.g. continuous vs. 2 samples per year).

3.1 Customer Satisfaction - *Information in case of disruptions*

NS ranks second, but significantly above average, on information during disruptions

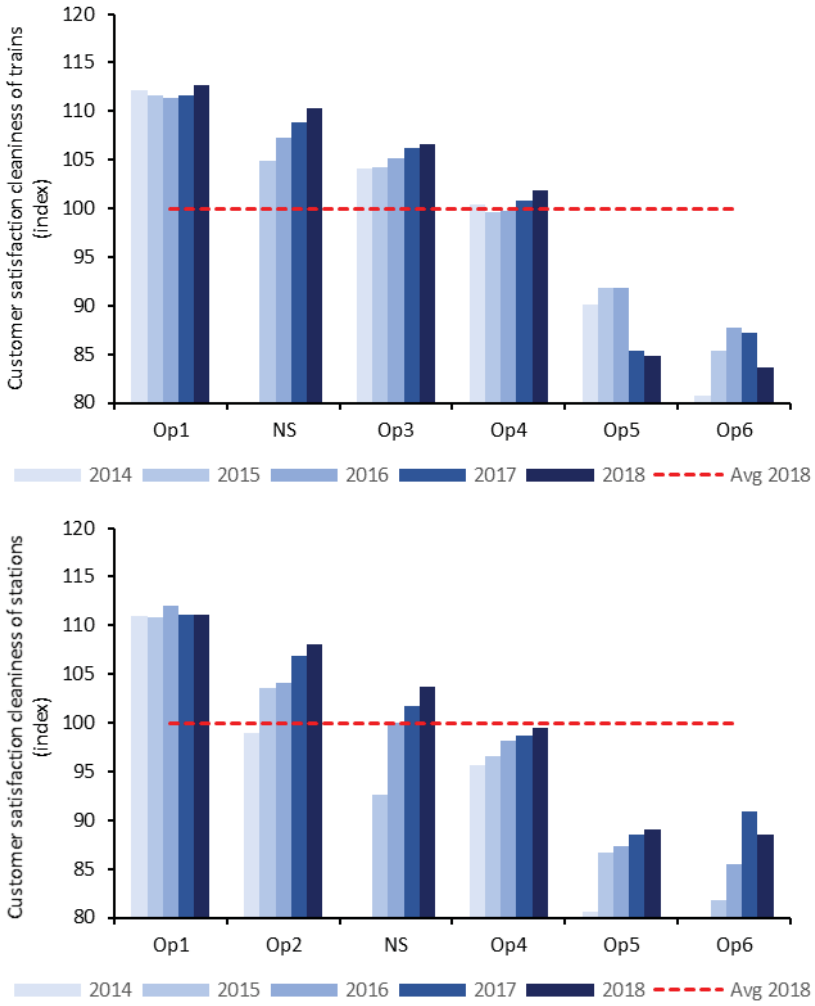




- NS ranks second, although satisfaction on information in the train has declined.
- Customer satisfaction on passenger information during disruptions varies widely over time, partly due to very small sample sizes for these questions. Outcomes are sensitive to incidents and cancellations.
- Measuring customer satisfaction only 2 times per year increases the volatility of the outcomes for some of the peers.
- Multiple peers have developed their customer satisfaction measurement methodology to focus on the experience during a specific trip.
- The best performer in both graphs has invested significant resources into minimizing the impact of disruptions.
- Causality is not clear; customer satisfaction can vary according to the quality of the information, but also correlates directly to variations in punctuality.
- There is no data concerning the impact of managing customer expectations regarding large disruptions (e.g. fall / winter conditions).

3.1 Customer Satisfaction - *Cleanliness*

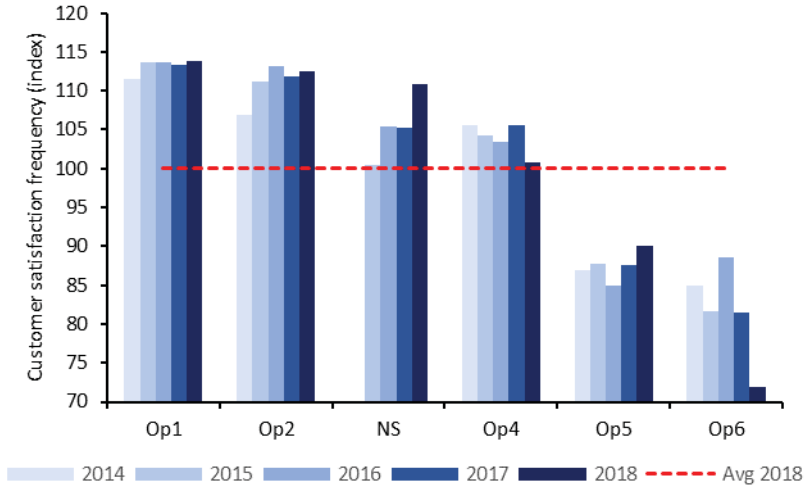
Satisfaction on cleanliness and stations is above average

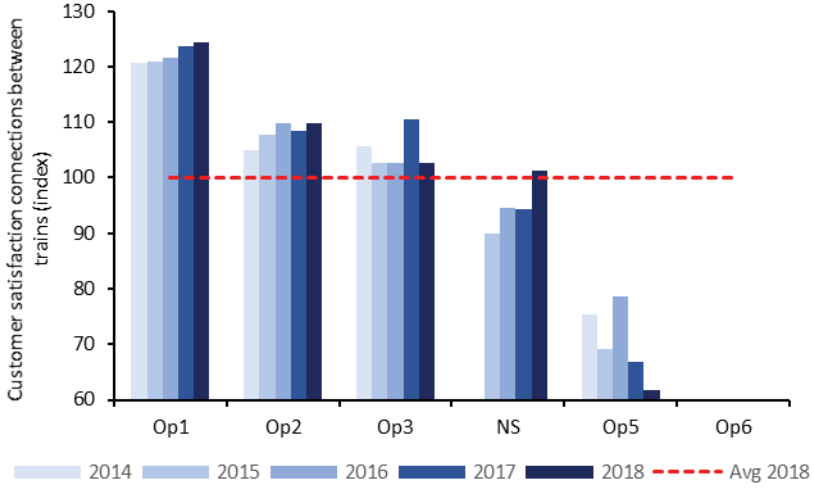


- NS' customer satisfaction about cleanliness of trains and stations is above average and increasing.
- Most operators show rising trends, although some have challenges regarding cleanliness of trains.
- NS' customer satisfaction on cleanliness of trains has partly been improved due to the introduction of new rolling stock and the overhaul of existing rolling stock.
- Renovation of stations has a positive effect on the experience of cleanliness of stations.
- Focused performance management on cleaning has further improved the customer satisfaction on cleanliness of NS' trains and stations.

3.1 Customer satisfaction – *Connections and frequency*

Satisfaction on train frequencies is above average, customer satisfaction on connections is improving



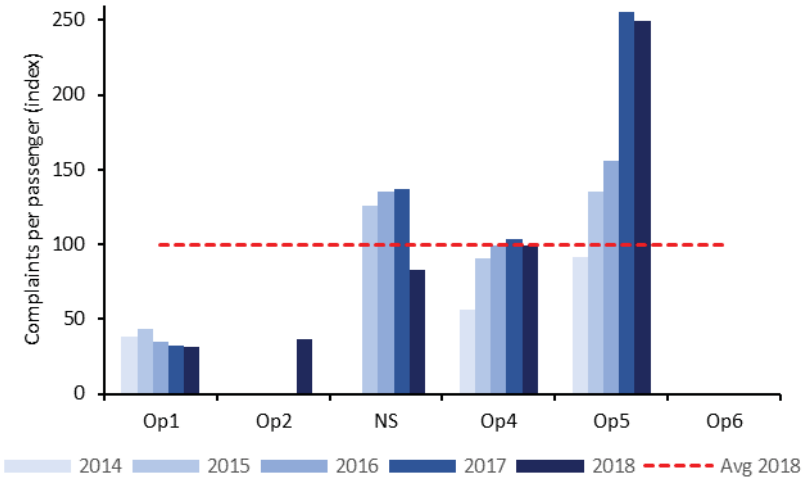


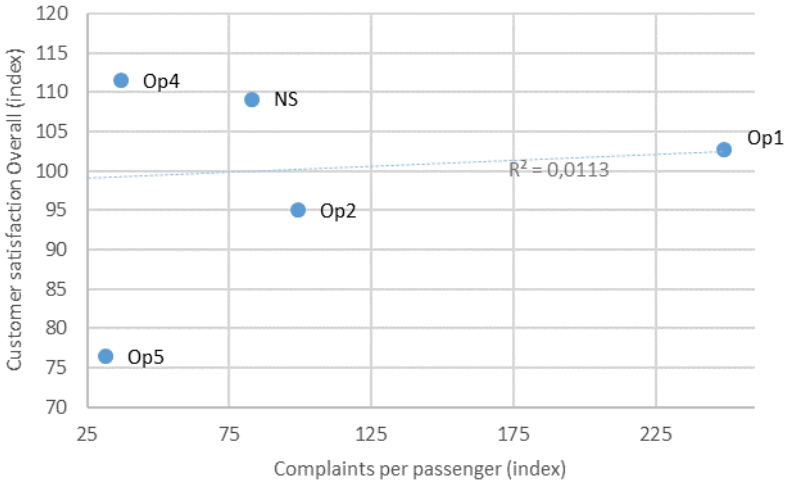
- Customer satisfaction about frequency of trains has increased, and is now well above the average for the peer group.
- NS increases frequencies from 4 to 6 intercity trains per hour per direction on the busiest lines.
- In 2018, NS increased the frequency on the busiest route ("A2-corridor") as a part of Programme High Frequent Rail (PHS).

- NS' customer satisfaction about connections between trains has improved and is now around the average of the peer group.
- For NS, the satisfaction on frequency and connections are highly related, as these are part of the design of the timetables. This was also shown in NS/ProRail *International Benchmark 2011-2015*.
- Op1-Op3 show also high frequencies of trains on the busiest parts of the network, providing many connections.
- Op1 has an elaborate national system of aligning timetables between different operators.

3.2 Complaints

Number of complaints by NS passengers has declined to a level below the average





The number of complaints by passengers NS has decreased considerably over the last three years and is now below average. Reasons for this decline include:

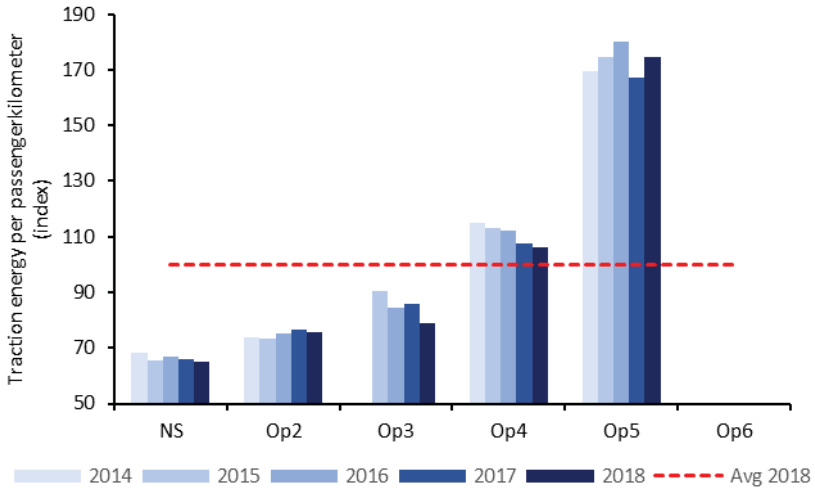
- Adoption of digital channels (OV-chipkaart, compensation claims, feedback possibilities)
- Improvement of passenger information (e.g. about seating availability)
- Improvements in the timetable (frequency, connections, speed)
- Assigning rolling stock with more seats to the busiest lines

Changes in communication and sales channels (digitalization) usually result in a short-term increase of complaints during the adoption period. Customers of NS have finished adopting the OV-chipkaart. Customers of operator 5 are still getting used to a more recent shift to digital channels and have a higher complaint rate.

The complaint rate is influenced by the ease of lodging complaints (e.g. web-based vs. paper form) and the scope of what is logged as a complaint. These differences limit the comparability of levels complaint rates.
Correlation between the complaint rate and overall customer satisfaction is weak .

3.3 Sustainability – *Energy efficiency*

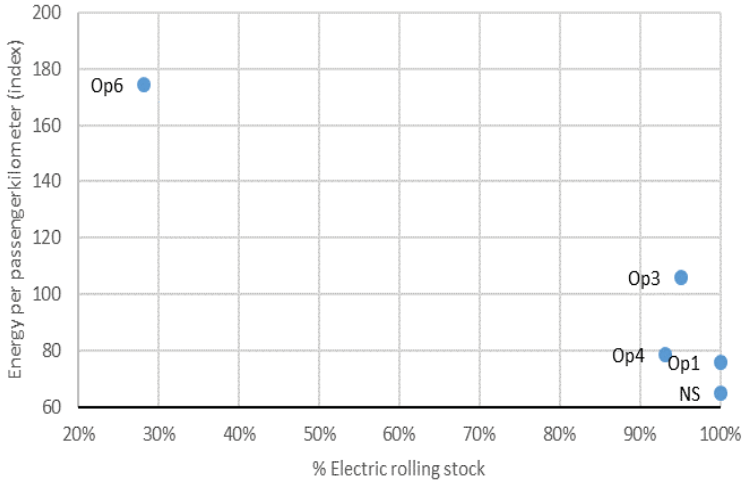
NS is leading the peer group in energy efficiency

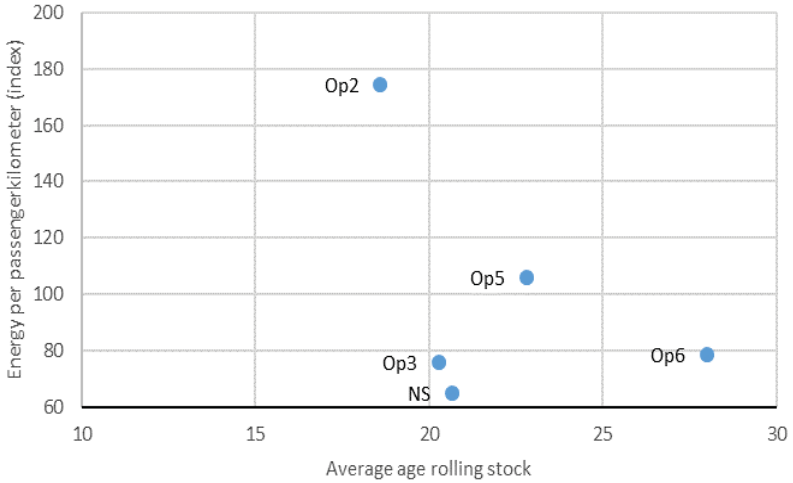


Energy consumption per passengerkm at NS varies slightly over the years, but stays around 30% below the average of the peer group.

Factors contributing to NS' low energy consumption are:

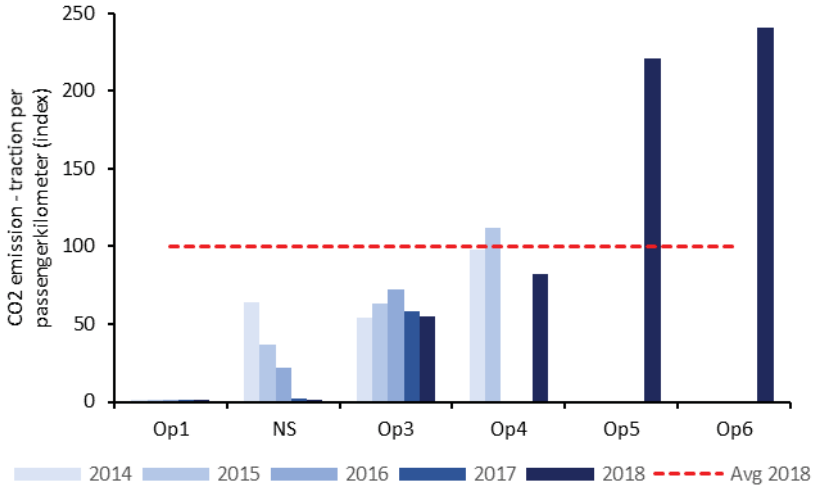
- Operating trains with electrical traction
- High numbers of passengers per train
- Relatively new rolling stock (with recuperative braking)
- Energy efficient driving, facilitated by a driver advisory system (developed in-house)
- Relatively low number of stops (compared to regional traffic of peers)

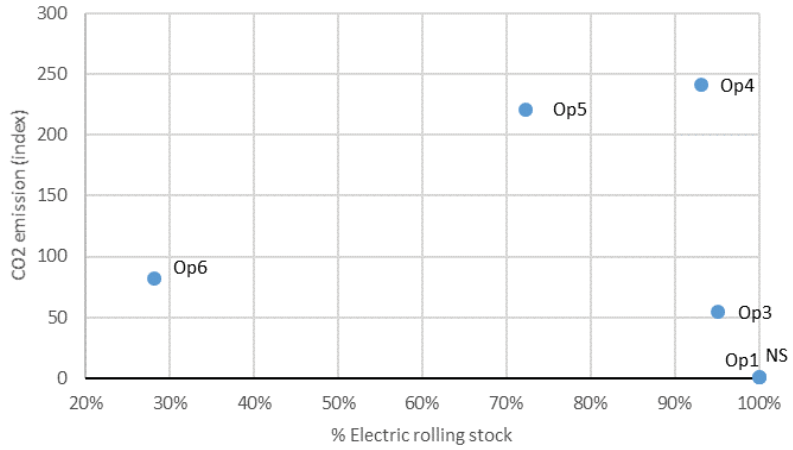




3.3 Sustainability – *CO_2 emissions*

NS' CO_2 emissions have approached zero in the benchmarking period





- NS' CO_2 emissions have decreased to negligible levels during the benchmarking period, resulting in NS ranking second.
- Factors contributing to low CO_2 emissions:
  - Operating trains with electrical traction
  - High energy efficiency
  - Sourcing energy from renewable sources
- NS has ended diesel powered operations and invested significantly in energy efficiency and sourcing from renewable sources in the Netherlands, Belgium, Finland and Sweden (wind power from newly build local wind parks). Peers have expressed their interest in this practice.
- Zero emission sources from other countries include nuclear power and hydroelectric power.

3.4 Trends, insights and best practices

Additional insights from discussion with peers

- Passenger demand
  - External factors have major impact on growth or decline of passenger demand.
  - The growth rate of one of the peers declined due to lower prices for car usage and the rise of travel sharing app services.

- Demand management
  - Multiple peers consider pricing signals to manage demand and shift growth of demand from the busiest trains to less busy trains .
  - One of the peers introduced a new targeted proposition; lower price, but with limitations for certain trains/times. Targeting younger passengers via digital channels proved to be very effective; the substitution ratio was very good.

- Targeted investments in performance improvement
  - Performance management is maturing in most operators of the peer group.
  - Multiple peers show more conscious decision making, making trade-offs between KPI improvement and the associated investments (e.g. portfolio approach).

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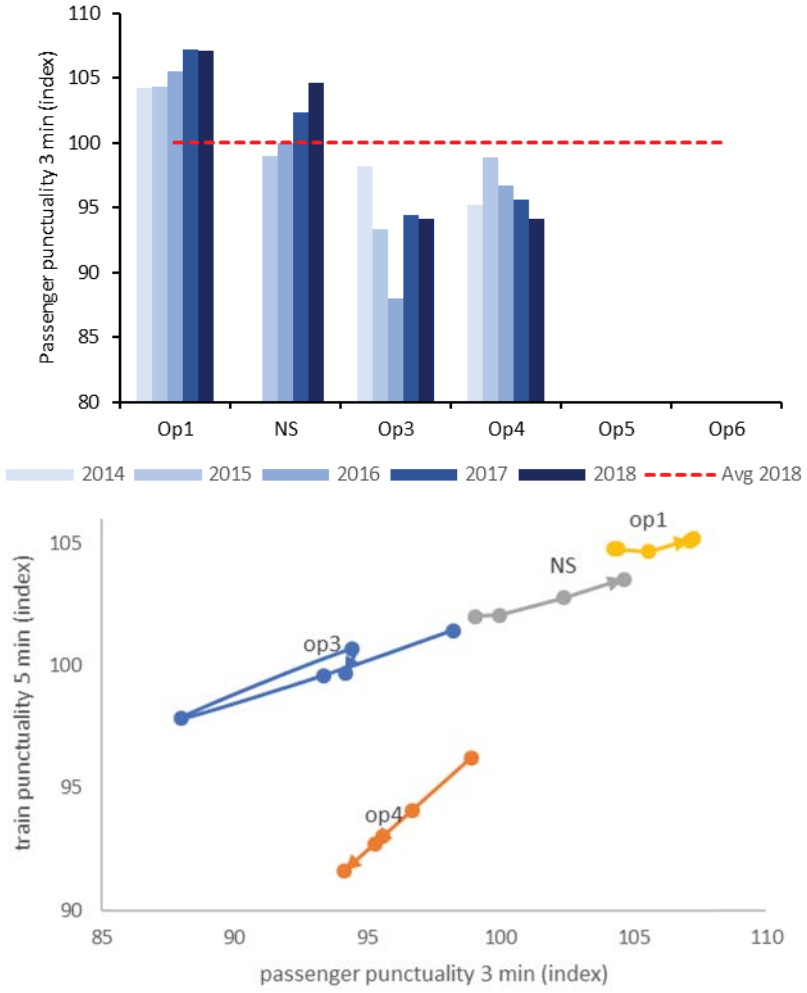
4. Quality of railway services

- 4.1 Reliability, punctuality and cancellations
- 4.2 Seating capacity
- 4.3 Safety and security
- 4.4 Insights and best practices

Quality of railway services is operationalized as the reliability of train services, passenger punctuality, train punctuality and cancellations (4.1). This includes a more in-depth review of factors impacting the cancellation ratio of trains.
Other aspects of the quality of railway services are seating capacity (4.2), safety of passengers and staff and personal security on stations and in train (4.3).
This chapter concludes with some additional insights and best practices found within the peer group (4.4).

4.1 Punctuality and cancellations – *Passenger punctuality*

Passenger punctuality has increased and is above average

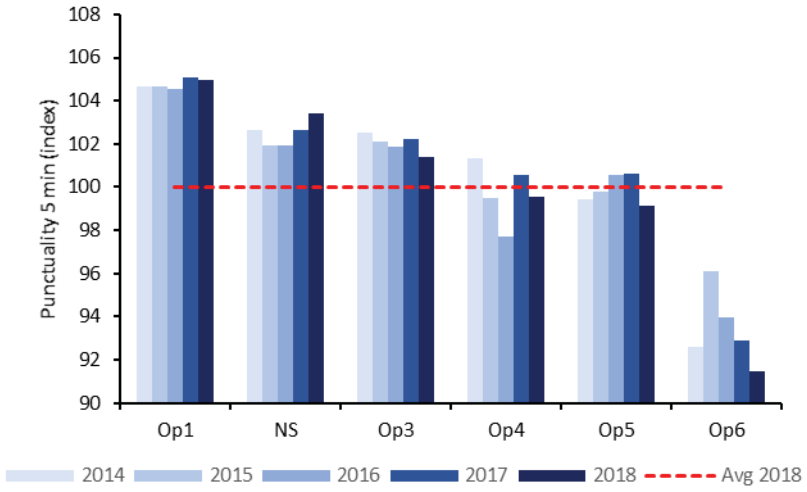


- The definitions and methodologies for passenger punctuality vary significantly. NS is unique using check-in and check-out data. Other operators use weighted train punctuality calculations.
- The figures have been harmonized to some extent, but evaluating trends is more meaningful than comparing absolute levels.
- NS passenger punctuality has improved over the past years and is above the average of the peer group.
- Four operators in the peer group use a passenger punctuality KPI. Other operators only measure train arrival punctuality and cancellations.

- Passenger punctuality is highly correlated to train punctuality and to a lesser extent to train cancellations.
- Focusing on improving passenger punctuality can lead to changes in dispatching and disruption management decisions. This may result in more trains being cancelled, but more passengers arriving on time.

4.1 Punctuality and cancellations – *Train punctuality*

Train punctuality has increased and is above average



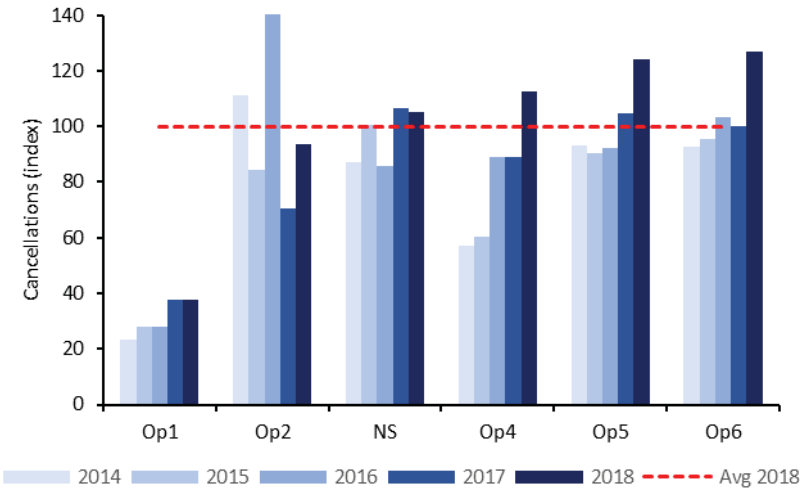
- Factors impacting manageability of punctuality cited by multiple peers:
  - Aligned targets for operator and infrastructure manager
  - Dispatching decisions
  - Constraints in the timetable
  - Impact of delayed international trains and trains of other operators on the same network
  - Reserve resources (rolling stock, staff)
  - Level of detail of planning systems

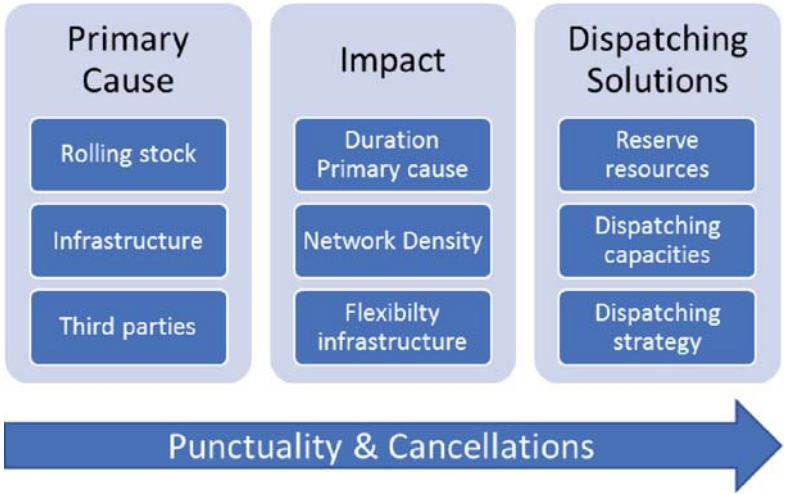
- Train punctuality is a main performance indicator for all operators, but methodologies and definitions vary.
- Figures have been harmonized as much as possible; delay threshold of 5 minutes and measurement on nodes (not only terminal stations) are used.
- Some uncertainty remains, so focusing on trends is more appropriate than absolute figures.

- NS' train punctuality at 5 minutes has increased over the years and is well above average of the peer group.
- NS has both improved reliability and increased frequencies of train services by:
  - Improving the timetable design process (aiming at operational executability)
  - Improving dispatch and exception handling
- Operator 1 has also improved its performance by introducing both new infrastructure and significant timetable improvements. The operator is unique in integrating the processes of designing timetables and new infrastructure.

4.1 Punctuality and cancellations – *Train cancellations*

NS' train cancellation ratio is around average





- NS' train cancellation ratio is around the average of the group.
- Cancellations are expressed with respect to the current timetable, which is in most cases set 24 or 36 hours before operation.
- There are some differences in definitions (e.g. measuring whole and/or partial cancellations, timing of reference timetable), limiting comparability. Therefore trend analysis is more meaningful than comparing absolute ratios.

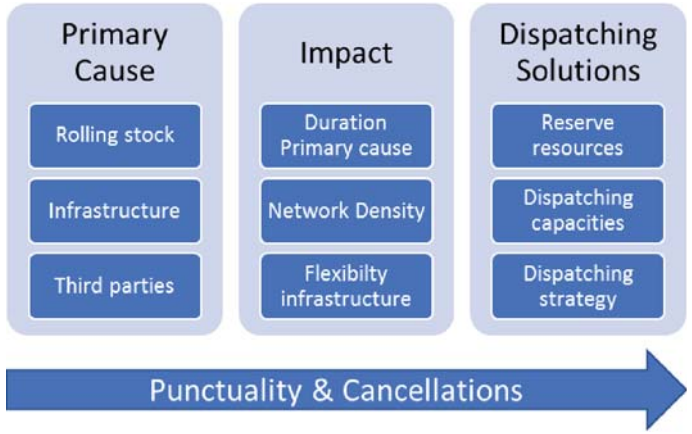
- Most peers show upward trends, citing a variety of causes:
  - Signaling problems
  - Quality of rolling stock
  - Dispatching goals and strategy
  - Weather conditions
  - Impact of performance of other operators.
- The top performing peer has a significantly lower ratio than all other peers. Differences will are explored further in the following pages.

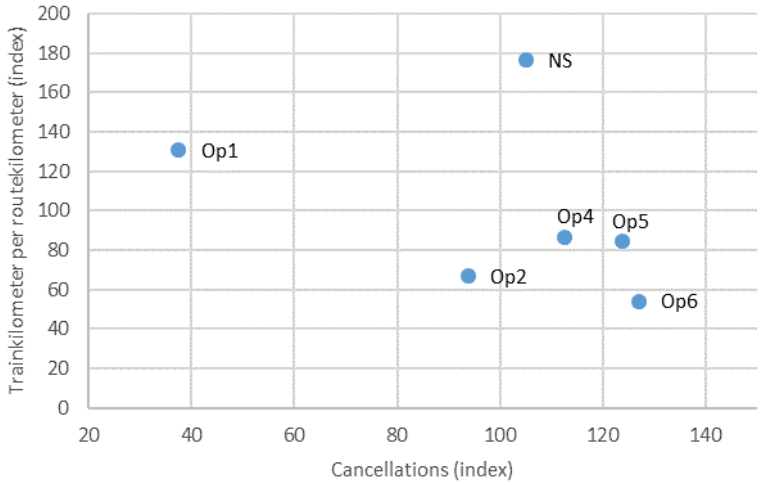
- To analyze the number of cancellations, the following factors can be considered:
  - Primary cause of the cancellation (e.g. infra failure, accidents, rolling stock problems),
  - Direct impact of the cause on trains,
  - Available solutions for the dispatchers.
- **Primary causes**: in the case of the top performing operator, considerable investments in quality of infrastructure reduce the number of incidents. NS has improved the quality of rolling stock preceding the high frequent operation on the A2 route.

4.1 Punctuality and cancellations – *Train cancellations vs frequency*

Higher frequencies can lead to more cancellations

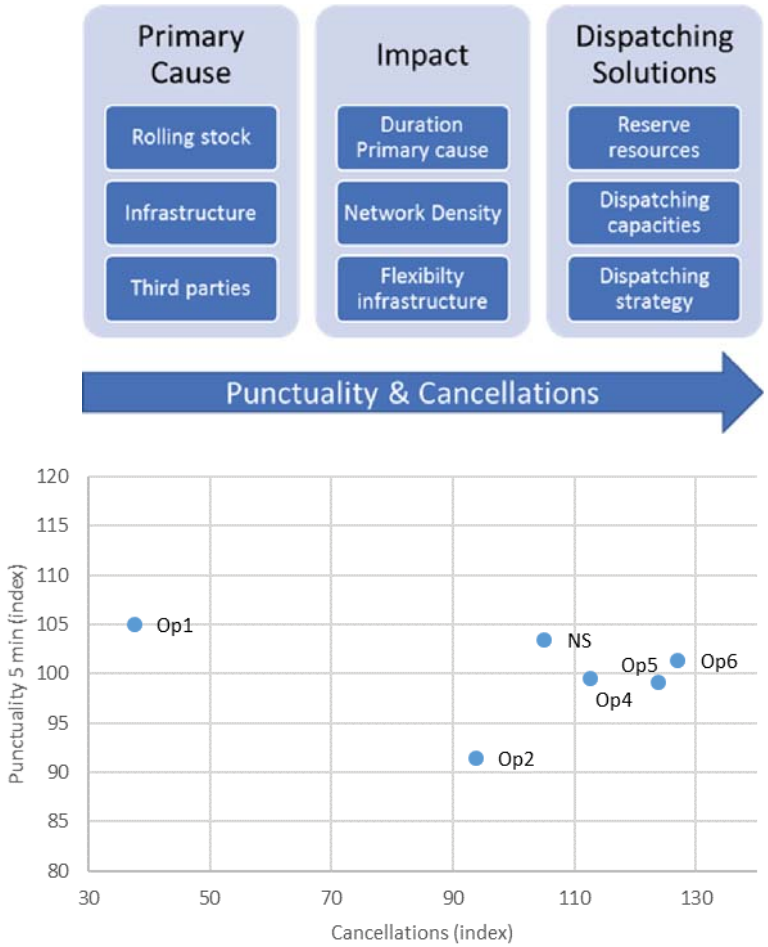
- Mitigating factors that help reduce the number of **primary causes** (that are mentioned by multiple peers) include close cooperation with the infrastructure manager (analyzing and preventing causes) and good maintenance of rolling stock.
- The **impact** of a primary cause depends on the duration of the incident, the network density and flexibility of the infrastructure layout.
- The infrastructure manager of the operator with the lowest cancellation reduces repair times on infrastructure-related disruptions by allowing repairs to take place between scheduled trains (during operations).
- The best performing operator also has a number of staffed locomotives standing by to quickly tow defective rolling stock from the tracks.
- The impact of a disruption on a timetable and the corresponding decision to cancel one or more trains depend on safety protocols (e.g. allowing repairs between scheduled trains) and the properties of the timetable itself.
- According to multiple peers, the density of the network is an important factor explaining a higher cancellation ratio. A higher frequency reduces the possibility to repair failures without impacting other trains.
- The graph shows that NS combines the highest network density with an average cancellation ratio.





4.1 Punctuality and cancellations – *Passenger punctuality vs cancellations*

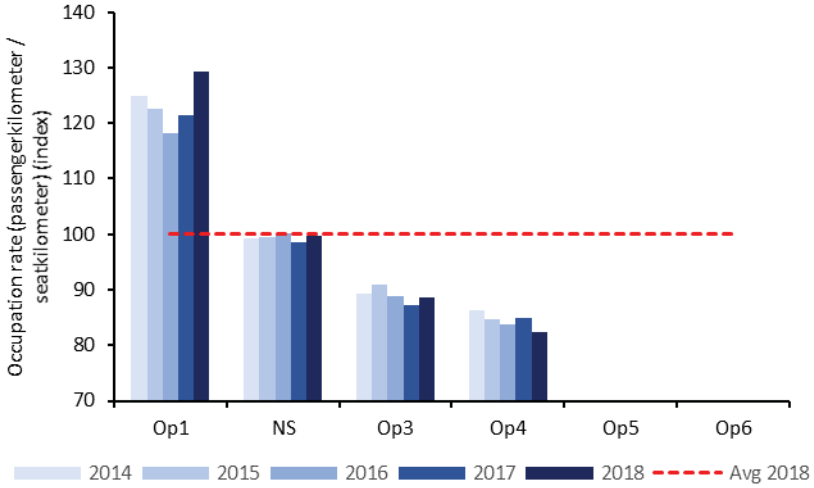
Passenger punctuality versus cancellations – dispatching decisions

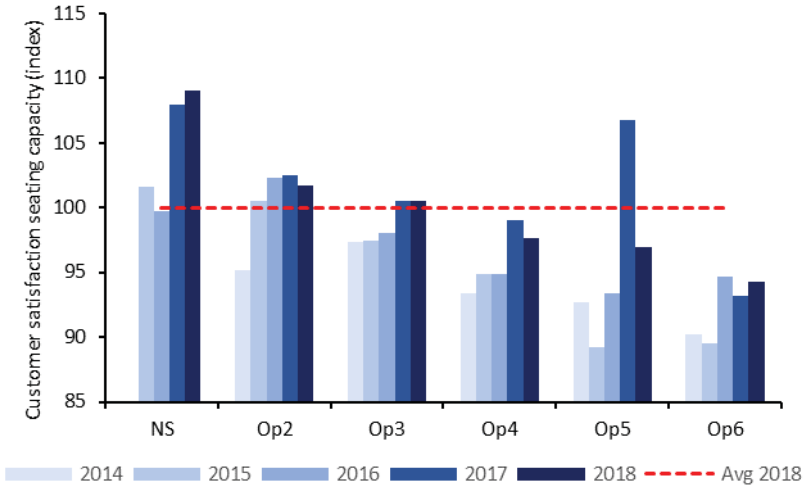


- Given the impact on primary causes, **dispatching solutions** can reduce the impact on the rest of the network.
- The best performing peer on cancellations has a number of staffed trains that are ready to take the place of cancelled or heavily delayed trains in the operational timetable in very short notice.
- NS and ProRail have invested in a better decision making process (CMBO) in case of incidents and cancellations. A number of peers also work co-located with the infrastructure manager in a control centre. However the actual collaboration varies widely between "just providing input" to more intense interaction during the decision making process.
- Multiple peers discuss the trade off between passenger punctuality and cancellations during dispatching decisions. Differences in strategies are connected to differences in goals and objectives and the operational context.
- There are two main strategies:
  - Minimize cancellation of delayed trains (this can be culturally unacceptable, or undesirable because of passenger flow)
  - Minimize the impact of delays, aiming for overall passenger punctuality (accepting a number of cancellations)
- ProRail and NS adhere to the second strategy, resulting in a positive trend in passenger punctuality.
- A strategy combining both passenger punctuality and capacity of trains at peak hours may be worth investigating.

4.2 Seating capacity

Seat occupation rate is average, customer satisfaction on seating capacity is high





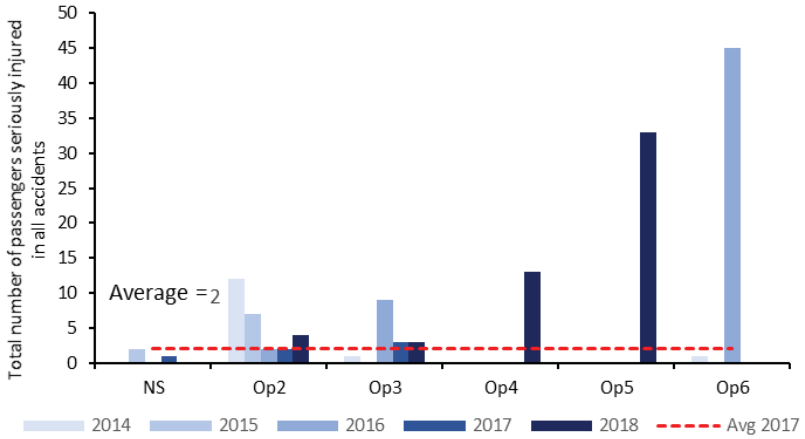
- The occupation ratio of seats in trains at NS is around the average of the peer group and remains stable.
- Customer satisfaction about seating capacity increased significantly, moving NS to the first place in the ranking.

- During the benchmarking period NS introduced several measures to improve seating capacity:
  - Actively managing seating capacity; monitoring, analysis, interventions in rolling stock allocation, e.g. extra capacity during “hyper peak” (7.30-8.00).
  - Increasing frequency of trains on busiest route and adding peak hour services on specific routes.
  - Providing seating capacity information to enable passengers to decide on alternative trains with more available seats (search tool in planner app, personal mail campaign, back to school campaign).
  - Developing new rolling stock planning tooling minimizing passengers’ 'standing minutes’.

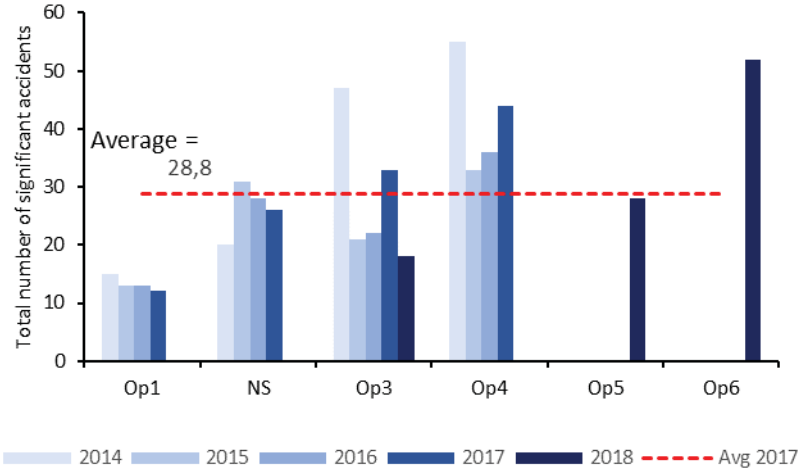
- The operator with the highest seat occupation ratio utilizes a seat reservation system and changes train length frequently during operations to match seat supply and demand as close as possible.

4.3 Safety and security – *Railway safety*

Railway safety in the Netherlands is above the average of the peer group



- During the benchmarking period there has been a low number of accidents that involve the serious injury of passengers.
- The number of significant accidents (including those without injury/death) is below the average of the peer group.

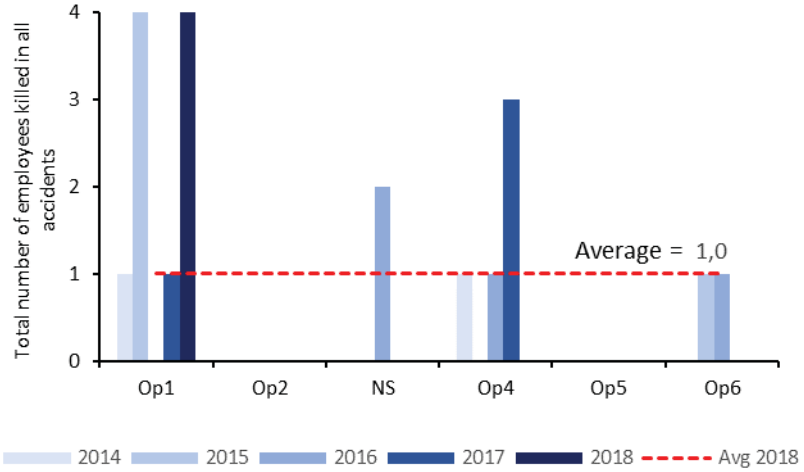


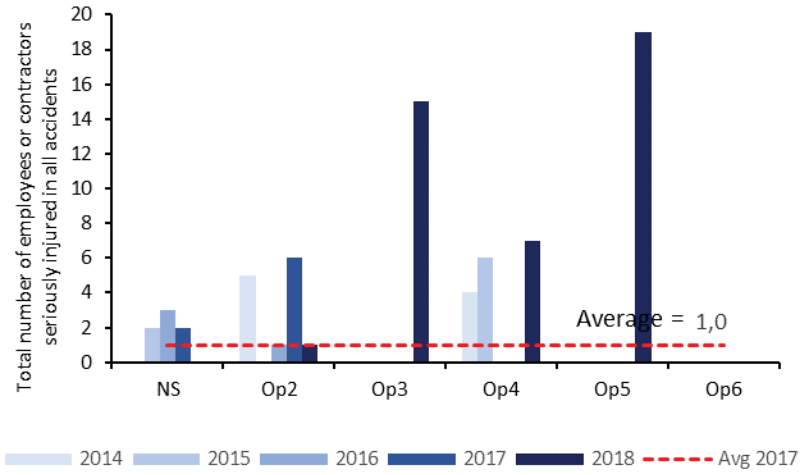
Remarks

- The comparisons show total numbers per country and not per peer (ERA Common Safety Indicators).
- Ranking in graphs is based on 2017 values, due to ERA data on 2018 not being available yet.
- Missing data and zero incidents both appear as "0" in the graphs.
- Safety comparisons like these are very sensitive to single incidents.

4.3 Safety and security – *Safety for employees*

A meaningful comparison of railway safety for staff is difficult due to low numbers of incidents





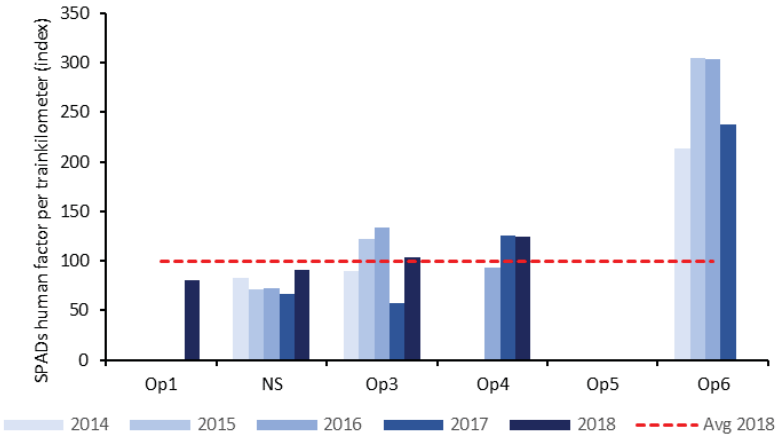
- The Netherlands have suffered relatively few accidents with a large impact (serious injuries, death) during the past few years.
- None of the peers show any stable trends.

Remarks

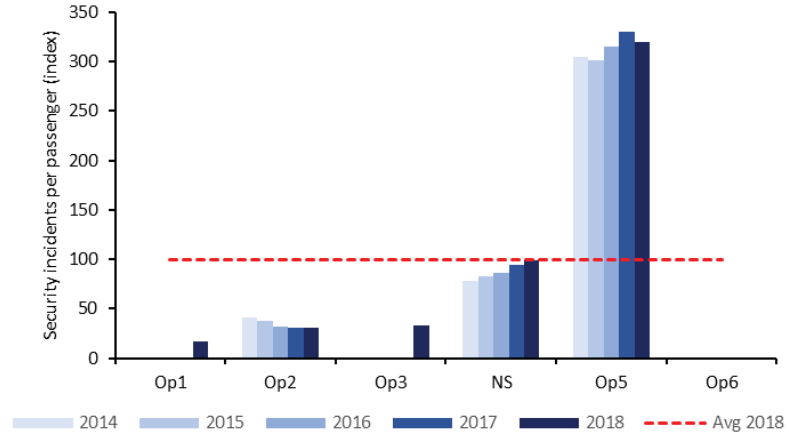
- The comparisons show total numbers per country and not per peer (ERA Common Safety Indicators)
- Ranking in graphs is based on 2017 values, due to ERA data on 2018 not being available yet.
- Missing data and zero incidents both appear as "0" in the graphs.
- Safety comparisons like these are very sensitive to single incidents.

4.3 Safety and security – *SPAD and security for passengers*

The level of signals passed at danger (SPAD) in the Netherlands is below average



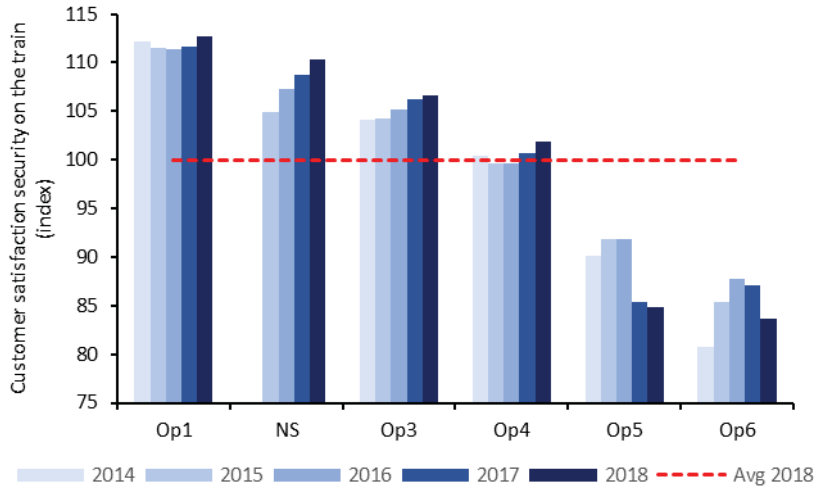
- All peers use signals passed at danger as a main operational safety indicator. Therefore here the graph shows the performance of individual peers and not performance on a country level.
- NS' SPAD ratio is below the average of the peer group.
- The peak in 2018 is mainly caused by transition of roles on shunting yards and can be expected to be incidental.
- The figure for Operator 4 is not comparable to those of the other operators, due to differences in definitions and scope.

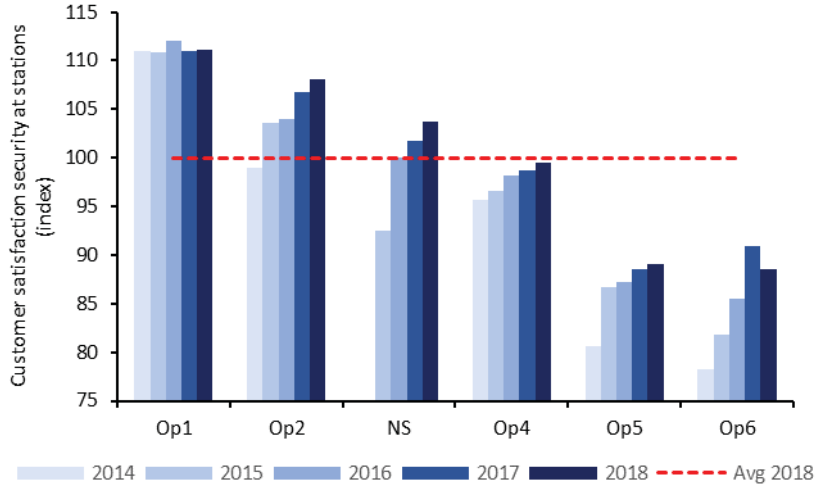


- Security incidents are registered incidents between passengers or between passengers and railway staff.
- The definitions of an incident varies between the peers. (incl/excl verbal and physical aggression), evaluating trends is more meaningful than comparing absolute levels.
- The number of incidents at NS is increasing during the benchmark period. Violence against public employees has been a problem in Dutch society.
- During 2018, security employees of NS were equipped with a bodycam.
- The number of incidents at NS dropped 18% in 2019.

4.3 Safety and security – *Customer satisfaction on security*

Customer satisfaction about security is above average and consistently rising





- Customer satisfaction about personal security (feeling safe in trains and on stations) has continuously increased in the case of NS.
- NS now also ranks above average for security on stations.
- NS ranks above average for security in trains during the entire benchmarking period.

- Developments with a positive impact on security are:
  - Closing passenger gates at stations
  - Opening of new stations or renovation of stations
  - Introduction of new rolling stock with a more transparent interior and CCTV
- The impact of these developments is recognized throughout the peer group.

- The questions to customers about security vary among the peer group. Therefore a comparison of the development of customer satisfaction is more meaningful than a comparison of the absolute levels.

4.4 Insights and best practices

Additional insights from discussion with peers

- Punctuality and cancellations
  - One operator of the peer group has very clear decision rules for rolling stock problems. If a train isn't able to leave within a given time, the train will be cancelled.
  - One operator of the peer group does not relieve a driver directly after an incident, but gives the driver the choice to be relieved immediately or at a subsequent staff location.
  - Multiple peers stress the importance of collaboration between operators and the infrastructure manager to manage and improve punctuality and reliability for the passengers.

- Seating capacity
  - Many operators require rolling stock that is in need of maintenance to be in the depot for at least one or two traffic peak periods. This requires a significant fleet reserve.
  - One of the peers has improved rolling stock availability by dividing the maintenance schedule in smaller time intervals that can be carried out between the rush hours. This results in a higher seat availability, but can have a negative impact on maintenance costs.

- ERTMS introduction
  - Some peers notice that the introduction of new rolling stock or ERTMS is very complex and has an impact on several performance aspects. Training of staff and the availability of sufficient siding and depot facilities can be bottlenecks.
  - For one operator the introduction of new rolling stock had a negative impact on the overall performance, due to the amount of attention and capacity (of the workshop) that was needed for this introduction.

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5. Capacity and utilization

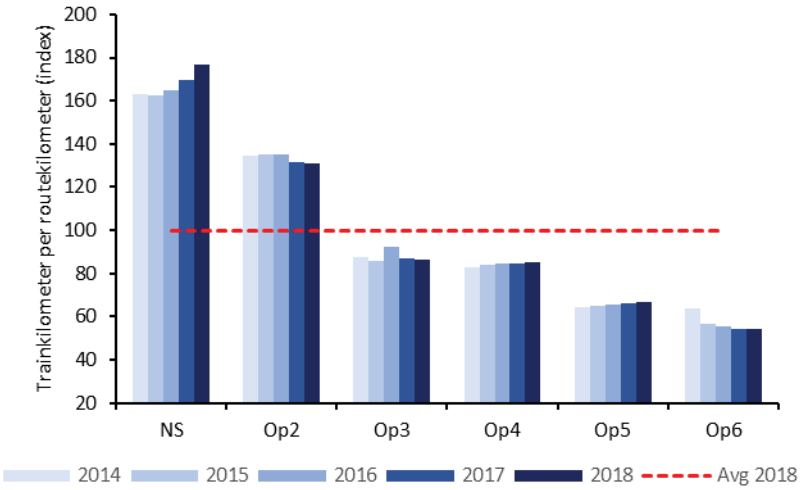
5.1 Utilization of the network, trains and stations

5.2 Utilization of the rolling stock

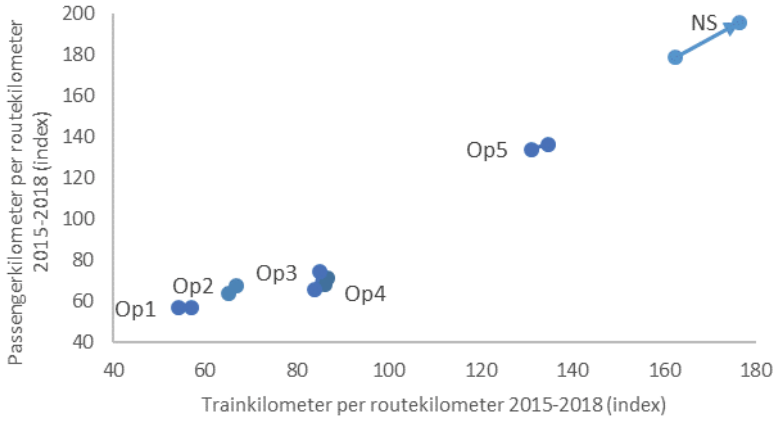
This chapter presents aspects of capacity and utilization. The most important aspects are the utilization of infrastructure (5.1) and rolling stock (5.2). An exploration of factors impacting the utilization of rolling stock is also presented.

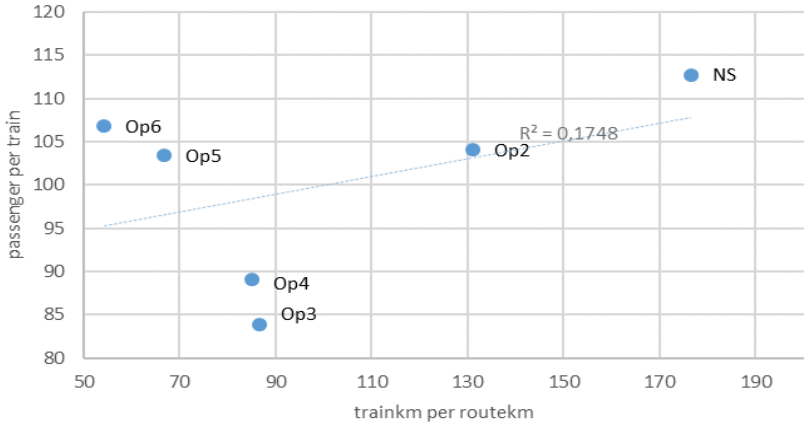
5.1 Utilization of the network, trains and stations

High utilization of the network, trains and stations



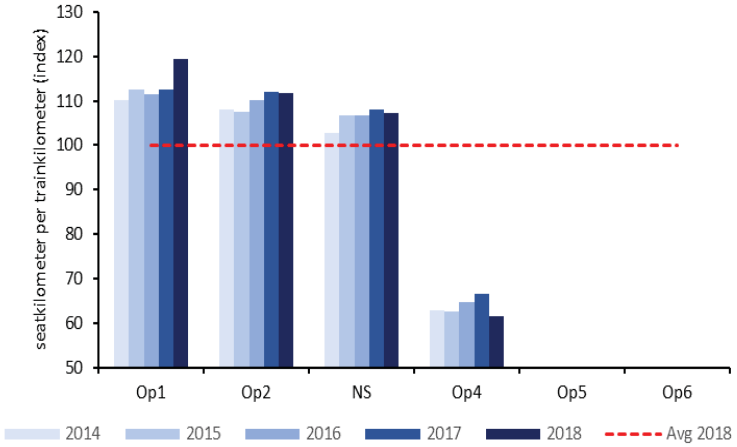
- NS' intensity of utilization of infrastructure, trains and stations is significantly above average.
- Characteristics of the core network operated by NS contribute to this high intensity of utilization:
  - High frequencies between large cities
  - High population density in the Randstad area
  - Low proportion of rural lines
  - Strategy to prioritize investing in the effective use of existing infrastructure rather than expanding.
- High intensity makes the operation more sensitive to disruptions. Interaction with other operators on the same network is mentioned as an important issue.



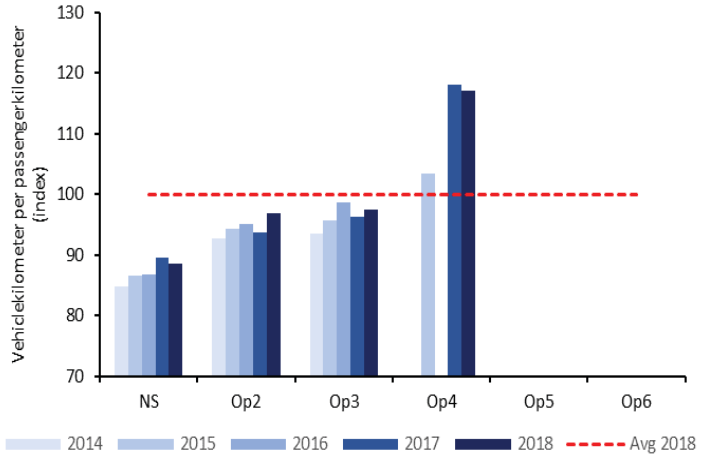


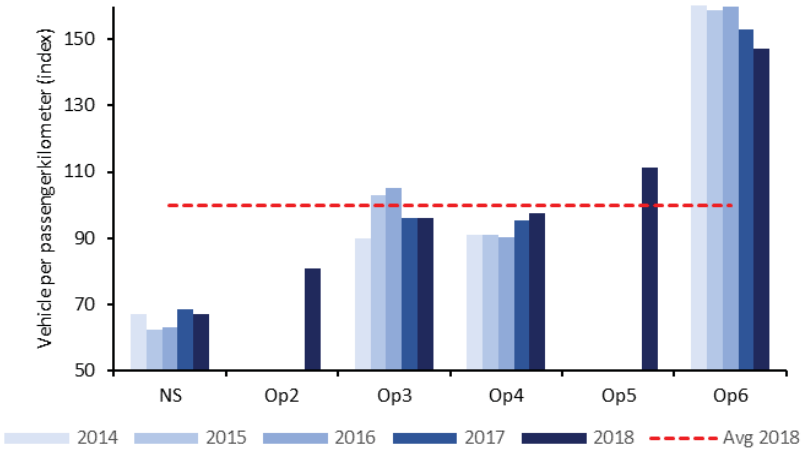
5.2 Utilization of the rolling stock - *Figures*

High utilization of rolling stock



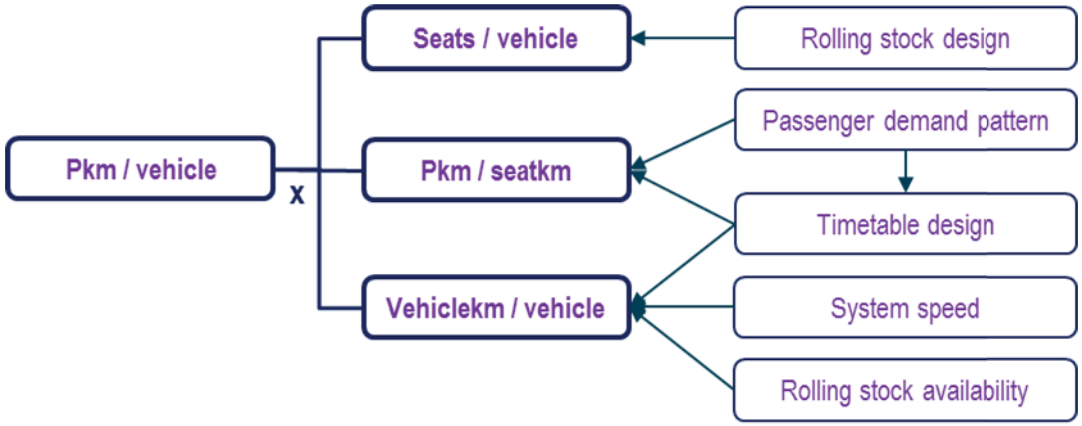
- NS' number of seats per train is above average.
- Train length is limited by infrastructure (platform length during peak hours) and efficiency considerations (during off peak hours).
- For productivity of rolling stock the numbers of vehicles are compared. A vehicle is a loco-hauled passenger car or a car in a multiple unit. This is a proxy for capacity and for the invested capital.
- NS has a relatively low number of vehicles and utilizes a relatively low number of vehicles and vehiclekm per passengerkm. This indicates a high level of productivity of the rolling stock, both in capital costs and operational costs.
- NS however still ranks highest at customer satisfaction on seating capacity, indicating an effective allocation of rolling stock, matching supply and passenger demand.





5.2 Utilization of the rolling stock– *Factors of influence*

Factors influencing utilization of rolling stock



- Factors driving rolling stock productivity are:
  - Occupancy ratio of seats
  - Even demand pattern (geographical distribution and peak hour percentage)
  - Timetable (system speed and diagramming)
  - Rolling stock availability
- The demand pattern of NS is relatively beneficial for productivity:
  - Peak / off-peak hour demand ratio is lower at some other peers
  - Demand is geographically evenly spread between multiple centres (large cities), whereas some other peers have peak hour traffic that is highly concentrated along one center.
- Some factors that have made rolling stock productivity challenging for NS are:
  - Strong growth of passenger numbers in peak hour
  - Temporarily large reserve of older fleet as a backup during introduction of new rolling stock

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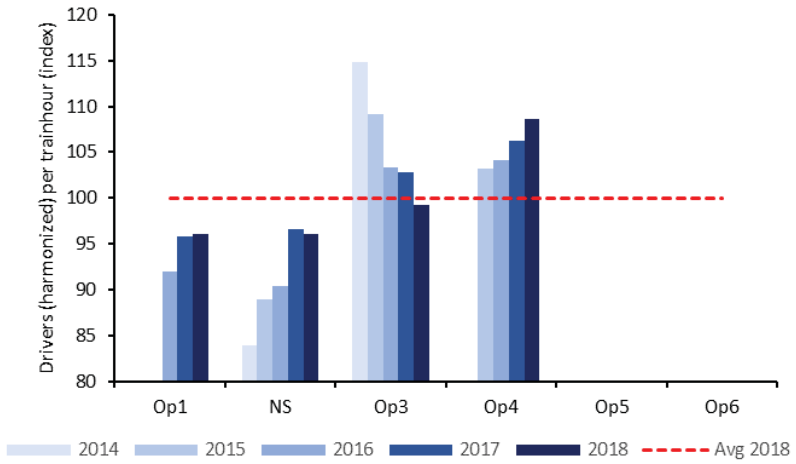
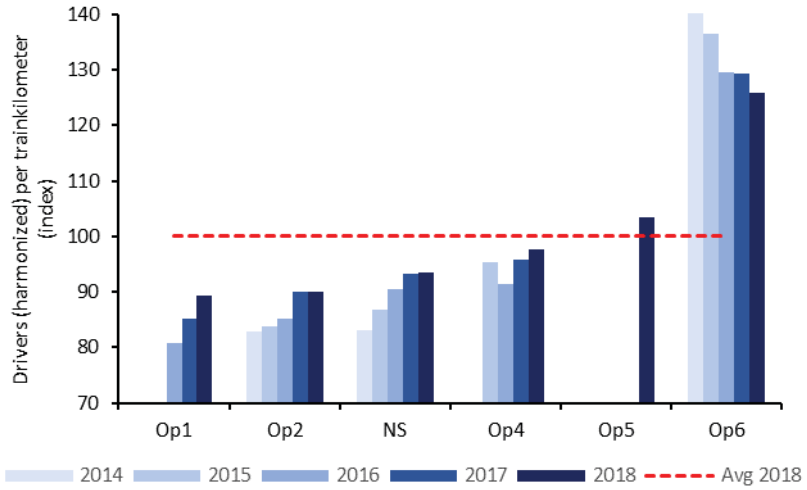
- 6.1 Train staff productivity
- 6.2 Rolling stock productivity

The most important cost categories for train operators are the costs for rolling stock and train staff. Therefore this chapter compares the productivity of train staff (6.1) and rolling stock (6.2). It also provides an overview of the main factors impacting these productivity indicators (e.g. system speed, timetable design, etc.) Chapter 7 expands this with an evaluation of the financial performance.

6.1 Train staff productivity - *Drivers*

NS productivity of drivers is above average. Most peers show a declining productivity.

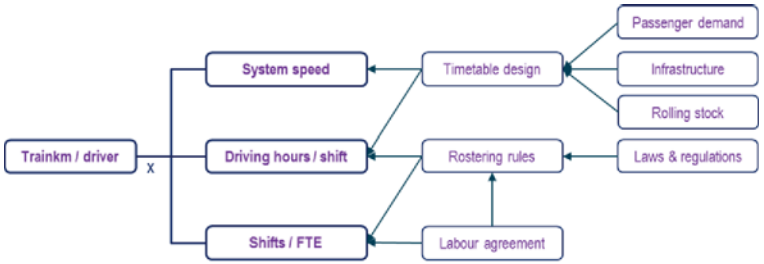




NS' driver productivity is above average, both in terms of trainkm per driver and driving hours per driver.

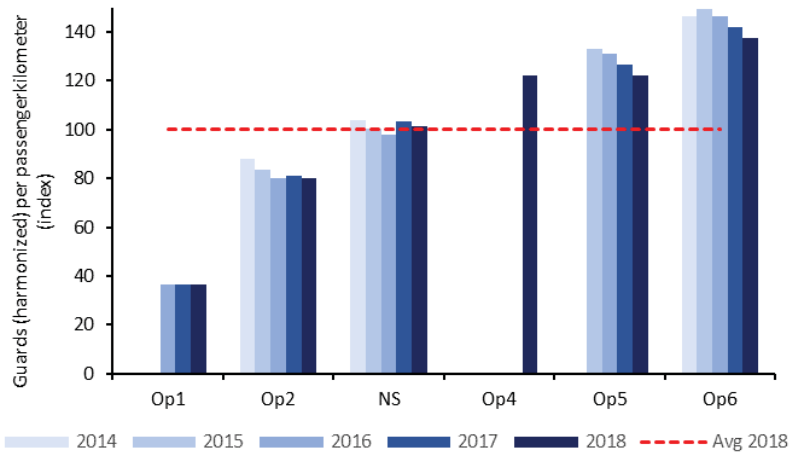
- Driver productivity is impacted by: system speed, labour hours, training hours and the efficiency of planning.
- Differences between the two comparisons are caused by differences in system speed.
- Both graphs have been harmonized for differences in contract hours per week.

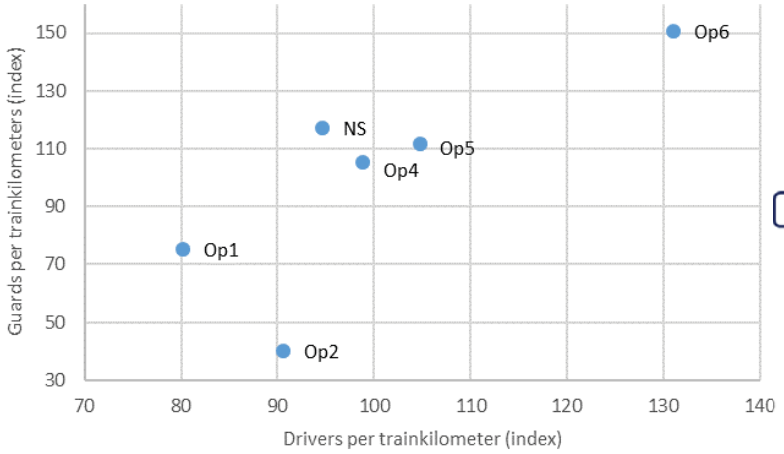
- Most peers show decreasing driver productivities. Increased training capacity is cited as a cause.
- For NS, main factors are:
  - Training of a significant amount of new drivers
  - Training of drivers for new rolling stock types
  - Increasing non-revenue train kilometers due to shortage of stabling / inspection capacity.



6.1 Train staff productivity – *Train guards*

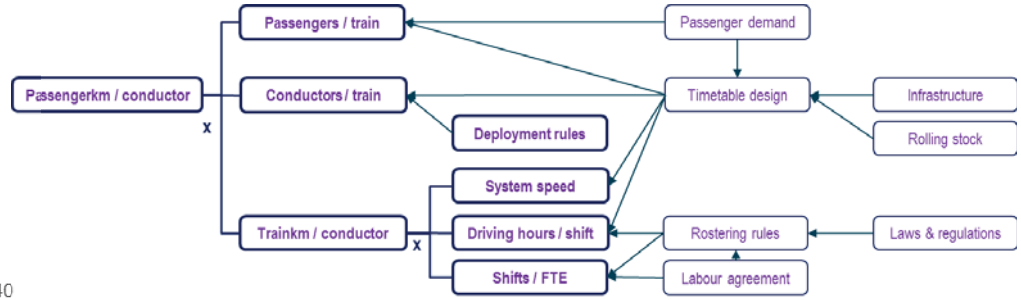
Productivity of NS train guards is around average. Large differences in staff deployment policies





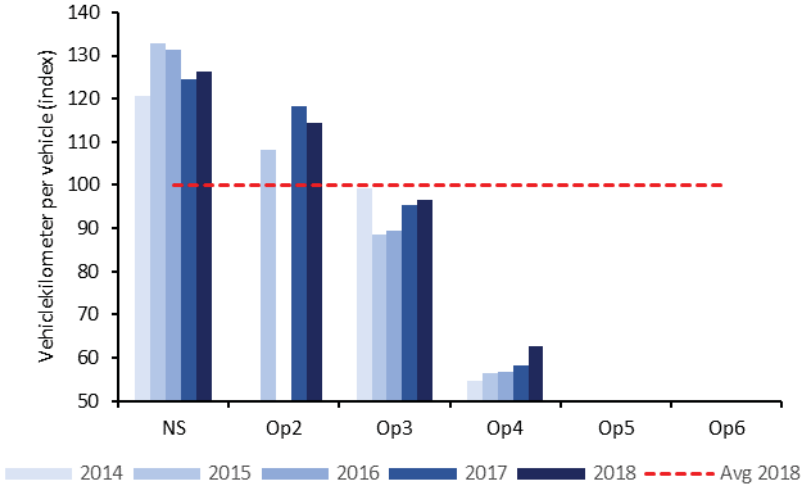
- NS' train guard productivity (guards per passengerkm) is around average and stable.
- Main factors impacting this productivity are:
  - Staff deployment policy (number of guards per train)
  - Train utilization (passengers / train)
  - System speed
  - Roster efficiency (contractual rules, planning software, timetable vs. network topology)

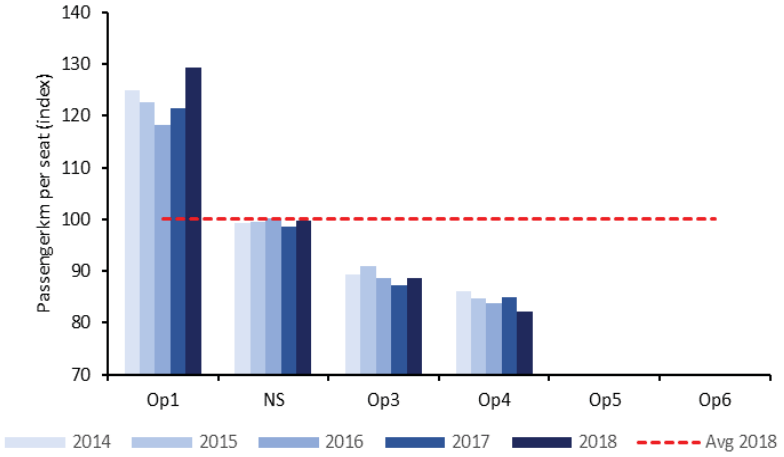
- Peers with a higher guard productivity (Op1 and Op2) do not have train guards on every train.
- NS has a relatively high number of guards per trainkilometer, to ensure personal security.



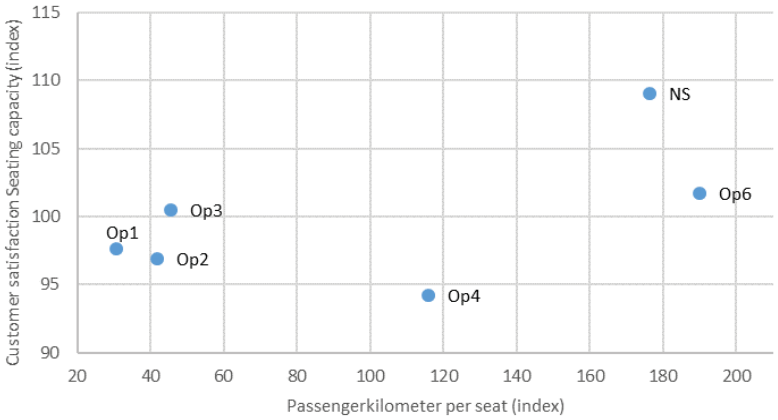
6.2 Rolling stock productivity

NS has a high rolling stock utilization ratio, while retaining a high level of customer satisfaction





- NS ranks first in rolling stock utilization, both with respect to passengerkm per seat and vehiclekm per vehicle.
- Factors impacting rolling stock productivity are:
  - Demand pattern (peak/off-peak, geographical)
  - Timetable structure and system speed
  - Rolling stock availability (efficient and effective maintenance)
- One operator has a higher number of passengerkm per seat, but this is associated with overcrowding of trains, resulting in a lower customer satisfaction on seating capacity.



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7. Financial performance

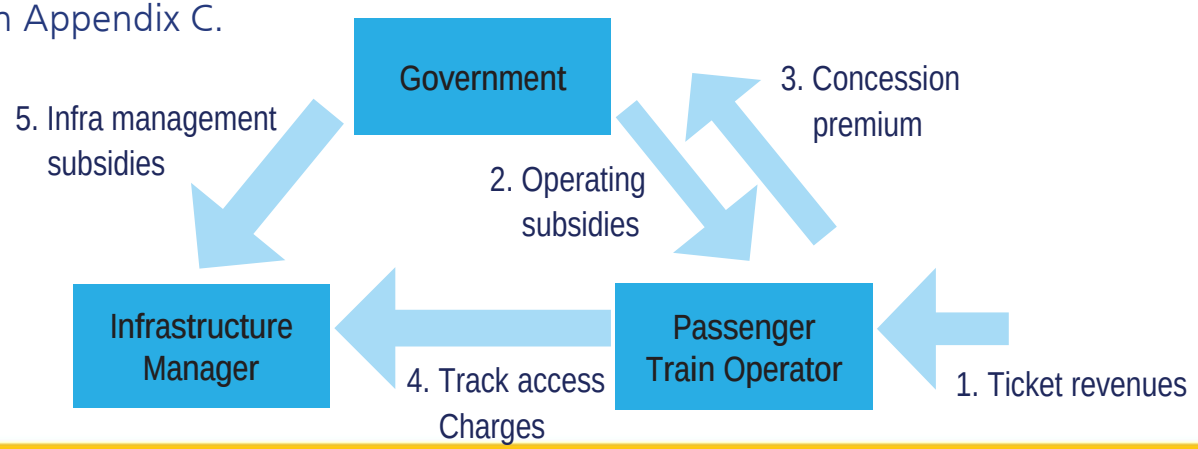
- 7.1 Introduction relevant factors and flows
- 7.2 Operator revenues
- 7.3 Net costs
- 7.4 Track access charges

A complete comparison of the financial performance of each operator should include all relevant factors and flows. These factors include average fare levels, contract payments and track access charges (7.1).
An overview of financial performance at the level of operator revenues (7.2) is followed by the net costs per operator (7.3) and a comparison of track access charges (7.4).

7.1 Introduction of relevant factors and flows

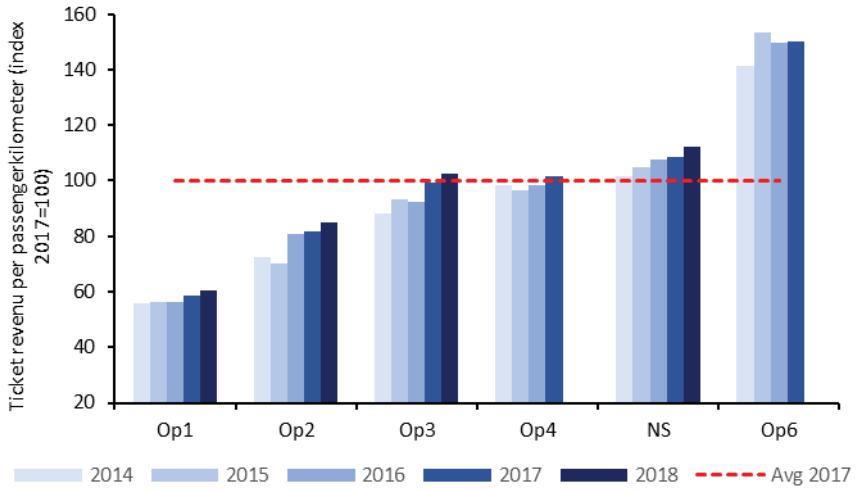
Financial flows to/from the government and the infrastructure manager vary between peers

- A comparison of financial performance should include all relevant financial flows.
- The total ticket revenues (1) divided by the total number of passengerkilometers indicates the cost level for passengers.
- The total operating subsidies (2) minus the concession premium (3) and minus the track access charges (4) indicates the total level of net public funding for the passenger train operator.
- The sum of ticket revenues (1) and net public funding (2. – 3. – 4.) indicates the net costs of the passenger train operator.
- The sum of operating subsidies (2) and infra management subsidies (5) minus concession premium (3) is a measure for the total public funding of the railway industry. Due to differences in operational situation (e.g. multiple passenger and freight operators) this comparison can not be included in this benchmark.
- The scope for this operations funding excludes funding of investments (e.g. infrastructure, stations and/or rolling stock).
- All financial comparisons are in current price levels, excluding VAT and corrected for purchasing power parities as described in Appendix C.



7.2 Operator revenues

NS' passenger fares are above average, while NS has below average net public funding

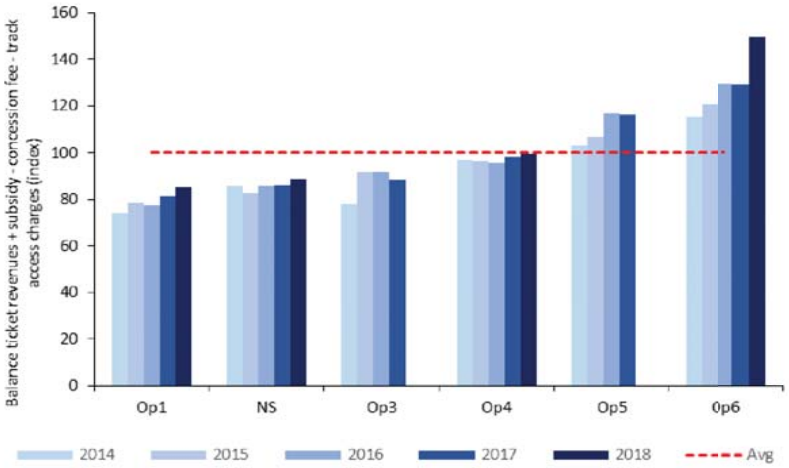


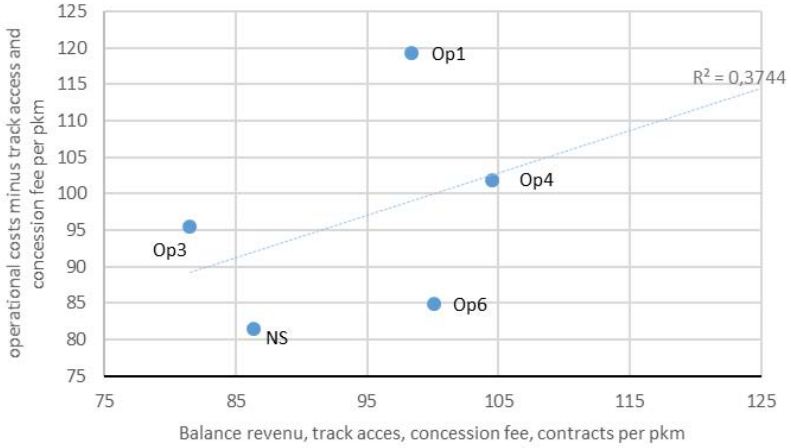
- NS' ticket revenues per kilometer are above the average of the peer group.
- Ticket revenues include direct ticket sales to passengers and large volume contracts (e.g. public transport contract for students).
- Most peers show a gradual increase of passenger fares, mainly due to inflation levels and/or increases in track access charges.

- Average ticket prices and the net public funding show a negative correlation; lower ticket prices correspond with higher levels of subsidies .
- Net public funding for NS is below the average of the peer group; NS pays both infrastructure charges and a concession premium. The student transport contract has an impact on the level of this concession premium.
- Most other operators receive net public subsidies. In the Netherlands this is the case for regional lines, that are out of scope for this benchmark.
- Operator 6 in this comparison pays a higher level of concession premium, resulting in higher prices for the passengers.

7.3 Net costs

NS' net costs of operation per passengerkm are below the average of the peer group

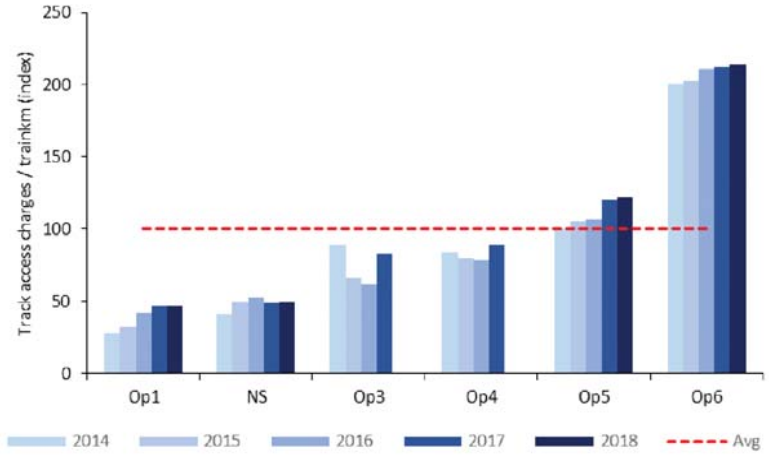


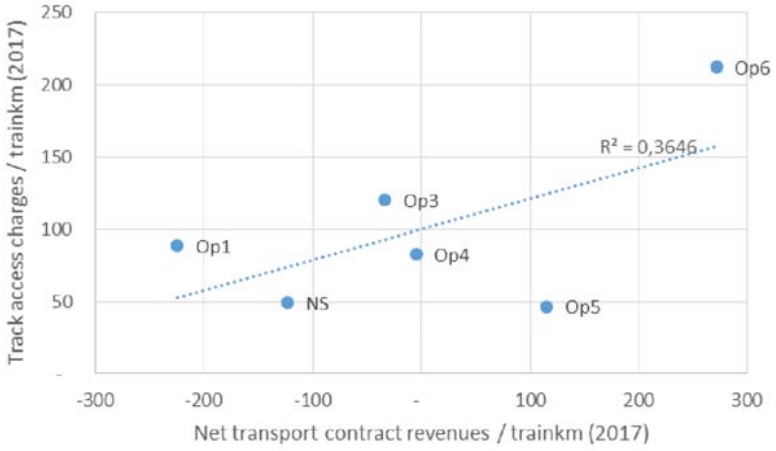


- Differences in financial methodology and scope make comparison complicated:
  - NS finances its investments, while some other operators receive capital subsidies.
  - NS has relatively new rolling stock, resulting in higher depreciation.
  - NS has a wider scope of activities than most other operators (e.g. timetable development)
- The first graph evaluates net costs of operation: ticket revenues + subsidies - the concession fee and track access charges.
- NS net costs of operation per passengerkm are significantly below the average of the peer group and stable, indicating an efficient operation.
- The lower net cost of Op1 is attributed to differences in investments in infrastructure and the division of costs between operator and infrastructure manager. The comparable cost level is therefore slightly higher.
- Significant cost increases are generally attributed to procurement of new rolling stock.
- NS' operational costs from the profit/loss account are also below average. However there is only a weak relationship between the two comparisons.

7.4 Track access charges

Track access charges are relatively low, incentivizing growth in supply of train services





- The peer group shows a wide variety in the levels of track access charges.
- Track access charges in the Netherlands are relatively low compared with these of peers.
- Low track access charges incentivize supply of train services, leading to a more attractive public transport offering.
- Compared to the peers, NS pays a relatively high fee for the concession and track access surcharge for the use of the high speed line.

- There is a relationship (to a certain extent) between track access charges and subsidies: operators with high track access charges often receive a high level of subsidies as well.

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Appendix A. Follow-up of the benchmark audit in 2017

- The International Benchmark of 2016 was audited in 2017 by Kennisinstituut voor Mobiliteitsbeleid. This audit made the following recommendations:

  1. Provide more explanation of differences to serve as input for learning and implementing the lessons.
  2. Be careful to draw conclusions, given the complex contexts, outliers, etc.
  3. Divide the report in separate NS and ProRail parts to improve clarity and readability.
  4. Focus on topics that are relevant to policy making and that are possible to influence.

- This benchmark study followed up on these recommendations by:

  1. Focusing more on context and explanations (less graphs, more text)
  2. Being cautious in drawing conclusions and providing more background information from the discussions with the peers.
  3. Dedicating this report to NS findings alone. ProRail makes a separate report. Both reports will be summarized in a joint report, with special focus on highlights and joint performance.
  4. This report focuses on key performance areas, such as punctuality, customer satisfaction and productivity. It also provides in-depth considerations about train cancellations and the development of customer satisfaction.

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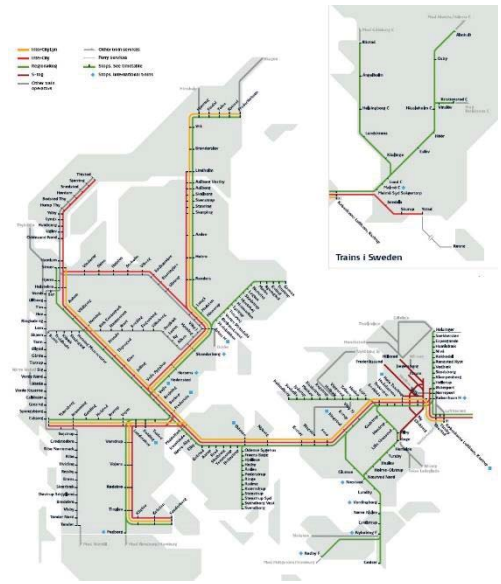
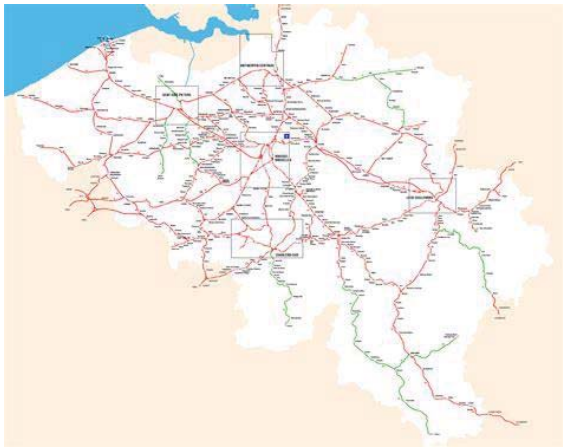
B1. Network of operators DSB, Greater Anglia and NMBS

B2. Network of operators NS, SBB and West Midlands

B3. Characteristics: station density, passengers per station and system speed

Appendix B1. Structural characteristics of the peer group

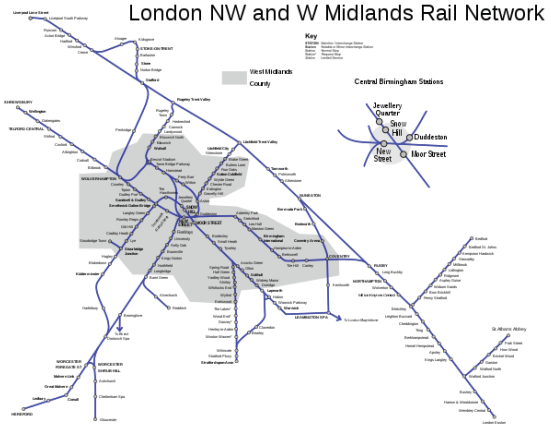




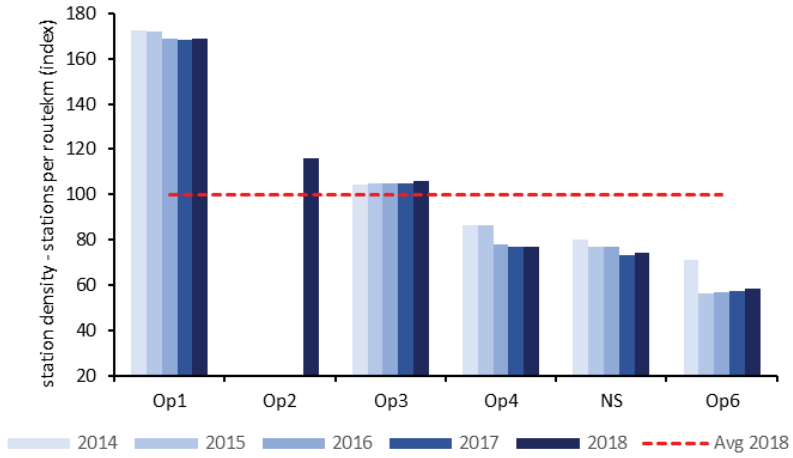
- DSB operates a network with a strong East-West axis. In the West the traffic is concentrated to and from Copenhagen. It operates less rural lines than average, since these are tendered out by the Danish government. The network length is around 67% of the network operated by NS.
- Greater Anglia operates a network around London, with mainly commuter rail, but also some intercity lines. Traffic is strong London centric. The network length is around 75% of the network operated by NS.
- NMBS operates a network with a strong East-West axis and a strong North-South axis. Peak hour traffic is concentrated to and from Brussels. The number of stations is relatively high. The network length is around 67% higher than that of the network operated by NS.

Appendix B2. Structural characteristics of the peer group

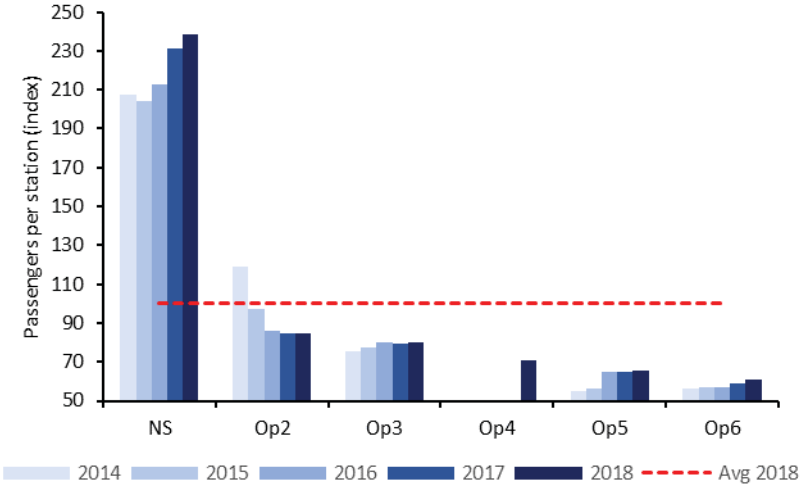
- NS operates an integrated national intercity and commuter network. Traffic is multi-centric in the Randstad area. Most regional lines are tendered out by regional authorities and operated by other operators.
- SBB operates integrated national intercity, commuter and regional networks. Traffic is multi-centric between the large cities. The total network length is around 50% higher than the Main Rail Network operated by NS.
- West Midlands Trains operates under two brands. London North Western is an intercity / commuter network between London and Birmingham. West Midlands Rail operates mainly commuter and local lines around Birmingham. The network length is around 40% of that of the Main Rail Network operated by NS.

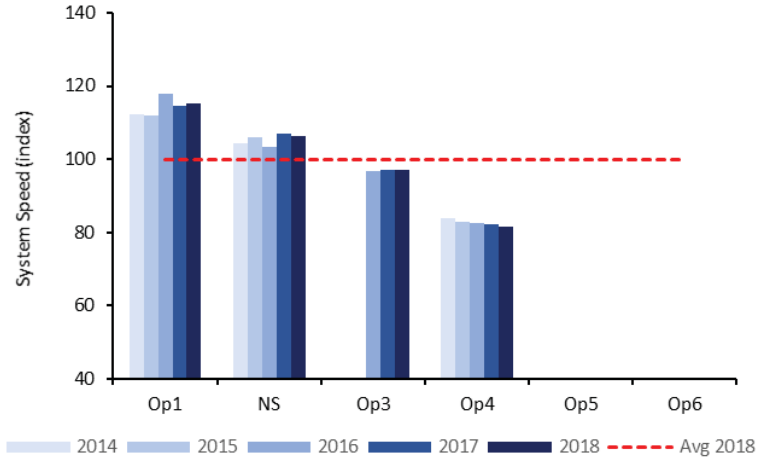


Appendix B3. Structural characteristics of the peer group



- In the peer group there is a wide variation in the number of stations on the network (station density). The main difference is in the amount of small stations.
- NS serves relatively few stations in a dense area, leading to a very high number passengers per stations. The smaller Dutch stations on local lines are operated by other operators.
- The number of stations is an important factor determining the system speed. Other factors include maximum speed and ratio local / long distance services.
- System speed is a main factor for attractiveness (traveling speed) and productivity (of both staff and rolling stock).





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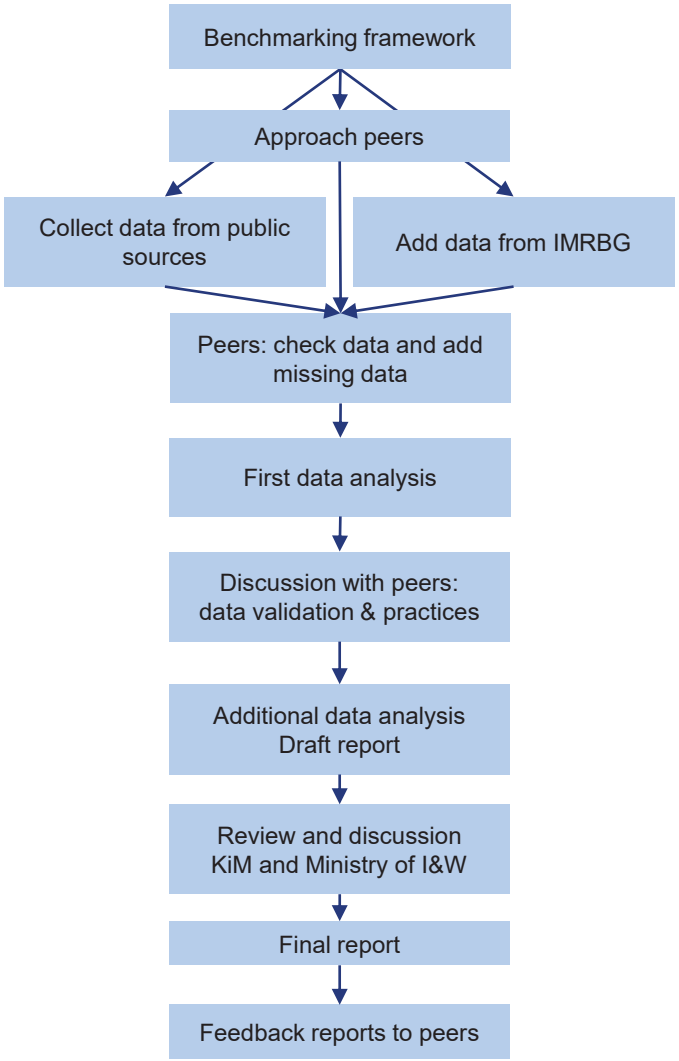
C2. Harmonization of customer satisfaction scores

C3. Harmonization of punctuality data

C4. Financial harmonization

Appendix C1. Methodology

Data collection, analysis and reporting process

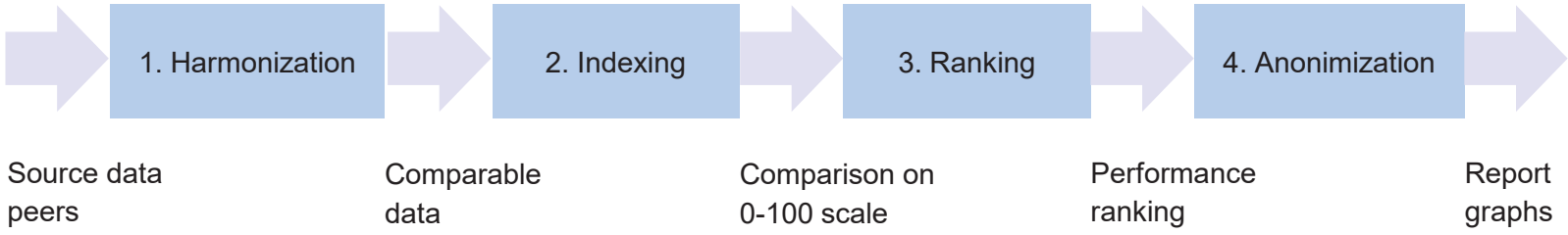


- Data has been collected as much as possible from public sources, such as annual reports, statistical agencies, government websites, etc.
- Data from the International Mainline Rail Benchmark Group (IMRBG) has been added, as verified data.
- Missing data has been added by the peers.
- After a first data analysis discussions with peers were held to verify data and identify best practices and contextual factors impacting performance.
- The draft report has been reviewed by KiM (Netherlands Institute for Transport Policy Analysis) and the Ministry of Infrastructure and Waterworks.
- After finalizing the report the peers receive customized feedback reports.

Appendix C1. Methodology

Harmonization and anonymization process

1. Harmonization
   In the following sheets the harmonization processes for a number of parameters (customer satisfaction, reliability, financial) are summarized.
2. Indexing
   The indexing step divides all data from the preceding step by the average of the scores in 2018 and multiplies by 100. Therefore all data are expressed as a percentage of the 2018 average.
3. Ranking
   After indexing the data is ranked by performance, in a descending order of performance.
4. Anonymization
   All peers are labelled by their performance ranking Op1 to Op6 (operator), except NS and/or the peer for which a feedback report is intended.
   Publicly available data however is not anonymized. If data is public, steps 2 and 4 are skipped in the process.



The indexing /ranking / anonymization protocol is in accordance with the confidentiality agreement of the International Mainline Rail Benchmarking Group, as designed by Imperial College in London

Appendix C2. Methodology

Harmonization of customer satisfaction scores

Comparable output

- Customer satisfaction scores are to be compared as close as possible to the NS score of "percentage respondents scoring a 7 out of 10 or higher". Most peers delivered data in this format.
- For SBB customer satisfaction figures this is the "percentage scoring 70 out of 100 or higher"
- UK customer satisfaction is measured as "percentage satisfied or very satisfied", which is comparable to "percentage 7/10 or higher".

Methodology of customer satisfaction survey

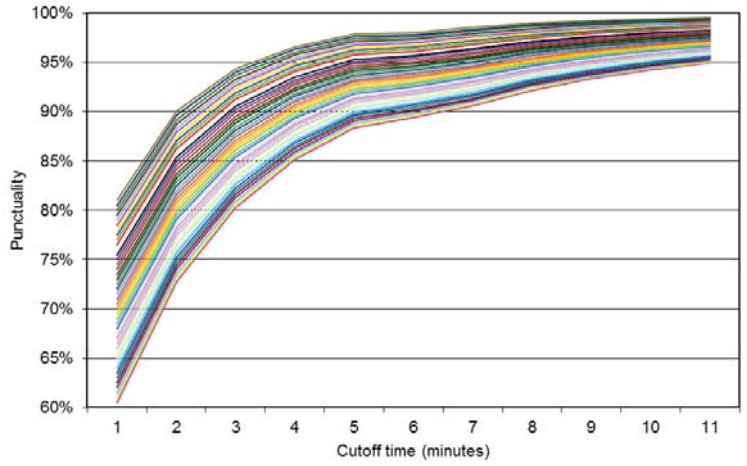
- Different peers use different survey methodologies:
  - Continuous vs. spring / fall surveys
  - Questionnaire online vs. paper forms that are distributed within trains
  - Inviting passengers on train for an online questionnaire vs. using a panel (including non-users)
- This benchmark does not correct for these differences

Appendix C3.1 Methodology

Harmonization of punctuality data

Punctuality of train arrivals

- Train arrival punctuality is compared based on the NS / ProRail measuring method and definitions; the percentage of trains arriving within 4 minutes 59 seconds from the planned time on the main (35) nodes on the network, excluding cancelled trains.
- For UK the 5 minute punctuality of arrivals on intermediate stations is used, and not the passenger performance measure that only measures on terminal stations.
- For the other operators, the effect of measuring on nodes or end points has not been taken into account for this comparison.
- Data from peers using different cutoff times for delays is harmonized using a linear regression model of arrivals of NS trains using different cutoff times (n = 3050, R^2= 0,9779).



Appendix C3.2 Methodology

Harmonization of punctuality data

Passenger punctuality

- Among this peer group passenger punctuality is only measured and/or calculated by DSB, NMBS, NS and SBB.
- DSB and SBB calculate passenger punctuality based on a 3 minute cutoff time (2.59). Therefore NS data is recalculated using this cutoff time for comparison.
- NMBS measures punctuality based on a 5 minutes 59 seconds cutoff time. Therefore NMBS data is converted with the linear regression model used for train arrival punctuality.
- Differences of calculation methods (e.g. using smart card passenger counts) are not taken into account for this comparison.

Cancellations

- Cancellations are compared based on the NS calculation of cancelled trains; number of trains passing measurement nodes divided by the planned number of trains to pass these nodes (based on the daily timetable, fixed 48 hours in advance)

Appendix C4. Methodology

Financial harmonization

- Financial data was harmonized using:
  - exchange rates from the European Central bank
  - Procurement power ratios from OECD

- Resulting correction factors are summarized in the table below

	2014	2015	2016	2017	2018
Belgium	1,011	1,012	1,021	1,012	1,018
Denmark	0,110	0,111	0,112	0,114	0,115
Netherlands	1,000	1,000	1,000	1,000	1,000
United Kingdom	1,158	1,170	1,160	1,144	1,139
Switzerland	0,631	0,655	0,660	0,663	0,670