KPMG

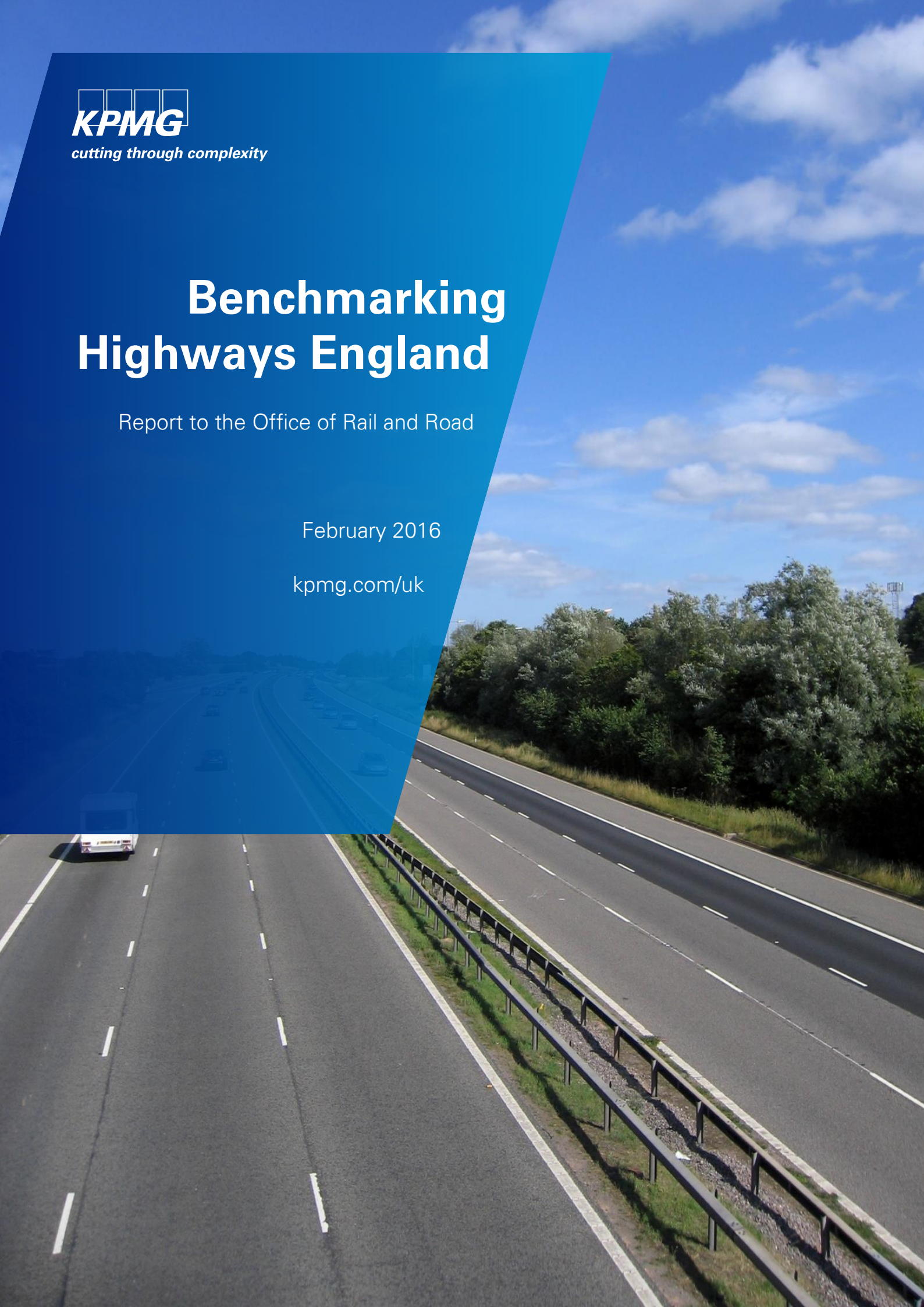
cutting through complexity

Benchmarking Highways England

Report to the Office of Rail and Road

February 2016

kpmg.com/uk



Contents

Important Notice

This report on Benchmarking Highways England ('Report') has been prepared by KPMG LLP in accordance with specific terms of reference ('terms of reference') agreed between the Office of Rail and Road (ORR) 'the Addressee' and KPMG LLP.

KPMG LLP wishes all parties to be aware that KPMG LLP's work for the Addressee was performed to meet specific terms of reference agreed between the Addressee and KPMG LLP and that there were particular features determined for the purposes of the engagement.

The Report should not therefore be regarded as suitable to be used or relied on by any other person or for any other purpose. The Report is issued to all parties on the basis that it is for information only. Should any party choose to rely on the Report they do so at their own risk. KPMG LLP will accordingly accept no responsibility or liability in respect of the Report to any party other than the Addressee.

The opinions expressed in this report are those of the authors and do not necessarily align with those of the ORR.

Executive summary

Background and objectives

The Office of Rail and Road (ORR) acting as the Highways Monitor is required to assess the performance of Highways England across a range of objectives and performance indicators. It is also required to assess the overall efficiency of the organisation and to highlight areas for potential improvement to inform its future business plans.

A key part of this process will involve benchmarking Highways England's costs and performance against comparable organisations in the UK and overseas to identify efficiency levels to which Highways England should aspire.

The objective of this study is to review and assess the benchmarking evidence and analysis across all aspects of Highways England's objectives and activities and to provide recommendations over how this evidence could be used and developed by the Highways Monitor and Highways England.

Key data

The review has identified data on the performance, expenditure and network characteristics of National Road Authorities (NRAs) from around the world. The scope and detail of the publicly available information is high relative to that found in most other regulated sectors. Information can be sourced from international datasets including those produced by the OECD, World Bank, International Road Federation, European Road Federation and World Economic Forum.

These organisations attempt to provide comparability in key metrics between countries, but the differences in definitions, environmental and geographical scope of the data make direct comparisons difficult to rely upon without further detailed investigation into the source and characteristics of the data.

NRAs produce a range of statistics and indicators to measure their own performance and there are a large number of reports which provide detailed analysis of performance and expenditure. These reports use different definitions to describe similar concepts which makes like-for-like comparisons difficult. Despite this, they do provide a source of data which could be useful for comparing the performance of Highways England across specific indicators.

Within the UK there is also data on the performance, expenditure and characteristics of local highway authority road networks. This data has significant advantages over international data as it is inherently more comparable. In the past the Department for Transport (DfT) has developed a benchmarking tool based on this raw data. This could be updated and used by the Highways Monitor to develop high level benchmarks across a variety of indicators. Clearly the structure of local highway networks is very different to Highways England's network however this could be taken into account to a greater or lesser degree in any analysis.

Key studies

Top-down international benchmarking studies by the Organisation for Economic Cooperation and Development (Braconier et al, 2013) and Conference of European Directors of Roads (CEDR, 2010) are particularly relevant for the Highways Monitor's objectives and could be developed further to provide efficiency analysis for regulatory purposes through engagement with the CEDR network. However there are material weaknesses with the data used in these studies which will need to be understood further and resolved if they are to be used for benchmarking in the context of setting an efficiency target for Highways England.

Over time, and with the participation of other NRAs, top-down benchmarking based on active data collection could become more accurate and robust to the extent that it could be used to inform the performance and efficiency framework. However the experience of international top-down benchmarking of Network Rail by ORR suggests that this form of analysis will always be subject to a degree of uncertainty and may therefore be open to challenge.

The Highways Maintenance Efficiency Programme (HMEP) and Customer, Quality and Cost (CQC) study (2014) analyses the performance of local highway networks using top-down econometric analysis to provide an assessment of relative efficiency. The road authorities are from the UK so it does not suffer from the same comparability issues as the OECD (Braconier et al, 2013) and CEDR (2010) studies, which is a significant advantage. It may be possible to develop this work to incorporate Highways England, or alternatively to derive benchmarks for maintenance and construction costs and use the findings of the study to identify the most efficient organisations for bottom-up benchmarking. Appendix 3 of this report provides more detail on how the study could be developed.

The Cabinet Office has undertaken benchmarking of construction and back office costs across all government departments and agencies including Highways England. The back office benchmarking report (Cabinet Office, 2009) provides benchmarks across a range of activities including finance, HR, IT and other organisational functions. This could be used to compare Highways England at a high level, although the comparability of the data is difficult to interpret in some cases. The construction cost benchmarking reports (Cabinet Office, 2012 and 2014) contain analysis of trends from 2010 to 2014. This includes analysis of Highways England's motorway and trunk road construction costs. There are also a wide number of construction based benchmarks for other departments which may be indirectly applicable to Highways England. The Highways Monitor should engage with the Cabinet Office to understand whether this work will continue and how it could be developed (through the Infrastructure Benchmarking Group for example).

Similar cross-departmental indicators of performance and efficiency have also been developed by HM Treasury (2010) in the past. These indicators do not appear to have been maintained over time, but the Highways Monitor could consider developing a similar metric to monitor Highways England's performance in the longer term.

There is also a wide range of cross-industry analysis and benchmarking evidence developed by economic regulators such as ORR (for Network Rail), CAA, Ofwat, Ofgem and Ofcom. For example there are several studies which provide analysis of 'frontier shift', employment costs and pensions across regulated sectors. These use generic methods which could also be applied to Highways England. In some cases these studies may provide useful benchmarks, although comparability needs to be considered.

The literature reviewed in this study contains some bottom-up analysis of maintenance and construction costs. These generally find that the England's and the UK's costs are higher than European comparators for several reasons, including relatively high design standards and input costs. These studies do not fully determine if that this is the sole reason or whether an efficiency gap exists. Further analysis could be undertaken by the Highways Monitor to explore this issue.

There are also several studies which examine best practice in areas such as construction and asset management, but do not provide quantitative assessments of efficiency. These studies are helpful in providing understanding and context to the relative performance of NRAs and factors which may be important but provide limited insight into the relative performance and efficiency of Highways England.

Other forms of analysis for benchmarking Highways England

The different datasets and forms of analysis described above each have strengths and weaknesses. The complexity and challenges of comparing the performance and efficiency of road networks and NRAs means that the Highways Monitor should consider using different and complementary forms

of benchmarking analysis for the performance and efficiency framework. There are several other methods that should be considered, based on our review of the evidence and approaches developed in other sectors, including:

- The use of top-down benchmarking for maintenance based on the performance of Highways England's maintenance areas. Each could be used to provide comparisons of performance and efficiency by identifying the most efficient region across different activities. This would provide an indication of the internal efficiency frontier.
- The use of DBFO contracts to derive implicit construction and maintenance cost benchmarks based on a derivation of the contract building blocks. Highways England and HM Treasury hold detailed information on these contracts, including the specification, construction costs, asset condition and unitary payments. These could be used to develop indicative benchmarks of construction and operating costs.
- Network asset based modelling to derive benchmarks for optimal maintenance investment. For example using the principles of the HDM-4 model which enables a road authority to determine its economically efficient level of maintenance investment. This is based on optimising network length, asset conditions and traffic with vehicle operating costs. From this an estimate of 'optimal' spend can be made balancing economic and asset performance with cost.
- The use of satellite based traffic data to develop consistent and comparable indicators of traffic congestion, delay and other factors.

A key point which has emerged from our review is that the performance and efficiency of Highways England should be considered in the context of both the economic benefits and costs of its activities. The costs of road maintenance are relatively small compared to the costs of vehicle operation and benchmarking needs to consider outcomes for road users. Developing a metric to estimate the economic value and benefits of Highways England's activities may be beneficial to provide better context and understanding to the performance and efficiency framework.

The Highways Monitor could consider how the economic contribution of the Strategic Road Network (SRN) and Highways England could be quantified to take account of its impact on the overall transport network and economy and to provide an alternative, overall indicator of impact of the SRN on society. This could be achieved through an economic impact study or through the development of an economic indicator such as that developed by ANAS (Italian NRA) to monitor the benefits to users and the wider economy based on the 'shadow price' of various outputs.

Recommendations

Based on the available evidence, data and potential methods that the Highways Monitor could develop, we have made the following recommendations.

In the short term (up to one year), the Highways Monitor should:

1. Review the studies highlighted in this report and develop a framework of the network characteristics and performance indicators which are important for the performance and efficiency of an NRA and road network.
2. Obtain the datasets highlighted throughout this report and use them to develop initial partial productivity metrics, rankings and performance indicators to compare Highways England with other NRAs. This will provide some overall indications of the relative performance of Highways

England across a range of metrics. It will also give some indication of how the road network and organisation compares against other NRAs (and which could be considered comparable).

3. Engage with CEDR, OECD and the HMEP / CQC network to determine if further top-down benchmarking analysis is likely to be undertaken and how the Highways Monitor could interface with this work and the resources and effort likely to be required.

   We consider that CEDR is likely to be a particularly useful source of benchmarking evidence and analysis and the Highways Monitor should consider engaging with this organisation to understand its existing evidence and future research activities in more detail.

   The organisation has already undertaken top-down and bottom-up international benchmarking of NRAs and appears to have undertaken further work in this area since its original report. It may be able to provide further support, guidance and data on this subject and may also provide a forum to develop other types of analysis.

4. Consider the development of an independent benchmarking group – for example, based on the members of CEDR, but co-ordinated and led by the Highways Monitor.

5. Consider to what extent the different forms of top-down benchmarking are likely to be helpful for the efficiency and performance assessment framework and its feasibility given the potential timescales and resource requirements. As an indication, the original BEXPRAC study took around 2 years to complete with a total costs of around €500,000 (of which the UK based participants contributed around €50,000). The Highways Monitor should consider which approach is likely to be most appropriate and seek to develop a methodology for the analysis.

6. Consider the lessons from the international top-down benchmarking analysis in other sectors, including the risks and uncertainties associated with this form of analysis. There could also be some issues associated with co-opting and relying upon analysis from an organisation which is primarily a forum for constructive engagement between NRAs. The extent to which CEDR can be independent from Highways England and the potential conflicts of interest for other NRAs needs to be considered.

7. Consider how regional performance, cost and network characteristic data could be used to develop intra-regional comparisons across Highways England's maintenance areas. This data should be accessible and could provide a general indication of the internal performance 'frontier'.

8. Consider how the Local Authority benchmarking analysis undertaken by the CQC network could be applied to Highways England and whether it would be beneficial and appropriate for Highways England to join the network.

9. Engage with other UK highway authorities to understand the applicability of their approach to benchmarking construction and maintenance costs, with the approach adopted by Highways England with a view to developing an established dataset and approach for the UK.

10. Review the analysis undertaken by the Cabinet Office to understand how ongoing construction (and back office) cost benchmarking could be developed and used by the Highways Monitor. Collect and review the data and reports produced by the Cabinet Office including reports on construction costs and back office costs and consider if this analysis could be continued.

11. Continue stakeholder engagement to exhaust the possibility of finding other benchmarking evidence and studies from organisations who have not yet responded to our consultation.

In the medium term (up to two years), the Highways Monitor should:

12. Identify specific NRAs with road networks and organisational structures which could be considered comparable to Highways England (potential comparators may include Austria, Sweden and the Netherlands). Seek to identify high performing NRAs based on partial metrics to highlight the organisations which may be able to provide the most useful comparisons of

Highways England's efficiency. Consider if these organisations could be engaged for bottom-up benchmarking.

13. Collect and analyse Local Authority data on highway network characteristics, performance and expenditure and use the data to develop high level comparisons with Highways England – taking account of differences in network structure. This could be achieved by updating the benchmarking toolkit developed by DfT.
14. Collect the data associated with the UK DBFO PPP contracts on road construction, maintenance and street lighting projects and consider how this information could be used to derive implicit construction and maintenance cost benchmarks. This would require a detailed understanding of the contract process and building blocks, the design and performance standards of the contact and the risk and profit margins included in the contract payments.
15. Engage with EuroRAP to understand how their cross-country safety data could be used to benchmark the safety performance of Highways England.

In the long term (more than two years), the Highways Monitor should:

16. Consider which activities and functions are most material to the efficiency and performance of Highways England and develop a specific bottom-up benchmarking proposition focusing on specific activities. This could be undertaken following the top-down analysis described above to estimate performance gaps and outliers. Once developed, engage with Infrastructure UK, NRAs, HMEP / CQC and other benchmarking groups to obtain information in key areas.
17. Review regulatory analysis of staff costs, frontier shift and pensions undertaken by other economic regulators and consider whether such intra-industry comparisons could be applied to Highways England.
18. Assess the long term benefits of investment in road maintenance - consider the potential application of the principles of HDM-4 or similar to derive the economic benefits associated with investment in road maintenance and consider how this analysis could be incorporated into the efficiency framework. This could enable benchmarking the economic benefits of different levels of spending to provide an alternative assessment of Highways England's investment in road maintenance.
19. Consider how the economic contribution of the Strategic Road Network could be quantified to take account of its impact on the overall transport network and economy and to provide an alternative, overall indicator of performance. This could be achieved through an economic impact study or through the development of an economic indicator such as that developed by ANAS (Italian NRA) to monitor the benefits to users and the wider economy.
20. Investigate the potential to develop inter-network performance indicators using satnav based traffic data - building on the metrics and data already used by Highways England and DfT. These could be used to develop consistent and comparable indicators of performance across European road networks. This could also be discussed with the CEDR group.

1 Introduction

1.1 Study objectives

The Office of Rail and Road (ORR) acting as the Highways Monitor is required to assess the performance of Highways England across a range of objectives and performance indicators. It is also required to assess the overall efficiency of the organisation and to highlight areas for potential improvement to inform its future business plans.

A key part of this process will involve benchmarking Highways England's costs and performance against comparable organisations in the UK and overseas to identify efficiency levels to which Highways England should aspire.

The objectives of the work are to:

- Undertake a literature review of academic and commercial benchmarking studies of highway infrastructure managers.
- Assess the availability, quality and comparability of cost and performance information suitable for benchmarking across a range of organisations.
- Identify relevant global benchmarking groups and networks.
- Consider wider issues associated with benchmarking analysis, including the applicability and validity of existing studies and materials to the current regulatory regime.
- Advise on which regimes/ jurisdictions are likely to provide additional information.

1.2 Our approach

Our approach has been to engage with a range of stakeholder organisations to identify data, methodologies and evidence on the costs and performance of highway infrastructure managers. This has been supported by a desk-based search of publicly available reports and information.

We have reviewed more than 100 separate pieces of evidence with a view to assess the feasibility of developing 'top-down' and 'bottom-up' approaches to benchmarking Highways England.

The breadth of our search and the timescales of our study has meant that we have not been able to investigate the availability of specific metrics in every case. We are confident however that we have found the most relevant studies as part of our search.

This report has been prepared in conjunction with the Institute for Transport Studies (ITS), University of Leeds who have provided specific guidance on the use of top-down benchmarking.

1.3 Structure of report

The rest of this report is structured as follows:

- Section 2 provides an overview of Highways England, its main activities, areas of expenditure and the background for this study.
- Section 3 provides a description of our stakeholder consultation process including the organisations we have contacted, their responses and key evidence and data we have uncovered through this process.
- Section 4 provides a summary of the key points from the review highlighting analysis and findings which may be of interest to the Highways Monitor.

- Section 5 highlights potential analytical methods that could be applied to benchmark Highways England in the short, medium and long term.

The report also includes six appendices providing additional information as follows:

- Appendix 1 provides a more detailed review of the literature, highlighting the key points from the most relevant studies.
- Appendix 2 provides a more detailed review of the data found as part of this study.
- Appendix 3 provides detailed comments on the CEDR, OECD and CQC top-down benchmarking studies, including more detailed recommendations on how this evidence could be developed by the Highways Monitor.
- Appendix 4 outlines a preliminary framework for understanding the performance of NRA and highway networks and the key factors that drive and affect performance and efficiency.
- Appendix 5 provides an overview of bottom-up indicators which the Highways Monitor could seek to develop as part of its efficiency framework.
- Appendix 6 shows the list of the evidence and reports we have found in the course of this study.

2 Background

2.1 Context

The ORR has been given by Parliament the role of the independent Highways Monitor. The Highways Monitor is required to ensure that the strategic road network is managed to deliver performance including efficiency, safety and sustainability for the benefit of road users and the public. The Highways Monitor also provides guidance to the government on Highways England's future performance objectives and the development of the next Road Investment Strategy (RIS).

As part of the current RIS several objectives were identified for Highways England, these are:

- Making the network safer.
- Improving user satisfaction.
- Supporting the smooth flow of traffic.
- Encouraging economic growth.
- Delivering better environmental outcomes.
- Helping cyclists, walkers and other vulnerable users of the network.
- Achieving real efficiency.
- Keeping the network in good condition.

The Highways Monitor will need to consider how Highways England is working towards these objectives, its outcomes and KPIs in each case and its overall efficiency and performance. It also has a duty to highlight other issues of concern with the operation of the organisation to help improve its performance.

A key part of this role is the assessment of Highways England's performance and efficiency and the Highways Monitor is in the process of developing an overall assessment framework for this process. Benchmarking has been identified as an important part of this framework and the Highways Monitor now wishes to understand what information, evidence and data exists which it could use to support the development of the framework.

2.2 Recent DfT analysis

During the Road Reform process, the Department for Transport (DfT) commissioned a study to provide advice on the development of an efficiency assessment framework for the Strategic Highways Company (now known as Highways England). This report, published in early 2014 is split into three sections:

- Section A reviewed alternative analytical approaches to benchmarking and presented a framework for considering the short-term and long-term efficiency of the organisation.
- Section B identified publicly available sources of data and evidence on benchmarking NRAs.
- Section C provided an overview of the cost and performance metrics available within Highways England and its standard accounting breakdown. The report also made some recommendations about how internal reporting should be developed to improve comparability over time.

We have sought to build on the findings and recommendations of the Department for Transport study in this analysis.

2.3 Performance and efficiency framework

In assessing the performance and efficiency of Highways England, the Highways Monitor will need to develop an understanding of its efficiency and effectiveness, where:

- Efficiency involves maximising outputs with a given set of inputs.
- Effectiveness involves delivering required economic, social and environmental outcomes.

The performance and efficiency framework will need to consider how efficiently inputs are used to generate specific outputs and how these outputs deliver required economic, social and environmental outcomes.

Performance and efficiency indicators

To start, the activities and expenditures of Highways England can be divided into well-defined categories including:

- Maintenance activities that involve maintaining the condition of the network within its current lifespan. Examples include grass cutting and clearance of drainage gullies.
- Renewal activities that increase the lifespan of the network (or its asset value) without increasing network capacity. Examples include carriageway resurfacing and bridge joint replacements.
- Enhancement activities that add capacity to the network. Examples include the construction of new roads, smart motorways, widening of existing roads and junction improvements.
- Operational activities which ensure the network is operated in a safe and efficient manner. Examples include network control centres and gritting.
- Customer-facing activities such as the traffic officer service.
- Support service activities such as finance, HR, IT and technical support.

These categories are then sub-divided into a set of indicators that can be used to measure performance and efficiency as part of bottom-up and top-down reviews:

- **Bottom-up benchmarking** is the comparison of specific inputs and costs to undertake specific activities or deliver certain outputs.
- **Top-down benchmarking** is the comparison of total inputs and costs to undertake specific activities or deliver certain outputs.

Examples of top-down and bottom-up indicators are presented in Table 1 and Table 2 respectively.

Table 1: Bottom-up benchmarking indicators

Category	Indicator	Possible Metric
Asset management expenditure – Maintenance	Grass cutting	£/km
Asset management expenditure – Maintenance	Drainage gullies	£/km
Asset management expenditure – Renewal	Carriageway resurfacing	£/km/lane
Asset management expenditure – Renewal	Bridge joint replacement	£/scheme
Operating expenditure	Network control centres	£/centre
Operating expenditure	Gritting	£/km/lane
Operating expenditure	Traffic officer service	£/km
Enhancement expenditure	Construction of new roads	£/km/lane
Enhancement expenditure	Widening of existing roads	£/km/lane
Enhancement expenditure	Junction improvements	£/scheme
Support expenditure	Human resources expenditure	£/FTE
Support expenditure	IT services	£/FTE
Support expenditure	Financial services	£/FTE
Support expenditure	Technical support	£/FTE
Support expenditure	Total staffing costs	£/FTE
Performance KPI	KSI	Total KSI or KSI/km
Performance KPI	User satisfaction	%
Performance KPI	Network available to users	%
Performance KPI	Incidents cleared within an hour	%
Performance KPI	Average delay	Time lost per vehicle km
Performance KPI	Noise important areas mitigated	Number
Performance KPI	Delivery of improved biodiversity	Plan achievement
Performance KPI	New and upgraded crossings	Number
Performance KPI	Savings on capex	£
Performance KPI	Delivery plan progress	Achievement by deadline
Performance KPI	Assets that do not require maintenance	%

Source: ORR, 2015

Table 2: Top-down benchmarking indicators

Costs	Network size/characteristics	Network usage
Asset management expenditure – Maintenance	Motorway km	Passenger km
Asset management expenditure – Renewal	APTR km	Freight km
Operating expenditure	Dual carriageway km	Passenger density
Enhancement expenditure	Single carriageway km	Freight density
Support expenditure	Total km	Total user density
Total maintenance and renewal costs		

Source: ORR, 2015

The availability and comparability of data on performance indicators is likely to be the main challenge for the benchmarking analysis. Comparing Highways England with other infrastructure managers is difficult because of differences in local circumstances including:

- Different contractor on-costs.
- Different design and construction standards.
- Different traffic demands.
- Land values.
- Project appraisal processes.
- Consideration of whole life costs.
- Planning processes.
- Investment cycles.
- Supply chain integration.

These factors are likely to make direct comparisons between countries difficult to interpret. Some such as land costs are largely unavoidable, others such as design standards may reflect different priorities, others such as stop-start investment cycles could be avoided and therefore represent a potential inefficiency.

The objective for this study is to assess the extent to which the information described above is available for suitable comparators. We also seek to assess the feasibility of using such information to develop a benchmarking framework for Highways England.

3 Stakeholder engagement

3.1 Introduction

Many NRAs both in the UK and internationally undertake and participate in benchmarking exercises to various degrees across different processes and activities. A central part of this work was to engage with a range of stakeholders to identify data and benchmarking evidence potentially available to the Highways Monitor. This section of the report describes the key findings from our stakeholder engagement.

3.2 Our approach

We corresponded with organisations from the following stakeholder groups:

- UK government including Highways England and the devolved road authorities.
- Local highways authorities and their representative bodies including the Highway Maintenance Efficiency Programme (HMEP).
- UK professional bodies and stakeholder groups such as Infrastructure UK, the RAC Foundation and Chartered Institution of Highways and Transportation (CIHT).
- Highway authorities overseas such as the Federal Highways and Works Administration in the US and Main Roads in Australia and representative groups such as World Road Association, CEDR, IRF and ERF.
- Universities.

The aim was to identify if these organisations had relevant benchmarking information available including data and studies and whether they would be willing to engage with the Highways Monitor as part of a future benchmarking process.

3.3 Participating organisations

We sent engagement letters to 62 stakeholders, of which we had a response from 39 (a response rate of 63%). Overall organisations were responsive and provided a number of relevant sources of information as well as showing interest in working with the Highways Monitor moving forward. The organisations from which we received positive responses from are shown in Table 3.

Table 3: Organisations which responded positively to our engagement

UK Government, Highways England and the Department for Transport
Highways England
Department for Transport
Transport Scotland
Northern Ireland Road Service
National Roads Authority (Ireland)
Transport for London (TfL)
National Audit Office
Infrastructure UK Network Rail
Local Highways Authorities and representative bodies from the sector
Highways Maintenance Efficiency Programme (HMEP)
Society of Scottish Technical Officers (SCOTS)
Association of Public Sector Excellence (APSE)
National Highways & Transportation Benchmarking (NHT)
Association of Directors of the Environment and Transport (ADEPT)
Highway Term Maintenance Association
Civil Engineering Contractors Association – CECA
Institute of Highways Engineers
UK Stakeholder groups
RAC Foundation
Chartered Institution of Highways & Transportation (CIHT)
Rees Jefferies Foundation

International Road Authorities and representative bodies from the sector
Vejdirektoratet – Denmark
Trafikverket – Sweden
Mexican Roads Research
Institute of Public Works Engineering Australia
Institute of Public Works Engineers New Zealand
USA Federal Highway Administration (FHWA)
STMI Bayern
Ministere de L'Ecologie du Development dur Able et de L'Engerie – France
Infrastructure Portugal
Australian Road Research Board (ARRB)
Transport Research Board
OECD
NZTA New Zealand
Director of Roads in Europe (CEDR)
Flemish Roads Belgium
Asfinag
Bureau of Infrastructure, Transport and Regional Economics
Universities
University of Leeds
University of Birmingham
University of Nottingham

Source: KPMG Analysis, 2015

3.4 Key findings from the stakeholder engagement

The information provided by stakeholders was a mix of internally and externally produced reports and datasets with much of the information publicly available. To further develop its approach to benchmarking it would be beneficial for the Highways Monitor to consult with the following organisations which undertake regular benchmarking activities and could be useful comparators to Highways England.

At a local highway authority level

- **Local Authority collaborative alliances** such as Midlands Highways Alliance – which has 14 local authorities working together delivering small to medium size capital schemes. It may be

possible to make useful bottom-up comparisons with Highways England unit costs, particularly for non-motorway roads and for activities such as pinch point schemes.

- **HMEP/CQC** – Comparisons could be made with over 50 local authorities using the top-down approach developed by m2i and University of Leeds (2014). Some of the larger authorities such as Surrey County Council may also be comparable with Highways England on a regional basis to some extent. Highways England/ Highways Monitor would need to consider how to engage with this organisation to avoid potential conflicts of interest.
- **APSE** (and SCOTS) – Bottom-up measures for highway maintenance may be obtained from APSE (2015). Again these may not be directly comparable but may provide useful information on where Highways England costs are similar.

At a UK Strategic road level

- **Transport Scotland** has indicated that, in principle, it would be willing to undertake benchmarking with Highways England. There are a number of regional differences between the Scottish and English road networks particularly traffic levels on the non-motorway network but comparisons could still be made particularly for the motorway network and for highway maintenance activities in the central belt.
- **Transport Northern Ireland** has also indicated in principle that it would be willing to undertake benchmarking with Highways England. There are likely to be structural differences between the Northern Irish and English road networks that would need to be taken into account.

Within Europe

- **CEDR** has undertaken top-down benchmarking and is considering a second phase of its previous study (2010). This provides an excellent opportunity to engage with European roads directors on the subject of benchmarking.
- The **National Road Authority** in Ireland has responded to our consultation and indicated that it would be willing to participate in benchmarking. It has some unit rate cost data which could be used for benchmarking. It also has a significant amount of new build roads some of which have been built through PPP contracts which could be used for benchmarking.
- **Asfinag** (Austria) has expressed an interest in collaborating with the Highways Monitor. As an arms-length government company its organisational structure is similar to Highways England. The road network is however quite different in terms of construction and the number of bridges and tunnels. It also undertakes a greater level of revenue collection through tolls. Nonetheless it could provide a useful source of benchmarking evidence.
- **Vejdirektoratet** (Danish Roads Agency) has expressed an interest in collaborating with the Highways Monitor. In terms of environment and geography there are some broad similarities with the English road network, which may make this organisation a good comparator.
- **Trafikverket** (Sweden) organisationally there are some broad similarities with Highways England and again it would be a useful organisation to develop benchmarking comparisons. It also has controlled motorways which may enable specific comparisons for this type of road asset.
- **Rijkswaterstaat** (The Netherlands) have a history of working with Highways England in benchmarking. Like Sweden it also operates controlled motorways that may provide useful comparison with the Highways England smart motorway programme.

Outside of Europe

- Both the **Bureau of Infrastructure, Transport and Regional Economics** and **NZTA** from Australia and New Zealand respectively have expressed an interest in benchmarking with Highways England. Certain parts of their networks such as Auckland Expressway are comparable to the Highways England network.

4 Evidence and data review

4.1 Introduction

In addition to engaging with stakeholders we undertook a desk-based review of published data and reports on the performance and efficiency of NRAs.

The desk-based review identified a considerable amount of material relating to the performance, efficiency and characteristics of highway networks and NRAs globally. This material includes top-down and bottom-up studies, surveys and qualitative assessments of performance and activities focussed on different aspects of performance.

4.2 Evidence review

We have identified three studies that stand out as particularly relevant to the Highways Monitor's objectives:

- OECD (Braconier et al) – The Performance of Road Transport Infrastructure and its Links to Policies, 2013.
- CEDR – BEXPRAC, 2010.
- HMEP/CQC – The efficiency of highways authorities in England, 2014.

Each of these provide an example of a top-down analytical framework which could be applied by the Highways Monitor to benchmark the performance of Highways England. They also provide analysis of the relative performance of Highways England and potential comparators. We have summarised the key points from each study below with further details provided in Appendix 3.

OECD study

The OECD have published a range of papers related to the benchmarking of transport infrastructure and road networks. These papers examine different techniques for making cross country comparisons of performance and efficiency and provide an overview of some of the issues and challenges associated with international benchmarking. These studies are typically focused at the macro-policy level and are not generally intended for use by regulatory authorities but provide some potentially useful analysis and techniques.

One of the most relevant OECD reports for the Highways Monitor provides a range of input, output and contextual data for 32 countries and uses this to develop several forms of analysis which seek to capture the performance of the overall road transport system in both a partial and comprehensive manner (Braconier et al, 2013). The study highlights the importance of looking at all of the costs and benefits arising from the NRA's activities, including those incurred by customers. Targeting a minimum cost benchmark without reference to the impacts on road users could result in net economic costs.

The OECD study is based on publicly available data and could be relatively easily developed by the Highways Monitor. With further investment the analysis could be tailored to better match the Highways Monitor's requirements but it will nevertheless face challenges relating to data comparability between different networks. In Appendix 4 we describe how this framework could be developed by the Highways Monitor to identify which inputs, outputs, characteristics and wider factors (such as the structure and organisation of the NRA and wider transport policies) should be considered when making top-down benchmark comparisons. This framework is helpful for considering how different factors might affect the performance of the road network and which variables should be included in benchmarking analysis.

CEDR study

The CEDR BEXPRAC study identifies data and monitoring information used to compare the performance of Highways England against other NRAs based on a commonly developed data collection process (although this data is based on the TEN-T network which differs slightly from the SRN). CEDR have attempted to develop consistent definitions and methods of data collection between NRAs which means that this data is likely to be more comparable than most other sources.

The study provides a range of data on the characteristics of road networks including variables related to the structure and performance such as road lengths, road types, traffic flows and number of lanes, tunnels and bridges, as well as other factors such as driver satisfaction, although the study concludes that further work on data harmonisation is required. CEDR uses this data to develop cost models for specific road networks but it notes that the accuracy of the model is in the region of ±40%.

The study makes several recommendations for how the work could be developed including a more in depth analysis needed on environmental issues, structure expenses and depreciation of assets with short lifetimes.

Further rounds of data collection based on the principles and definitions developed by CEDR could, over time, lead to the development of a roughly comparable benchmarking dataset which could be used by the Highways Monitor to compare the performance and efficiency of Highways England to other NRAs.

HMEP/CQC studies[1]

The HMEP/CQC studies provide an example of top-down econometric benchmarking applied in a highways context and provides a potential template for the kind of methodology which could be developed and applied by the Highways Monitor to Highways England and its comparator NRAs. The approach is similar to that used by the ORR for benchmarking Network Rail as part of its regulatory review.[2]

The study uses data from 65 local authorities covering a five year period from 2008 to 2013 including data on 'Cost, Quality and Customer' variables which include:

- Total highway network length.
- Average highway condition.
- Public satisfaction with condition of road surfaces.
- Number of lighting columns and proportion of units in operation.
- Public satisfaction with street lighting repairs.
- Length of precautionary salting routes.
- Number of salting runs.
- Public satisfaction with Winter Maintenance.

The HMEP/CQC study uses these variables in combination with expenditure on pavement maintenance, street lighting and winter maintenance to identify the most efficient organisations and to develop an assessment of overall efficiency gaps for individual local authorities. This data is combined with a survey of approaches to maintenance activity.

[1] More information on this study can be found online at: http://nhtcqc.econtrack.co.uk/Content.aspx?2522

[2] More information on this study can be found on the ORR's website http://orr.gov.uk/what-and-how-we-regulate/regulation-of-network-rail/how-we-regulate-network-rail/periodic-review-2013/pr13-publications/efficiency-benchmarking-of-network-rail

The study provides a range of findings about the relative efficiency of local authorities and the factors associated with efficiency:

- Authorities have an efficiency opportunity equal to reducing average road maintenance expenditure by 21% whilst maintaining the same network, quality and traffic usage.
- For the 'average' authority increasing traffic on the network by 1% increases maintenance costs by 0.11%.
- Increasing the size of an authority's road network by 1% increases costs by 0.67%, but economies of scale start to reverse between 6,000 km and 10,000 km (depending on mix of roads).
- Increasing the average number of road defects increases cost, probably reflecting the need to do more maintenance to bring the network back up to a desired quality.
- At average levels of public satisfaction the cost of improving satisfaction is small. For low and high levels of public satisfaction, improving customer satisfaction is associated with a large increase in expenditure.

In principle this study and the underlying data and information could provide useful benchmark data to compare against Highways England although the nature of the road networks would need to be taken into account when making comparisons. Further analysis of the relationship between road types and maintenance spending could be useful for example. It may be possible to incorporate Highways England into this analysis or to use it to identify best in class local authorities for more detailed bottom-up comparisons. The approach used by the study could also be applied to international NRAs if a suitable dataset could be developed (through the CEDR network for example).

Other studies

In addition to the three studies described above there are other studies which provide useful insights into the factors, policies and practises which can impact the performance and efficiency of NRAs. Highlights of this work are set out below.

Separate studies by the Danish Roads Directorate (2005) and the Highways Agency (TRL, 2009) undertook bottom-up comparisons of construction costs across European countries. The studies found that UK costs are generally high but that this can be partially explained by higher design standards, higher input costs, and differences in definitions and activities included and excluded from the cost data. The studies highlight many of the difficulties associated with making cost comparisons between networks.

The study by Turner and Townsend (2013) examines labour and input costs in the construction industry and provide some analysis of the inherent structural factors affecting costs in the UK relative to other countries.

The Cabinet Office has undertaken a programme of benchmarking work across Government Departments and Agencies including the Highways Agency (Cabinet Office, 2009, 2012 and 2014). This work has focussed on construction and back-office costs and provides a wide range of cross-sector benchmarking information. The analysis provides some useful indicators of ongoing trends in cost and performance and specifically reviews trends in highway construction costs. Back office costs are also compared in a separate report which provides details on finance, HR, IT and other functions. The 2014 report also explains progress towards inter-organisational benchmarking across Departments, highlighting some of the work done by the Highways Agency with the Environment Agency for example.

A study by HM Treasury (2011) develops a metric for analysing the performance of the road network by combining multiple performance indicators such as traffic, average speeds and asset condition into an overall indicator to assess whether performance is improving or deteriorating over time.

Another study by HM Treasury (2010), examines the potential causes of the UK's relatively high infrastructure costs. The report provides comparisons of infrastructure costs with other countries based on structured interviews with central government bodies, client organisations and construction companies in Spain, France, Germany, the Netherlands, Sweden and Denmark. The study concludes that there are several important factors for efficient infrastructure delivery including:

- Strong political commitment.
- A clear regulatory framework.
- Well-structured long term investment programme.
- Organisation of the public sector with competent technical teams.
- Management of the private sectors capacity and good use of competition.
- Stronger larger contractors.
- Competition and collaboration.
- Processes for planning, prioritising and delivery.

This study also reviews international benchmark data from the Infrastructure Journal Online, the European Investment Bank and the Road Traffic Technology. Overall this analysis supports the hypothesis that building infrastructure is more expensive in the UK than elsewhere in Europe. It finds that the trend is for Southern Europe to have the cheapest infrastructure costs and Eastern Europe the most expensive with North Western Europe somewhere in between. Within the North Western countries, the UK is consistently more expensive.

European Road Assessment Programme (EuroRAP) country reports (2014), and underlying data provide a detailed analysis and assessment of the level of safety risk across the European road network. This could be adopted to provide an additional form of benchmarking, for example, to compare the levels of safety based on the proportion of routes classified as high risk.

A report by WSP/University of Birmingham (Odoki et al, 2009) describes the development of the HDM-4 model for DfT. This has been used to evaluate the optimum levels of investment in road maintenance based on an assessment of road asset conditions, the impact of investment and the outcomes for road users in terms of vehicle operating costs and delays. The model enables a comparison of net economic costs and benefits based on empirical evidence developed by the World Bank, for example the relationship between vehicle operating costs and roughness of the road pavement. This form of analysis could be applied to the strategic road network to develop an alternative assessment of 'efficiency' of Highways England maintenance spending incorporating user outcomes. The analysis captures user benefits it could be particularly helpful in measuring the economic benefit of different investment levels. However the calibration and validation of the model would require a large number of evidence based assumptions and so its analysis would need to be interpreted with care.

Finally, a study by the European Commission (2012) shows how GPS based satellite navigation data can be used to develop consistent and comparable metrics of road network performance based on comparisons of free flowing and peak period speeds. In principle a similar indicator based on Europe wide data could be used to assess Highways England's performance relative to comparators. This would enable raw comparisons of overall network performance across several of Highways England's objectives and KPIs, but may require some detailed analysis to enable an understanding of the factors which are likely to affect these indicators including population density, demand, road design, land use, etc.

4.3 Data review

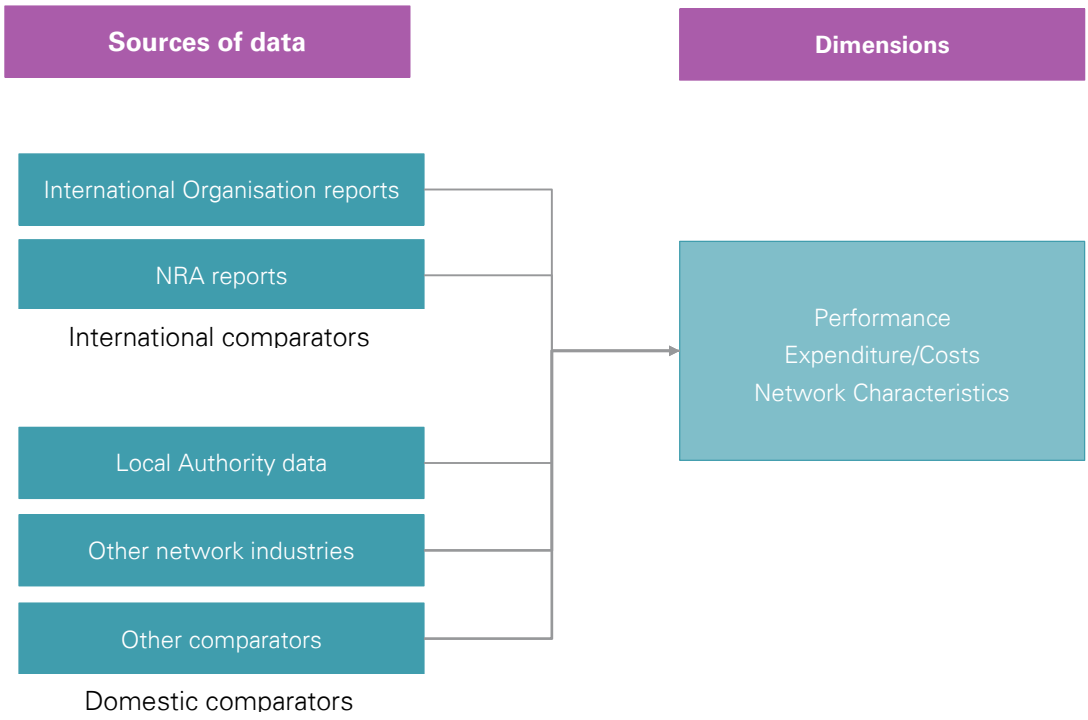
We have also reviewed the availability of data across three 'dimensions' which are key for the development of a performance and efficiency framework. These include:

- Performance - based on Highways England's objectives and KPIs.
- Expenditure - based on categories defined by Highways England.
- Network characteristics - based on the variables used in the BEXPRAC study.

We have assessed the availability of these variables across international and domestic comparators based on several sources including international reports and datasets, NRA reports, Local Authority data, data from other network industries and other comparators.

Our methodology for the data review is described in Figure 1.

Figure 1: Methodology of data review



Source: KPMG Analysis, 2015

Our assessment of the availability and comparability of the data is based on the following criteria:

- Scope and coverage of the data and its compatibility with Highways England objectives/ definitions.
- Provenance of the data, in terms of its source, whether it has been audited and any underlying assumptions or special factors.
- Comparability of the data in terms of the definitions, time period and method of capture.

In the following sections we have described and summarised the key sources of data reviewed as part of our study. A more detailed review examining the availability of performance expenditure and network characteristic data is provided in Appendix 2.

4.4 International comparators

International datasets

International organisations including the International Road Federation, the OECD, the European Union Road Federation, EuroRAP, the World Bank and the World Economic Forum all produce a range of information covering the performance and efficiency of road networks. Table 4 provides a summary of this data.

Table 4: International organisations and their publications reviewed as part of data review

Organisation	Publications	Summary
OECD	Road Safety Annual Report	Detailed information on road safety across 39 countries. Information is given regarding mode of travel and road type. The report also contains a summary of laws related to road safety and definitions.
	Road Infrastructure Spending database	Contains statistics on investment, maintenance as well as freight and passenger statistics for 36 OECD countries. Based on a survey sent to member countries.
International Road Federation	World Road Statistics	Includes data for topics including road networks, traffic, vehicles, accidents, expenditure and energy consumption. Data is available for 33 countries between 2000 and 2013.
European Union Road Federation	European Road Statistics	A publication of statistics that covers length, density, investment and safety for the EU-27 and in some cases other countries.
EuroRAP	Country Specific Reports	Reports on the safety and risk on roads across Europe, country specific reports are published for several countries.
World Bank	Road Statistics online databases	Provides high level data on road network length, traffic, vehicles and energy consumption, based on IRF produced statistics.
World Economic Forum	World Competitiveness Index	Index is based on a variety of indicators including several related to infrastructure. Provides survey based measure of road infrastructure quality.

Source: KPMG Analysis, 2015

In combination these data sources provide a rich source of information related to the performance, expenditure and network characteristics for road networks around the world. There are however significant complexities associated with data comparability, definitions and the activities of different road networks and NRAs. This can mean that direct comparisons of the data need to be treated with care in most cases. In general the key challenges associated with the data include:

- The UK is generally considered as a single entity, which means that the data represents the other UK NRAs as well as Highways England.
- The geographic definitions of the data are often inconsistent reflecting fundamental differences in administrative geography across countries – for example in the UK there is a distinction between England and other countries in the UK, and also distinctions between the strategic highway network and the local highway network. These distinctions differ in other countries so that survey respondents may not be perfectly comparable.
- The procurement of road projects differ throughout the world and some countries have high levels of private funding and finance, which may be captured in different ways. For example some countries may exclude PPP costs from construction and maintenance cost data.

- Survey based measures – of road quality for example – are likely to suffer from significant issues associated with stakeholders perceptions and understanding of context. The comparability of the data may be limited or difficult to interpret in some cases.

National road authority reports

Most NRAs produce an annual report providing an assessment of the organisation's performance over the course of the year alongside a set of audited financial accounts. In addition, some NRAs produce and publish other data on network performance, user satisfaction and safety, for example. Table 5 provides a list of NRA reports and research reviewed as part of this work.

Table 5: NRAs reviewed as part of data review

UK	Europe	Rest of world
Highways England	Ireland: National Roads Authority	Missouri: Department of Transportation
Welsh Government	Bavaria: STMI	Washington State: Department of Transportation
Transport Scotland	Netherlands: Rijkswaterstaat	USA: Federal Highway Administration
Northern Ireland Road Service	Italy: ANAS	Western Australia: Main Roads Australia
Transport for London (TfL)	Denmark: Vejdirektoratet	Victoria: Vicroads
	Austria: Asfinag	Chile: Direccion de Vialidad, Ministerio De Obras Publicas
	Portugal: Infrastructure Portugal	

Source: KPMG Analysis, 2015

The most detailed sources of data are provided by the US states of Missouri and Washington which produce very detailed regular documents covering a broad range of metrics on performance, expenditure and network characteristics.

Ireland's National Roads Authority, STMI, ANAS, Vicroads and Main Roads Australia all produce detailed annual reports which contain audited financial accounts giving detailed breakdowns of expenditure.

Transport Scotland and Rijkswaterstaat publish user satisfaction surveys that cover a range of topics and provide useful insights into this metric.

TfL produces a quarterly performance report for the TLRN covering network usage, availability of assets and user satisfaction.

Performance data

Table 6 provides an overview of the range of data generally available for NRAs that could be used to benchmark the performance of Highways England. The analysis is structured to map against each of Highways England's objectives (see Section 2.1 above).

Table 6: Overview of data availability for performance metrics

Objective	KPI	Availability of data
Making the network safer	**Road safety** The number of killed and seriously injured (KSIs) on the SRN.	**Widely available** Large number of data sources with OECD annually produced safety statistics being one of the most useful. The issue is ensuring that comparison with similar road types is used.
Improving user satisfaction	**User satisfaction** The percentage of National road users' satisfaction survey (NRUSS) respondents who are Very or Fairly Satisfied.	**Available, but data generally has significant comparability issues** There are several NRA specific and wider satisfaction surveys. The issues is ensuing that there is enough crossover of methodology to ensure direct comparison is feasible.
Supporting the smooth flow of traffic	**Network availability** The percentage of the SRN available to traffic.	**Could be developed** A mix of data is available although it is non-consistent meaning it may be difficult to evaluate. Lots of real time information (RTI) data is produced but it is difficult to evaluate how this could be used. Data from INRIX, TomTom or Traffic Master could be developed to provide a comparable indicator, for example.
	Incident management Percentage of motorway incidents cleared within one hour.	**Limited availability** Limited data exists for this variable with only TfL, Missouri and Washington reporting on this indicator.
Encouraging economic growth	**Economic growth** Average delay (time lost per vehicle per mile).	**Limited availability** A limited mix of data is available. More usable data appears to exist for road usage, specifically freight transport which can be an indication of economic growth.
Delivering better environmental outcomes	**Noise** Number of Noise Important Areas mitigated.	**Not currently available** Limited directly comparable data is produced, there are wider studies regarding energy usage, emissions and particulates that may provide more useful data to benchmark against.
	Biodiversity Delivery of improved biodiversity as set out in the company's biodiversity action plan.	**Not currently available** No equivalent data found.
Helping cyclists, walkers and other vulnerable users of the network	**Cycling and walking** The number of new and upgraded crossings.	**Not currently available** No equivalent data found.
Achieving real efficiency	**Cost savings** Savings on capital expenditure.	**Could be developed** Large amounts of data is produced regarding construction cost of road projects, but savings are not widely reported. DBFO data from the UK is a potential source of very useful data, although other NRAs are also producing data such as economic value added which may be useful.
Keeping the network in good condition	**Network conditions** The percentage of pavement asset that does not require	**Limited availability** A number of road condition surveys are undertaken which give an indication of the road condition.

Objective	KPI	Availability of data
	further investigation for possible maintenance.	The comparability of this data is not clear. Data for other assets such as structures is more limited outside of the UK.

Source: KPMG Analysis, 2015

Expenditure data

Table 7 provides an overview of data availability on NRA expenditure by broad expenditure category. As with other data comparisons, there are difficulties related to the geographical and institutional definitions which often do not differentiate between the SRN and whole network for example. NRA produced data is also subject to category definitions used and issues such as the inclusion or exclusion of PPP related costs for example.

Table 7: Overview of data availability for expenditure/costs

Expenditure/Cost	Availability of data
Total expenditure	**Widely available – But issues associated with definitions of expenditure and inclusion of non-strategic road network** Total expenditure data is contained in both the IRF and the OECD datasets, but the definitions vary across NRAs and there are likely to be comparability issues. The geographical and institutional definition of the data is also unclear in some cases – for example covering public and private sources, urban and non-urban areas etc. Most NRAs also report total expenditure/costs in their annual reports, providing a greater level of detail.
Maintenance	**Widely available – But issues associated with definitions of expenditure and inclusion of non-strategic road network** Road maintenance expenditure is provided in the IRF statistics, there are also historic cost data provided by the International Transport Forum. This data is subject to the same issues described above. A number of NRAs publish maintenance expenditure in their annual reports including: Wales, Scotland, Northern Ireland, Ireland, Netherlands, Bavaria, Italy, USA and Australian states. But the definitions can vary between NRAs which can make raw comparisons difficult. The definition of renewal or enhancement spending for example is likely to differ widely.
Capital	**Widely available at top-down level and some limited bottom-up data but suffers from comparability issues** The IRF and OECD produce multi country data on investment in the road network. A number of NRAs also report capital expenditure in their annual reports. The definitions of capital spending differ between countries and there can also be differences in capitalisation and depreciation policy. Some NRA do not include costs associated with PPP for example. Some NRAs publish capital expenditure on specific projects either as part of their annual report or online. As such, schemes can be reviewed in terms of scope, costs and progress. The data from the DBFOs is likely to be some of the most useful data here in estimating an efficient cost profile in the same market area as Highways England.
Administration	**Limited availability at a high level but some data provided by with NRAs or other infrastructure provide** Administrative cost data is available to a limited degree from NRA annual reports, including Ireland, Netherlands and Austria. Further analysis of similar infrastructure organisations in the UK such as Network Rail, Environmental Agency and TfL through IUK may prove to be a useful source of information.
Staff	**Widely available at a high level from NRA annual reports, potential to also consider other infrastructure providers** High level staff cost data is published by NRAs in Ireland, Bavaria, Italy, Austria, Western Australia and Victoria. Further analysis of similar infrastructure organisations in the UK such as Network Rail, Environmental Agency and TfL through IUK may prove to be a useful source of information.

Source: KPMG Analysis, 2015

Network characteristics

The international datasets and NRA reports contain a wide range of network characteristic data including data related to network structure, usage and assets. Generally there is a large amount of information available on these factors. Table 8 provides a summary of data availability relating to network attributes.

Table 8: Overview of data availability for network attributes

Variable	Availability of data
Network size	**Widely available** IRF and the World Bank produce detailed databases providing the total size of the road networks in countries. NRAs also often publish data about the size of the network.
Network type	**Widely available** IRF provides a breakdown of road types. Data on bridges and tunnels, is more limited, with some insights being provided in annual reports. The BEXPRAC report provides a useful indication of total road network covered by bridges and tunnels for the countries involved although this is a single dataset and may now be out of date.
Network usage	**Widely available** IRF produce statistics on vehicle usage, broken down by passenger and freight travel, although potentially there are issues about what road network is covered. The OECD also produce statistics on freight and passenger road usage at a country level.
Environmental factors	**Widely available** World Meteorology Organisation and Met Office provide ongoing weather statistics at a country level. BEXPRAC contained specific data on number of days the temperature was below freezing. The OECD have also developed indicators for topography.
Network value	**Limited availability** Limited data exists regarding consistently reported network value, with different approaches possible, notable historic cost and gross replacement cost. The BEXPRAC study does provide an estimate of network value based on notional road asset values.
Organisation structure	**Some availability but with limited comparability** Most NRAs reports provide a description of the organisational structure, activities functions and variables such as the total number of employees, although data regarding HQ costs is often limited.

Source: KPMG Analysis, 2015

4.5 Domestic comparators

In addition to the international datasets described above, we have reviewed data from domestic comparators including data from local authorities, other network industries, Government Departments, PPPs and other sources.

Local authorities

Local Authority level data collated by the DfT and DCLG on an annual basis. This covers a range of topics including network characteristics, reliability, safety as well as revenue and capital expenditure across categories. Project assessments are also published as part of DfT Major Projects. Previously, the DfT has produced specific roads benchmarking toolkits for local authorities using publicly available data. It may be possible to replicate this analysis to derive benchmarks for performance, construction, maintenance and operational expenditure across local authorities for high level comparison with Highways England.

The benefit of using Local Authority data for benchmarking is that the organisations are operating in largely the same economic and institutional situation as Highways England, with similar suppliers and having to adhere to the same underlying design and safety rules. For this reason, issues of comparability are significantly reduced. However, it is important to appreciate that Local Authority

road networks differ to the strategic road network considerably in that they have a greater proportion of B, C and U roads which will affect comparisons. Differences also exist in road usage intensities and speeds as well as the urban/rural environment which may influence underlying performance and cost.

UK networked industries

The UK has a number of regulated network industries, many of which have similarities to Highways England and many of which have regulators who use benchmarking as part of their regulatory instruments. These include:

- Network Rail (ORR).
- Heathrow Airport (CAA).
- NATS (CAA).
- Electricity transmission and distribution companies (Ofgem).
- Telecoms networks companies (Ofcom).
- Water and waste water companies (Ofwat).
- Northern Ireland Utility Regulator (Ofreg).
- Water Industry Commission for Scotland (WICS).
- Other international regulatory bodies such as the Commission for Aviation Regulation in Ireland (CAR).

Each organisation is subject to some form of economic regulation and each has some similarities to Highways England. Network Rail in particular has particular similarities as a large transport network infrastructure provider which undertakes large amounts of construction and maintenance activities, although clearly the nature of these activities is often quite different to those undertaken by Highways England.

The respective regulatory bodies publish information and analysis on the performance and efficiency of the regulated industries. Important methodologies used by regulators to assess efficiency and performance include:

- Frontier shift studies – These studies typically seek to assess the average rate of productivity growth that network industries could be expected to experience based on historic trends across sectors. They provide analysis including assessments of changes in total factor productivity, input costs and other indicators which can be used to assess the performance of an industry or sector. Frontier shift studies have been produced by ORR, CAA, Ofwat and Ofgem and have been widely used in setting price controls.
- Employment cost benchmarking studies – These studies examine employee costs within the network industries against comparative benchmarks based on various sources. Studies have been published by ORR and CAA. It may be possible to use this information to develop some high level benchmarks for Highways England's internal staff costs, although the roles and benchmarks would need to be considered carefully.[3]
- Pension cost studies – Regulators often review the efficiency and management of pension costs in regulated industries including the management of defined benefits pension schemes and the recovery of deficit costs for example. The Government Actuary Department has undertaken a range of studies including for the CAA and Ofgem.
- Other efficiency studies – In addition to these studies which are based on a generic methodology applicable to all sectors, regulators have also undertaken a range of ad-hoc efficiency studies

[3] IDS/Thomson Reuters (2013) Benchmarking Employment Costs at Network Rail

focussed on particular aspects of a company's performance. This evidence may provide some benchmarking evidence for the Highways Monitor in some limited cases. These studies include the bottom-up studies undertaken by ORR with regard to Network Rail, analysis of airport maintenance, central service other operating and capital costs undertaken by CAA.

Government Departments and Agencies

The Cabinet Office Efficiency and Reform Group have undertaken analysis of the spending and efficiency of Government Departments and Agencies. This includes reviewing major projects across government and benchmarking spending in common areas. In addition to the wider work of the Group, there are two main studies which could be useful for benchmarking Highways England which focus respectively on construction costs and back office costs.

The construction study (Cabinet Office, 2012 and 2014) provides analysis of top-down Departmental spending and bottom-up costs across a range of activities reflecting the activities and policy priorities of the respective Departments. The Cabinet Office has monitored the costs of Trunk Road Improvement, Junction Improvement, and Managed Motorway costs since 2010 for example. The main objective of the report is to provide an ongoing analysis of cost trends over time but the data in the report could also be used to provide cross department benchmarks in some cases.

The back office cost report (Cabinet Office, 2009) contains detailed information on the back office costs of all government organisations with over 250 members of staff. The report contains indicators including spending, headcount and KPIs related to finance, HR, IT, Procurement, estates, communications, legal and knowledge management and provides average values for each of these indicators. These indicators could be used to provide high level benchmarks of Highways England's performance and structure relative to other government organisations – although the comparability of the data would need to be considered with care. The back office benchmarking report was published in 2009 and it is not clear if this analysis has been repeated.

DBFOs and PPP projects

DBFO concessions are operated independently by private sector operators based on a contract which includes requirements to maintain roads to agreed standards – similar to those now being applied to Highways England. The contracts provide an alternative form of benchmark of the maintenance and operation costs for parts of the road network, which could be used to estimate implicit unit costs for benchmarking Highways England. DBFOs cover a range of road types which also have a mix of traffic densities and structures. There are 11 DBFOs currently in operation and Highways England/DfT holds data on all of these contracts.

HM Treasury also holds a database of all UK PPP projects across all Government Departments. This contains details on over 700 separate projects spanning a range of activities from transport to construction in health, education and defence. The database includes information on the scheme design, operation dates, unitary payments and capital costs and could be used to derive high level benchmarks for Highways England's own projects.

These contracts provide an alternative benchmark for the maintenance and operation costs for parts of the road network, which could be used to estimate unit costs for benchmarking Highways England. This could be achieved through deriving the implicit construction, maintenance and operating costs included within these contracts through unpicking the components of the contract – for example the capital costs, cost of capital and performance metrics which determine the unitary payments. This would require a detailed understanding of how the contracts have been developed. The outcome of this form of analysis would be an estimate of the construction and operating costs per km or unit associated with such contracts.

This approach has significant advantages over other forms of benchmarking because the DBFO/PPP operators exist in the same jurisdiction as Highways England and operate similar kinds of road network and therefore differences in the design, safety and legal frameworks are much less significant than with other international comparisons. DBFOs are also competitive entities which, in

principle should have stronger incentives for efficiency than Highways England meaning that the benchmarks may provide a good indication of 'frontier performance'.

On the other hand, there are some challenges and issues with this approach, including the need to make assumptions about profit margins, risk profiles and other parts of the contract to derive a residual operating cost which may require a range of assumptions and therefore be subject to a degree of uncertainty. For various reasons, including the nature of the projects, level of standards applied and the profit margins, in general these benchmarks may not be directly comparable with the wider Highways England network and may tend to be relatively high cost, nonetheless this may provide a useful upper benchmarks for specific projects.

In addition to data on the DBFO contracts held by Highways England, DfT and HM Treasury hold data on over 700 separate PPP projects which could also be used to derive benchmarks in some cases. Most of these projects are related to construction in health/defence and education but there are several related to local highways maintenance and street lighting which should be relevant.

Network asset models

The DfT has developed a HDM-4 road asset model for the local road network to assess the performance and efficiency of local authorities and to estimate optimum levels of investment. This model has been used to allocate funding to local highway authorities and is based on a well-developed methodology designed by the World Bank to assess the costs and benefits of different maintenance strategies. The model has been applied in case studies around the world.

This type of model provides a direct analysis of the optimum level of maintenance spending – Based on the size and structure of the road network, levels of traffic and other variables such as existing asset conditions. This is based on empirical linkages between maintenance spending, asset conditions and the economic benefits of improved road network performance.

The model could be developed for the SRN to assess the optimal level of maintenance spending, this would requires a high level of calibration and optimisation and means that the analysis is subject to some uncertainty. The advantage of this approach is that it could be used to develop an estimate of optimum levels of road maintenance spending and activity through first principles based on an assessment of the outcomes for road users.

Satellite data

The review of evidence and data has revealed that there are several sources of Europe wide traffic data which provide metrics about traffic levels, speeds, congestion and other factors in a consistent and comparable manner. This type of data is usually captured from satellite navigation units or smart phones and underpins geographic location services. We also understand that some of this data is already used by Highways England and the DfT for the measurement of traffic and delay. We consider that this data therefore may have great potential for providing the Highways Monitor with directly comparable metrics to benchmark the performance of Highways England. Examples include the TomTom Traffic Index and INRIX Urban Mobility Scorecard which rank European countries and cities based on the average delay experienced by drivers. Such datasets could be adapted to meet the specific needs of the Highways Monitor for benchmarking the performance of Highways England relative to other countries.

Other sources

There are other sources of proprietary benchmarking data which provide cross industry benchmarks on specific areas of business activity including functional and organisational cost and process efficiency. Other organisations maintain databases on staff costs benchmarks. These sources could be used to compare Highways England's internal structure and organisation with other businesses – although the relatively unique function and structure of Highways England needs to be taken into account.

Proprietary benchmarking data provides cost benchmarks across a range of functions and activities including finance, HR, IT, procurement, executive, sales, marketing, and service activities. It also provides process benchmarks for accounts to report processes, enterprise performance management, order to cash and purchase to pay processes. These benchmarks can be tailored to match the size, sector and structure of the organisation to improve comparability and can be provided in different forms such as the percentage of revenue or cost per member of staff. Other organisations provide specific benchmarking analysis of IT costs and processes for example datacentre costs and staff head count and productivity.

Bottom-up benchmarking metrics

Table 9 provides an overview of data availability to support bottom-up benchmarking analysis. This information can be more commercially sensitive and is therefore less widely reported that information used in top-down benchmarking exercises.

Table 9: Overview of data availability for bottom-up analysis

Category	Variable	(Public) Availability of data
Asset management expenditure – Maintenance	Grass cutting	Not available as part of an ongoing dataset
	Drainage gullies	Not available as part of an ongoing dataset
Asset management expenditure – Renewal	Carriageway resurfacing	Not available as part of an ongoing dataset
	Bridge joint replacement	Not available as part of an ongoing dataset
Operating expenditure	Network control centres	Not available as part of an ongoing dataset
	Gritting	Not available as part of an ongoing dataset
	Traffic officer service	Not available as part of an ongoing dataset
Enhancement expenditure	Construction of new roads	Some data from DBFO/PPP + Non Highways England Projects Review and local authorities
	Widening of existing roads	Some data from DBFO/PPP + Non Highways England Projects Review and local authorities
	Junction improvements	Some data from DBFO/PPP + Non Highways England Projects Review and local authorities
Support expenditure	Human resources expenditure	Some evidence available from Cabinet Office benchmarking and other regulatory studies
	IT services	Some evidence available from Cabinet Office benchmarking and other regulatory studies
	Financial services	Some evidence available from Cabinet Office benchmarking and other regulatory studies
	Technical support	Some evidence available from Cabinet Office benchmarking and other regulatory studies
	Total staffing costs	Some evidence available from Cabinet Office benchmarking and other regulatory studies

Source: KPMG Analysis, 2015

Renewal and enhancement data is generally available and could be used for some comparisons. Support expenditure is also available largely from annual accounts although it may be more difficult to break down into individual activities. The usefulness of these indicators without wider contextual evidence on the quality of performance and outputs however may be limited. This is because many

of the maintenance activities are not readily identifiable as separate costs as they are part of lump sum activities undertaken by maintenance contractors. We discuss potential bottom-up indicators further in Appendix 5.

5 Summary

5.1 Stakeholder engagement

We have contacted and received responses from a large number of organisations in the course of this work. Respondents were generally positive about sharing efficiency and performance information with the Highways Monitor and Highways England and were open to opportunities to collaborate. Whilst most of the information identified by respondents was relatively high-level, individual NRAs collect and assemble more detailed information.

The Highways Monitor will need to consider which NRAs would be most appropriate to benchmark Highways England against and will need to develop a more detailed proposition on how it would work. A benchmarking proposition could involve for example the selection of a range of specific costs and activities and a request for data broken down into specific categories and with explanatory information to understand the definitions of the data. Ensuring that data is comparable will likely require several iterations of this process. Any benchmarking study is therefore likely to require a high level of commitment from agency staff over a sustained period of time.

5.2 Key findings from the evidence review

Our review identified a large volume of material relating to the performance and efficiency of highway networks and NRAs. The material covers top-down and bottom-up benchmarking, surveys and qualitative assessments. The work helps to provide context and understanding to shape the specification of new analysis or comparisons between NRAs.

Of all of the studies reviewed, three stand out as being particularly relevant to furthering the Highways Monitor's objective to develop a performance and efficiency framework for Highways England.

The **OECD** benchmarking report (Braconier et al, 2013) provides an example of the kind of analysis that could be developed based on publicly available data. The study provides some useful findings but also has significant limitations related to the definition and comparability of the data. The margins of error of the efficiency analysis in the report suggest that it will probably not be possible to rely upon this analysis and data for setting efficiency targets without significant data harmonisation. However the Highways Monitor could seek to replicate and extend the analysis based on wider sources of available data. This is likely to be a key first step in the development of an efficiency framework.

Despite the limitations of the data, the OECD report (Braconier et al, 2013) does provide an indication of the best and worst performing NRAs (based on a particular definition of inputs and outputs) which may be helpful for considering further analysis – for example by identifying NRAs with similar characteristics to Highways England and those which out-perform Highways England on a wide range of metrics. The OECD report has been developed to provide general transport policy analysis of the road transport sector but the Highways Monitor could also adapt the input and output measures to provide a more appropriate regulatory analysis of NRA performance with a greater focus on efficiency and Highways England's core objectives.

The **CEDR** study (2010) provides an example of how top-down analysis could be further developed to better take account of data comparability issues through active data collection. The study provides a range of findings, including comparisons of operation and maintenance costs. It also provides a definition of the key network characteristics such as: network length, lane km, assets and asset conditions, traffic, weather and user satisfaction. These factors could provide the foundations for developing a model of NRA performance and efficiency.

The report also develops a methodology to take account of these factors and to estimate their effect on operating costs. Although the basis for this method is not entirely clear, it is illustrative of the kind of analysis and adjustment which could be made to compare different NRAs. However, despite the

efforts of this study, the comparability of the data remains imperfect. The study concludes that further work is required for the comparisons to provide meaningful evidence on relative efficiency.

Despite this, the achievements of the study should not be underestimated and it is the most developed form of international data collection and top-down analysis we have found as part of our review. It presents a significant opportunity for the Highways Monitor as a foundation to develop more reliable international top-down analysis through engaging with the CEDR network. Over time data collection and harmonisation efforts this could be improved to the extent that the model could provide a useful input into the overall performance and efficiency framework.

The **HMEP/CQC** study (2014) analyses the performance of local highway networks using top-down econometric analysis to provide an assessment of relative efficiency. Because the organisations are from the UK this study does not suffer from comparability issues to the same extent as the OECD and CEDR analysis. However local road networks have different characteristics and are generally built and maintained to a lower standard, which means that any comparison of performance and efficiency would need to be interpreted with care. Nonetheless the study does provide a range of findings about the factors associated with efficiency amongst LTAs. It may be possible to develop this work to incorporate Highways England, or alternatively to derive benchmarks for maintenance and construction costs and use the findings of the study to identify the most efficient organisations for bottom-up benchmarking.

The CQC network is a collaborative body and engagement is predicated on the anonymity of data and confidential analysis of results for each stakeholder. The Highways Monitor needs to be aware of the potential conflicts of interest this could involve should this information be used for regulatory purposes. It may be more appropriate for Highways England to join the organisation independently of the Highways Monitor. Highways England would have knowledge of its own efficiency score from the analysis, and could also utilise the CQC efficiency network to identify and build relationships with comparator authorities to help develop more bottom-up process type comparisons. This information could then be shared with the Highways Monitor.

The CQC work also provides an analytical template that could be replicated across NRAs. More details of how this could be developed are outlined in Appendix 3.

The Cabinet Office has undertaken benchmarking of construction and back office costs across all government departments and agencies including Highways England in order to monitor the performance and efficiency of government as a whole. The back office benchmarking report (Cabinet Office, 2009) provides benchmarks across a range of activities including finance, HR, IT and other generic organisational functions. This could be used to compare Highways England at a high level – although the comparability of the data is quite difficult to interpret in some cases. The construction cost benchmarking reports (Cabinet Office, 2012 and 2014) contains analysis of trends in construction costs over time from 2010 to 2014. This includes analysis of Highways England's motorway construction costs. There are also a wide number of construction based benchmarks for other departments which may be indirectly applicable to Highways England. The Highways Monitor should engage with the Cabinet Office to understand whether this work will continue and how it could be developed by the Highways Monitor.

Similar cross department indicators of performance and efficiency have also been developed by HM Treasury in the past – based on the combination of a number of metrics. These indicators do not appear to have been maintained, but the Highways Monitor could consider developing a similar overall metric to monitor Highways England's performance over time.

There is also a wide range of cross-industry analysis and benchmarking evidence developed by other economic regulators such as CAA, Ofwat, Ofgem and Ofcom. There are several studies which provide analysis of frontier shift, employment costs and pensions across regulated sector and which use generic methods which could be applied to Highways England. In some cases these studies may provide useful benchmarks to compare Highways England, although comparability needs to be considered. In addition to these cross-industry studies some regulators (particularly ORR, Ofgem and

CAA) have undertaken a range of studies which focus in specific activities which may provide some indirect benchmarks for maintenance, energy and other costs.

The literature contains some bottom-up analysis of maintenance and construction costs which generally find that the UK's costs are higher than European comparators for several reasons including: relatively high design standards, comprehensive provision of non-pavement features and more comprehensive provision of measures to support the construction process. These appear to be important factors which increase UK costs, but these studies do not fully determine if these factors fully explain the apparent costs differences and whether there is an efficiency gap.

There are also several studies which examine best practice in areas such as construction and asset management, but which do not provide quantitative assessments of efficiency. These studies are helpful in providing understanding and context to the relative performance of NRAs and factors which may by important but provide limited insight into the relative performance and efficiency of Highways England.

5.3 Key findings from the data review

International data

The review of data has identified information on the performance, expenditure and network characteristics of a number of NRAs. The range and level of detail of the publicly available information is significant relative to most other regulated sectors and this information can be sourced from several international datasets assembled by OECD, World Bank, International Road Federation, European Road Federation and World Economic Forum for example.

These organisations have attempted to provide some harmonisation between countries but the geographical scope and definitions of data and costs is likely to be an issue which makes direct raw comparisons difficult to rely upon without a detailed investigation into the source and definition of data in each case. Most of these datasets are also based on the UK rather than the English road network for example which means that some adjustments would be required to make comparisons appropriate for Highways England.

Inherent differences in the structure of national road networks including the differences in administrative geography (between metropolitan and strategic road networks and other geographical boundaries) is likely to be a complicating factor in some instances. The definitions of performance metrics such as delay, accidents, congestion and cost metrics such as maintenance and renewals usually differ slightly between countries. There may also be differences in the inclusion or exclusion of PPP related costs which can skew the results of analysis by excluding parts of the network which are generally high performing and high cost.

Despite these issues the wide range of data and the relatively high level of detail provided by these international datasets is a significant asset for the Highways Monitor and is likely to be very useful for understanding the overall performance of the road network in comparison with other countries. There could be considerable value in collecting, organising and 'cleaning' this information in more detail to undertake some high level analysis of the performance of Highways England against other road networks to inform understanding of general performance. This could help to provide some partial assessments of the performance and efficiency of NRAs, rank the organisation and identify best in class comparators. More detailed comparisons could then be considered based on more detailed NRA based data.

That said, the Highways Monitor needs to be aware of the limitations of this data and take care to ensure that the issues described above are understood and addressed as much as possible. Whilst analysis based on this data is likely to be useful as a first step, it will probably not be sufficient to rely upon in setting performance and efficiency targets for Highways England, without extensive supporting analysis.

NRA and other data

NRAs produce a range of data to measure the performance of their road networks and there are a large number of reports which provide detailed analysis of performance and costs. These often provide data on cost, performance and network characteristics but usually with slightly different definitions which can make comparisons difficult. Despite this, NRAs provide a rich source of 'passive' data which could be useful for comparing the performance of Highways England across specific indicators, particularly where the NRA is considered comparable to Highways England.

Comparing cost information across different NRAs can be difficult as they generally have different approaches to cost allocation, different structures and can also undertake different activities which can complicate comparisons. For example Rijkswaterstaat is responsible for the waterways of the Netherlands which has implications for its organisational structure, activities and overhead costs.

Similar differences are likely with other NRAs. Even where the activities undertaken by an NRA are similar there can be organisational differences which may affect comparisons. For example Highways England has the highest level of outsourced costs of all European NRAs. One effect of this is that its employments and cost structure are different and probably more 'top-heavy' with a higher number of managers. This would tend to result in a higher cost per staff member for example.

The data collected and published as part of each NRA generally has some consistency over elements at a high level such as staff, admin and operating costs. Lower level data tends to differs substantially and even where the same metrics are published there may be differences in definition and calculation which can make direct comparisons difficult. Nonetheless NRA reports are likely to provide a useful source of raw network benchmarking data in some cases. Some NRA reports also provide details on individual project expenditure and performance or link based analysis. This indicates that some NRAs hold a large amount of detailed data which could potentially be used in collaborative benchmarking analysis.

Within the UK there is extensive data on the performance, expenditure and characteristics of local highway authorities. This has significant advantages over international NRA data because the definitions and collection methods are consistent and the design standards and economic context of the local authorities is more similar to Highways England. In the past the DfT has developed a benchmarking tool based on this raw data which could be updated and used by the Highways Monitor to develop high level benchmarks across a variety of indicators including costs. Clearly the structure of local highway networks is very different to the SRN however this could be taken into account in any analysis.

Important data sources

We have identified key datasets which provide data on the performance of road networks across a range of countries and regions based on surveys and other data collection methods. These provide a potentially useful source of comparative information for the Highways Monitor. The Highways Monitor may wish to obtain some or all of these datasets to develop some high level raw comparisons of Highways England against other NRAs and other comparators. These datasets are described in Table 10.

Table 10: Key sources of data

Organisation	Dataset	Description
International Road Federation	World Road Statistics	Includes data for topics including road networks, traffic, vehicles, accidents, and expenditure and energy consumption. Data is available for 33 countries between 2000 and 2013.
OECD	Road Infrastructure Spending database	Contains statistics on investment, maintenance as well as freight and passenger statistics for 36 OECD countries.
European Union Road Federation	European Road Statistics	A publication of statistics that covers length, density, investment and safety for the EU-27 and in some cases other countries.
World Bank	Road statistics online databases	Provides high level data on road network length, traffic, vehicles and energy consumption.
DfT	Road accidents and safety Road congestion and reliability Road traffic	Contains multiple data for a range of safety, reliability, road condition and performance statistics for local authorities' road networks across England.
DCLG	Local Authority revenue and capital expenditure budgets	Contains data on LA spend on road network categorised into revenue and capital segments.

Source: KPMG Analysis, 2015

In addition to these international datasets, many individual NRAs produce annual monitoring reports which contain a variety of statistics and performance metrics, often including information on spending and KPIs. Examples include:

- Federal Highway Administration.
- Missouri DOT.
- Washington DOT.
- Austroads.
- VicRoads.
- Rijkswaterstaat.

We have generally found that there is a large amount of data relating to the performance of the network (KSIs, delay, road condition etc.), and network characteristics (lane kilometres, number of bridges, number of junctions etc.). Information on expenditure is also generally available at a total level, but breakdowns by activity tend to differ between organisations and are generally unlikely to be perfectly comparable.

5.4 Implications for the development of a performance and efficiency framework

When assessing the efficiency of an NRA it will be important to consider the costs and benefits to the infrastructure manager and the road user. The performance of the road network has an important effect on the economic costs of road users, which are very large relative to the costs of the NRA. This means that any assessment of efficiency needs to balance the costs of the NRAs activities with the outputs achieved and the benefits derived by road users.

Targeting a minimum cost benchmark without reference to the potential impacts on road users could result in significant net economic costs if it results in a decline in outcomes for users. This means that the Highways Monitor needs to ensure that benchmark comparisons are made against organisations with appropriate standards, performance and outputs, whilst accounting for differences in the characteristics of the networks. Where this is not possible the Highways Monitor will need to make adjustments to reflect such differences. It may be beneficial to develop some metrics which reflect the economic benefits of Highways England's activities to understand the value of its activities and place costs in context.

Across the top-down benchmarking studies there is a large amount of information related to network characteristics and performance. This means that differences in network characteristics and performance could be accounted for to some extent, although the comparability and definition of these metrics is often imperfect. The main challenge and weakness in the analysis is the comparability of the cost data and even where studies have made efforts to harmonise this data, this remains an issue.

Over time and with engagement with other NRAs – through CEDR and CQC for example – it may be possible to develop a comparable database which could be used for more advanced econometric benchmarking, but this is likely to require significant effort and engagement from Highways England and other NRAs. Without this data it will be difficult to place much weight on any analysis.

Without this data, top-down benchmarking should still be a part of the Highways Monitor's efficiency and performance framework, but the Highways Monitor must be aware of the limitations and must be cautious in the selection of comparator organisations and consider a range of factors when interpreting the analysis. Thus the robustness of top-down benchmarking is likely to improve over time provided there is active development of the database.

For example it may be beneficial to use top-down benchmarks to identify and select individual NRAs and other organisations which appear to outperform Highways England on a variety of metrics. The Highways Monitor could then investigate the performance of these organisations in more detail and through bottom-up comparisons to understand apparent performance gaps, rather than relying on comparisons based on potentially unreliable data.

The Highways Monitor should also use different and complementary approaches to estimate overall efficiency gaps for example making comparisons with other NRAs, local highway authorities, other domestic comparators and itself based on the evidence we have highlighted above.

Based on our review of the available evidence and data it is very likely that bottom-up evidence and analysis, based on more detailed data adjusted to take account of differences and to improve comparability, will be required for the assessment of efficiency and to identify performance gaps. The NRAs and other comparators contacted as part of this study are likely to hold a large amount of useful information. The Highways Monitor should consider which aspects of performance or activity are most appropriate for this form of analysis.

Possible methods for efficiency and performance analysis

Based on the evidence and data reviewed in the course of our work, we consider that there are several options that could be used as part of the Highways Monitor's overall efficiency and performance framework:

- The development of partial metrics and raw and adjusted comparisons and rankings of NRA/road network performance based on publicly available data to identify best in class NRAs and those which are most comparable to Highways England at a high level for further more detailed analysis and comparison.
- The development of a top-down benchmarking dataset based on publicly available data and the use of partial and comprehensive analytical methods to derive high level estimates of efficiency and performance gaps – taking account of the issues described above and with a careful

interpretation of the results. This data could be developed over time through engagement with other NRAs.

- The use of top-down benchmarking based on the performance of separate regional units of Highways England. Highways England has 14 regional units which could each be used to provide comparisons of performance and efficiency by identifying the most efficient region across different activities. This would provide an indication of the most and least efficient regions, but may not provide a truly independent assessment of the potential efficiency frontier.
- The use of top-down benchmarking to assess the performance of local highway authorities. The HMEP/CQC study and the data which underpin its analysis may enable the Highways Monitor to develop an alternative efficiency frontier, although comparisons with Highways England would need to be interpreted with caution. This work is undertaken on a collaborative bases and therefore the Highways Monitor needs to consider the potential for conflicts of interest. It may be more appropriate for Highways England to join the network and engage with the benchmarking analysis directly.
- Benchmarking the performance of Highways England at a strategic level against other organisations and regulated network industries such as Network Rail, National Grid, BT etc. There are several examples of studies which develop cross industry comparisons of Real Unit Operating Expenditure and frontier shift which could be applied to Highways England to assess its performance compared with other industries. Comparisons could also be made of common institutional factors such as central service costs, pension costs, and absence rates and staff structures for example.
- The use of DBFO and PPP contracts to derive implicit construction and maintenance cost benchmarks based on a derivation of the contract building blocks. Highways England and HM Treasury holds detailed information on these contracts including the specification, construction costs, and asset condition and associated unitary payments. This could be used to develop rough indicative benchmarks of construction and operating costs across a range of activities.
- Network asset based modelling analysis of efficient maintenance spending, for example using the principles of the HDM-4 model (originally funded by the World Bank for investment appraisal). This model optimises road maintenance decisions based on their impact on road user costs and provides an assessment of the economically efficient level of maintenance spending based on a model of network length, asset conditions and usage.
- The use of satellite based traffic data to develop consistent and comparable indicators of traffic congestion, delay and other factors.

6 Recommendations

6.1 Overview of recommendations

We consider that the Highways Monitor has a number of options for developing an efficiency and performance framework for Highways England. The methodology for some of these options are well developed and are likely to be feasible for the Highways Monitor in relation to Highways England. Others may require additional investigation to determine the reliability of the analysis, the comparability of the data and the associated costs. In this section we provide a set of recommendations for the Highways Monitor and Highways England taking account of these practical issues.

Each of the approaches has strengths and weaknesses and all suffer from issues related to the comparability of data, which means that the analysis will require careful judgement and interpretation by the Highways Monitor. The key issue for any form of efficiency analysis is the availability of comparable data and in particular the willingness of potential partners to take part in any further data collection and benchmarking activity.

On balance, based on our understanding of the available data and analytical methods, the most appropriate approach for the development of an efficiency and performance framework is likely to be to develop a range of analysis. This can then be used to 'triangulate' performance and efficiency targets based on careful judgement and weighting of the evidence in each case.

Top-down benchmarking of NRAs in other jurisdictions based on publicly available data should be helpful for understanding Highways England's relative performance and efficiency and could provide a rough indication of the performance frontier across different metrics. Developing raw and adjusted comparisons of performance, costs and network characteristics with other NRAs should be a key foundation of any efficiency framework, upon which initial analysis can be undertaken and more advanced analytical techniques then built. Based on the current data this type of analysis needs to be interpreted with care bearing in mind the potential issues associated with geographical definitions and other factors.

Over time and with the participation of other NRAs top-down benchmarking based on active data collection (from the CEDR dataset for example) could become more accurate and robust to the extent that it could be used to inform efficiency targets. However the experience of top-down benchmarking of Network Rail by ORR suggests that the issues of comparability and the various factors which affect performance mean that this form of analysis will always be subject to a degree of uncertainty and therefore require supporting analysis. There is also a fundamental difference in the aims and incentives of the Highways Monitor and the NRAs for engaging in benchmarking activities which needs to be understood.

This suggests that alternative approaches should also be used and we have described several possible methods including top-down and bottom-up comparisons with internal regions of Highways England, local highway authorities, other regulated network industries and benchmarks derived from DBFO and PPP contracts. These methods could provide supporting complementary form of analysis and sense check on the results of top-down benchmarking with other NRAs.

Bottom-up benchmarking should be a key part of the efficiency framework and the Highways Monitor should seek to define specific activities, projects and costs for more detailed investigation. Through the stakeholder consultation we have identified numerous organisations who have expressed a willingness in principle to engage with such a process – but the specific requirements will need to be defined. This would however need to be compared with key performance data in order to draw meaningful conclusions.

A key point which has emerged from the literature is that the performance and efficiency of Highways England needs to be considered in the framework of the overall benefits and costs of its

activities, and in particular its impact on road users. Benchmarks of maintenance cost per km are of limited use without an understanding of the quality of the road network which is achieved through this input – and the secondary effects on users operating costs – which account for the vast majority of the economic costs of the road network. Developing a metric to estimate the value and benefits of the organisations activities may be beneficial to provide better context and understanding to the benchmarking.

6.2 Recommendations for the short term

In the short term (up to one year), the Highways Monitor should:

1. Review the studies highlighted in this report and develop a framework of the network characteristics and performance indicators which are important for the performance and efficiency of an NRA and road network.
2. Obtain the datasets highlighted throughout this report and use them to develop initial partial productivity metrics, rankings and performance indicators to compare Highways England with other NRAs. This will provide some overall indications of the relative performance of Highways England across a range of metrics. It will also give some indication of how the road network and organisation compares against other NRAs (and which could be considered comparable).
3. Engage with CEDR, OECD and the HMEP / CQC network to determine if further top-down benchmarking analysis is likely to be undertaken and how the Highways Monitor could interface with this work and the resources and effort likely to be required.

   We consider that CEDR is likely to be a particularly useful source of benchmarking evidence and analysis and the Highways Monitor should consider engaging with this organisation to understand its existing evidence and future research activities in more detail.

   The organisation has already undertaken top-down and bottom-up international benchmarking of NRAs and appears to have undertaken further work in this area since its original report. It may be able to provide further support, guidance and data on this subject and may also provide a forum to develop other types of analysis.
4. Consider the development of an independent benchmarking group – for example, based on the members of CEDR, but co-ordinated and led by the Highways Monitor.
5. Consider to what extent the different forms of top-down benchmarking are likely to be helpful for the efficiency and performance assessment framework and its feasibility given the potential timescales and resource requirements. As an indication, the original BEXPRAC study took around 2 years to complete with a total costs of around €500,000 (of which the UK based participants contributed around €50,000). The Highways Monitor should consider which approach is likely to be most appropriate and seek to develop a methodology for the analysis.
6. Consider the lessons from the international top-down benchmarking analysis in other sectors, including the risks and uncertainties associated with this form of analysis. There could also be some issues associated with co-opting and relying upon analysis from an organisation which is primarily a forum for constructive engagement between NRAs. The extent to which CEDR can be independent from Highways England and the potential conflicts of interest for other NRAs needs to be considered.
7. Consider how regional performance, cost and network characteristic data could be used to develop intra-regional comparisons across Highways England's maintenance areas. This data should be accessible and could provide a general indication of the internal performance 'frontier'.
8. Consider how the Local Authority benchmarking analysis undertaken by the CQC network could be applied to Highways England and whether it would be beneficial and appropriate for Highways England to join the network.
9. Engage with other UK highway authorities to understand the applicability of their approach to benchmarking construction and maintenance costs, with the approach adopted by Highways

England with a view to developing an established dataset and approach for the UK.

10. Review the analysis undertaken by the Cabinet Office to understand how ongoing construction (and back office) cost benchmarking could be developed and used by the Highways Monitor. Collect and review the data and reports produced by the Cabinet Office including reports on construction costs and back office costs and consider if this analysis could be continued.

11. Continue stakeholder engagement to exhaust the possibility of finding other benchmarking evidence and studies from organisations who have not yet responded to our consultation.

6.3 Recommendations for the medium term

In the medium term (up to two years), the Highways Monitor should:

12. Identify specific NRAs with road networks and organisational structures which could be considered comparable to Highways England (potential comparators may include Austria, Sweden and the Netherlands). Seek to identify high performing NRAs based on partial metrics to highlight the organisations which may be able to provide the most useful comparisons of Highways England's efficiency. Consider if these organisations could be engaged for bottom-up benchmarking.

13. Collect and analyse Local Authority data on highway network characteristics, performance and expenditure and use the data to develop high level comparisons with Highways England – taking account of differences in network structure. This could be achieved by updating the benchmarking toolkit developed by DfT.

14. Collect the data associated with the UK DBFO PPP contracts on road construction, maintenance and street lighting projects and consider how this information could be used to derive implicit construction and maintenance cost benchmarks. This would require a detailed understanding of the contract process and building blocks, the design and performance standards of the contact and the risk and profit margins included in the contract payments.

15. Engage with EuroRAP to understand how their cross-country safety data could be used to benchmark the safety performance of Highways England.

6.4 Recommendations for the long term

In the long term (more than two years), the Highways Monitor should:

16. Consider which activities and functions are most material to the efficiency and performance of Highways England and develop a specific bottom-up benchmarking proposition focusing on specific activities. This could be undertaken following the top-down analysis described above to estimate performance gaps and outliers. Once developed, engage with Infrastructure UK, NRAs, HMEP / CQC and other benchmarking groups to obtain information in key areas.

17. Review regulatory analysis of staff costs, frontier shift and pensions undertaken by other economic regulators and consider whether such intra-industry comparisons could be applied to Highways England.

18. Assess the long term benefits of investment in road maintenance - consider the potential application of the principles of HDM-4 or similar to derive the economic benefits associated with investment in road maintenance and consider how this analysis could be incorporated into the efficiency framework. This could enable benchmarking the economic benefits of different levels of spending to provide an alternative assessment of Highways England's investment in road maintenance.

19. Consider how the economic contribution of the Strategic Road Network could be quantified to take account of its impact on the overall transport network and economy and to provide an alternative, overall indicator of performance. This could be achieved through an economic impact

study or through the development of an economic indicator such as that developed by ANAS (Italian NRA) to monitor the benefits to users and the wider economy.

20. Investigate the potential to develop inter-network performance indicators using satnav based traffic data - building on the metrics and data already used by Highways England and DfT. These could be used to develop consistent and comparable indicators of performance across European road networks. This could also be discussed with the CEDR group.

Appendix 1 Literature Review

1.1 Overview

The amount of evidence we have found through the stakeholder consultation and desk based search has meant that we have had to take a structured and focused approach to the literature review. In order to ensure that we have reviewed the most interesting and relevant information we have recorded each of the reports and studies we have found, and made an initial assessment of the relevance of the study based on quick scan of its contents. Based on this 'sift' we have highlighted the studies which we consider to be the most useful and relevant to the Highways Monitor objectives based on the evidence they contain, the objectives of the study and the potential for the Highways Monitor to replicate the analysis. We have then focused the literature review on this subset of studies.

In this section we draw out the key points from studies in each category, based on the most important studies identified in the evidence sift. To provide some structure to the review, we have categorised the reports into five broad categories:

- **Top-down benchmarking** – studies which attempt to compare NRAs top-down performance quantitatively across different metrics based on active or passively collected data.
- **Surveys** – studies which compare NRAs performance qualitatively based on surveys or other comparative methods to provide descriptions or explanations for differences in performance, policy and practice.
- **Bottom-up/process** – studies which compare individual processes across NRAs from a bottom-up perspective to identify best practice and performance gaps.
- **Policy** – studies which provide policy analysis or recommendations across different topics such as approaches to international benchmarking, performance monitoring, maintenance or construction planning etc.
- **Other** - studies which do not fit into the previous categories, including academic research and research in other sectors that may be useful for the development of a benchmarking framework.

1.2 Top-down studies

OECD (Braconier et al, 2013)

The performance of road-transport infrastructure and its links to policies, 2013

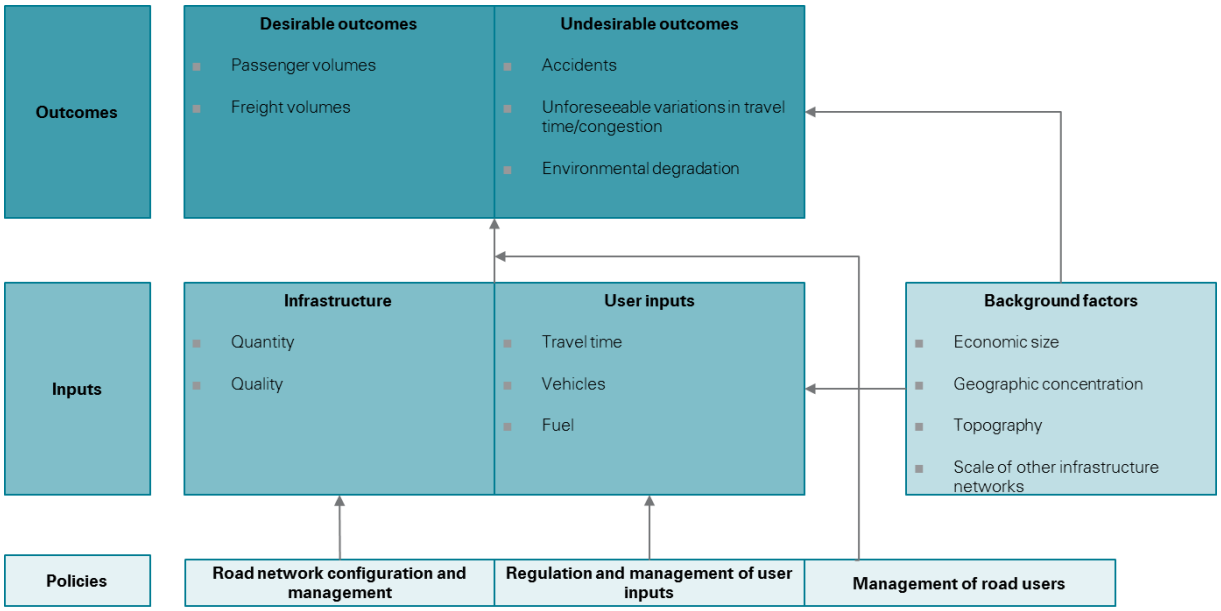
This report provides a top-down analysis of the performance of the road network of 32 different countries using Data Envelopment Analysis (DEA) to assess the 'efficiency' of each based on defined inputs and outputs. This form of analysis estimates the gap between an organisation's performance and the efficiency 'frontier' which represents the observed maximization of outputs, given a particular set of inputs (or vice versa). The report describes the development of this model based on a theoretical framework for assessing the efficiency of NRAs based on key inputs and outputs, but is constrained by the data available to the authors.

The report states that this framework must consider the economic costs and benefits of the road network – highlighting that (from an economic perspective) road costs can be divided into three categories – user, infrastructure and maintenance and negative externalities. User input costs - in the form of time, vehicle capital and operating costs - are estimated to form around 91% of total marginal transport costs and because of this - when considering overall efficiency, the NRA's operating costs need to be balanced against the benefits to users. This requires an understanding of the relative benefits and costs associated with different outcomes and levels of performance.

The report presents an outline framework for considering the performance of NRAs through the monitoring of desirable outcomes (passenger volumes and freight volumes) and undesirable

outcomes (accidents, emissions, and congestion and travel time variability) relative to inputs of infrastructure spending, vehicle fleet, fuel consumption, travel time, and other background factors. The theoretical framework is illustrated in Figure 2, showing the outline relationship between inputs, outputs, background factors and policy variables which can affect performance in a variety of ways.

Figure 2: Performance and policy framework



Source: Braconier et al, 2013

The report also draws connections between countries efficiency performance and wider policy measures that may explain differences highlighting that there are important qualitative issues which are difficult to capture in analytical models. For example in some areas such as energy consumption there are clear links between national policies and the fleet composition and the level of performance in accidents and pollution which are not directly controlled by the inputs of the NRA.

Road infrastructure also has qualitative aspects – including surface roughness, safety characteristics and resistance to wear and tear which should be captured in modelling – but can be difficult to measure. The design of the network and its ability to deal with changes in demand and supply is important for the economic benefits of the network and the consideration of costs and efficiency.

The key point is that in order to assess the efficiency of an NRA relative to its peers, there needs to be an assessment of the benefits as well as the costs of its activities. This requires the definition of input and output measures which represent such costs and benefits effectively. Whilst the Highways Monitor may be able to define theoretical measures for Highways England based on the performance plan – it may be very difficult to populate such a framework with actual data.

The study reviews the availability of data across a variety of indicators and sources and highlights that cross-country analysis of road transport is hampered by a complete lack of national data in some dimensions and partial coverage or limited comparability in others. This means that performance indicators have to be treated with some caution. The study uses a mixture of data from; International Transport Forum, World Bank, International Energy Agency, United Nations Economic Commission for Europe, International Traffic Safety Data and Analysis Group, International Road Federation and OECD, to develop a set of input, output and background factors across different countries.

The report highlights that even where data is available there is often a lack of harmonisation in collection methods and definitions which creates uncertainty in some variables. The report also shows

that different sources of data have different numbers for the same variable for some indicators. One of the challenges with investment and maintenance data is that in some countries data covers only expenditure on motorways or main roads, and may refer to specific territories, whilst in others the data may exclude urban roads. Some of these issues are summarised in Table 11.

Table 11: Examples of data issues limiting the evaluation of road sector performance

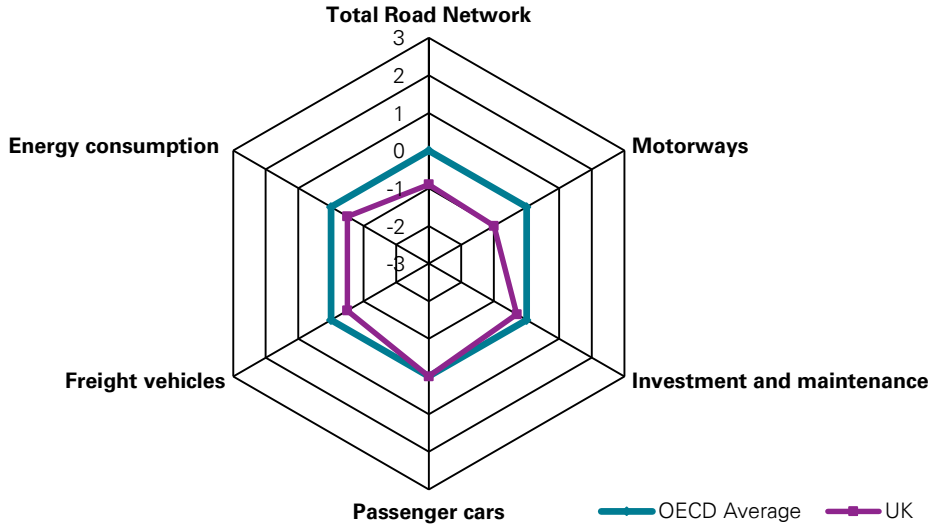
Variable	Availability of data	Comparability issues	Potential source or compilation method
Trips	Available in some national transport surveys	Survey based information - definitions and estimation methods need to be harmonised	National transport authorities
Connectivity	None	Definitions and estimation methods need to be agreed	A connectivity indicator for OECD countries could be developed
Unpredictability/congestion	Available for a subset of countries and for cities/regions	Regional and city studies often based on different measurement methods	Commercial services or own calculation based on web based map services
Travel time	Available for 12 EU countries	Survey based information definitions and estimation methods need to be harmonised	National time use or household surveys
Lane-km	None	Road definitions	Commercial or public mapping entities
Road quality	None	Regional data based on different measurement tools	Regional transportation authorities

Source: Braconier et al, 2013

The report uses input and output 'diamonds' to represent the performance of different NRAs in terms of inputs and outputs relative to the OECD average and highlights some high performing NRAs across these. Input and Output diamond charts for UK are shown in Figures 3 and 4, indicate that in outcomes - the UK is close to the OECD average in terms of freight traffic, passenger traffic, injuries and emissions. Inputs – such as the length of the network, and number of freight vehicles are generally below the OECD average, which might suggest the UK NRA is performing above the OECD average.

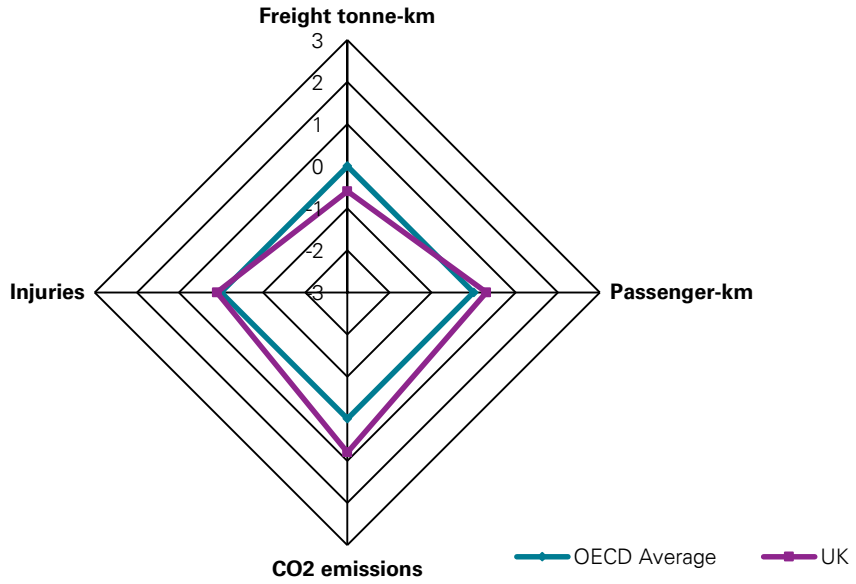
We consider that this is a potentially useful way of comparing the performance of different NRAs as it enables direct comparisons of performance without placing any ordinal weighting on the variables considered. The Highways Monitor could replicate this analysis and build upon it to incorporate additional data where available.

Figure 3: Road input indicators for UK compared to OECD average



Source: Braconier et al 2013, using data from OECD International Transport Forum, World Bank Development Indications, IRTAD and IRF World Road Statistics 2011

Figure 4: Road output indicators for UK compared to OECD average



Source: Braconier et al 2013, using data from OECD International Transport Forum, World Bank Development Indications, IRTAD and IRF World Road Statistics 2011

The report provides a number of one dimensional performance indicators such as passenger km per km of road network, investment and maintenance spending per km and accidents per km. Based on these indicators the UK has one of the most densely used networks both for passengers and freight traffic. People within the UK appear to travel similar distances to the OECD average, and spending on investment and maintenance per km is also around the average.

While useful these indicators cannot capture the complexity of the production function of the road transport sector as outputs are jointly determined. Multiple outputs could be combined into a single aggregate, however this would require shadow prices for each of the outputs – which are not

currently available. Similar issues arise on the input side due to complementarities and substitutability. This means that any comprehensive technical efficiency indicator needs to be based on a production function approach which captures all inputs and outputs in a single formulae.

In order to address this issue the study develops a DEA model to assess the overall efficiency of the various countries road networks. The study develops several models based on the following variables:

- Number of motor vehicles.
- The length of the road network.
- Energy consumption.
- Passenger km.
- Freight tonne km.
- Number of injuries.

The models are based on data averaged for the 2000s and adjusted for small sample bias. The length of the road network and the number of vehicles are treated as fixed factors. The efficiency scores therefore reflect the proportional improvement in freight and passenger traffic, energy consumption and the number of injuries that could be achieved for a given size of network and fleet.

The efficiency scores indicate the proportional improvement in output variables which could be achieved given the organisations inputs. For example a score of 0.7 means that a country could reduce energy consumption and accidents and increase passenger and freight traffic by 30%. Efficiency scores for three different specifications of the model are shown in Table 12 and indicate that the UK has an efficiency gap of between 5% and 11%.

The basic interpretation of this is that the UK could improve its outcome measures by between 5% and 11% - however there are numerous factors which are not included in the models which need to be taken into account when considering this as a potential target, including the policy issues and other factors not included in the analysis which are likely to have an impact on outcomes. The inputs and output variables used in the analysis are also largely focussed on the overall size and performance of the road network as a whole – rather than the activities of Highways England. This means that the efficiency score – in its current form - is not directly relevant for Highways England target setting.

Table 12: OECD DEA efficiency scores of alternative models

Country	mkpf (1)		mkepf (2)		mkeipf (3)	
AUS	0.93		0.98		0.96	
	(0.47	1.00)	(0.87	1.00)	(0.78	1.00)
AUT	0.92		0.96		0.97	
	(0.44	1.00)	(0.80	1.00)	(0.80	1.00)
BEL	0.8		0.88		0.89	
	(0.41	0.87)	(0.72	0.91)	(0.73	0.91)
CAN	0.92		0.96		0.97	
	(0.45	1.00)	(0.79	1.00)	(0.80	1.00)
CHE	0.73		0.89		0.92	
	(0.39	0.79)	(0.75	0.91)	(0.77	0.93)
CZE	0.85		0.88		0.88	
	(0.44	0.91)	(0.77	0.90)	(0.77	0.90)
DEU	0.92		0.96		0.97	
	(0.44	1.00)	(0.82	1.00)	(0.83	1.00)
DNK	0.89		0.95		0.95	
	(0.42	1.00)	(0.73	1.00)	(0.71	1.00)
ESP	0.76		0.75		0.8	
	(0.42	0.80)	(0.66	0.77)	(0.71	0.81)
EST	0.90		0.95		0.95	
	(0.50	1.00)	(0.67	1.00)	(0.67	1.00)
FIN	0.91		0.96		0.96	
	(0.44	1.00)	(0.78	1.00)	(0.76	1.00)
FRA	0.83		0.95		0.98	
	(0.42	0.89)	(0.84	0.97)	(0.88	1.00)
GBR	0.89		0.95		0.95	
	(0.42	1.00)	(0.84	1.00)	(0.88	1.00)
GRC	0.38		0.64		0.65	
	(0.27	0.39)	(0.56	0.67)	(0.56	0.67)
HUN	0.84		0.92		0.92	
	(0.44	0.90)	(0.80	0.94)	(0.80	0.94)
IRL	0.9		0.96		0.95	
	(0.42	1.00)	(0.78	1.00)	(0.72	1.00)
ISL	0.92		0.96		0.97	
	(0.47	1.00)	(0.83	1.00)	(0.83	1.00)
ITA	0.91		0.96		0.96	
	(0.46	1.00)	(0.76	1.00)	(0.76	1.00)
JPN	0.6		0.91		0.91	
	(0.35	0.63)	(0.85	0.93)	(0.85	0.93)
KOR	0.89		0.95		0.96	
	(0.39	1.00)	(0.67	1.00)	(0.68	1.00)
LUX	0.89		0.95		0.95	
	(0.39	1.00)	(0.67	1.00)	(0.67	1.00)
MEX	0.9		0.96		0.95	
	(0.42	1.00)	(0.75	1.00)	(0.67	1.00)
NLD	0.89		0.95		0.95	
	(0.41	1.00)	(0.68	1.00)	(0.67	1.00)
NOR	0.79		0.96		0.95	
	(0.39	0.87)	(0.74	1.00)	(0.68	1.00)
NZL	0.92		0.96		0.96	
	(0.49	1.00)	(0.83	1.00)	(0.83	1.00)

Country	mkpf (1)		mkepf (2)		mkeipf (3)	
POL	0.92		0.97		0.97	
	(0.49	1.00)	(0.88	1.00)	(0.88	1.00)
PRT	0.76		0.8		0.8	
	(0.41	0.81)	(0.69	0.83)	(0.69	0.83)
SVK	0.9		0.95		0.96	
	(0.45	1.00)	(0.77	1.00)	(0.77	1.00)
SVN	0.91		0.96		0.96	
	(0.47	1.00)	(0.79	1.00)	(0.80	1.00)
SWE	0.78		0.84		0.86	
	(0.41	0.84)	(0.70	0.87)	(0.72	0.88)
TUR	0.89		0.95		0.95	
	(0.39	1.00)	(0.67	1.00)	(0.68	1.00)
USA	0.77		0.76		0.77	
	(0.41	0.83)	(0.61	0.79)	(0.61	0.79)

Source: Braconier et al 2013

The analysis indicated that France, Poland and Canada have the most efficient road networks, whilst Greece, the USA and Spain have the least efficient. The UK is ranked 16th of the 32 countries, however the confidence intervals are wide for many of middle ranked countries meaning that this ranking is highly uncertain.

The report notes that changes in assumptions and time periods do result in some change in the rankings but the results appear robust to changes in input and vectors. Specifically the report considers the same type of analysis applied to different input and output measures such as the motorway network and levels of investment and maintenance spending. Further modifications such as adding travel times, and background factors (roughness of topography and internal distance) are also tested, and frontier comparisons of specific output measures. The key point is that different models and data can be used but the analysis appears to be generally stable regardless of the model used.

Based on this analysis, the report provides an assessment of the potential savings that could be achieved by each network through moving to the frontier (changing only one input variable). The analysis suggests that the UK is relatively efficient with a potential saving in investment and maintenance spending and energy consumption equivalent to around 0.1% of GDP.

Overall the study provides a highly useful framework for considering the performance of an NRA, emphasising the importance of taking account of inputs, outputs, policy and structural factors which influence performance. The study provides a range of data for 32 NRAs and uses this to develop several forms of analysis which seek to capture the performance of NRAs in both a partial and comprehensive manner.

The study is based on publicly available data and therefore could be replicated and developed at a relatively low cost. As with many top-down studies this means that the output measures are slightly limited and may not fully reflect the Highways Monitor's objectives for Highways England, nonetheless this analysis is likely to be useful for understanding the relative performance of Highways England and best in class NRAs in both a partial and comprehensive manner.

It may also be possible to develop the analysis for example by incorporating additional data from other sources and adding additional data over time to capture a wider range of outputs such as asset condition or average delay and to expand the number of observations. The study also highlights a range of policy issues which are useful for comparing different NRAs and provides a useful set of references and data which could be used to compare the performance of Highways England. However the comparability of the data means that the

analysis would need to be treated with care. Further work may be required to ensure that cost data is comparable for example.

Directors of Roads in Europe (CEDR)

Benchmarking of Expenditures PRACtices of maintenance and operations (BEXPRAC), 2010

The NRAs of 13 European countries[4] undertook a survey based project to understand and compare differences in performance and efficiency and obtain references to define performance targets. This study was undertaken collaboratively by the NRAs based on the sharing of data and information with a set of commonly agreed variables and definitions. The study undertook two forms of analysis; top-down comparisons of the overall costs of maintenance and operations of NRAs accounting for differences in network characteristics, and bottom-up comparisons of performance based on a limited number of road projects which sought to provide a more detailed examination and explanation of the differences between NRA costs.

The survey was based on information for 2007 (in some cases information was collected over multiple years, using an average to represent 2007 values). The top-down study included several variables described below:

- The length of the road network and the proportion of single, duel, dual+ and ramp length in each network.
- The proportion of the length of the network with bridges and tunnels and the proportion of pavements, bridges and tunnels in need of maintenance.
- The AADT and the share of HGV traffic.
- The number of days per year when the temperature falls below 0.
- The user satisfaction index.
- The actual Individual Consumption Index (Eurostat).
- The proportion of head office expenses.
- The breakdown of M&O expenses by task blocks and by purpose (road without structures, bridges, tunnels, environment and 'others').

The data collected is shown in Table 13, 14 and 15 for each NRA considered as part of the study. This data is used to analyse general patterns and links between maintenance spending and various network characteristics. More detailed information is contained within the appendices of the report.

This data indicates that relative to European comparators the UK has a mid-sized network with a high proportion of dual+ road length and with a high amount of traffic. The total length of tunnels and bridges is relatively low, but total ramp length is high. User satisfaction and asset condition are both relatively high/good.

[4] Countries included in the survey are: Austria, Belgium-Flanders, Denmark, England, France, Hungary, Ireland, Italy, the Netherlands, Portugal, Spain Sweden and Switzerland.

Table 13: Network size, structure and characteristics

Characteristic	AT	CH	DK	ES	FL	FR	HU	IE	IT	NL	PT	SE	UK
Network Length km	2,062	1,764	3,790	24,185	824	11,734	7,528	5,335	21,040	3,198	654	8,046	7,235
Single carriageway 1 to 3 lanes	*5.2%*	*19.8%*	*67.5%*	*65.6%*	*0.0%*	*44.6%*	*89.2%*	*88.5%*	*81.8%*	*15.6%*	*1.3%*	*59.2%*	*12.1%*
Dual carriageway - 4 lanes	*76.3%*	*74.6%*	*29.4%*	*30.6%*	*56.0%*	*51.9%*	*10.1%*	*10.5%*	*18.2%*	*72.4%*	*95.4%*	*39.6%*	*49.0%*
Dual + 5 or more lanes	*18.5%*	*5.6%*	*3.1%*	*3.9%*	*44.0%*	*3.6%*	*0.8%*	*0.9%*	*0.0%*	*12.0%*	*3.3%*	*1.2%*	*38.9%*
Dual equivalent ratio	1.08	0.93	0.68	1.23	0.81	0.57	0.56	0.59	0.59	0.97	1.01	0.67	1.11
% length (bridge)	*7%*	*13%*	*2%*	*3%*	*4%*	*2%*	*1%*	*0%*	*6%*	*3%*	*6%*	*2%*	*2%*
% length (tunnels)	*9%*	*11%*	*1%*	*1%*	*1%*	*1%*	*0%*	*0%*	*2%*	*1%*	*0%*	*0%*	*0%*
% length (ramps)	*18%*	*10%*	*7%*	*7%*	*8%*	*8%*	*8%*	*2%*	*6%*	*8%*	*5%*	*5%*	*16%*
Pavement in need of maintenance	*4%*	*2%*	*60%*	*5%*	*10%*	*15%*	*10%*	*23%*	*33%*	*11%*	*na*	*8%*	*1%*
Bridges in need of maintenance	*6%*	*5%*	*2%*	*4%*	*2%*	*8%*	*40%*	*11%*	*9%*	*2%*	*na*	*0%*	*3%*
Tunnels in need of maintenance	*9%*	*3%*	*0%*	*0%*	*0%*	*1%*	*0%*	*0%*	*30%*	*0%*	*na*	*15%*	*0%*
User satisfaction index	*63%*	*79%*	*67%*	*na*	*61%*	*73%*	*na*	*46%*	*53%*	*70%*	*na*	*66%*	*68%*
Number of days below 0c	92	98	79	75	54	32	100	23	4	51	1	151	37
Weighted AADT	41,000	41,000	19,000	18,000	86,000	29,000	13,000	18,000	10,000	66,000	21,000	10,000	56,000
% HGV	*13%*	*8%*	*13%*	*18%*	*22%*	*18%*	*17%*	*8%*	*12%*	*18%*	*10%*	*14%*	*13%*

Source: CEDR, 2010

Table 14: Expenses by task bloc per 4 lane km, in €1,000

Task block	AT	CH	DK	ES	FL	FR	HU	IE	IT	NL	PT	SE	UK
Traffic management	4	12	3	-	6	4	5	-	1	36	4	3	1
Routine operation	36	46	5	7	7	*	18	2	21	34	14	3	16
Winter service	17	10	12	3	4	3	11	3	3	7	-	12	3
Routine maintenance of roadways, structures and roadside fittings	21	30	27	6	35	36	18	8	9	40	11	5	38
Maintenance of road signs and markings	9	3	3	3	19	*	2	5	3	9	3	1	1
Maintenance of restraints and safety equipment	2	11	1	1	3	*	2	1	2	5	1	1	1
Preventative maintenance and rehabilitation	151	207	17	24	38	18	21	6	27	120	7	22	33
Grand Total	239	319	67	43	112	61	77	25	67	251	39	48	94

Source: CEDR, 2010

* included in routine maintenance

Table 15: Data for the comparison of 4Leq ratios and DeqAV ratios

€ million per network km	AT	CH	DK	ES	FL	FR	HU	IE	IT	NL	PT	SE	UK
Road & equipment	13.6	8.6	4.9	5.3	22.1	6.5	2.9	3.0	3.1	10.9	9.0	4.8	19.7
Interchanges and ramps	2.5	0.9	0.3	0.4	1.8	0.5	0.2	0.1	0.2	0.9	0.4	0.2	3.2
Bridges	3.7	7.6	0.9	1.3	1.8	0.7	0.6	0.2	3.0	1.5	3.1	0.8	1.4
Tunnels	13.9	17.1	0.6	1.1	1.0	0.7	-	0.2	3.6	0.9	0.3	0.1	0.1
Total	33.7	34.2	6.8	8.1	26.7	8.3	3.8	3.4	8.8	14.2	12.8	5.9	24.3
Dual equivalent asset value (€M)	4.2	4.3	0.9	1.0	3.3	1.0	0.5	0.4	1.2	1.8	1.6	0.7	3.0

Source: CEDR, 2010

The analysis conducted in this study contains a breakdown of expenses across different categories of activity, but notes that the allocation of expenses between rehabilitation and improvements may differ significantly from one country to the other and that this is likely to be one of the main causes of cost variation. Ultimately there are differences in the way that expenses are calculated which makes cost comparisons difficult – e.g. the inclusion of depreciation, financing charges, building charges, environment charges and organisational overheads. In some cases this may also be complicated by the allocation of joint costs for organisations with different functions for example Rjikswaterstaat which has responsibility for maintaining roads and waterways.

The study provides some high-level benchmark data and a useful illustration of the challenges associated with making international comparisons of performance between NRAs. Despite the active engagement of the NRAs there were difficulties associated with missing or incomplete data in some countries, differences in the expense allocation rules and the allocation of expenses to parts of the road network.

The study develops the concept of Duel equivalent Asset Value lengths (DeqAV) to provide a notional asset value for each of the NRA networks in order to benchmark expenditures relative to the level of assets on each network. This metric is calculated based on the following notional values[5]:

- 2 M€/km single carriageway.
- 8 M€/km dual carriageway.
- 40 M€/km dual + (mainly urban) + additional length for ramps.
- +50 M€/km bridge.
- 150 M€/km tunnel.

On this basis the UK has the 4th most asset intensive road network with an average DeqAV of 24 €m per km. Switzerland and Austria are found to have the most asset intensive roads – reflecting the high number of tunnels and bridges, Ireland and Hungary are found to be the least asset intensive.

The study notes that in most countries, NRAs are responsible for the maintenance and operation of the trunk road network, but in some public or private concessionaires are also involved. The treatment and allocation of these costs is therefore important for understanding relative NRA performance. No data was available from private concessionaires for the networks of France, Italy and Spain. This means that the analysis excludes the costs of the most expensive part of the network.

Overall the (macro) study concludes that expenses for road maintenance differ across countries and appear linked with several factors including; the size and complexity of the network, the level of traffic, rates of preventative maintenance and other factors such as service quality – but no quantification of these effects is provided.

The study states that it is difficult to collect information on road maintenance and operation expenses in a way that allows for easy comparisons between countries – and despite the application of strict definitions of expenses and road maintenance and operation tasks, the differences in the data collected prohibit clear conclusions on efficiency levels, although the survey does help to explain some of the reasons for differences between countries.

[5] The basis of these values is not explained in detail and this estimation is noted to not reflect true asset values – "these values are theoretical and average values. They in no way represent the real value of a single stretch of a specific motorway; they do not include a cost of living index, the cost of very expensive land acquisitions, or the complexity of building roads in heavily populated areas.

The study develops a model to explain the costs of M&O expenses based on the collected data. This model is able to explain costs per km by between -27% and +37%. The model estimates and actual data for each country are shown in Table 16.

Table 16: CEDR model results

Country	User satis-faction index	M&O Expenses €1,000 without VAT/year/network km									
		Traffic management, operation, routine maintenance, preventative maintenance & rehabilitation		Winter service		**Sub-Total**			Over-heads, environ-nment and others	**Total O&M**	Improve-ments
		Data	Model	Data	Model	Data	Model	Model/ Data	Data	Data	Data
AT	63	184.3	182.2	15.8	11.5	200.1	193.7	0.67	21.7	221.8	202.2
CH	79	211.7	224.0	9.0	10.3	220.7	234.3	1.06	53.2	273.9	123.2
DK	67	28.7	35.9	5.9	4.4	34.6	40.3	1.16	2.1	36.7	1.3
ES	64	23.9	28.1	1.7	4.4	25.6	32.5	1.27	0.0	25.6	9.4
FL	61	102.1	111.6	3.7	6.4	105.8	118.0	1.12	10.3	116.1	0.0
FR	64	43.3	43.9	2.5	2.5	45.8	46.4	1.01	0.0	45.8	3.5
HU	64	14.5	19.5	2.4	3.7	13.7	23.2	1.37	0.0	16.9	0.0
IE	46	12.1	16.6	1.6	0.8	29.8	17.4	1.27	0.2	13.9	0.0
IT	53	28.5	38.9	1.3	0.2	182.1	39.0	1.31	5.0	34.8	6.8
NL	70	176.4	128.2	5.7	5.3	32.9	133.5	0.73	33.7	215.8	9.3
PT	64	32.4	38.5	0.5	0.1	24.0	21.9	1.17	0.0	32.9	0.9
SE	66	17.9	15.7	6.1	6.3	24.0	21.9	0.91	2.3	26.3	0.0
UK	68	83.8	75.3	2.5	4.3	86.3	79.5	0.92	2.3	88.6	69.9
AVRG	64	73.8	72.7	4.5	4.6	78.3	78.3	1.00	10.1	88.4	32.8

Source: CEDR, 2010

Table 16 shows that traffic management, operations and maintenance spending in the UK is €83,000 per km per year relative to an average of €73,800. The highest levels of spending are in Switzerland at €211,700 and the lowest are in Ireland at €12,100.

The model underestimates UK expenses by 8% and notes that high expenses for improvements and difference in cost allocations and currency exchange may influence the results.

The study states that with updated and complete data, it would probably be possible to explain expenses within a range of ±20% but adds that in order to improve the model, a more in depth analysis is needed on the countries specific environmental issues, expenses on structure and the depreciation of assets with short lifetimes.

In addition to the macro-based analysis, the study also undertook 'micro' analysis of the costs of individual road projects based on analysis of 36 road sections, representing different types of roads across seven different countries. Based on these samples the study estimates average expenditure which range from €50,000 to over €200,000 per 4 lane equivalent km across several categories of spending.

The study draws several conclusions from the analysis which are highly relevant to the objectives of our own study:

- Expenses for busy urban roads with six lanes or more are substantially higher per km than those for narrow roads, even if the number of lanes is taken into account suggesting that expense increase more than proportionally as the width of a road increase.
- The survey shows that when expressed per network km, annual M&O expenses for a six lane or more roads are 2 to 4 times the level of expenses for a 4 lane road. Expenses for 2 lane roads with high traffic are half the expenses of a 4-lane road, whereas expenses for a 2-lane road with low traffic are a quarter of the expenses of a 4-lane road.
- Expense levels for a 4-lane road do not appear to be affected by the level of traffic. For some countries, a comparison of the cases shows that the roads with night-time maintenance have higher maintenance level than those with day-time maintenance.
- Despite higher expense levels per network kilometre, complex and busy roads are clearly more efficient in terms of costs per driven vehicle km.
- It is difficult to relate differences in expense level between countries to differences in the levels of service provided. While such differences appeared relevant to expense levels for traffic management and operation, for other task blocs such relations between level of service and expenses appear less pronounced.
- It is difficult to assess the impact of differences in the organisation of maintenance and operation tasks on expense levels. As most countries have outsourced most of the work, differences in such practises may influence cost levels less than anticipated when setting up the benchmark.
- The differences in definitions and accounting systems maintained by NRAs appear difficult to overcome. This affects the comparisons made between countries. A more uniform way of recoding data across countries would increase the insight provided by future benchmark studies.
- The comparison of micro and macro analysis did not provide significant conclusions – possibly because the individual road sections compared are not representative of the wider network. In the future the micro analysis must ensure that the selected road sections are representative of its category and should be selected according to defined criteria to ensure this.

The report also seeks to examine best practice across the NRAs relating to outsourcing, procurement practice, and the improvement of in house activities. The study survey includes an analysis of NRA expenditures by category. This shows that the UK has the highest level of outsourced procurement related expenditure of all the NRAs in the sample – accounting for around 99% of all spending. Spain (97%), Sweden (91%) and Switzerland (84%) also have high levels of outsourcing costs Ireland has the lowest levels at 29%.

The study considers the options for developing the findings into a next stage, and concludes that the results and lessons of the analysis should be integrated into the more general framework for CEDRs Strategic Plan activities, a second benchmarking study was discussed as an option but not taken forward because of the challenges associated with data collection and comparison which need to be resolved for results to be reliable. An appendix to the study provides recommendations for how a future survey could be developed and makes several recommendations including:

- Make sure that all participants have the same definitions of road maintenance and operation activities.
- Make sure all participants have the same understanding of the way in which the level of service is described.
- Make sure all participants collect information to calculate expenses according to a uniform definition, even if such expenses are made by others and/or are not charged to the NRA.
- Make sure that there is a common understanding of the condition of roadways and structures and that intervention levels can be translated into a common definition.

The BEXPRAC report is highly relevant to our own study and provides an example methodology for how top-down comparisons of maintenance spending could be made across NRAs, and providing a general framework for understanding key maintenance cost drivers and qualitative differences in NRAs functions and organisation. The report introduces a useful concept of maintenance costs per asset lengths and develops a theoretical calculation of road asset values to compare the complexity of the road network in different countries.

The study has collected and developed a range of useful indicators which help to understand and explain maintenance costs throughout the countries, supported by bottom-up analysis. It also provides a range of benchmarks which could be used to roughly compare the performance of Highways England relative to other countries.

However – whilst the study has gone to great lengths to ensure data coverage and comparability the study has encountered several challenges including – missing or incomplete data in some countries, major differences in the expense allocation rules among the task blocks and the allocation of expenses to a stretch of the road network. These are highlighted as significant problems which hamper the comparison of costs between NRAs and which requires further work and harmonisation to be resolved. The study suggests that this is a research priority for CEDR and therefore it may be useful to engage with the organisation to understand if progress has been made on this issue since this study was published.

The micro analysis of road costs provides some particularly interesting findings – highlighting that maintenance costs appear to increase disproportionately with road width and showing that maintenance costs do not appear to be strong affected by traffic levels.

Road user survey, 2006

One of the inputs into the BEXPRAC study was a user satisfaction indicator, based on a survey developed by CEDR. This is a relatively rare indicator because the survey was undertaken across European countries and therefore provides a consistent and comparable indicator of road user satisfaction across European countries.

Table 17 is reproduced from the report, and shows user satisfaction across a variety of indicators for England and its neighbouring countries. This shows that overall user satisfaction in England is higher than Ireland, but lower than the Netherlands and France. The worst performing metric was the cleanliness of service or rest areas, the best the understandable and clear direction signs and traffic signs. The report conducts analysis of other issues such as user perceptions and satisfaction with traffic information, delays and safety.

Table 17: Satisfaction with aspects of the English and surrounding networks and their importance

	England		Ireland		Neth.		France	
(satisfaction and importance)	**s**	**i**	**s**	**i**	**s**	**i**	**s**	**i**
Quality of the road surface	59	89	42	90	71	83	77	90
Cleanliness of the road	60	80	51	76	70	75	73	84
Provision of lighting on major roads	66	81	56	84	66	70	64	82
Visibility of markings on the road surface	75	89	49	89	73	84	75	90
Understandable and clear direction signs	77	92	46	93	74	86	76	92
Understandable and clear traffic signs	77	92	51	92	75	86	77	91
Clear and understandable signing at road works	73	88	54	86	71	92	74	91
Availability of var. message signs along major motorways	68	80	27	81	67	70	70	80
Availability of places to stop, such as service or rest areas	54	85	19	84	64	76	74	84
Cleanliness of service or rest areas	47	85	27	85	59	75	67	85
Safety of places to stop	49	89	26	88	56	82	66	90
Total average	64	86	41	86	68	80	72	87

Source: CEDR, 2006

This report provides evidence on the relative performance of the European road network in terms of user satisfaction and has been used as an input into the BEXPRAC benchmarking study. The analysis provides interesting comparisons of user satisfactions and perception of the road network across countries. However the results are now quite dated and so the relevance of the findings may now be limited. It is not clear whether CEDR intends to update this analysis – but it does provide a template for future cross-border studies of passenger satisfaction.

Trans-European road network TEN-T 2013 performance report, 2013

This is the third biennial report produced by CEDR and provides a summary of the performance of the trans-European road network (TEN-T). It seeks to show that it is possible to produce comparable information on the performance of the European road network. The report contains information on 24 of the 27 CEDR members and is based on monitoring the variables shown in Table 18.

Table 18: Variables in CEDR performance report

Structure of the network	Performance of the network
Road type	Average traffic flow
Number of lanes	Traffic density
Length of bridges	Proportion of heavy goods vehicles
Length of tunnels	Heavy goods vehicles traffic flow
Road environment	Fatal accident rates
ITS and PPP schemes	Performance of ITS sections

Source: CEDR, 2013

CEDR's intention in producing these reports is to establish a stable set of data with which to monitor trends and identify changes in the performance of the TEN-T network. The report notes that the effort involved in extracting and providing data from individual NRAs can be considerable and the lack of common location referencing models and data definitions make meaningful comparisons difficult. As a result CEDR has undertaken work to develop a common performance reporting framework to be used by all members to provide such data. A summary of the data is shown in Table 19.

Table 19: Summary data for European TEN-T networks

Country	Pop. (1000's)	Total Area (km)	All Road (km)	Motorway (km)	Express-way (km)	Ordinary (km)	Traffic Flow (AADT)	Traffic Density (AADT/Lane)	Prop. HGV (%)
Austria	8,404	83,872	1,782	1,667	115	-	46,909	10,388	11
Belgium (Flanders)	7,497	13,683	946	802	67	79	-	-	-
Belgium (Wallonia)	3,524	16,844	882	791	91	-	51,100	10,513	14
Denmark	5,561	43,098	916	863	-	53	35,321	8,087	16
Estonia	1,340	45,228	1,017	113	44	860	10,717	3,697	13
Finland	5,375	338,424	4,058	713	137	3,208	15,010	4,669	10
Germany	81,752	357,021	10,150	9,874	132	144	56,860	11,472	15
Greece	11,310	131,990	3,943	1,580	1,486	871	6,805	4,920	11
Iceland	318	103,001	1,803	3	59	1,741	11,396	3,169	7
Ireland	4,481	70,280	2,051	768	117	1,166	23,679	6,784	-
Italy	60,626	301,338	8,029	6,211	1,093	725	44,708	9,419	21
Lithuania	3,245	65,200	1,652	320	198	1,059	8,109	2,994	21
Luxembourg	512	2,586	90	90	-	-	43,097	10,703	16
Malta	418	364	51	-	26	25	13,045	8,523	-
Netherlands	16,656	41,543	1,841	1,831	10		78,567	16,915	14
Norway	4,920	385,252	4,900	487	479	3,934	14,625	4,905	14
Slovenia	2,050	20,273	609	538	-	71	28,564	7,187	14
Spain	46,153	504,030	12,114	10,350	-	1,764	27,979	6,266	15
Sweden	9,416	449,964	5,617	1,737	237	3,643	17,408	4,508	14
Switzerland	7,870	41,290	1,325	678	-	647	25,060	7,435	9
UK	60,631	223,010	6,547	3,079	1,692	1,776	58,556	11,633	14
Total/Average	342,058	3,238,291	70,325	42,495	5,983	21,766	30,876	7,710	14

Source: CEDR, 2013

This report provides a useful source of data and monitoring information for comparing the performance of Highways England against other NRAs based on a commonly developed data collection process (although this data is based on the TEN-T network which may differ slightly). CEDR have attempted to develop consistent definitions and methods of data collection which means that this data is likely to be more appropriate for making comparisons than publicly available data. It also provides additional information on assets including lanes, bridges and tunnels which are not publicly available and which are likely to be particularly important for explaining variance in maintenance expenditure. It may be possible to incorporate this data into other forms of analysis such as the top-down benchmarking described above to strengthen the explanatory power of the models.

University of Leeds and Measure to Improve – CQC/HMEP

Cost Quality Customer: Statistical Benchmarking, Report to stakeholders, 2015, and The efficiency of highways authorities in England; An investigation into the practices that lead to superior performance, 2014

The Cost Quality Customer Statistical Benchmarking study carried out by the Institute for Transport Studies at the University of Leeds with Measure to Improve (m2i) under the Highways Efficiency Maintenance Programme (HEMP) have produced a range of analysis focusing on the efficiency of local highway authorities. The studies examine overall maintenance costs and lower level activities including roads, street lighting, winter service and drainage.

To produce the report, data from 65 highways authorities was analysed and a method of measuring highways maintenance efficiency was developed. The efficiency performance of each authority was calculated based on data collected over a five year period from 2008/09 to 2012/13. This analysis showed that UK highways authorities varied in efficiency by up to 40%.

The analysis considered the following questions:

- Are smaller authorities less efficient?
- Do the most efficient authorities pursue strategies that differ from those of the least efficient authorities?
- Does the delivery model adopted by an authority determine its efficiency?
- Do authorities achieve better efficiencies by cutting back on maintenance?
- Is there an optimum investment that produces the most efficient outcome?
- Does innovation drive up efficiency?
- Do IT systems make the difference?
- Does the position in the investment cycle determine efficiency?

The study provides a range of findings about the factors associated with greater or lesser efficiency amongst LTAs. Some of these findings may be useful for the Highways Monitor when considering the Highways England. It also provides an analytical template that could be replicated across NRAs. The study identifies a total efficiency gap of up to £225m for example. Some of the key findings are highlighted below.

Road Maintenance:

- On average, authorities have an Efficiency Opportunity of 21% and could reduce road maintenance expenditure by this amount and continue to maintain the same network, quality and traffic usage.
- For the 'average' authority increasing traffic on the network by 1% increases maintenance costs by 0.11%.
- Increasing the size of an authority's road network by 1% increases costs by 0.67%, but economies of scale start to reverse between 6,000 km and 10,000 km (depending on mix of roads).
- Increasing the average number of road defects increases cost, probably reflecting the need to do more maintenance to bring the network back up to a desired quality.
- At average levels of public satisfaction the cost of improving satisfaction is small. For low and high levels of public satisfaction, improving customer satisfaction is associated with a large increase in expenditure (this could reflect the 'law of diminishing marginal returns').

Winter Service:

- On average, authorities have an efficiency opportunity of 8% and can reduce winter service expenditure by this amount and continue to maintain the same service.
- All other things being equal, the model predicts that if the scale of an authority is increased by 1% then costs increase 1.20%, that is, there are dis-economies of scale.

- Increasing provision of winter service by increasing the precautionary network by 1% and the total salt used by 1%, increases cost by only 0.70%.
- Authorities with a higher proportion of rural roads have lower winter service costs for a given size precautionary network and a given length of A, B and C roads.
- More non-precautionary days increase costs, for the average authority, one extra precautionary day increases annual costs by 1.6%.
- The findings on public satisfaction are not fully conclusive, but there is an indication that a 1% increase in public satisfaction is associated with a 0.8% increase in cost.

Street lighting - The statistical model has proved to be complex and contains a degree of uncertainty, at this stage the results are tentative at this stage:

- On average an authority has an efficiency opportunity of 8% and can reduce their costs by this amount, while at the same time maintaining the same street lighting network and public satisfaction.
- For the average authority, the model estimates that a 1% increase in the number of street lights maintained results in a 1.13% increase in costs i.e. at the size of the average authority, unit costs increase if that authority gets larger.
- The unit costs of small authorities (measured by number of lighting columns) fall as they get larger. However costs start to rise if the number of lighting units exceeds approximately 40,000.

Drainage (Gully Clearance) - This was the first attempt to produce a gully clearance model, so the results are tentative:

- On average an authority has an efficiency opportunity of 17%.
- At the sample average a 1% increase in gullies cleared results in a cost increase of only 0.26%.
- For all authorities there are economies of gully clearance i.e. unit costs (average cost divided by the number of gully cleared) fall as more gullies are cleared for a fixed size network of gullies. For authorities which clear a large amount of gullies, the cost of further increase is lower than for an authority clearing fewer gullies.

Based on a survey of local authorities and their approach to highways maintenance, the study also made a number of findings related to the factors associated with higher or lower levels of efficiency:

- Authorities with superior efficiency (or aiming to achieve it in future) are more likely to:
  - Have a clearly defined strategy.
  - Have clear goals and measures to monitor progress.
  - Use comprehensive asset registers backed by condition surveys.
  - Have defined points where service arrangements are reviewed and changed; these are at intervals that allow enough time for long-term, preventative strategies to be implemented (e.g. 5 or 6 years).
  - Provide incentives to make savings; these include financial rewards, extensions of contracts and performance targets.
  - Use strategies that are: Integrated, with clear forward plans, are long term, and are measured & incentivised.
- Some authorities are efficient, but at the expense of quality. Analysis of the efficiency data together with road condition and public satisfaction data can identify which authorities these are.
- Analysis using both the efficiency scores and measures of quality (road condition and/or public satisfaction) indicates that an optimum level of investment is needed to maintain highways effectively and efficiently.
- Authorities can be classified using an efficiency/effectiveness grid which identifies what improvement strategy authorities need to address to improve.

- Authority size doesn't affect efficiency (see road maintenance above), but a factor for size is built into the efficiency score to allow comparisons between authorities of different sizes to be made.
- Innovation alone does not give an authority an efficiency advantage over its peers.
- IT systems alone do not give an authority an efficiency advantage over its peers.
- Investment decisions, including the magnitude and timing, must affect the measured efficiency of an authority. The data sources available were not specific enough to be able to assess the impact with confidence.

The CQC studies provide an interesting example of top-down econometric benchmarking applied in a highways context and provides a potential template for the kind of methodology which could also be developed and applied to NRAs (similar to the approach used for Network Rail). However, this would require the development of a comparable dataset and more detailed understanding of the how the performance and efficiency of different NRAs is influenced by inherent factors.

The benchmarking analysis of local authorities may also be useful in itself for deriving benchmarks for Highways England – although local road networks have some fundamental differences which need to be taken into account when making comparisons. It may be possible to incorporate Highways England into this analysis or to use it to identify best in class local authorities for more detailed bottom-up comparisons.

European Transport Safety Council

How far from zero? - Benchmarking of road safety performance in the Nordic countries, 2009

This report is based on European Transport Safety Council data and provides an overview of the safety performance of the road networks of five Nordic countries including Denmark, Finland, Iceland, Norway and Sweden – which are amongst the safest countries in the world. The aim of the report is to identify strengths and weaknesses in road safety performance.

Sweden is identified as the best performing of the Nordic countries, whilst Denmark has achieved the greatest improvement in its performance. The report identifies several priority areas including speeding, alcohol, powered two wheelers and the safety of elderly road users.

1.3 Survey studies

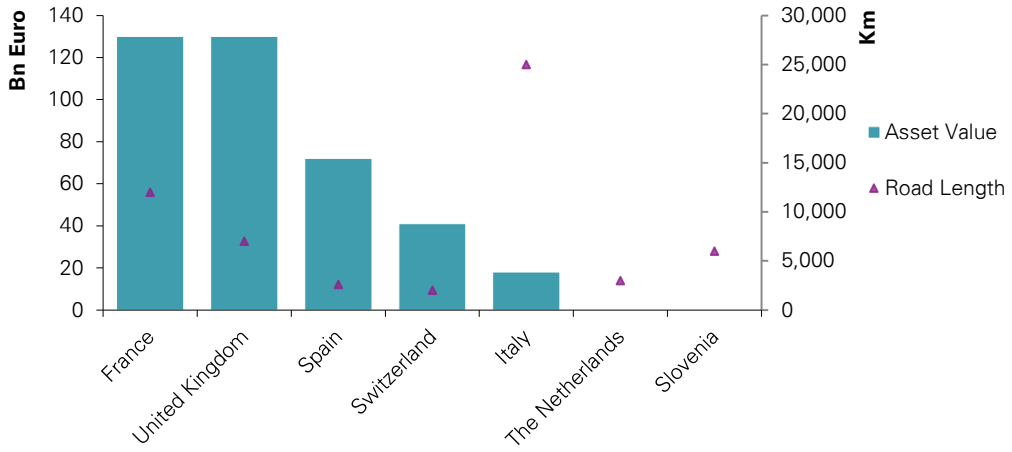
Directors of Roads in Europe (CEDR)

Life Cycle Costs and NRAs, 2013

This study is a follow up to the previous BEXPRAC benchmarking study described above. A task group of 7 countries from the CEDR network analysed the Life Cycle Costs (LCC) and Asset Management (AM) approaches adopted by NRAs. The objective was to collect and analyse data from individual NRAs, and to synthesise the lessons learned in order to get to a common set of definitions and core system.

The ultimate goal of this was to formulate a workable best practice guide for the adoption of a broad LCC and AM approach. Depending on the results of this deepening of the context of BEXPRAC, a second international study similar to BEXPRAC could be launched with a view to getting to a fully workable set of comparable operational data.

Figure 5: Summary data for asset valuation of European road networks



Note: UK value is based on Gross Replacement Cost, the other networks are valued through a historical cost approach.
Source: CEDR, 2013

Trafikverket

The road to excellence – An international benchmarking project between NRAs, 2010

The aim of this study is to benchmark sustainable, innovative and best practises in winter services, pavements and rest areas and approaches to innovation and training across NRAs including Sweden, Finland, Norway, Denmark, Slovenia, Scotland, USA and Canada. The study involved developing questionnaires for four main areas of interest; customer satisfaction, energy and environmental efficiency, quality, effectiveness and efficiency of rendered services and competence development and best practice for R&D.

The study provides quantitative and qualitative data across a range of specific subjects. It notes that all of the participating countries have conducted customer satisfaction surveys using different means and methods and most are using a well-developed and scientific survey system. The report also provides data for amounts of salt used for winter service, training and R&D budgets and provides a discussion of some of the techniques used by different NRAs to manage winter service process. It also highlights the different de-icing products and techniques used by different NRAs and highlights a range of innovative practices across the such as the use of contract incentive mechanisms, GPS monitoring of winter vehicles and Automatic Road Analysers to replace physical inspections. The annex to the report contains a detailed survey responses from each country to a range of questions across the issues described above.

The report provides some detailed analysis of the activities, processes and techniques used by a range of NRAs and highlights some innovative practices across the group. It also contains quite detailed data on a range of subjects related to the focus areas of the study. The study does not seek to provide an analysis of the 'efficiency' of each NRA and is more concerned with understanding different approaches.

OECD – International Transport Forum

Spending on Transport Infrastructure 2005-2011 – Trends, Policy, Data, 2013

This report provides data on transport infrastructure spending based on a survey of 52 member countries. The survey covers total investment (new construction, extensions, reconstruction, renewal and major repair) in road, rail, inland waterways, maritime ports and airports including all sources of financing. For financing the questionnaire covers only expenditure financed by public administrations.

The report highlights that a lack of common definitions and practices to measure transport infrastructure spending hinders comparisons between countries, although data for road and rail are highlighted as relatively comprehensive. There are also some differences in countries territorial reporting with 65% including spending in urban areas.

The report provides aggregate and regional analysis of transport spending and analyses relationships between different variables such as spending and income. The key content of the report is the appendices which includes tables for investment and maintenance spending from 1995 to 2011 across different categories of spending.

The data contained in this report is highly relevant to this study and the Highways Monitor's objectives to benchmark maintenance and construction costs. It provides the largest publicly available source of statistics of transport expenditure and is a key input into the OECD top-down benchmarking study described above. We note that the report highlights that there are some important issues with the data which make like for like comparisons difficult in some cases.

Performance Measurement in the Road Sector: A Cross-Country Review of Experience, 2012

This report provides a conceptual framework for the design of performance management systems for NRAs and describes the key inputs, outputs and outcomes for the road network. The report highlights the need to monitor performance across several areas including; accessibility and mobility, safety, environment, equity, community, program development, program delivery and program performance highlighting potential indicators for policy makers, the NRA and road users.

The report reviews performance managements systems used by a variety of NRAs and systems proposed in other reports. Based on this review the report suggests a 'comprehensive yet relatively small group of indicators' for measuring the performance of NRAs to be field tested to assess their applicability. The report notes that indicators for economic development and security are not clearly defined within the existing categorisation.

CIHT and World Road Association

Road Maintenance Review International Comparison, 2012

The aim of the study was to support the highways efficiencies programmes underway in England and Scotland by looking at what other countries are doing. As part of this there were two key aims: firstly to establish how the UK was performing compared to other countries and, secondly, to learn about any particular international policy or practices that the UK could implement

1.4 Bottom-up studies

Danish Road Directorate

Analysis of costs for construction of motorways, 2005

This report estimates the costs for a typical 1km motorway section in open land in urban areas respectively and with different types of interchange. The objective was to understand how motorway construction costs could be optimised in Denmark. The analysis is based on data submitted by organisations in the different countries in response to a questionnaire. The countries included in the analysis are Denmark, Sweden, England, Germany, the Netherlands, and Belgium.

The analysis indicates that total costs per km of 4 lane motorway in open land in England are €19.2 million - the highest in the sample relative to around €5 million in Belgium and €12 million in the Netherlands. The report provides some high level explanations for this including greater population density in the UK and high levels of environmental mitigation measures.

Highways Agency

EC Harris and TRL, European Cost Comparison - Cost differences between English and Dutch Highway Construction, 2009

Highways Agency commissioned EC Harris and TRL to conduct a study on four road schemes in England and the Netherland and evaluate the costs of completing these schemes to estimate differences in costs between the countries. The main findings were that after taking account of differences in scheme design and other factors road construction costs in England and the Netherlands are similar.

This study built upon a previous 2008 study with the aim of providing more direct comparisons between costs in England and the Netherlands, who were seen to be comparable countries.

A summary of the previous study was provided in the 2009 report, details obtained regarding this are provided below;

Overall the 2008 study found that the costs of labour, plant and materials in the UK were similar to those in Germany and France, but higher than in Italy, Spain, Austria and Poland. However, the study found when on-costs are included the relative comparisons between the countries changes with UK costs higher than the others.

The study relied on information from a survey which indicated that there are considerable differences between countries in the cost of items included in the cost of road schemes, timescales for development, design standards criteria and the provision of non-pavement features.

A key factor for the UK that the study made clear is that all costs incurred in the construction of a road – from identification to completion of construction is included in cost estimates. It noted that this is not the case in all other countries with some costs excluded and partially explains the UK's apparently high costs. UK roads were also found to be designed to a relatively high standards – reflecting high levels of traffic. Key difference between roads in the UK and other countries are:

- The use of design standards which are towards the upper end of the range in comparison with other countries – for example concreate thickness is the highest of all comparators.
- A comprehensive provision of non-pavement features.
- A comprehensive provision of measures to support the construction process e.g. traffic management, vehicle recovery, accommodation works and diversionary works.
- The frequency of intersections and bridges.
- The use of comprehensive appraisal and evaluation processes for road projects.
- Relative high on-costs.

The report concludes that these factors plus the relatively high cost of land, and the processes associated with environmental mitigation largely explain the UK's higher costs compared with European comparators.

These studies highlight many of the difficulties associated with making cost comparisons between countries highlighting the numerous differences in design standards, input costs, definitions and activities which can cause differences between NRAs costs. It provides some explanation for why UK costs are found to be higher than European comparators.

European Road Assessment Programme (EuroRAP)

British Results, 2014

EuroRAP undertake analysis of the safety and risk on roads across Europe with the aim of making drivers aware of the most dangerous roads in their countries. EuroRAP provide summary reports for some countries based on a detailed assessment of the accident risk across the road network. The analysis is based on two test protocols;

- The Risk Rate Map – which shows the individual risk to the driver based on analysis of road accident and traffic statistics.
- The Road Protection Score – which provides an assessment of how well road infrastructure protects drivers from injury or death once an accident has occurred based on an inspection of road design.

This report provides detailed analysis of the number of accidents on the UK's roads and their location – highlighting the most dangerous sections. The report states that there were 1,713 people killed on Britain's roads in 2013, with an annual serious injury cost of £0.3 billion on motorways, £0.6 billion on national trunk roads and £2 billion on Local Authority A roads.

The report assess the risks rating of the UK's road network and classifies 2% of roads as high risk and 12% as medium/high risk. This analysis is also presented on a route by route basis using maps. It also provides some analysis of the types of accidents that have occurred.

Similar reports are produced for other countries including France, Sweden, Netherlands, Catalonia, Italy, Ireland, Austria and Switzerland, although the statistics, time periods and indicators appear to differ slightly possibly reflecting the availability of data within each country.

The EuroRAP country reports potentially provide a detailed analysis and assessment of the level of risk across the European road network. The country reports may provide an additional form of benchmarking to compare the levels of safety based on the proportion of routes classified as high risk for example. However, based on a scan of the organisations website the country reports do appear to have some inconsistencies which may complicate direct comparisons.

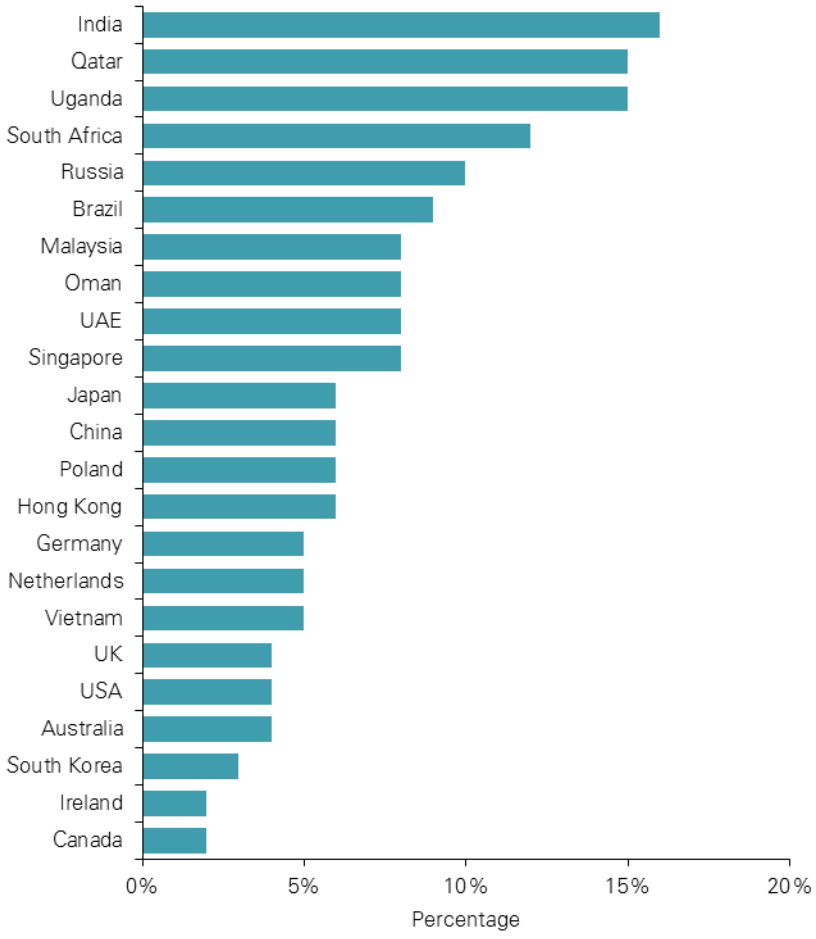
Turner and Townsend

A brighter outlook; International construction cost survey 2013

This is a construction cost survey that covers 23 countries across the world, including the UK. It is based on a survey undertaken and analysed by a team of construction economists. Its aim is to provide insights to organisations planning major programmes. Where it seeks to help them to compare future construction costs between countries and regions. In attempting to allow for better country-to-country comparisons to be made, Turner and Townsend have made use of the purchasing power parity methodology. Some of the aspects considered as part of the survey include market growth, cost changes, contractor margins, staff costs, tender competitiveness, preliminaries and cost trends.

Analysis of contractor margins suggests UK based projects have a contractor margin of around 4%, similar to Australia and the USA. This is higher than Canada and Ireland but lower than most other countries. This is shown in Figure 6.

Figure 6: Contractor Margins



Source: Turner and Townsend, 2013

The study also examines high level comparisons of labour costs between countries. The UK in general is shown to have similar labour costs to Ireland, Netherlands, Australia and Germany. The USA has higher costs whilst the other countries considered have lower costs. These countries include Brazil, Poland and South Africa, with India and China having yet lower costs compared to these countries as well.

In relation to cost for specific aspects of construction, the report notes the cost per square metre for a range of building types including airports, carparks, commercial and public sector. It also notes the cost of activities as part of this construction such as composite, labour, material and plant costs, giving a detailed breakdown at a square metre level.

The document provides comparisons across 23 countries, helping to highlight some of the reasons costs vary between them. It provides forward looking analysis which is useful in attempting to understand potential future cost trends. However, it does not contain specific data related to road construction.

1.5 Policy studies

HM Treasury

Infrastructure Cost Review, Technical Report, 2010

This study provides a summary of an investigation by Infrastructure UK into how to reduce the delivery of civil engineering works for major infrastructure projects. The report examines costs across several sectors of infrastructure spending including rail, road, flood defences, tunnels and rail stations and provides a range of analysis to assess the causes of the UK's relatively high construction costs.

In 2009, work on the High Speed 2 cost estimates identified specific evidence that infrastructure spending delivery in the UK is more costly than for similar projects in other European countries and UK rates for civil engineering works (e.g. tunnels and viaducts) for a high speed rail line appear to be around double those in Europe. Following this evidence – this report has attempted to explain this gap by identifying key differences between the UK and Europe and formulate a series of recommendations and actions to improve efficiency.

The study reviews a range of data and highlights that the UK is generally found to be one of the most expensive countries for civil engineering projects. A Eurostat OECD PPP survey estimates that the UK price index for civil engineering is around 60% higher than the EU average. Similar analysis by Gardiner and Theobald, EC Harris and Faithful and Gould each place the UK in the top 4 most expensive countries.

The study finds several reasons to explain the UK relatively high construction costs – a higher degree of supply chain fragmentation with a highly cyclical investment cycle leading to increased internal transaction costs. Typical project complexity is also increased by higher population density which often requires brown field development and extended public consultation processes. Regulatory compliance and health and safety controls are also relatively heavy compared with other countries.

The report provides comparisons of infrastructure costs with other countries based on structured interviews with central government bodies, client organisations and construction companies in Spain, France, Germany the Netherlands, Sweden and Denmark. This noted several important factors for efficient infrastructure delivery including:

- Strong political commitment.
- Clear regulatory framework.
- Well-structured long term investment programme.
- Organisation of the public sector with competent technical teams.
- Management of the private sectors capacity and good use of competition.
- Stronger larger contractors.
- Competition and collaboration.
- Processes for planning, prioritising and delivery.

This study also reviews international benchmark data from the Infrastructure Journal Online, the European Investment Bank and the Road Traffic Technology. Overall this analysis supports the hypothesis that building infrastructure is more expensive in the UK than elsewhere in Europe. It also finds that the trend is for South Europe to have the cheapest infrastructure costs and Eastern Europe the most expensive with North West Europe in between. Within the North West – the UK is consistently more expensive than other countries in this zone.

National Infrastructure Plan, 2011

The National Infrastructure Plan is an annually produced document that describes the priority infrastructure for the UK and sets out a strategy for delivery. This version is notable for its production

of a performance indicator across each of the infrastructure sectors. The major roads performance indicator is shown in Tables 20 and 21. The index is based on the collection and aggregation of a series of indicators to provide an overall assessment of the performance of the road network over time. All indicators with the exception of capacity, show improvement – with a 15% overall improvement between 2005 and 2010. We are not aware that this analysis has been repeated in subsequent plans.

Table 20: HM Treasury – Major roads performance indices

Indicator	2005	2006	2007	2008	2009	2010
Major roads performance index	100	99	101	106	110	115
Capacity, Access and availability	100	100	100	100	100	100
Motorway density	100	100	100	99	99	99
Motorway density	100	101	101	101	102	102
Motorway density	100	100	98	98	98	99
Asset or capacity utilisation	100	99	98	98	99	100
Average capacity utilisation of motorways	100	99	98	98	99	100
Service quality and reliability	100	93	92	105	104	104
Average vehicle delay on the slowest 10 percent of journeys on the SRN	100	93	92	105	104	104
Asset Condition	100	101	101	101	102	103
Motorways and HA managed truck roads asset condition	100	101	101	101	102	103
Carbon emissions	100	101	102	105	108	108
Carbon emissions by road vehicles	100	101	102	105	108	108
Safety	100	103	112	129	145	172
Fatalities on all roads	100	103	112	129	145	172

Source: HM Treasury, 2011

Table 21: HM Treasury – Major roads cost indices

Indicator	2005	2006	2007	2008	2009	2010
Major roads cost index	100	110	130	123	133	158
Investment and maintenance expenditure on major roads	100	110	130	123	133	158

Source: HM Treasury, 2011

Cabinet Office

Construction and back office cost benchmarking

The Cabinet Office Efficiency and Reform Group have undertaken various studies and analysis of the spending and efficiency of government departments and agencies. This includes reviewing major projects across government and benchmarking spending in common areas. In addition to the wider work of the group, there are two main studies which could be useful for benchmarking Highways England which focus respectively on construction costs and back office costs.

The construction study provides analysis of top-down departmental spending and bottom-up costs across a range of activities reflecting the priorities of the respective departments. The Cabinet Office has monitored the costs of Trunk Road Improvement, Junction Improvement, and Managed Motorway costs since 2010. The main objective of the report is to provide an ongoing analysis of cost trends over time but the data in the report could also be used to provide cross department

benchmarks. The report also provide a description of efforts being made by government departments to develop cross-organisation benchmarks. The report states that the Highways Agency has established an efficiency review group to facilitate the sharing of knowledge and best practice across its portfolio of schemes. It also notes that the HA is working with the Environment Agency to map programmes of work to explore where projects could be jointly delivered to save money. The report also contains a large number of bottom-up indicators which could be used by the Highways Monitor/Highways England to develop high level benchmarks for particular activities – although comparability would need to be considered.

The back office cost report contains detailed information on the back office costs of all government organisations with over 250 members of staff. The report contains data on numerous indicators including spending, headcount and KPIs related to finance, HR, IT, Procurement, estates, communications, legal and knowledge management and provides average values for each of these indicators. These indicators could be used to provide high level benchmarks of Highways England's performance and structure relative to other government organisations – although the comparability of the data would need to be considered with care. The back office benchmarking report was published in 2009 and it is not clear if this analysis has been repeated.

The Cabinet Office analysis of construction and back office costs provide some useful indicators of ongoing trends in cost performance across government departments/agencies including DfT/ Highways England. The reports specifically analysis trends in ongoing costs of highway construction and therefore provide useful analysis for the Highways Monitor. Back office costs are also compared and the report also explains progress towards inter-organisational benchmarking. The analysis is likely to be particularly useful for the Highways Monitor.

1.6 Other studies

WSP/University of Birmingham

HDM-4 adaptation for strategic analysis of UK local roads, and Development of socio-economic models for highway maintenance, 2011

The DfT commissioned WSP and the University of Birmingham to develop a HDM-4 model for the UK local road network. The objective of this model is to enable the DfT to assess the economic benefits of a marginal change in maintenance expenditure and the implications of this on traffic delays, asset condition and overall economic outcomes. The HDM-4 model has been linked to the National Road Maintenance Condition Survey database and has been adapted and calibrated to road conditions in England.

The development of the model requires the representation of the road network into a matrix of homogenous sections, with a representation of the vehicles that use the road network and a definition of traffic characteristics in terms of volumes loading and growth rates. Assumptions about the conditions of the road network is based on NRMCS data collected in 2006, with a range of assumptions to account for missing data. Two road network matrices were produced – the first with an optimistic assumption that the distribution of the current condition of principal roads gives an average roughness of about 2 IRI, the second with an IRI of about 3.

The models operate by modelling the pavement life cycle to predict road deterioration, road work effects, road user effects, and socio-economic and environmental effects. Depending on the levels of each variable the road network IRI will either improve or deteriorate over time resulting in the need for reactive maintenance and or vehicle damage. Road user costs comprise vehicle operation costs, costs of travel time and costs to the economy of road accidents.

The report presents analysis for a range of maintenance cost scenarios estimating the benefits and costs associated with different levels of activity. The study concludes that from the relationship between NPV/financial cost, and the level of annual expenditure for both capital and recurrent works, the study indicates that the optimal level of expenditure which maximises the economic benefits is

around £500m per year which equates to an average figure of around £18,000 per km per year. The study provides further analysis of a range of different scenarios analysing different levels of spending.

The report notes that – as with any theoretical model - there are some uncertainties associated with the analysis. The model is based on a range of assumptions and data which may not truly reflect the actual relationships between the variables. It report provides several recommendations for how the model can be developed in the long term.

The HDM-4 model developed for the DfT by WSP/University of Birmingham has been used to evaluate the optimum levels of investment in road maintenance based on an assessment of road asset conditions, the impact of investment and the outcomes for road users in terms of vehicle operating costs and delays. The model enables a comparison on net economic costs and benefits based on empirical evidence developed by the World Bank. This form of analysis could be applied to the strategic road network to develop an alternative assessment of 'efficiency' of HE maintenance spending incorporating user outcomes. Because the analysis captures user benefits it could be particularly helpful – although the calibration and validation of the model require a large number of assumptions and so its analysis would need to be interpreted with care.

European Commission

Measuring Road Congestion, 2012

This study presents an experimental methodology to measure and monitor road congestion across Europe using data from TomTom in vehicle navigation systems. The approach is based on the analysis of a large number of real vehicle speeds that have been measured on each road link using algorithms that allow the estimation of congestion indicators for specific types of roads during selected time periods.

The data used represent real speed measurements from in-vehicle navigation systems based on over 1 trillion observations giving a highly accurate and representative picture of the actual driving conditions across the European road network.

The methodology is considered to be potentially useful for mapping and comparing congestion across Europe. The paper presents a series of equations which can be used to analyse the dataset to assess speeds and levels of congestion. This is achieved by assessing speeds on sections of road – maximum speeds, average peak speeds and using rations between these indicators to assess the road type and its level of congestion. The ratio of average to free flow speed is highlighted as an easy to understand indicator of capacity and performance.

The output of the analysis is shown in Table 22. This indicates that the UK has one of the highest levels of congestion and delay, with an average to free flow speed ratio of 80% relative to 86% across the EU as a whole (for hour peak periods on <50km roads) and average delay of 24 seconds per km relative to 14 across the EU.

Table 22: Analysis of congestion and delay on European roads based on TomTom data

	Ratio of average to free flow speed %						Average delay sec per km				
	<50km/h		<80km/h		>100km/h		<50km/h		<80km/h		>100km/h
Country	1 h	3 h	1 h	3 h	1 h	3 h	1 h	3 h	1 h	3 h	1 h
Austria	86.7	88.2	92.8	94.1	93.9	95.1	15.7	13.7	3.0	2.4	2.0
Belgium	84.0	85.9	89.8	91.3	88.9	90.3	19.9	17.1	4.4	3.6	4.3
Czech Republic	88.0	89.5	92.5	94.2	92.5	94.3	13.3	11.5	3.1	2.4	2.5
Germany	85.0	86.6	89.9	91.2	89.9	90.9	17.3	15.3	4.2	3.6	3.5
Denmark	85.9	87.7	92.5	93.9	92.4	94.2	17.1	14.5	3.2	2.6	2.8
Spain	89.5	91.2	92.5	94.1	92.0	93.7	12.7	10.4	2.9	2.2	2.8
Estonia	87.3	88.9	95.6	96.8	93.5	95.2	14.6	12.5	1.9	1.3	2.5
Finland	87.4	88.9	94.3	95.5	94.4	95.6	14.5	12.6	2.4	1.9	2.0
France	87.6	82.7	93.0	94.3	92.7	94.3	15.2	13.1	2.9	2.3	2.5
UK	80.9	84	90.4	92.2	90.2	92.4	24.3	21.5	4.3	3.4	3.9
Hungary	82.2	82.1	91.3	92.9	91.0	92.8	22.1	19.3	3.5	2.8	3.1
Ireland	80.7	89.3	93.1	94.3	94.7	96.0	26.7	24.4	3.1	2.5	1.9
Italy	87.7	85.7	93.2	94.5	93.8	95.0	15.0	12.8	2.8	2.3	2.2
Lithuania	84.0	87.7	93.8	95.5	93.4	95.3	19.6	17.2	2.5	1.8	2.3
Luxembourg	85.8	87.2	87.3	89.6	84.4	87.0	16.8	14.1	5.7	4.4	6.6
Netherlands	85.6	83.6	88.2	90.0	86.6	88.7	17.8	15.6	5.4	4.3	5.6
Poland	82.2	83.6	92.9	94.4	93.2	94.7	23.1	20.9	3.1	2.4	2.4
Portugal	88.7	90.3	93.3	94.8	93.3	95.0	13.3	11.2	2.6	2.0	2.3
Slovakia	84.9	86.5	91.6	93.2	91.3	93.1	17.5	15.3	3.6	2.8	3.0
Sweden	86.5	87.9	94.3	95.4	94.3	95.4	15.8	13.9	2.4	1.9	2.1
EU Weighted Average	86.3	87.9	92.2	93.6	91.8	93.4	16.6	14.4	3.3	2.6	3.0

Source: European Commission (2012)

This study indicates that GPS based satellite navigation data can be used to develop consistent and comparable metrics of road network performance based on comparisons of free flowing and peak period speeds. This would require some detailed analysis and interpretation of the data and may require specialist expertise.

We understand that Highways England uses a similar metric for calculating journey reliability based on Trafficmaster in-vehicle GPS installed in a fleet of around 70,000 vehicles.[6] In principle a similar indicator based on Europe wide data could be used to assess Highways England's performance relative to comparators. This would enable raw comparisons of overall network performance across several of Highways England's objectives and KPIs, but may require some detailed analysis and research to enable an understanding of the inherent and

[6] See – Reliability of journeys on the highways agencies motorway and 'A' road network: the on time reliability measure for the details of the calculation.

structural factors which are likely to affect these indicators such as population density, patterns of trip demand, road design and land use etc.

Key points from literature review

In addition to the wider issues and general findings described above, the literature review has revealed a range of specific findings about the relative performance, organisational structure and network characteristics of Highways England which are interesting in themselves. These key points are summarised below:

- Econometric benchmarking by the OECD indicates that France, Poland and Canada have the most efficient road networks whilst Greece, the USA and Spain have the least efficient in terms of the number of car and freight trips, accidents and carbon emissions relative to the size and investment in the road network.
- The UK is ranked 16th most 'efficient' of the 32 countries analysed in the OECD report, however the confidence intervals for this analysis are wide for many of the middle ranked countries which means this ranking is somewhat uncertain. The efficiency gap for the UK is estimated to be between 5% and 11%.
- OECD analysis suggests that the UK is relatively efficient with a potential saving in investment and maintenance spending and energy consumption equivalent to around 0.1% of GDP respectively. The analysis suggests that the UK could reduce spending by this amount and achieve the same outcomes as presently achieved. This saving is roughly equivalent to £400 million per year.
- The UK has one of the most densely used networks in the OECD both for passengers and freight traffic. People within the UK appear to travel similar distances to the OECD average, and spending on investment and maintenance per km is also around the average.
- The BEXPRAC survey indicates that relative to European comparators the UK has a mid-sized road network with a high proportion of dual+ road length and with a high amount of traffic. The total length of tunnels and bridges is relatively low, but total ramp length is high. User satisfaction and asset condition are both relatively high compared with European comparators.
- The study estimates that the UK has the 4 most asset intensive road network with an average Dual equivalent Asset Value of €24 million per km. Switzerland and Austria are found to have the most asset intensive roads – Reflecting the high number of tunnels and bridges, Ireland and Hungary are found to be the least intensive.
- Reflecting these characteristics, the report finds that traffic management, operations and maintenance spending in the UK is €83,000 per km per year relative to an average of €73,800. The highest levels of spending are in Switzerland at €211,700 and the lowest are in Ireland at €12,100.
- In addition to the macro-based analysis, the BEXPRAC study also undertook 'micro' analysis of the costs of individual road projects based on analysis of 36 road sections, representing different types of roads across seven different countries. Based on these samples the study estimates average expenditure which range from €50,000 to over €200,000 per 4 lane equivalent km across several categories of spending.
- The UK has the highest level of outsourced procurement related expenditure of all the NRAs in the sample. Outsourced costs accounting for around 99% of all spending. Spain (97%), Sweden (91%) and Switzerland (84%) also have high levels of outsourcing costs Ireland has the lowest levels at 29%. This indicates that the Highways England procurement model is very different to most other NRAs.
- The HMEP/CQC analysis finds that on average local authorities have an efficiency opportunity of 21% and could reduce road maintenance expenditure by this amount and continue to maintain the same network, quality and traffic usage.
- Cabinet Office benchmarking of DfT/Highways England costs indicates that Trunk Road (P50) unit costs have fallen from around £10 million per km in 2009/10 to around £6.5 million in 2014/15. Managed motorway unit costs have fallen from around £6 million per m^2 to around £3.9 million per m^2 over the same period.

- The World Economic Forum Competiveness Index ranks the UK as 30 out of 144 members for infrastructure and scoring an average of 5.2 out of 7 for the quality of the road network based on a survey of senior executives. Based on this metric, the UK is behind many countries with the Portugal, Austria, France and the Netherlands all scoring over 6.
- Experimental analysis using TomTom data indicates that the UK has one of the highest levels of congestion and delay across Europe, with an average to free flow speed ratio of 80% relative to 86% across the EU as a whole (for hour peak periods on less than 50km roads) and average delay of 24 seconds per km relative to 14 across the EU.
- A study by the Danish Road Directorate indicated that total construction costs per km of 4 lane motorway in open land in England are €19.2 million – the highest in the sample relative to around €5 million in Belgium and €12 million in the Netherlands.
- Following up on this research, a survey by TRL/EC Harris found that UK input costs for road construction were around 12% higher than the average and 27% higher than the sample when on-costs are considered. This study also found that higher costs are generally explained by several factors including relatively high design standards, comprehensive provision of non-pavement features and more comprehensive provision of measures to support the construction process. Further bottom-up comparisons between England and the Netherlands indicates that higher costs in England are largely explained by differences in design standards.
- The DfT's HDM-4 model of the local road network has used data and information that is readily available from local highways authorities. Highways England has similar datasets. It has been used to estimate the marginal costs and benefits of changes in road maintenance activity. The model indicates that the optimal level of expenditure which maximises the economic benefits is around £500 million per year which equates to an average figure of around £18,000 per km per year.

Appendix 2 Data review

2.1 Overview

For benchmarking to be insightful, data quality and comparability are of the utmost importance. In this Appendix we provide a review of the available data based on our stakeholder consultation and literature review. A large volume of data exists but the comparability of this information is often limited, particularly for cost data where definitions are often inconsistent or unclear.

As part of this review we have examined data based on several main sources:

- **NRA Annual reports** – Most NRAs[7] produce an annual report which sets out the organisations performance for the year alongside a set of audited financial accounts on an ongoing basis. Due to the frequency and information recorded they are useful sources of benchmarking data. The main issue is comparability. Notably even with high quality data, difficulties exist with lexicon and definitions, which can be further exacerbated by the level of responsibility that the NRA holds.
- **Other NRA reports** – A number of NRAs produce information/data that is not in the form of traditional annual accounts. This can be in related to network performance, user satisfaction, safety or reports produced by independent authorities.
- **Multi-country reports and datasets** – International organisations are a source of information and data, which is often presented in a more comparable way. The OECD through IRTAD[8] produces an annual report on road safety. The International Road Federation, the European Union Road Federation, EuroRAP and the World Bank all also provide data on road networks across a number of countries and topics.
- **Bespoke data sources** such as the DfT's DBFO contracts and Local Authority data, Treasury PPP contracts and online databases
- **One-off studies** – One-off studies have produced useful datasets that often go into more detail and attempt to draw comparisons through surveys and working groups. Notably the most useful example of this is the BEXPRAC work. The weakness of this type of data is that it is not ongoing but instead fixed at a point in time.

Through the review we have sought to link available data to the measurements that the Highways Monitor has highlighted as important for benchmarking performance, costs and network characteristics. This is based on the details as set out in RIS1.

2.2 Performance data

Highways England has eight objectives as set out in RIS1 and for each objective corresponding KPIs have been identified. As part of this review we have identified potential sources of information which correspond to these objectives and KPIs.

In general, data appears to be available for a number of these objectives/KPIs although comparability appears to be the key challenge for many. Where data is limited we have suggested active data sources and other potential variables that could be considered for benchmarking.

[7] Regions reviewed: England, Wales, Scotland, Northern Ireland, London, Ireland, Bavaria, Netherlands, Italy, Denmark, Austria, Missouri, Washington State, FWHA, Western Australia, Victoria

[8] International Traffic Safety Data and Analysis Group

Objective 1: Making the network safer

KPI: The number of KSIs on the SRN

A number of datasets exist which provide information on this objective/KPI with many of these presented in a comparable way. The data in this area is high quality in nature reflecting the importance of accident statistics and the definitions is by nature relatively comparable (although there are some differences). This data is shown in the Table 23.

Table 23: Making the network safer data

Organisation	Source	Data	Annually Produced
OECD IRTAD	Road Safety Annual Report	■ Road fatalities by road type ■ Road fatalities by road user group ■ Road fatalities by age group ■ Injury crashes	Yes
European Transport Safety Council	Road Safety Performance Index	■ Road deaths	Yes
European Union Road Federation	ERF Road Statistics	■ Road accidents involving personal injury ■ Road fatalities in EU-27	Yes
International Transport Federation	World Road Statistics	■ Road accident figures and rates	Yes
Wales (Welsh Government)	Statistical Bulletin: Road Safety	■ KSIs	Yes
Scotland (Transport Scotland)	Reported Road Casualties	■ Reported accident rates	Yes
Northern Ireland (Police Service of Northern Ireland)	Detailed Trends Report 2014	■ Road traffic collisions and fatalities by speed limit of road	Yes
London (Transport for London)	Fact sheet: Casualties in Greater London	■ KSIs	Yes
Ireland (Road Safety Authority)	Road Accident Statistics	■ Deaths on Irish Roads	Yes
Bavaria (STMI)	Statistics Report	■ Number of road accidents	Yes
Missouri (MsDOT)	Tracker	■ KSIs	Yes
Washington State (WSDOT)	The Grey Book	■ Traffic Fatalities	Yes
USA (FHWA)	Highway Statistics	■ Motor vehicle traffic fatalities	Yes
Western Australia (Main Roads Australia)	Annual Report	■ Fatalities and Hospilitisations	Yes
Victoria (VicRoads)	Annual Report	■ KSIs	Yes

Source: KPMG Analysis, 2015

The international data sources such as OECD IRTAD data is likely to be very useful, providing coverage of numerous countries and road type breakdown. The majority of countries apply the same definition for road fatalities (being one in which an individual dies within 30 days of the crash).[9]

There is also a large amount of data published in NRA annual reports which often provide more detailed information on accident statistics. Other sources such as EuroRAP also provide detailed comparison data. However in all of these sources there is a general need to understand the

[9] The definition of a serious injury is where an individual is admitted to hospital with an injury of recordable severity or requiring a certain length stay, whilst this severity level may vary to a degree it tends to excludes sprains, minor cuts, bruises and shock.

characteristics of the road network for example the inclusion or exclusion of urban road networks and the proportion of motorway to non-motorway roads across comparators.

Data for this objective is widely available. The OECD and other sources produced safety statistics with good levels of comparability on an annual basis and provided data for a number of countries. There could be some issues with using this information for benchmarking associated with ensuring that comparison with similar road networks and types are used. Country specific reports provide more detailed data on the subject and when NRAs are considered it is often possible to compare performance of a similar road type to the SRN.

Objective 2: Improving user satisfaction

KPI: The percentage of National Road Users' Satisfaction Survey (NRUSS) respondents who are Very or Fairly Satisfied

User satisfaction data is published by a number of NRAs. A number of consumer indexes are also produced that cover wider industrial segments and companies and can be used to gauge user satisfaction to some extent. Table 24 provides a list of data sources related to this objective.

Table 24: Improving user satisfaction data

Organisation	Source	Data	Annually Produced
Scotland (Transport Scotland)	IPSOS: Perception of the trunk road network in Scotland	■ Overall statisfaction as well as specific catagories	Yes
London (Transport for London)	Performance Report	■ Overall statisfaction as well as specific catagories	Yes
Netherlands (Rijkswaterstaat)	TNS NIPO: Gebruikers-tevredenheidsonderzoek automobilisten	■ Overall statisfaction as well as specific catagories	Yes
Missouri (MsDOT)	Tracker	■ Overall statisfaction as well as specific catagories	Yes
AusRoads USI	User Satisfaction Index (Covers road networks in each Australian State and New Zealand)	■ Overall statisfaction as well as specific catagories	Yes
American Consumer Satisfaction Index	American Consumer Satisfaction Index	■ Satisfaction levels across a range of companies and sectors in USA	Yes
Institute of Customer Service	UKCSI Consumer Satisfaction Index	■ Satisfaction levels across a range of companies and sectors in UK	Yes
KPMG Nunwood	Customer Experience Excellence Centre: UK Analysis	■ Satisfaction levels across a range of companies and sectors global	Yes

Source: KPMG Analysis, 2015

Comparability is generally a major issue when attempting to compare user satisfaction results across countries based on this data. Survey methodology can vary for example being face-to-face, telephone or internet based, focussing on different questions and different parts of the network. The variation of performance across the road network also means that sample sizes will probably need to be very large to provide robust results. We note that Highways England has undertaken detailed regional surveys for example

The nature of the questions and answers are very important for influencing the response and generally different surveys of user satisfaction across different countries cannot be considered directly comparable.

Data is available for this objective for many individual NRAs but generally has significant comparability issues reflecting differences in methodology, questions and the priorities of road users. At a very high level comparisons of user satisfaction could be made, but these need to be carefully interpreted.

Objective 3: Supporting the smooth flow of traffic

KPI: The percentage of the SRN available to traffic

KPI: Percentage of motorway incidents cleared within one hour

There is limited publicly available data related to these objectives within international datasets. However, individual NRAs do publish a range of metrics, although this data is generally not perfectly comparable.

Table 25: Data produced regarding the smooth flow of traffic

Organisation	Source	Data	Annually Produced
Scotland (Performance Audit Group)	Annual Report	■ Network availability ■ Number of roadworks	Yes
London (Transport for London)	Annual Report Performance Report	■ Asset Availability ■ Indexed Traffic Flows ■ Average length of planned and unplanned incidents	Yes
Missouri (MsDOT)	Tracker	■ Traffic impact of closures on major interstate routes ■ Average time to clear accident	Yes
Washington State (WSDOT)	The Grey Book	■ Annual Average Clearance Time ■ Total Incident Responses	Yes

Source: KPMG Analysis, 2015

Whilst specific data related to this objective is limited most NRAs have RTI Traffic portals that monitor the road network on an ongoing basis and therefore more detailed information may be available within organisations.

Regions that are known to have a system such as this include: Ireland, Wales, Bavaria, Northern Ireland and Scotland, although it is likely that the majority of NRAs will have some form of RTI data which could be used for comparisons. Organisation such as TomTom and INRIX are also known to produce multi-regional data summary reports based on consistent data and methodology, however this is not publicly available.

A limited mix of data is publicly available for both 'supporting the smooth flow of traffic' KPIs based on data published by individual NRAs. Most NRAs have RTI systems which could also be used to develop comparisons. Satellite navigation data from INRIX, TomTom and Traffic Master could, for example, also be used for this objective.

Objective 4: Encouraging economic growth

KPI: Average delay (time lost per vehicle per mile)

Encouraging economic growth is based on the KPI of the average delay experienced by road users. The measurement of delay is complex and data for this indicator is limited and where reported are often not directly comparable. This would make it difficult to establish specific approaches to benchmarking for this KPI.

Table 26: Encouraging economic growth data

Organisation	Source	Data	Annually Produced
Scotland (Transport Scotland)	Transport Scotland Online	■ % of journeys delayed	Yes
London (Transport for London)	Performance Report	■ Hours of serious and severe disruption	Yes
Missouri (MsDOT)	Tracker	■ Reliability of Travel Times for Freeways	Yes
Washington State (WSDOT)	The Grey Book	■ Travel Delay	Yes
Victoria (Vicroads)	Annual Report	■ Travel time delay (sec/km)	Yes

Source: KPMG Analysis, 2015

As with the previous objective, satnav based data has been used to develop consistent cross country comparisons of average delay which could be developed and used by the Highways Monitor. Vehicle usage, notably freight and passenger statistics and average speeds could also be used as indicators of economic growth. Both the IRF and World Bank produce annual statistics on these variables.

Table 27: Data produced regarding road usage

Organisation	Source	Data	Annually Produced
International Road Federation	World Road Statistics	■ Road Freight Transport ■ Road Passenger Transport	Yes
World Bank	Statistics	■ Goods transported (million ton-km)	Yes

Source: KPMG Analysis, 2015

Limited data is available for the economic growth objective and KPI, some NRAs publish data on delay, but the definition and calculation tend to be different. It may be possible to use INRIX, TomTom or Traffic Master datasets to estimate average journey delays expected on the network. Alternatively other measures could be used to assess performance across this objective such as freight and passenger miles which can be an indication of economic growth.

Objective 5: Delivering better environmental outcomes

KPI: Number of Noise Important Areas mitigated

KPI: Delivery of improved biodiversity as set out in the companies' biodiversity action plan

The KPIs for this objective are difficult to measure as noise and improved biodiversity are rarely reported by most NRAs and definitions are generally not comparable or measured in the same way. Data does exist regarding emissions such as CO2, Sulphur Oxides and Particulates attributed to road transport as published by the IEA, EMEP and World Bank. Some NRAs also publish their energy usage, and some have biodiversity plans which provide some more detailed information although there is often limited quantitative data recorded in these.

Table 28: Delivering better environmental outcomes data

Organisation	Source	Data	Annually Produced
International Energy Association (IEA)	CO2 emissions from fuel combustion	■ CO2 emissions from Fuel combustion	?
European Monitoring and Evaluation Programme (EMEP)	Centre on Emissions Inventories and Projections	■ Road Transport Sulphur Oxides ■ Particulates (PM 2.5) from road Transport	Yes
World Bank	Road Statistics	■ Energy consumption in road sector	Yes
Scotland (Transport Scotland)	Fitting Landscapes: Securing More Sustainable Landscapes	■ Environmental/biodiversity plans	Yes
London (Transport for London)	Corporate Environment Strategy	■ Environmental/biodiversity plans	Yes
Washington State (WSDOT)	The Grey Book	■ Environmental/biodiversity plans	Yes
Ireland (NRA)	Annual Report	■ Energy Usage	Yes
Italy (ANAS)	Annual Report	■ Energy Usage	Yes
Western Australia (Main Roads Australia)	Annual Report	■ Energy Usage	Yes
Bavaria (STMI)	Statistics Bulliten	■ Money spent on 'Green' Places	Yes
Missouri (MsDOT)	Tracker	■ Number of tons of recycled material ■ Number of environmental warnings and violation	Yes

Source: KPMG Analysis, 2015

Limited directly comparable data regarding noise mitigation or bio-diversity plans is produced. Some NRAs produce reports on energy usage, emissions and particulates that may provide some data to benchmark Highways England against.

Objective 6: Helping cyclists, walkers and other vulnerable users of the network

KPI: The number of new and upgraded crossings

Limited data on the number of cyclists and walkers on the road network is produced by the NRAs that we have considered. Some NRAs produce project related data and plans for cycling investment. Where data is mentioned or recorded it is difficult to determine if it is comparable.

Table 29: Helping cyclists, walkers and other vulnerable users data

Organisation	Source	Data	Annually Produced
London (Transport for London)	Cycling Vision Portfolio	■ Summary of Schemes	?
Missouri (MoDoT)	Tracker	■ Investment in Pedestrian Facilities ■ Progress Toward Completion of Transition Plan	Yes
Washington (WSDoT)	The Grey Book	■ Bicycle and Pedestrian Documentation Project ■ Bike Share Programs ■ Pedestrian and Bicycle Safety Grant Program	Yes

Source: KPMG Analysis, 2015

Very limited data sources exist for this objective and the comparability of the available data may be limited.

Objective 7: Achieving real efficiency

KPI: Savings on capital expenditure

In order to achieve the objective of encouraging efficiency it is useful to consider the financial accounts of organisations.

The underlying result from this analysis is whilst large amounts of cost and expenditure exists there is limited consistent information on capital savings in the form being applied by Highways England for this objective. It is possible to review specific projects that have been undertaken, specifically by DBFOs and other UK based NRAs in order to determine the expected cost of a project.

In some cases, data is available for road construction project costs both at an aggregate level and at a project specific level. Savings are not generally reported and are difficult to define.

Objective 8: Keeping the network in good condition

KPI: The percentage of pavement assets that do not require further investigation for possible maintenance

Road conditions are important for the overall performance of the road network and the efficiency of NRA asset management. This objective considers monitoring the state of the road network and ensuring that Highways England continues to provide a high level pavement for road users. Many NRAs produce data related to this objective although the comparability is often imperfect as different measurement techniques can be used including measurements of roughness, state of repair and other definitions.

Table 30: Keeping the network in good condition data

Organisation	Source	Data	Annually Produced
EuroRAP	SENSoR Star Rating Reports	■ Skid resistance/grip	No
Wales	Statistical Bulletin: Road lengths and conditions	■ Road conditioning monitored by Deflectograph technology	Yes
Scotland (Performance Audit Group)	Annual Report	■ Detailed inspections	Yes
London (Transport for London)	Performance Report	■ State of Good Repair (SOGR) metrics for the TLRN	Yes
Missouri (MsDOT)	Tracker	■ % of highways in good condition	Yes
Washington State (WSDOT)	The Grey Book	■ Pavement conditions	Yes
USA (FHWA)	Highways Statistics	■ Pavement roughness	Yes
Western Australia (Main Roads Australia)	Annual Report	■ Preventative Maintenance Indicator - surfacing age younger than its optimal target age	Yes

Source: KPMG Analysis, 2015

A number of road condition surveys are undertaken by different NRAs which can provide an indication of the quality of network conditions. However these metric are generally not directly comparable – and in some cases are fundamentally different approaches to monitoring the conditions of the road network.

2.3 Expenditure/cost data

There is a large amount of data related to NRA and general government expenditure/ costs on road transport, but there can also be significant challenges with comparing this information between countries.

The IRF and OECD publish international datasets based on a survey of member states which provide high level data on capital and maintenance costs which is roughly comparable, with some significant caveats. NRA's audited financial accounts and annual reports provide more detailed information on spending, often with breakdowns and analysis by activity. In general total cumulative expenditure on the road network is widely available and broadly comparable but costs associated with lower level activities suffer from differences in different definitions and structural factors between countries.

International Organisation Data

The International Road Federation, OECD and EuroRAP all publish details of expenditure on the road network. The sources of information for these is a combination of national statistics offices, road administrations, associations, international bodies and governmental departments. As such it is important to note there may be discrepancies in the data between counties arising from different reporting structures and accounts.

Table 31: International expenditure data

Organisation	Source	Data	Annually Produced
International Road Federation	World Road Statistics	■ Total road expenditure ■ Total road expenditures per adminstrative level ■ Total road expenditure per catagory	Yes
OECD: International Transport Forum	Spending on Transport Infrastructure 1995-2011	■ Investment in road infrastructure ■ Maintenance expenditure in road infrastructure	No
OECD	Statistics Database	■ Road infrastructure investment ■ Road infrastructure investment; of which motorway	Yes
EuroRAP	SENSoR project partner AMZS Slovenia	■ Cost of 94 countermeasures, inlcuding: infrastructure, improvements, widening, replacements, lighting, across 6 road types	?

Source: KPMG Analysis, 2015

NRA Specific Data

Audited annual reports by NRAs are another potential source of information on road expenditure – which provide more detail and breakdowns of activity – but which are less readily comparable than the international sources shown above. Because this information is independently audited it is likely to be more reliable, however this does not mean that it is always comparable.

We have reviewed the accounts of NRAs, across the UK, Europe and elsewhere and have attempted to highlight key categories that are specified in the accounts which could be used for benchmarking. In addition to standard financial reporting on staff costs, admin and other general categories, some NRA accounts include data on maintenance, lighting and administration costs for example. The precise definition of these categories and their comparability is difficult to assess.

Table 32: NRA expenditure data

Organisation	Source	Details in accounts
Wales (Welsh Government)	Stats Wales	■ Planning, Policy and Strategy ■ Construction ■ Maintainence ■ Enviroment and safety ■ Winter Service ■ Street Lighting Traffic Management
Scotland (Transport Scotland)	Scottish Budget Spending Review	■ Trunk Road Maintanence Capital expenditure on motorways and trunk roads
Northern Ireland (Northern Ireland Road Service)	Annual Report	■ Strategic Road Improvements ■ Maintenance ■ Local Transport and Safety Measures

Organisation	Source	Details in accounts
		■ Bridge Strengthening ■ Street Lighting SRI Scheme Expenditure
Ireland (NRA)	Annual Report	■ Road construction and improvement ■ Road maintainence and management ■ Private Public Partnership and Tolling ■ Depreciation ■ Salaries and PRSI ■ Pension costs ■ Travel ■ Other adminstrative costs ■ Accomodation costs ■ Depreciation Directors fees and expenses
Bavaria (STMI)	Annual Report	■ Road construction projects ■ Operations management ■ Traffic technology Technical road administration
Netherlands (Rijkswaterstaat)	Annual Report	■ Management and maintenance costs ■ Direct and indirect organisational costs Expenditure on construction projects
Italy (ANAS)	Annual Report	■ Basic Maintenance and Other Interventions for recovery ■ Cost for Personnel ■ Other operating expenses ■ Capitalization of costs in intangible New Works and Special Maintenance ■ Operating cost management Ex-FCG ■ Operating cost management ANAS/MIT SVCA ■ Operating expenses Management Contracts Foreign ■ Training costs Value Added
Austria (Asfinag)	Annual Report	■ Cost of material and purchased services ■ Personnel expenses ■ Other expenses

Organisation	Source	Details in accounts
		■ Depreciation, amortisation and impairment
USA (FWHA)	Highways Statistics	■ Capital Outlay ■ Maintenance ■ Expenditure of Federal Funds Administered by the Federal Highway Adminstration
Western Australia (Main Roads Australia)	Annual Report	■ Employee benefits expense ■ Supplies and services ■ Depreciation expense of infrastructure assets ■ Depreciation and amortisation expense of other assets ■ Road Safety ■ Road System Management ■ Road Efficiency Improvements ■ Infrastructure for Community Access ■ Road Network Maintainance ■ Infrastructure for State Development ■ Office of Road Safety ■ Roadwork Capitalised/Expenses not allocated to Outputs
Victoria (Vicroads)	Annual Report	■ Employee benefits ■ Supplies and services ■ Depreciation ■ Interest expense ■ Grants and other transfers ■ Capital asset charge ■ Fair value of assets transferred to other entities

Source: KPMG Analysis, 2015

Capital Expenditure Projects

Many NRAs publish data on construction expenditure and some also publish data on the construction costs of specific projects. Information that is widely published includes a summary, cost, lifetime and progress update of the project. For PPP contracts the unitary charges associated with the project are also often available. A database of projects with costs and type could be developed to understand the average cost of specific scheme. Notably DBFOs in England are likely to be the most relevant organisations to consider as they are operating in the same legal and regulatory environment as Highways England.

Table 33: Capital expenditure data

Organisation	Document	Data
DBFOs in England	Online Database/ Highways England contract managers	■ Overview of project ■ Estimated Contstrution Cost (as per PQQ) ■ Unitary charge
Ireland (NRA)	Annual Report	■ PPP Contracts ■ Construction involved ■ Road length ■ Payments ■ Length of contract
Northern Ireland (North Ireland Road Service)	Annual Report	■ Scheme description ■ Cost ■ Scheme progress
Scotland (Transport Scotland)	Online Database	■ Scope ■ Cost
Wales (Welsh Government)	Online Database	■ Scope ■ Cost
Austria (Asfinag)	Online Database	■ Project details
Missouri (MsDOT)	Tracker	■ Projected cost compared to final cost

Source: KPMG Analysis, 2015

2.4 Bottom-up data

The Highways Monitor specified a variety of bottom-up indicators as part of the review. These indicators and our assessment of their availability – based on NRA reports, the stakeholder consultation and other sources are shown in Table 34.

We have identified limited amounts of information for bottom-up indicators. This information may exist in some form within individual NRAs however respondents have not provided this information in response to our consultation – possibly because of the wide ranging nature of the request and the detailed nature of the costs.

Table 34: Notable data that is produced regarding bottom-up analysis

Category	Variable	Availability of data
Asset management expenditure - maintenance	Grass cutting	Not available as part of an ongoing dataset
	Drainage gullies	Not available as part of an ongoing dataset
Asset management expenditure – renewal	Carriageway resurfacing	Not available as part of an ongoing dataset
	Bridge joint replacement	Not available as part of an ongoing dataset
Operating expenditure	Network control centres	Not available as part of an ongoing dataset
	Gritting	Not available as part of an ongoing dataset
	Traffic officer service	Not available as part of an ongoing dataset
Enhancement expenditure	Construction of new roads	Could be derived from DBFO + Non Highways England Projects Review
	Widening of existing roads	Could be derived from – DBFO + Non Highways England Projects Review
	Junction improvements	Could be derived from – DBFO + Non Highways England Projects Review
Support expenditure	Human resources expenditure	Not available as part of an ongoing dataset
	I.T. services	Not available as part of an ongoing dataset
	Financial services	Not available as part of an ongoing dataset
	Technical support	Not available as part of an ongoing dataset
	Total staffing costs	Widely available from NRA Financial Accounts

Source: KPMG Analysis, 2015

2.5 Network characteristics data

Road network characteristics such as the size, design and levels of traffic are important factors which influence the efficiency and performance of the road network. A road network with a larger quantity of assets, or higher levels of traffic is likely to require greater levels of investment and maintenance spending for example. This is very important for considering the performance and efficiency of different NRAs. In Table 35, we set out some of the key variables which are likely to be important factors affecting road network performance.

Table 35: Network characteristics as given in BEXPRAC

Variable	Example Indicators
Network size	Total km
	Breakdown by type of road (4 lane, 3 lane, 2 lane, 1 lane etc.)
Network type	Number/length of bridges
	Number/length of tunnels
Network usage	AADT
	% HGVs
Environmental factors	Number of days per year when the temperature falls below 0
Network value	Depreciated value of network assets
Organisation structure	Employees
	Central support (HQ) costs

Source: KPMG Analysis, 2015

These variables are just examples of the kind of factors which are important for considering performance and efficiency. Other factors are also likely to be important for example - procurement procedures, planning laws and health & safety standards amongst others. The availability of these indicators in international datasets is highlighted in Table 36.

Table 36: Network characteristics data

Organisation	Document	Data	Annually Produced
International Road Federation	World Road Statistics	■ Main characteristics of road networks per country ■ Total length of road network per country ■ Density of total road network per country ■ Proportion of motorways per country ■ Annual traffic volume	Yes
EuroRAP	SENSoR project	■ ADDT ■ Operating speed	?
World Bank	Statistics	■ Road density (km of road per 100 sq. km of land area) ■ Roads, paved (% of total roads) ■ Roads, total network ■ Motor vehicles (per 1,000 people) ■ Passenger cars (per 1,000 people) ■ Vehicles (per km of road)	?

Source: KPMG Analysis, 2015

NRA reports also contain a range of information on network characteristics, although this tends to be less consistent than the data from international datasets. Individual reports such as BEXPRAC also contain specific information on these variables.

2.6 Local Authority data

Local Authority road network data is published by both the DfT and DCLG. Detailed statistics are provided which cover a range of aspects of the road network including expenditure, road characteristics and performance. The key sources are discussed below.

Benchmarking Tool 2011

In 2011, DfT produced a benchmarking toolkit for comparing Local Authority road networks. This contained data from 2002 to 2010 on network characteristics, expenditure and performance of Local Authority road networks including numerous variables such as KSIs, average vehicle speeds, road condition and other indicators. The aim of this tool was to bring together statistics that were publicly produced to enable Local Authorities to directly benchmark themselves and compare performance and efficiency at a high level. The data included make it possible to identify trends over time in relation to expenditure and performance of road networks. More efficient authorities can be identified based on relative levels of expenditure per road length (and taking account of performance). However it is important to appreciate Local Authority road networks differ to Highways England's network considerably and generally have a much larger proportion of B and C roads for example. Differences also exist in road usage intensities as well as the urban/rural environment the roads are in, which may influence underlying cost factors.

Table 37: Data included in the DfT Benchmarking Toolkit 2011

Factor	Revenue Expenditure	Capital Expenditure	Characteristics
Road safety - KSI	Highways maintenance planning policy and strategy	Roads (incl. structural maintenance), street lighting & road safety	Daytime population estimates
Road safety - Child KSI	Public and other transport planning policy and strategy	of which: New construction/improvement of roads	LA managed road traffic (million vehicle miles)
Congestion (average vehicle speeds)	Construction - roads and bridges	of which: Structural maintenance - principal roads	A road lengths (miles)
A road condition (roads where maintenance should be considered)	Structural maintenance - principal roads	of which: Structural maintenance - other LA roads	B+C road lengths (miles)
B&C road condition (roads where maintenance should be considered)	Structural maintenance - other Local Authority roads	of which: Expenditure on bridges	
Access to services	Structural maintenance - bridges	of which: Road safety	
Access to employment	Environmental safety and routine maintenance - principal roads	of which: Street lighting	
Bus & LR patronage	Environmental safety and routine maintenance	of which: Other	
Bus punctuality	Environmental safety and routine maintenance	Parking of vehicles (including car parks)	
School travel	Winter maintenance	Public passenger transport (GRFA) - Bus	
	Street lighting	Public passenger transport (GRFA) - rail & other	
	Congestion charging	Tolled road bridges, tunnels & ferries, public transport companies	
	Road safety education & safe routes	Local Authority ports and piers	
	Other traffic management	Airports	
	On-street parking	Total transport	
	Off-street parking		
	Concessionary fares		
	Support to operators - bus services		
	Support to operators - rail services		
	Support to operators - other		
	Public transport co-ordination		
	Airports harbours and toll facilities		
	Total highways and transport services		

Source: DfT, Benchmarking Toolkit 2011

As shown in Table 37, a considerable amount of cost, performance and characteristic data is produced for LTAs which should enable a detailed assessment of the performance and efficiency of local highway authorities – taking account of their inherent characteristics and performance. This data could be used to develop top-down benchmarks of construction and maintenance spending – albeit for road networks with different structure to Highways England. This could provide some indicative benchmarks for Highways England.

Other Local Authority data

As part of this study we have reviewed ongoing datasets produced by DfT and DCLG that cover local authorities and the road network. Data exists for various road network indicators including reliability, performance, condition, length as well as revenue and capital expenditure. These datasets are set out in detail in Table 38 and 39.

Table 38: Ongoing data produced by the DfT regarding Local Authority road networks

Table	Description
CGN0201a	■ Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads: by Local Authority in England, annually from 2006/07
CGN0201b	■ Average journey times (flow-weighted) during the weekday morning peak on locally managed 'A' roads: by Local Authority in England, annually from 2006/07
CGN0202	■ Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads: from 2011/12
CGN0203a	■ Average vehicle speeds (un-weighted) during the weekday morning peak on locally managed 'A' roads, by Local Authority in England: annually from 2006/07
CGN0203b	■ Average journey times (un-weighted) during the weekday morning peak on locally managed 'A' roads, by Local Authority in England: annually from 2006/07
CGN0204	■ Average vehicle speeds (un-weighted) during the weekday morning peak on locally managed 'A' roads: 2010/11
CGN0206a	■ Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads, by Local Authority in England: annual average from year ending July 2007
CGN0206b	■ Average journey times (flow-weighted) during the weekday morning peak on locally managed 'A' roads, byLocal Authority in England: annual average from year ending July 2007
RAS10014	■ Reported accidents by region, Local Authority and road class, England, 2014
RAS10015	■ Reported accidents by region, Local Authority, road surface condition and severity, England, 2014
RAS30038	■ Reported fatal casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average ■ Reported KSI casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average ■ Reported casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average
RAS30039	■ Reported fatal child casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average ■ Reported child KSI casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average

Table	Description
	■ Reported child casualties by region and Local Authority, England, 2010 - 2014 and 2005-09 average
RAS30040	■ Reported casualty rate per billion vehicle miles by Local Authority, England, 2010 - 2014 and 2005-09 average ■ Reported casualty rate per billion vehicle kilometres by Local Authority, England, 2010 - 2014 and 2005-09 average
RAS30043	■ Reported fatal casualties by region, Local Authority and road user type, England, 2014 ■ Reported KSI casualties by region, Local Authority and road user type, England, 2014 ■ Reported casualties by region, Local Authority and road user type, England, 2014
RAS30044	■ Reported KSI casualties by region, Local Authority and road user type, England, 2005-09 average ■ Reported casualties by region, Local Authority and road user type, England, 2005-09 average
RAS30045	■ Reported casualty rate per million population by region, Local Authority and road user type, England 2014
RAS30046	■ Reported fatal casualties by region, Local Authority, urban/rural and road class, England, 2014 ■ Reported KSI casualties by region, Local Authority, urban/rural and road class, England, 2014 ■ Reported casualties by region, Local Authority, urban/rural and road class, England, 2014
RDL0102	■ Total road length (miles) by road type and local authority in Great Britain, 2014 ■ Major road dual carriageway road length (miles) by road type and Local Authority in Great Britain, 2014
RDL0202	■ Total road length (kilometres) by road type and Local Authority in Great Britain, 2014 ■ Major road dual carriageway road length (kilometres) by road type and Local Authority in Great Britain, 2014
RDC0120	■ Principal and non-principal classified roads where maintenance should be considered, by Local Authority in England, 2007/08 to 2013/14
RDC0130	■ Percentage of unclassified roads where maintenance should be considered, by Local Authority in England, 2007/08 to 2013/14

Source: DfT, 2015

Table 39: Ongoing data produced by the DCLG regarding Local Authority road networks

Revenue Account Budget; Highways and Transport Services	Capital Expenditure Budget; Roads (incl. struct maint), Street lighting & Road safety
■ Transport planning, policy and strategy	■ Acquisition of land & existing buildings
■ Structural maintenance	■ New construction conversion & renovation
■ Environmental, safety and routine maintenance	■ Vehicles
■ Winter service	■ Plant machinery & equipment
■ Street lighting (including energy costs)	■ Intangible fixed assets
■ Traffic management and road safety: congestion charging	■ Total expenditure for capital purposes on fixed assets
■ Traffic management and road safety: traffic management - bus lane enforcement	■ Expenditure for capital purposes on grants
■ Traffic management and road safety: road safety education and safe routes (including school crossing patrols)	■ Expenditure for capital purposes on loans and other financial assistance
■ Traffic management and road safety: other	■ Total expenditure
■ Parking services	■ Sale & disposal of tangible fixed assets
■ Public transport: statutory concessionary fares	■ Sale of intangible assets
■ Public transport: discretionary concessionary fares	■ Repayments of grants, loans and other financial assistance
■ Public transport: support to operators	■ Total In-years receipts
■ Public transport: co-ordination	
■ Airports, harbours and toll facilities	
■ Total Highways and Transport Services	

Source: DCLG, 2015

This data provides further detailed information on various aspects of Local Authority road performance and could be used to support and develop the benchmarking tool highlighted in the Table 37.

Local Authority Major Transport Schemes

The DfT records a database of all the major transport schemes that Local Authorities are undertaking including detailed information on the costs and design of the projects.

Many of these are road schemes that relate to new build, widening or other enhancement projects. These may provide a useful source of benchmarking analysis for the Highways Monitor against projects Highways England is involved in – although the design and standards of the scheme need to be considered carefully. In most cases the schemes contained in this databased are also based on cost forecasts and therefore represent forecast rather than actual costs. The DfT also requires that these schemes have a monitoring and evaluation framework to understand how they perform once completed. Current Major Road Projects being undertaken by Local Authorities and part funded by the DfT are shown in the following list:

- Norwich Northern Distributor Road (NDR).

- A18-A180 Link.
- A45 South Bridge Replacement Scheme.
- A6182 White Rose Way.
- A4184 Evesham (Abbey) Bridge Major Maintenance Scheme.
- A164 Humber Bridge to Beverley Improvements.
- A684 Bedale-Aiskew-Leeming Bar Bypass.
- Bexhill to Hastings Link Road.
- A452 Chester Road.
- A43 Corby Link Road.
- Crewe Green Link Road.
- A380 South Devon Link Road (Kingskerswell Bypass).
- A58M Leeds Inner Ring Road (IRR) Highway Structures Maintenance Scheme.
- Nottingham Ring Road.

There are data held by the DfT on funded road schemes, including cost estimates, descriptions and detailed assessments of outcomes and economic benefits associated with local projects. This database could provide a useful source of benchmarking information for the Highways Monitor to understand and benchmark the costs of highway projects. Comparisons would need to take account of the diverse nature of the projects, but as LTAs are required to competitively bid for funding this may be a useful source of information to compare with Highways England.

2.7 Other data/ indicators

Value Added – ANAS

The Italian Road Authority ANAS records value added from the network in its annual accounts. This metric attempts to capture the economic value of the road network and is based on a variety of indicators. It appears to be based on the total value of three outcomes metrics; economic, environmental and social, which are each based on a variety of other indicators. These are shown in Figure 7. Unfortunately limited details are given on how this metric is calculated or the economic theory on which it is based (economic value, asset value etc.).

Figure 7: Components of ANAS value added metric

Economic outcomes

- Creation and distribution of value added to stakeholders.
- Economic and financial stability.
- New opportunities for private investments (project finance).

Environmental outcomes

- Direct and indirect environmental mitigation.
- Energy efficiency.
- Protection of biodiversity.
- Achieving White Paper goals.

Social outcomes

- Modernization of Italy.
- Quality and network safety increase.
- Staff development.
- Corruption prevention.

Source: ANAS, 2015

In principle this or a similar economic value metric could be developed by Highways England /Highways Monitor to place an indicative economic value on the activities and performance of Highways England and provide an overarching outcome measure to provide balance to the assessment of the organisations inputs – the net present value of its activities. In practise this may be quite complex to achieve as it would require developing shadow values for all of the organisation's

outcomes, which would require a range of assumptions and analysis. This would therefore be subject to a high degree of uncertainty.

World Economic Forum – Global Competitiveness Rankings

The World Economic Forum produces an annual report on the competitiveness of member states across 12 pillars – institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication and innovation. These pillars are assessed and compared separately across different countries based on a mix of an executive opinion survey and freely available data from the 144 members. The infrastructure pillar is based on several indicators including:

Questions (scored 1-7) related to:

- Quality of overall infrastructure.
- Quality of roads.
- Quality of railroad infrastructure.
- Quality of air transport infrastructure.
- Quality of electricity supply.

And quantitative indicators related to:

- Available airline seat km (airline seat km available on all flights originating in country).
- Mobile telephone subscriptions (number of mobile telephone subscriptions per 100 population).
- Fixed telephone lines (number of active fixed telephone lines per 100 population).

Within the infrastructure pillar is a ranking of quality of roads. The UK is currently ranked 30th out of 144 members on this metric. The report also considers other aspects of transport infrastructure, so it is possible to determine roads relative global position against other transport modes.

Executive opinion accounts for around 2/3rds of the position of this pillar and means that it is somewhat subjective in nature and may not reflect the opinion of all road users. However, these metrics may be a useful reference for the Highways Monitor to compare the performance of the road network at a high level, but the comparability of individual metrics needs to be treated with care.

The WEF Global Competitiveness Rankings provide a useful source of information to compare the overall performance of UK infrastructure against other countries based on a basket of high level indicators. One of these indicators is based on a survey of 'executives' overall satisfaction with the road network and could therefore be used to provide a high level indication of user satisfaction – although the methodology and reliability of the survey would need to be examined in more detail and there are likely to be some comparability issues especially given it is the UK rather than England that is being considered.

Treasury PPP contracts

In the expenditure/cost data described above we have referred to DBFO contract data held by Highways England/DfT for major road projects, which could be used to provide high level benchmarks of capital and maintenance costs for particular types of projects. HM Treasury holds similar data for over 700 separate PPP projects which could also be used to develop similar benchmarks for different types of project.

These include numerous road construction projects, but also road maintenance contracts for Sheffield, Birmingham, Hounslow and the Isle of Wight and numerous street lighting contracts. The database includes information on the scheme design, operation dates, unitary payments and capital costs and

could be used to derive high level benchmarks for Highways England's own projects. The contracts for highways maintenance and street lighting are likely to be particularly useful.

Appendix 3 Development of top-down benchmarking studies

3.1 Introduction

In this section we consider how the CEDR (2010) and OECD (Braconier et al, 2013) approaches could be developed to provide suitable top-down benchmarks for Highways England to inform the scope for catch-up efficiency. Catch-up efficiency measures the extent to which an organisation maintains and/or renews its road network at minimum cost given its road characteristics (such as network length, traffic and climate factors) as compared to the performance of other organisations. This ultimately feeds into the setting of an efficiency target over a control period. Of course the above interpretation could be broadened further to incorporate "outcome" measures (reflecting, for example, measures of availability, capacity and congestion); however, such an approach also raises issues about what is and is not in the control of Highways England, at least in the short-term.

Two studies are reviewed in depth. First, the BEXPRAC benchmarking study undertaken by Conference of European Directors of Roads (CEDR) (2010). This is a study which collected bespoke data from highways authorities in 13 participating counties with the view of comparing the performance of the highways authorities. The second study (Braconier et al, 2013) utilises data from international organisations (such as OECD) to try and determine the social efficiency of transport systems in each of the 32 countries considered. This has less direct relevance to the issue at hand and has substantial data issues and so the review primarily focuses on the BEXPRAC study. In informing our work we draw on parallels for our experience in international rail and domestic road benchmarking. We also discuss the CQC Efficiency Network involving Local Authorities and how the Highways Monitor and Highways England could make use of this for benchmarking Highways England.

3.2 BEXPRAC benchmarking study (CEDR, 2010)

The BEXPRAC study has been identified as an example of international benchmarking in this sector. It utilises bespoke data collected from National Road Authorities in 13 European countries in 2007. Data is collected on a number of cost items e.g. Routine maintenance expenditure and Preventative maintenance and rehabilitation expenditure, as well as a number of cost drivers including variables that characterise network size, network type, network usage, network condition/quality, environmental factors, network value and organisation structure.

In terms of the analysis undertaken, unit cost comparisons and some work to normalise costs between countries is considered (Appendix 3 of the report), however there is no attempt to model within a multiple cost driver efficiency model, such as mathematical programming or statistical techniques (e.g. corrected ordinary least squares or stochastic frontier analysis). The conclusion of the report is that while the approach is promising, there remain data barriers to providing comparisons which are considered by the authors of the BEXPRAC report to be substantive and not easy to overcome.

The key successes and limitations of the BEXPRAC work

The successes of the BEXPRAC work should not be underestimated:

- Facilitated 13 countries coming together for benchmarking purposes.
- Collected data on several cost categories and appears to have attempted to provide participants with guidance as to what activities fall within and outside these categories.
- Collected data on a number of cost drivers.
- Undertook unit cost analysis (and input/output ratio analysis) to try to quantify the extent of performance differences between countries.
- Backed up this top-down work with work looking at process reasons (i.e. reasons on the ground) why costs differ between countries.

The key limitations of the study relate to data. Both issues with respect to the consistency of cost data and data on some cost drivers (e.g. definition of lane km) are highlighted. This in turn limits the extent to which the results of the analysis are informative as it is not clear to what extent differences in performance are attributable to data inconsistencies or to genuine differences in performance. This issue affects all benchmarking studies. However the report does give the strong impression that such a concern is sufficiently strong in this study that its usefulness to the Highways Monitor is questionable.

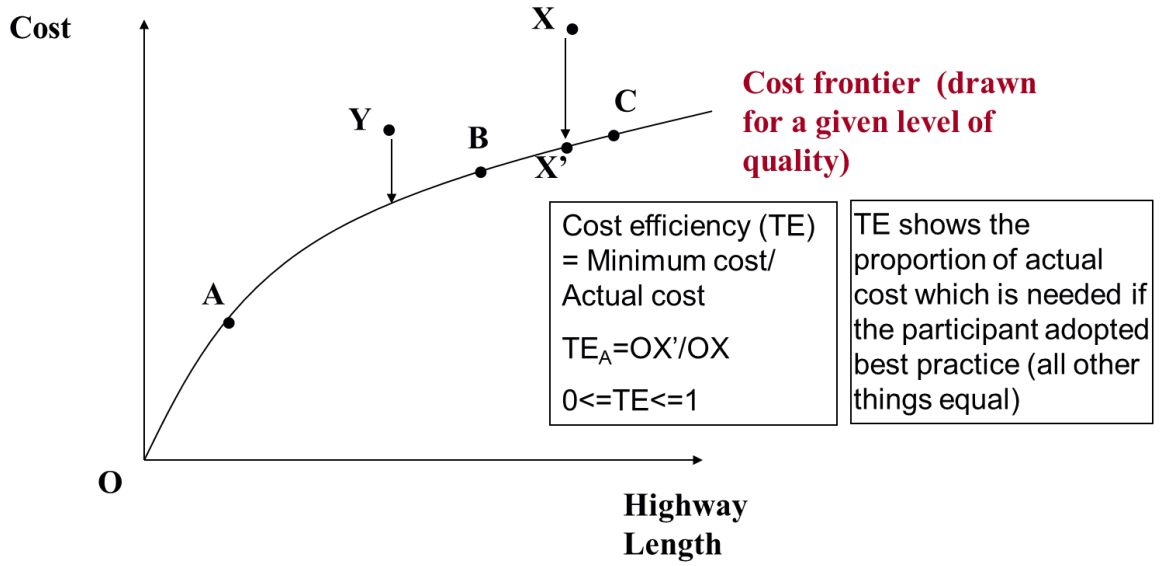
A further limitation that should not be overlooked is that the data collected only covered a single year. Since there are only 13 countries this is a major limitation in terms of the ability to carry out robust econometric or other work, unless panel data can subsequently be assembled.

The importance of the consistent cost data

It cannot be emphasised enough that cost data needs to be consistent across different participants. What this means is that costs must refer to the same activities and exclude the same definition of central overheads. Clearly there will always be a degree to which cost coverage differs between participants, however the more aligned costs are across participants, the less this is an issue. Given the importance of panel data in efficiency modelling, maintaining definitions over time is also important.

The reason for the need for consistent cost data can be shown by consideration as to how efficiency is measured from a conceptual perspective. Figure 8 shows a plot of highway length and cost of five hypothetical networks (a single cost driver is shown for illustrative purposes). The task of the analyst faced with cost data and a set of cost drivers is to determine the shape of the cost frontier (the line in Figure 8). This shows the minimum cost possible to provide a highway of a specific length holding the level of other cost drivers at some arbitrary hypothetical level (in practice the frontier represents the minimum cost relationship with respect to a number of cost drivers and not just highway length (e.g. also including the influence of traffic and environmental factors). Depending on the modelling strategy this frontier may be a straight line (as would be the case using unit cost comparisons) or more generally be a curve since there is generally a finding that there are economies/diseconomies of scale at different sizes of operations.

Figure 8: Illustration of cost efficiency



Once the frontier has been 'drawn' then (assuming it is a reasonable representation of reality) any country on the frontier is efficient i.e. it cannot reduce costs without compromising output and/or quality of output. A, B and C are on the frontier in this example and so are 'efficient'. If however countries are above the frontier line then they are producing their outputs (taking account also of the influence of traffic environmental factors etc.) at above minimum possible cost. As such they are 'inefficient' as they can lower cost without sacrificing output or quality, X and Y are inefficient.

All the above assumes that the points X and Y are plotted at the correct cost point, and the same for the frontier, as the measure of potential saving is the (vertical) distance from the cost point to the frontier. If cost definitions differ between countries then this distance will be over or under inflated and the results could be called into doubt.

Some methods do provide explicit allowance for the influence of "noise" in the cost data, notably stochastic frontier methods. However such methods are not without assumptions and predictions of inefficiency will have increasing uncertainty around them as the degree of noise increases. Thus comparability of cost data is essential for credible benchmarking.

Comparisons with work in railways and its context in regulation

Previous international rail benchmarking using International Union of Railways (UIC) data

There are interesting parallels between the CEDR work done for roads, and how the Highways Monitor may use this, as compared to work done by the International Union of Railways (UIC) in railways, and how that was used by ORR in the 2008 Periodic Review (PR08).

In short, UIC had developed a similar benchmarking club and had used the data to compute some simple unit cost measures and other KPIs. They had also carried out single-variable regression modelling work to establish harmonisation factors that were used to adjust unit costs to make them more comparable across networks (for example, adjusting them for differences in measures such as the degree of electrification). The cost data had been collected to a common set of definitions. Data was available for 13 countries and eleven years at the time of PR08.

However, the dataset had never been subject to econometric methods. UIC were interested in exploring the benefits offered by the econometric approach, as were ORR, given their need to set efficiency targets for Network Rail. UIC therefore agreed to supply the data to ITS Leeds (and ORR) on the basis that it could be used to set efficiency targets for Network Rail. The proviso was that the efficiency scores for other countries remained confidential.

This was, at the time, a successful approach. ORR used it as the main method to set efficiency targets for Network Rail at PR08. However, after 2008, Network Rail succeeded in raising doubts over the true comparability of the cost data. In addition, some other countries were uncomfortable with continuing to cooperate in using the data in a similar way because of the way it had been used before by ORR in the regulatory process. Thus this approach was relegated to being a cross-check against bottom-up methods in the 2013 Periodic Review, as opposed to being the main regulatory tool, as it was in 2008. It remained, nevertheless, one of the approaches used in the regulatory process. Of course, with a near-40% efficiency target already set for 10 years in 2008 and the gap closing steadily, there was less need in 2013 for top-down benchmarking. One issue that is relevant to the current project is that because Network Rail was/is a member of UIC, the ORR had to work through and with Network Rail when accessing data and holding discussions about data. As a result, ORR was only able to have limited visibility of the data issues raised post-2008 since, as a non-member, ORR was not able to attend relevant meetings with other members.

At first sight, the CEDR study sounds rather similar in many respects. There exists a dataset and a benchmarking club that has not yet been subject to econometric work and could potentially be used for regulatory purposes. That said, as yet there is no panel data, so new data would clearly need to be added to make this dataset amenable to econometric modelling.

Thus, there may be an opportunity to take the CEDR study forward in a similar way to the previous rail work with UIC. However, given the past experience that ORR had with rail, great care would be needed at the outset to ensure that similar problems did not emerge again. Having said that, the CEDR report contains so many strong statements about the non-comparability of the data that it does not seem appropriate for ORR to use this data, without further information about the data issues, as part of a benchmarking exercise. This position is very different from the UIC case where, at the time, it was considered that the data was good and had been collected to a common set of definitions. Further, there seem to be very strong statements about the fact that a large effort would be required to make the data comparable and that future analysis should focus on bottom-up work.

Thus, for the Highways Monitor, it seems that engagement with CEDR would be a useful starting point, but they would be embarking on a very long term exercise which may not yield very much in terms of top-down benchmarking results in the short-term. It is well recognised in the regulatory sphere that international benchmarking requires a long time frame in most cases. A further issue is that engagement by the Highways Monitor with road administrations raises issues of incentive-compatibility.

Previous international rail benchmarking: the ORR's "own" benchmarking club

In addition to the approach described in 3.2.3.1, in 2008 ORR (with ITS Leeds) also embarked on its own benchmarking exercise. This involved getting cooperation from several railways to collect data, as far as possible to a common definition. The innovation in this approach, apart from being a new regulator-driven approach, was that it involved the collection of regional data within each country, thus greatly increasing the number of observations for statistical analysis and also enabling a richer comparison of efficiency between and within railways. In principle it also offered greater scope to compare like-with like, by recognising the major differences that exist within countries (e.g. between London and the South East and Scotland).

This approach was successful in that it formed part of the evidence base during the 2008 Periodic Review and it corroborated the results of the main study using the UIC data. Detailed one-to-one face-to-face discussions occurred about data definitions and all participants also met together in London. Having said that, it was not considered that all data definition issues had been resolved.

This work was subsequently developed further and used again as supporting evidence in 2013. The issues that emerged were as follows:

1. Maintaining commitment over time proved difficult as the staff involved in the work changed jobs.
2. The investment and commitment from both sides to address the data issues were not trivial.
3. There was an imbalance in the approach in that there was a British regulator working with overseas railways – and it was the regulator that was funding the approach. Clearly the objectives of the regulator and the other firms may well be different.
4. Whilst data definitions around costs did vary, in some cases these were small and could be dealt with. However, this is clearly a complex area so caution is needed.

Summary remarks

ORR has found it possible to use international benchmarking in rail but it is not straightforward. A key lesson may be that involvement from other regulatory bodies or funding bodies (i.e. the organisation responsible for setting efficiency targets for the railway undertaking) would in principle be a better group to make contact with in order to retain the focus on top-down benchmarking (though there are other models – see below for the discussion on CQC). In the rail approach, ORR was interacting with railway undertakings, and therefore had very different aims and incentives. That said, progress was made and some useful results obtained. It would be worth interviewing staff within ORR involved with international benchmarking and other benchmarking of Network Rail, as the above discussion does not take account of any work that may have been ongoing since 2013. In general ORR we believe has placed greater onus on Network Rail to do benchmarking and the shift has moved to

bottom-up work. However, that partly reflects the degree of maturity of the benchmarking process and the narrowing of the efficiency gap over time.

A further important point is that looking at regional or section-based disaggregation is useful, given the substantial differences that exist within countries.

How international benchmarking compares to national and internal benchmarking

Before proceeding to discuss how international benchmarking could be developed into the future, it is important to note that there are other ways to (top-down) benchmark Highways England. Firstly, instead of international comparators, comparators within England or in other nations comprising the UK could be sought. Thus Highways England could be benchmarked against Local Authority highway departments in England and/or TfL. It could also be benchmarked against the Wales, Scottish and/or Northern Irish strategic highway authorities. Secondly, there could also be analysis using regional data inside Highways England, which implies internal benchmarking.

To contrast the approaches, first consider that international benchmarking provides an opportunity to benchmark Highways England against an international frontier. In contrast internal benchmarking can only be measure performance relative to the best performing zone within Highways England, whilst 'national' benchmarking only compares Highways England to the best performing strategic highway authority in the UK. Thus international benchmarking is likely to yield the greatest scope for improvement, all other things equal.

However, getting consistent and good quality data across international collaborators can be problematic (as noted in the BEXPRAC study). Internal and to some extent, national benchmarking exercises tend to be able to collect data which is more consistent across comparators (the obvious reason in the internal case is that data is coming from the same company). In addition the (non-efficiency related) differences between zones in internal benchmarking could be easier to identify, in contrast to national and international comparators where there may be more 'heterogeneity' between them. Ideally such heterogeneity will be incorporated into models by collecting variables that characterise the differences (observed heterogeneity), or in the case of stochastic frontier modelling, using statistical methods to isolate efficiency from unobserved heterogeneity (although this is not without assumptions and requires multiple time periods to be observed). This issue may be of particular importance when using national benchmarks as many Local Authorities are quite different to Highways England and other UK nations have a highway network of quite different composition to Highways England. Finally in international benchmarking and national benchmarking, the regulator only has direct authority over one of the participating companies. This may present difficulties in terms of control of the benchmarking process both in terms of timescales and in terms of data quality assurance.

Overall, international benchmarking is undoubtedly ambitious and the results will always have to be interpreted with caution given the difficulty in data collection and consistency verification. However it does provide an opportunity to benchmark Highways England against an international frontier rather than national or internal comparators. At the current stage of development of the benchmarking framework, it would be useful to explore international benchmarking in parallel with developing national level benchmarking (e.g. comparing with other Local Authority or other UK nations) and internal benchmarking (comparing zones within Highways England). Such an approach will act to mitigate the risk that one set of comparators may not provide suitable comparators.

A possible way to develop the BEXPRAC into a robust top-down efficiency analysis: the CQC Efficiency Network approach

The BEXPRAC initiative is a good example of a set of international organisations coming together to attempt to learn from one another. It potentially provides for a readymade list of 'willing' contacts to develop a more robust comparison framework which would stand up to regulatory scrutiny.

Overall, it is the conclusion of the BEXPRAC report that it is the comparability of data that is the limiting factor in using this work as robust top-down benchmarking. As such any subsequent development must address this issue. It does appear that work is ongoing by the group behind BEXPRAC to continue the work on data collection in terms of the cost drivers, for example (CEDR, 2013). However it is unclear that work is continuing regarding development of costs (which is where the key limits in the data were identified).

A potential approach going forward is with reference to the CQC Efficiency Network. This network involves top-down cost benchmarking of participating Local Authorities. The issue of cost data comparability between LAs is considered to be a major issue and as such much effort has been directed at improving this aspect of the data collection. As such the following steps are a suggestion as to how the BEXPRAC analysis could be developed based on the process followed in the CQC Efficiency Network:

1. Initial approach to each country contacts to gauge interest in restabilising the benchmarking activity. Follow-ups as appropriate. It will be important to agree the extent to which data and results (in particular efficiency scores and rankings) need to be kept confidential as this is critical to maintain countries involvement in the exercise.
2. Meeting with the group of interested country contacts to discuss the way forward. Specific attention to developing discussions on data comparability issues, particularly cost data, as well as identifying any further explanatory variables/verify that the existing variables are appropriate.
3. Formation of a working group of contacts from, for example, three or four countries to discuss finer details of composition of costs under each category. The aim is to develop a description of each cost category which clearly defines the coverage of applicable cost elements. Some suggestions for refinement of the cost definitions are given in Appendix 5 of the BEXPRAC report.
4. Collect data from participants based on a proforma. Include both space for a quantitative response but also for a qualitative response. In particular the qualitative response is so that participants can indicate any non-conformities in the definition of costs (or other variables) that their country can provide with that requested. This can be very useful in interpreting the efficiency measures resulting from the modelling as well as informing changes to data definitions in subsequent iterations.
5. Analysis of data using appropriate methods e.g. COLS/SFA or DEA.
6. Discussion with participants.
7. Reanalyse the data as appropriate.
8. Perform a set of process benchmarking case studies drawing on the best performers identified in the top-down analysis to provide tangible "on the ground" reasons for the differences between participants.
9. Return to step 2 and repeat on, for example, an annual basis. This allows for both more years of data to be collecting (establishing a panel or enhancing an existing panel dataset) and also to revisit issues of data comparability identified within the previous iteration.

Ultimately, the above approach is aimed at resulting in incremental improvements over time, as well as increasing the number of observations over time (by collecting multiple years of data). This requires a number of iterations with participants, which in turn requires maintenance of their interest in the work over a sustained period of time. As noted above it is important not to underestimate the scale of the challenge to obtain comparable data that would stand up in a regulatory setting.

One limitation of top-down benchmarking from an engagement perspective is that it is aimed at quantifying the extent of a 'gap' and thus providing an estimate of the extent to which a participant has the opportunity to make a saving. However, it does not indicate why there is a gap in terms of what processes are different in one organisation vis-à-vis another which in turn results in the gap. Continuing the case study type (bottom-up) analysis in the BEXPRAC study (see section 4.5) may be a useful vehicle to maintain interest in the work as it helps illustrate what is driving the 'gap'. The CQC approach tries to link the results from the top-down analysis (the best performers) with the process analysis and thus in turn provides a clear reasoning for the top-down work in the first place.

Appropriate cost drivers (explanatory variables)

The BEXPRAC work collected data on a number of cost driving variables, detailed in Table 40). Many will be useful in top-down cost benchmarking. Economic theory (under the assumption of cost minimisation at the efficient frontier) states that costs are driven by the level of outputs produced and the input prices faced by a firm. In reality many firms and particularly infrastructure firms produce many different outputs, so numerous that it is difficult to imagine that 'full' data could be collected or analysed (e.g. every km of road is different). As such it is useful to consider a broad measure of output (here road km or road km by type) and then collect variables which characterise the key features of these variables such as traffic (usage), structures and quality and condition indicators. Further, there are also levels of fixed factors of production, such as 'Environmental factors' which drive cost and should be included. Overall the cost drivers in the BEXPRAC study do attempt to characterise output in this way. Clearly they could be improved, but at this stage of development it is probably more important that any data request is manageable to participants and if this data is available then it is an obvious candidate to be collected again (noting that the BEXPRAC report does consider there to be unresolved issues in definitions of some of the variables across countries). Indeed the list of variables in Table 40 seems comparable and indeed favourable to those available for other benchmarking studies that we have been involved in.

However what is missing are measures of the differences in input prices faced by countries. The exclusion of such measures is not uncommon in top-down benchmarking since the input price (index) ideally needs to relate to the infrastructure manager rather than the sector or country. So an index of travel costs by road is not appropriate, instead the price indexes refer to the inputs to the maintenance and renewal process of the infrastructure manager (such as raw material costs, labour costs). This is usually difficult to collect, but such collection should be borne in mind if opportunities present. Use of a Purchasing Power Parity (PPP) exchange rate might partly address this issue, though it is imperfect.

Table 40: Cost drivers collected in the BEXPRAC study

Cost driver characteristic	Example variables
Network size	Total km
	Breakdown by type of road (4 lane, 3 lane, 2 lane, 1 lane etc.)
Network type	Number/length of bridges
	Number/length of tunnels
Network usage	AADT
	% HGVs
Network condition/quality	% of network in need of maintenance
	User satisfaction
Environmental factors	number of days per year when the temperature falls below 0
Network value	Depreciated value of network assets
Organisation structure	Employees
	Central support (HQ) costs

Source: CEDR, 2010

Appropriate methods for analysis

The broad methods of top-down analysis range from the unit cost type work undertaken in the BEXPRAC work, to studies which provide explicit modelling of efficient costs and then quantify the distance (in £s) between the infrastructure managers. These include Data Envelopment Analysis, as well as Corrected Ordinary Least Squares and Stochastic Frontier Analysis. The exact appropriate

technique depends on the characteristics and quality of the data. However the more advanced efficiency methods (DEA/COLS/SFA) do have the advantage that they provide efficiency scores i.e. a measure of the gap, which is ultimately needed for economic regulation. Unit cost measures have the difficulty of giving different answers depending on what cost drivers are used in the computation, while multiple normalisations introduce a degree of arbitrariness into the process. In contrast DEA/COLS/SFA are data driven and so remove (to some extent) arbitrariness and additional evidence as to the uncertainty associated with individual efficiency predictions (for a given highway authority) can be presented alongside the headline number. One big advantage of the econometric approach, over DEA, is that it provides information on the elasticity of cost with respect to different cost drivers; further, these can be sense-checked from an engineering perspective, in order to improve confidence in the modelling approach.

We discussed an approach to collect further data through an iterative process. As well as providing a process to address data comparability issues, this also allows the collection of multiple data points for each participant over time. This forms a panel dataset. Panel data could be very important here. Firstly, there are only 13 participants and this may be considered a maximum for further analysis, since all 13 are not guaranteed to be willing to take the approach forward. Clearly 13 observations is a very small number of observations to hope to provide robust cost models and thus performance benchmarks. As such multiple years dramatically increases the size of the dataset for analysis. Secondly, there exists an established set of econometric models which utilise the panel data structure to better decompose efficiency from the influence of omitted but time invariant factors (such as missing data on climate for example). Thus there are clear benefits from further data collection in addition to the yielding better data comparability through alignment of definitions, if such efforts yield a panel.

The model reported in Appendix 6 of the BEXPRAC report

Appendix 6 of the BEXPRAC report does contain a model which provides a cost expression for each sub-cost category. Unfortunately due to lack of details in the documentation it is difficult to be sure whether this model has promise. It does not seem possible that it is a statistical model, given the number of data points (13), although it could possibly be a set of single variable regression models with 13 observations (though the rounding associated with the coefficients suggests some ex post adjustment if this is the case). This type of single-variable regression approach was used in the UIC rail benchmarking work to create harmonisation factors.

Alternatively, the approach could be based on engineering judgement; if so, that limits its usefulness considerably, unless there is a way of agreeing the judgements. Indeed, this discussion emphasises the critical issue, which is that some evidence for the cost impact (elasticities) of these variables is needed – and top-down techniques provide a source of such evidence.

Appendix 6 of the BEXPRAC report offers some promise perhaps but ultimately the model must either be econometric, in which case more and better data is needed, and if not, then it is important to understand whether established engineering rules have been used. Clearly additional information on this modelling approach is needed and would be useful.

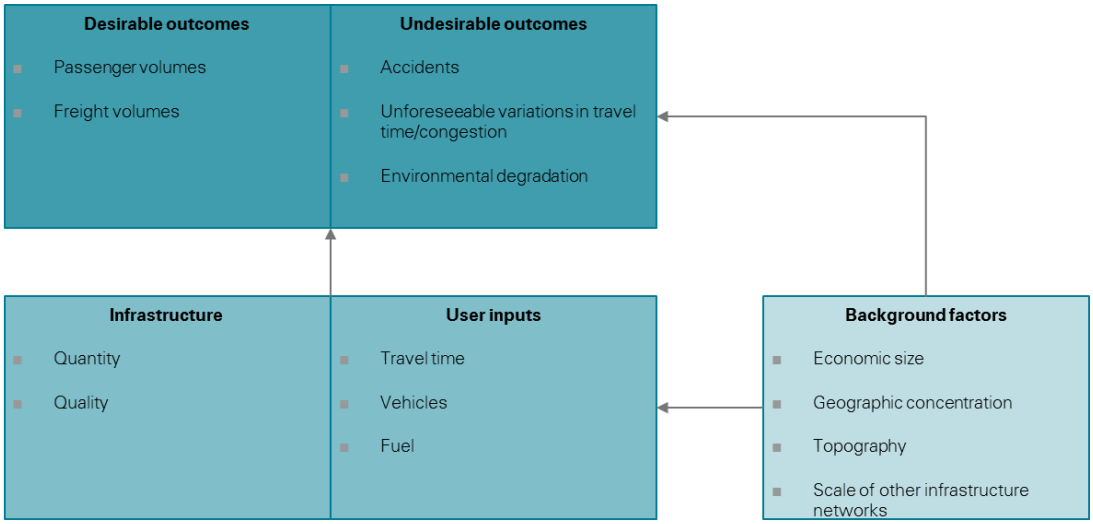
The BEXPRAC report also hypothesises that a further study may yield a model (similar to that in Appendix 6) which can predict costs within +/- 20%, as opposed to +/-40% at present (evaluated over the 13 countries. This sounds reasonably positive in the context of international benchmarking, though it is not totally clear what this means. Firstly, if all the parameters (the numbers) in Appendix 6 can be adjusted, then from a purely data fitting perspective there is no reason why there cannot be a perfect fit, as there are 13 data points and over 13 parameters to vary. Clearly such parameter values may not be plausible but it does illustrate the arbitrariness of using a large model to fit a small number of data points. Secondly, if there is a large efficiency gap then there would be a large prediction error even if the model was perfect. The big issue is always whether prediction error is inefficiency or omitted factors.

3.3 OECD Study (Braconier et al, 2013)

Objective of the study

This study is aimed at measuring "*the social efficiency of the road transport sector, including non-market inputs – such as travel time – and negative outputs – such as accidents and emissions*" (Braconier et al, 2013, p.2). The framework that is developed in the report to analyse road transport infrastructure is summarised by Figure 9.

Figure 9: A framework for analysing road transport infrastructure performance



Source: Braconier et al (2013, p12)

On first inspection this framework is interesting as it incorporates user inputs as well as the infrastructure inputs into the assessment. Thus social efficiency refers to the extent that the desirable outputs are maximised for a given set of inputs (and undesirable outputs). Or alternatively social efficiency is the extent to which inputs (and undesirable outputs) are minimised for a given output.

The data was sourced from 32 OECD countries. It seems that panel data was used as Appendix 3 in the report indicates that data from 2001 to the last available year (presumably for each country) was used. Inspection of the data description tables in Appendix 3 suggests that this is up to 2008 (based on the road length data availability).

The DEA study in practice

Data Envelopment Analysis is used to compute efficiency scores in this study. However as stated the base line model includes three inputs: namely number of motor vehicles, length of road network and energy consumption, one undesirable output: road injuries, and two desirable outputs: passenger and freight traffic. As such infrastructure costs do not feature in the DEA models reported[10].

[10] P. 32-33 of Braconier et al (2013) discuss potential savings for each country based on maintenance and investment expenditure (expressed as a % of GDP). The notes to Figure 4.7 in the report seem to indicate that this is computed as the GDP proportion which is highways maintenance and investment expenditure multiplied by the % efficiency saving (1-efficiency score). Given the other documentation we still believe that maintenance and investment expenditure is not in the DEA model, although this to some extent this is a judgement. However, and more importantly, it is unclear to which this potential saving could ever be realised by the highways infrastructure manager in practice.

Further there is discussion in the main report body that infrastructure costs are dwarfed by user costs. This raises an important consideration as to whether such costs will ever have a major impact on this measure of efficiency. Finally we note that the confidence intervals for the efficiency scores are relatively large potentially indicating data consistency or sample size issues.

Applicability to regulation of Highways England

This study aims to understand at a high level whether the overall provision of roads is optimal. This question is however more broad than that faced in economic regulation of an infrastructure manager. At its simplest level RPI-X regulation aims at encouraging an infrastructure manager to produce a given set of outputs at minimum costs. As such outputs tend to be fixed or at least set by policy makers, as are user inputs (e.g. congestion target). Given the empirical observation that infrastructure costs are a small proportion of all input costs (i.e. the sum of user and infrastructure) then in its current form it is doubtful the analysis could be used for benchmarking Highways England. That said, the regulatory framework could be broadened to focus on outcome measures, though this increases the complexity and also raises issues as to what Highways England can actually control in practice.

However, that is not to say that the data could not be used for benchmarking Highways England in the future. This however depends on the quality of the data and how comparable it is across countries. This should be investigated further. However the comment in the abstract of the paper that "*Data issues in terms of availability, quality and comparability are significant, and the empirical results have to be interpreted with caution*" (Braconier et al, 2013 p. 3) indicate there are several known issues already with the data, Appendix A of the report provides more information on data issues.

3.4 CQC study – The efficiency of highways authorities in England

The CQC Efficiency Network is administered by Measure 2 Improve and the University of Leeds. Currently, it has 64 Local Authority members. The Network launched in April 2015, having previously been funded for two pilot studies through HMEP. The most recent stakeholder report (from the second pilot study) is reviewed in the main body of this report (Wheat, 2015).

CQC is an abbreviation for Cost, Quality, Customer, and reflects the aspiration of the work to simultaneously control for the influence of cost of both physical cost drivers (such as length of roads, type of road etc.) but also for the quality of the outturn product (the quality of the network) and how the network is perceived by the public (through use of survey satisfaction measures).

As well as quantifying the opportunity for cost savings (cost efficiency), the network also aims to provide participants with tools to allow them to examine the cost impact of changing the scale of operation (such as merging highway functions across authorities) and the impact of changing the quality of output. Further the analysis aims to provide authorities with a list of peer authorities so that they can network with them to understand the reasons for differing performance. This in turn will be complemented by case study type work by the network to understand performance differences in general.

The CQC efficiency network is a collaborative body and engagement is predicated on the anonymity of data and confidential analysis of results for each stakeholder. The Highways Monitor needs to be aware of the potential conflicts of interest this could involve should this information be used for regulatory purposes. In particular the CQC Efficiency Network is aiming to enable Local Authorities to improve through providing information on the potential opportunities for cost saving and highlighting best practice rather than forcing authorities to adopt specific cost saving targets. There is a danger that the Highways Monitor could undermine this approach if it attempts to force the work in a different direction.

It may be more appropriate for Highways England to join the organisation independently of the Highways Monitor, as doing so maintains the collaborative nature of the work. Highways England would have knowledge of its own efficiency score from the analysis, and could also utilise the CQC efficiency network to identify and build relationships with comparator authorities to help develop more bottom-up process type comparisons.

To aid comparability of Highways England with Local Authorities and reflect the management structure of Highways England, it may be beneficial if Highways England joined the network as several regions rather than one entity. An element of the CQC work is the use of public satisfaction data as an explanatory variable of cost (to reflect the quality of output perceived by users). We do not believe that such data is currently available for Highways England and such data could be collected in collaboration with the NHT who administer the relevant survey for Local Authorities.

3.5 Summary

This review has considered how studies can be developed to provide top-down evidence as to the catch up efficiency of Highways England. Two of the studies attempt international benchmarking. International benchmarking does present unique challenges in terms of how to facilitate the collection of consistent data for a variety of countries whose organisations are very different. In addition the regulatory environment in each country may be very different which presents challenges to incentivise parties to work positively and over time with such exercises. However, the potential benefit of international benchmarking, namely the ability to compare Highways England to an international best practice frontier is a positive goal and so it is suggested that international benchmarking be developed over time.

It is important to recognise that this will potentially be a long term venture as data quality (and panel dataset length) are likely to improve with time. Given this potential time lag, and indeed the risks associated with maintaining participation, it is suggested that international benchmarking is taken forward alongside other internal or national benchmarking exercises, as well as bottom-up benchmarking.

In terms of facilitating international benchmarking, it is important to consider how to keep parties incentivised to continually participate. Some suggestions are contained under 3.2 in this Appendix. However given ORR's previous experience in international benchmarking in the railway context, a consultation exercise with the railway team in ORR may be appropriate to learn from past experience.

In terms of developing the specific studies, both show promise with particular recognition to the BEXPRAC study which attempted to collect bespoke data from participants. The key limiting factor is however data, both in terms of number of observations but quality and comparability of data across time. Any development work will need to address these data issues.

Appendix 4 Framework for performance and efficiency

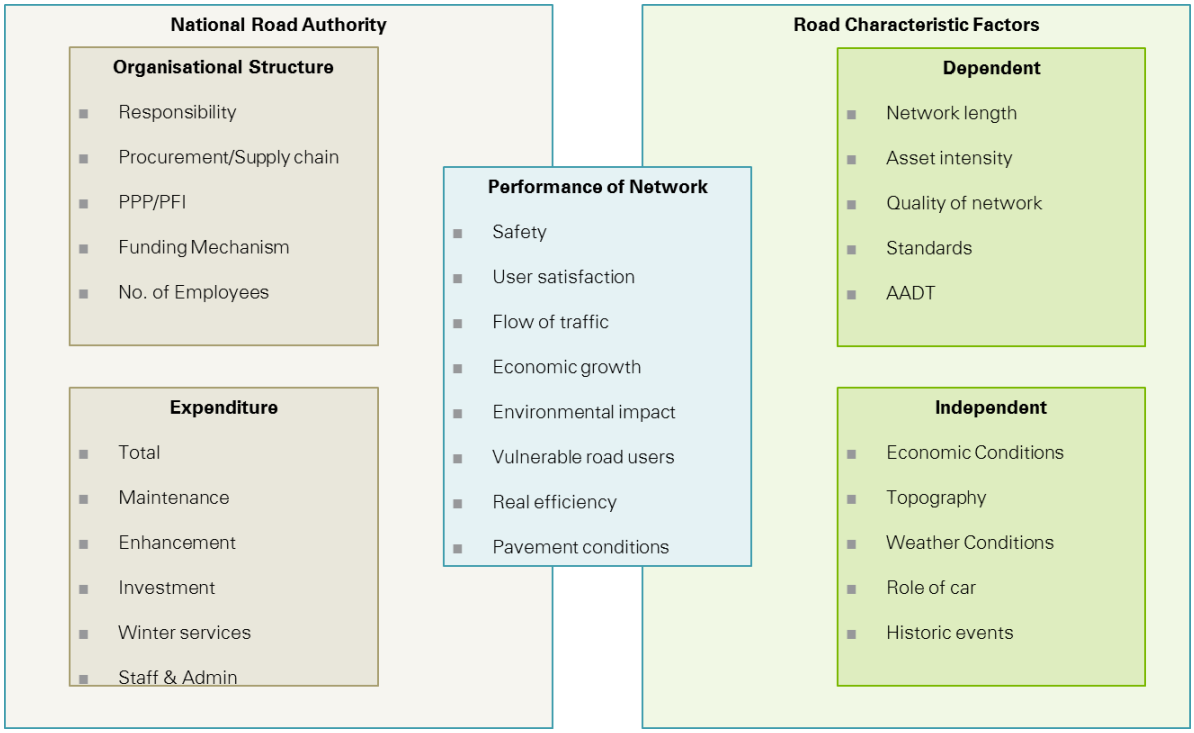
Regulatory Framework

International benchmarking of the efficiency and performance of a road network or NRA is difficult for several reasons:

- Road networks have different characteristics which can affect costs and performance in uncontrollable ways – including the design standards, levels of traffic, weather, number of assets and density of the network to name a few.
- Countries have different characteristics including input costs, legal frameworks, administrative geography and standards for vehicle and driver licencing which can all influence the performance of the road network.
- NRAs are structured in different ways with different responsibilities and roles and method of procurement which affect their performance and expenditure. Organisations also often have different accounting methods and definitions which can further complicate analysis – for example related to different levels of outsourcing.

In order to use benchmarking analysis to make an assessment of the performance gap. Ideally each of these factors needs to be understood and accounted for. In practice this can be quite difficult but the first step in this process is the development of a theoretical framework to understand the issues and how they impact on performance and efficiency. A potential framework is illustrated in Figure 10.

Figure 10: Potential framework to analyse road infrastructure efficiency



Source: KPMG Analysis, 2015

This draft framework was developed based on input from the RIS as well as other sources that were reviewed throughout the project, notably the BEXPRAC (CEDR, 2010) and OECD (Braconier et al, 2013) studies. In our framework we have considered four aspects that impact performance of the network considering NRA specific features and road characteristic specific features.

1. National Road Authority Factors

a. **Organisational Structure** – The organisational structure is important in establishing efficiency as it sets out the responsibility, strategy and approach undertaken by the NRA in delivering against its objectives. NRAs are known to have multiple organisational structures with correspondingly different mandates. NRAs usage of in-house or outsourcing varies and this has an impact on cost allocation. The procurement strategy and the inclusion in contracts of performance, roles and responsibilities and flexibility metrics can all have an impact. In terms of activities such as traffic management, maintenance determination, winter services and maintenance mitigation, all of these can influence the outcomes on the network.

b. **Expenditure** – Categorised into maintenance, enhancements, investments and organisational. The total spend and the relative allocation of funding across the different categories is likely to be dependent on a mix of funding allocation and lifecycle of the network. On top of this there is expenditure on organisational structure such as staff, administration and other. Different types of expenditure have different time impacts meaning expenditure in one period is likely to impact on performance in subsequent periods. In general aspects that are likely to influence expenditure are proportionate number of lanes, traffic levels and complexity of the network.

2. Road Characteristics Factors

a. **Dependent** – These characteristics are likely to be driven by independent factors as well as investment in the network over time. Asset intensity for example is likely to be influenced by both topography and investment spend, and will likely influence ongoing maintenance costs. Other factors such as quality of network, standards and AADT are also all likely to be influenced by inputs and characteristics as well as having an impact on expenditure.

b. **Independent** – These factors are likely to impact on the inputs into road network though are unlikely to be directly affected by it. The weather for example may create delays or require increased winter maintenance spend on the network. The topography of the land may require more assets, require longer routes or prevent travel. Economic conditions are likely to impact travel demand. On top of this a number of routes are based on decisions taken decades if not centuries ago, which may not necessarily mean the network is as efficiently laid out as possible. These are important to understand and account for to some degree as they cannot be changed but may still play a role in efficiency and performance.

Only by reviewing the network in relation to different factors and characteristics will benchmarking allow for determining the efficiency of the network. These factors must also be reviewed across time as a change in input may take many years to influence performance. By benchmarking specific factors as well it is likely to encourage certain incentives and behaviours, which needs to be understood and accounted for.

The Highways Monitor will need to consider and decide what it considers important and ensure the benchmarking is undertaken in such a way as to prevent perverse incentives. For instance benchmarking maintenance per km may encourage the reduction in spending, which could be due to efficiency gains or it could be due to not undertaking activities which are importance for the long term performance of the network. The framework also needs to consider the time periods it is reviewing, with trade-offs between ensuring long term performance and encouraging short term efficiency.

Appendix 5 Benchmarking framework

In this Appendix we provide some suggestions for how the benchmark metrics highlighted by the Highways Monitor could be expanded and developed as part of the performance and efficiency framework. Table 41 provides some possible indicators that could be used by the Highways Monitor with some commentary on the availability of data and the metrics that could be used.

Table 41: Asset Management Expenditure Maintenance

Category	Variable	Comments	Data	Measures
Asset maintenance– routine & cyclical maintenance Maintain a safe network	Grass cutting	Part of lump sum duty for Highways England, data likely not to be available.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£/km – The approach adopted by Highways England risk based, costs may not be directly comparable.
	Bulk lamp change	Part of lump sum duty for Highways England, data likely not to be available. Move to LED lighting will reduce long term costs.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£/lighting columns. This is a cyclical activity, Highways England approach is risked based so may provide an unreliable measure.
	Cleaning including signs	Part of lump sum duty for Highways England, data likely not to be available.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£/km - Routine maintenance costs risk based.
	Repair safety fencing	Will be damaged mostly by traffic and requires emergency repair.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£/km
	Patching	Normally as part of emergency response or patching pothole. Costs normally part of lump sum duty.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£lane/km – measure will provide reliability of the condition and safety of the network.
Asset maintenance expenditure (reactive maintenance) Maintain a serviceable network	Filter drain replacement	Normally would be undertaken as separate scheme so could be benchmarked.	Likely to be undertaken as part of a renewal scheme so data should be available	£/km of filter drain there is a significant amount of filter drains so it would be more.
	Soft estate management	Normally be lump sum duty benchmarking would be difficult.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities but likely to be unreliable.	£/cost of landscape area.
	Cleaning drainage gullies	Normally undertaken on a cyclical or risk based approach	Data difficult to obtain as not broken down in current Highways England	£/km length per km will account for risk based approach adopted by Highways

Category	Variable	Comments	Data	Measures
			contracts. Could obtain from other road authorities but likely to be unreliable.	England as not all gullies will be cleaned.
	Repairing potholes	Not available as part of an ongoing dataset.	Data difficult to obtain as not broken down in current Highways England contracts. Could obtain from other road authorities, likely to have a reasonable level of confidence.	£/potholes repaired per km.
	Refreshing white lines	Normally undertaken on a cyclical or risk based approach.	Data should be obtained if it is undertaken as part of a separate scheme. Should be available from other road authorities.	£/lane km
	Repair safety fencing	Will be damaged mostly by traffic and will require emergency repair.	Likely to be undertake as part of carriageway resurfacing. Otherwise may be part of cyclical maintenance and costs would be difficult to obtain.	£/km
Asset management expenditure – renewal	Carriageway resurfacing	Lanes will be resurfaced separately. This measure should apply to surface course only (40mm).	Cost data should be readily available. Structures inventory should also be available.	£lane/lm
	Carriageway replacement	This is for deeper treatments and includes the surface course and binder course up to 150mm.	Cost data should be readily available. Structures inventory should also be available	£lane/km
	Waterproof replacement	This is undertaken infrequently for structures but has a major impact on traffic flow.	Cost data should be readily available. Structures inventory should also be available	£/structures
	Parapet replacement	This is undertaken infrequently and may cause traffic damage.	Cost data should be readily available. Structures inventory should also be available	£/structures
	Bridge joint replacement	This is undertaken infrequently for structures but has a major impact on traffic flow.	Cost data should be readily available. Structures inventory should also be available	£/structures
	Electronic traffic equipment	This is undertaken on a cyclical basis.	Cost data should be readily available	£/lane km
Operating expenditure	Network control centres	These primarily comprise technology and staffing. After the initial development is likely to be one off cost.	Most strategic road authorities operate control centres. The measure needs to be network wide.	£/km

Category	Variable	Comments	Data	Measures
	Precautionary treatments	The amount of salt spread may vary and this measure is inclusive. It may be difficult to compare with other climatic zones and where different policies exist. There is an investment from Highways England on the winter fleet which will not be included. The maintenance of the fleet will be.	Cost data should be readily available. It will include different rates of spread and also maintenance of the fleet.	£lane/km
	Energy costs	Energy and it procurement is a major cost for Highways England.	Cost data should be readily available.	£cost/km
	Traffic officer service	Undertaken for the motorway network only. As it is a unique service will be difficult to compare.	Cost data should be available.	£cost/km
Network enhancements	Construction of new roads	Outturn cost of RIS scheme.	Cost data will be available.	£cost/lane km
	Widening of existing roads	Outturn cost of RIS scheme.	Cost data will be available.	£ cost /lane km
	Construction of SMART motorways	Outturn cost of RIS scheme.	Cost data will be available.	£ cost /lane km
	Junction improvements	Some data from DBFO + Non Highways England Projects Review.	Cost data will be available.	£ cost / scheme
Support expenditure	Human resources expenditure	Not available as part of an ongoing dataset. However should be available from end of year accounts.	Cost data will be available.	£ cost / FTE or £/km
	I.T. services	Not available as part of an ongoing dataset. Licencing agreements should be captured in the accounts but will not include contractors systems.	Cost data will be available.	£cost / FTE or £/km
	Financial services	Not available as part of an ongoing dataset.	Cost of support.	£ cost / FTE or £/km
	Technical support	Not available as part of an ongoing dataset.	Cost of support.	£ cost / FTE or £/km
	Total staffing costs	Some data from NRA Financial Accounts.	Cost data will be available.	£ cost / FTE or £/km

Source: KPMG Analysis, 2015

The data in Table 41 is indicative of what could be measured using bottom-up data. However the way routine maintenance tends to be contracted by Highways England has resulted in reactive, routine and cyclical maintenance being specified in the Trunk Road Maintenance Manual (TRMM) and the Asset Maintenance Operations Requirements (AMOR). TRMM was prescriptive and the AMOR is risk based. Therefore the data is unlikely to be available in a comparable format and other components of cost – such as traffic management may be included in the costs.

Consequently it is difficult to benchmark the cost of any one activity as they tend to be priced as part of a lump sum or risk based specification. It is common for most contractors to base their pricing on numbers of depots and staff to run winter routes. Using this as a common basis for resource the price of the other maintenance activities are determined. Routine maintenance therefore can be benchmarked most simply by determining the lump sum payments to the maintenance contractors per lane km.

On the whole reliable data may be obtained from bottom-up measures that would be broadly comparable. There are a number of measures which this data would need to be compared against. In particular there is currently no indicators other than pavements that could be used to measure asset condition. In order to reliably measure asset renewal expenditure these would be required for structures, drainage, electronic traffic equipment and lighting. Net Present Value can also be used to determine the long term cost of the programme the expenditure is being benchmarked for.

On the whole reliable data can be obtained for all the measures above. These may be compared against the operational performance measures in Table 42. Support expenditure will vary according to the model that Highways England use. Insourcing as the Area 7 model will increase Highways England staffing costs when compared to HA. However it will also reduce the maintenance expenditure. It may therefore be useful to look at the total number of staff employed in the supply chain for relevant activities, rather than just for Highways England. This data may however be difficult to obtain from the supply chain.

Table 42: Factors affecting benchmark comparisons

Indicator	Factor affecting comparisons
Asset maintenance – routine & cyclical maintenance **Maintain a safe and serviceable network**	Accident rate
	Cost of 3rd part claims
	User satisfaction
	Lane availability
Asset management expenditure - Renewal	Accident rate
	Cost of 3rd part claims
	User satisfaction
	Lane availability
	Asset condition (pavements and other assets)
	Net Present Value (NPV)
Operating expenditure	Accident rate
	Cost of 3rd part claims
	User satisfaction
	Lane availability
	Set of incidents cleared
Network enhancements	Post Operating Evaluation (POPE)
	% contingency utilised
	% outturn v estimate
	% on time
	No departures

Appendix 6 References

AASHTO–TRB (2012) Maintenance Management.

AASHTO (2014) ADOT P2P.

ANAS (2014) Annual Report.

Annual Conference of the Transportation Association of Canada (2009) Measurable Performance Indicators for Roads: Canadian and International Practice.

Ansell, Mary, et al (2009) "Delivering Best Value in Highways Major Maintenance Schemes: Case Study." Journal of Construction Engineering and Management 135.4; 235-245.

APSE (2015) Highways funding, self-assessment and capitalisation of repairs in England.

Arup/RAC Foundation (2011) Providing and Funding Strategic Roads; An International Perspective with Lessons for the UK.

Asphalt Industry Alliance (2015) Annual Local Authority Road Maintenance Survey.

Australian Automobile Association (2013) Benchmarking the Performance of the National Road Safety Strategy (NRSS).

Australian National PIARC Committee (1994) The Role, Outcomes and Performance of the Australian Road System.

Austroads (1997) Benchmarking Framework.

Austroads (2002) Road network asset management: international benchmarking study.

Austroads (2007) National performance indicators for network operations.

Austroads (2015) National Performance Indicators.

Braconier, H., M. Pisu and D. Bloch (2013) "The Performance of Road Transport Infrastructure and its Links to Policies", OECD Economics Department Working Papers, No. 1016, OECD Publishing.

Cabinet Office, 2009 Commentary to Back Office Benchmark Information 2009/10.

Cabinet Office (2012) Government Construction: Cost Benchmarking Principles and Expectations.

Cabinet Office (2014) Government Construction: Construction Cost Reductions, Cost Benchmarks & Cost Reduction Trajectories to March 2014.

Cambridge Economic Policy Associates (2010) High Level Review of track access charges and options for CP5.

CE Delft (2008) Road infrastructure cost and revenue in Europe.

Chartered Institution of Highways and Transportation/World Road Associations (2012) Road Maintenance Review International Comparison.

Chen, Anthony, et al, 2002, Capacity reliability of a road network: an assessment methodology and numerical results. Transportation Research Part B: Methodological 36.3: 225-252.

Conference of European Directors of Roads (CEDR) (2010) BEXPRAC.

Conference of European Directors of Roads (CEDR) (2013) Trans-European road network, TEN-T (Roads): Performance Report.

Conference of European Directors of Roads (CEDR) (2013) Life cycle costs and NRAs.

Convention of Scottish Local Authorities (COSLA) (2011) Roads Maintenance Review and SCOTS Road Maintenance Backlog Study.

CQC, NHT, HMEP, ITS (2014) The efficiency of highways authorities in England; An investigation into the practices that lead to superior performance.

Danish Road Directorate, 2005, Analysis of costs for construction of motorways.

Deloitte Access Economics (2014) Major infrastructure projects: costs and productivity issues (for Australian Constructors Association).

Department for Communities and Local Government (2015) Local Authority capital expenditure, receipts and financing.

Department for Communities and Local Government (2015) Local Authority revenue expenditure and financing.

Department for Transport (2015) Road Accidents and Safety.

Department for Transport (2015) Road Congestion and Reliability.

Department for Transport (2015) Road Network Size and Condition.

Department for Transport (2015) Road Traffic Statistics.

Direccion de Vialidad, Ministerio De Obras Publicas (2014) Balance De Gestion Integral.

Egilmez, G. and McAvoy, D. (2013) Benchmarking road safety of US states: A DEA-based Malmquist productivity index approach. Accident Analysis & Prevention 53: 55-64.

ERA Net (2012) SBAKPI, Strategic Benchmarking and Key Performance Indicators, Final Report.

ERA Net (2012) HeRoad, Holistic Evaluation of Road Assessment, Final Report.

European Commission (2006) Benchmarking of use of Construction (Costs) Resources in the Member States (Pilot Study).

European Commission (2012) Measuring Road Congestion.

European Investment Bank (2013) The Economic Appraisal of Investment Projects at the EIB.

European Road Assessment Programme (EuroRAP) (2014) British Results.

European Union Road Federation (2012) European Road Statistics.

Federal Highways Administration (2013) Highway Statistics.

Highways Agency (2014) Cost of maintaining the Highways Agency's motorway and A road network per lane mile.

Highways Agency (2015) Annual Report and Accounts.

HM Treasury/Infrastructure UK (2010) Infrastructure Cost Review: Technical Report.

HM Treasury (2011) National Infrastructure Plan.

House of Commons Committee of Public Accounts (2014) Maintaining strategic infrastructure: roads.

House of Commons (2015) Roads: strategic road network (SRN).

Imperial College London, 2006, Investing in Roads: Pricing, Costs and New Capacity.

International Road Federation (2015) World Road Statistics.

IPPR (2008) Benchmarking and the Bottom Line: A proposal to improve infrastructure value for money in Britain.

Kargah-Ostadi, N. and Stoffels, S. (2015) Framework for Development and Comprehensive Comparison of Empirical Pavement Performance Models." Journal of Transportation Engineering.

Karlaftis, M. and Kepaptsoglou, K. (2012) Performance Measurement in the Road Sector, International Transport Forum.

Lam, T. and Gale, K. (2015) Framework procurement for highways maintenance in the UK: can it offer value for money for public-sector clients? Structure and Infrastructure Engineering 11.5: 695-706.

Litzka, Johann, et al (2008) The Way Forward for Pavement Performance Indicators Across Europe, COST Action 354: Performance Indicators for Road Pavements.

Main Roads Australia (2014) Annual Report.

Marsden, G. and Bonsall, P. (2006) Performance targets in transport policy. Transport policy, 13.3: 191-203.

Marsden, G. and Pinkney, S. (2013) M*easuring and benchmarking user satisfaction with transportation.* In: TRB Annual Meeting Online. Proceedings of the 92nd Transportation Research Board Annual Meeting, 13 - 17 Jan 2013, Washington DC. Transport Research Board of the National Academies.

Missouri Department of Transportation (2015) Tracker: Measures of Departmental Performance.

National Assembly for Wales: Public Accounts Committee (2015) Value for Money of Motorway and Trunk Road Investment.

National Audit Office (2014) Maintaining strategic infrastructure: roads.

National Cooperative Highway Research Program (2012) Best Practices in Performance Measurement for Highway Maintenance and Preservation.

National Roads Authority (2013) Annual report and accounts.

Oberste Baubehoerde im Bayerischen Staatsministerium des Innern, fuer Bau und Verkehr (2014) Jahresbericht der Staatsbauverwaltung.

Oberste Baubehoerde im Bayerischen Staatsministerium des Innern, fuer Bau und Verkehr (2014) Bayerische Strassenbauverwaltung - Statistische Daten.

Oberste Baubehoerde im Bayerischen Staatsministerium des Innern, fuer Bau und Verkehr (2014) Betriebskostenrechnung (BKR) in Zahlen.

Oberste Baubehoerde im Bayerischen Staatsministerium des Innern, fuer Bau und Verkehr (2014) Controllingbericht der Bayerischen Staatsbauverwaltung.

Odoki. J., Amyala. A. and Bunting. E (2009) HDM-4 adaptation for strategic analysis of UK local roads.

OECD (1999) Transport Benchmarking; Methodologies, Applications & Data Needs.

OECD (2001) Performance Indicators for the Road Sector; Summary of the Fields Test.

OECD (2012) Performance Measurement in the Road Sector: A Cross-Country Review of Experience.

OECD (2012) Options for Benchmarking Infrastructure Performance.

OECD International Transport Forum (2013) Spending on Transport Infrastructure 1995-2011; Trends, Policies, Data.

OECD: International Transport Forum (2014) Road Safety Annual Report.

Office of Rail Regulation/RailKonsult (2010) Relative Infrastructure Managers' Efficiency.

Office of Rail Regulation (2010) International cost efficiency benchmarking of Network Rail.

Office of Rail Regulation (2013) PR13 Efficiency Benchmarking of Network Rail using LICB.

Oxera (2009) Recommendations on how to model efficiency for future price reviews.

Pinkney, S. and Marsden, G. (2013) Measuring and Benchmarking User Satisfaction with Transportation, TRB 2013 Annual Meeting.

Poister, T.H. (2010) The future of strategic planning in the public sector: Linking strategic management and performance, Public Administration, Review 70, s246-s254.

Police Service of Northern Ireland (2014) Police Recorded Injury Road Traffic Collisions and Casualties Northern Ireland.

Rijkswaterstaat (2013) Gebruikerstevredenheidsonderzoek Automobilisten.

Rijkswaterstaat (2015) Annual Report 2014.

Rouse, P., Putterill, M. and Ryan, D. (1997) Towards a general managerial framework for performance measurement: A comprehensive highway maintenance application, Journal of Productivity Analysis 8.2, 127-149.

Rouse, P. and Putterill, M. (2000) Incorporating environmental factors into a highway maintenance cost model." Management Accounting Research, 11.3: 363-384.

Rubenstein, R., Schwartz, A.E., and Stiefel, L. (2003) Better than raw: A guide to measuring organizational performance with adjusted performance measures. Public Administration Review 63.5: 607-615.

Saeideh, F., Triantis, K., Rahmandad, H. and de la Garza, J. (2014) Measuring dynamic efficiency of highway maintenance operations.

SANRAL (2014) Annual Report.

Santos and Flintsch (2015) A life cycle assessment model for pavement management: methodology and computational framework, International Journal of Pavement Engineering 16.3; 268-286.

Scottish Government (2014) National Benchmarking Overview Report.

The Performance Audit Group (2014) Annual Report.

The Royal Automobile Association of South Australia (2013) Assessing our National Highway Network: Highway Reviews and AusRAP – A Combined Approach.

Transportation Association of Canada (2015) Infrastructure optimising road infrastructure investments and accountability.

Transport for London (2014) Casualties in Greater London during 2013.

Transport for London (2014) Transforming London's Roads – Road Investment Programme.

Transport for London (2015) Annual Report 2014/15.

Transport for London (2015) Street performance report.

Transport Research Board (2003) Research for Customer-Driven Benchmarking of Maintenance Activities.

Transport Research Board (2004) Guide for Customer- Driven Benchmarking of Maintenance Activities.

Transport Research Laboratory (2009) European Cost Comparison - Cost differences between English and Dutch Highway Construction.

Transport Scotland (2012) Transport Scotland Corporate Plan 2012-2015.

Transport Scotland (2013) Reported Road Casualties Scotland.

Transport Scotland (2014) Perceptions of the Trunk Road Network in Scotland.

Transport Scotland (2014) Fitting Landscapes; Securing More Sustainable Landscapes.

Transport Scotland (2015) Statistics Database.

Turner and Townsend (2013) A brighter outlook; International construction cost survey.

ITS (2013) Cost Quality Customer Statistical Benchmarking Report to Stakeholders.

Vejdirektoratet (2013) Survey of current conditions and development the trunk road network in Denmark.

VicRoads (2015) Annual Report 2014/15.

Vinci (2015) Annual Report 2015.

Washington State Department of Transportation (2015) The Grey Notebook.

Welsh Government (2014) Road lengths and conditions.

Welsh Government (2015) Roads and transport revenue expenditure.

Wheat, P. (2015) Cost Quality Customer: Statistical Benchmarking, Report to stakeholders.

World Road Association (2004) Planning and Programming of Maintenance Budgets.

World Road Association (2004) Role and Positioning of the Road Administration.

World Road Association (2004) A Conceptual Performance Indicator Framework for the Road Sector.

World Road Association (2004) Asset Management for Roads - An Overview.

World Road Association (2012) High Level Management Indicators.

World Road Association (2014) Importance of Road Maintenance.

Xiaofeng, D. and Kuosmanen, T. (2014) Best-practice benchmarking using clustering methods: Application to energy regulation. Omega 42: 179-188.

Contact us

Gerard Whelan
Economics and Regulation
T: +44 (0)7747 021002
E: gerard.whelan@kpmg.co.uk

Alan Taggart
Major Projects Advisory
T: +44 (0)7788 224534
E: alan.taggart@kpmg.co.uk

kpmg.com/uk

Produced by Create Graphics/Document number: CRT051313A

KPMG