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Call 2019 Safe Smart Highways

Final Programme Report

SHADAR

Stopped vehicle Hazards – Avoidance Detection And Response

SAFEPATH

SAFE caPAciTy Highways

August 2023

Call 2019 Safe Smart Highways Final Programme Report
CEDR Contractor Report 2023-02

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Executive Summary

The CEDR Transnational Research Programme Call 2019 Safe Smart Highways funded two projects:

- SHADAR (Stopped vehicle Hazards - Avoidance, Detection, And Response) aimed to enhance safety of highways by researching stopped vehicle detection and response, as well as studying road user behaviour in these situations.
- SAFEPATH (SAFE caPAciTy Highways) aimed to identify good practices for increasing highway capacity while improving safety through smart safe highways.

SHADAR researched stopped vehicle detection, response by traffic managers, and road user behaviour around these hazards. A study of the state-of-the-art of detection showed that most countries use various types of fixed sensors that can detect stopped vehicles but dedicated stopped vehicle detection on open highways is limited. Connected vehicle sources (including Waze, eCall, C-ITS, and Data for Road Safety) are used operationally only in a few countries, although coverage of the vehicle population is increasing in these sources.

The project explored various new or improved detection methods, including eCall data, Waze, aerial imagery, and improved radar capabilities. Data fusion can achieve better overall performance than any one source. SHADAR showed how stopped vehicle alerts can be fused, and how performance of a fusion system can be characterised, so that an authority can understand the value of investment in the sources and their fusion. The confidence in any fused alert can be calculated and used to influence reporting and prioritisation for an operator. A study applying data fusion to real stopped vehicle data from two sources showed that each source was missing true stopped vehicle events that were detected by the other source. Using these sources together in a data fusion system would have provided an increased overall detection rate and a `reduced overall false alarm rate.

Figure 1. SHADAR VR simulation example – approaching stopped vehicle.

Virtual reality simulations with 80 volunteers in three countries (see Figure 1) showed a wide range of behaviours when encountering a stopped vehicle hazard, and a lack of knowledge of how to behave. When the volunteers received warnings (whether by signs, in-car information, radio, or impact protection) that showed that the hazard was known to the road operator, the unsafe behaviour significantly decreased.

SHADAR findings are detailed in six reports and several refereed papers. The findings suggest both further research and the potential for more immediate action that can be considered by each country according to its needs and priorities.

SAFEPATH addressed the challenges faced by NRAs in managing congestion, improving safety, and meeting the demands of drivers and environmental concerns. It followed a structured approach, involving system analysis, empirical research, road safety analysis, developing a Practitioners' Guide, and dissemination. The Practitioners' Guide is a comprehensive resource for planning, designing, and implementing measures to increase highway capacity. It categorises them into those increasing basic capacity, those improving up-time of capacity, and those enhancing compliance.

The project's findings highlighted the need for continuous research and evaluation of capacity-increasing measures, particularly in quantification of their success, transferability of measures, and road users' attitudes. The research identified gaps in knowledge and emphasised the importance of robust data collection to assess impacts.

Figure 2. Front page of the Practitioners' Guide to Safe Smart Highways.

Key external outputs included the Practitioners' Guide (an interactive PDF providing an overview of measures and decision support tools), an online measures database showcasing implemented measures, and the SAFEPATH-IIT (Impact Indicator Tool) for evaluating the safety impact of measures. Measures included, for example, All Lane Running (to increase basic capacity), eCall (to increase up-time, by means of faster response to incidents), and CCTV (to increase road user compliance).

Dissemination activities raised awareness among stakeholders and NRAs. The project faced initial challenges in engaging end-users but made efforts to increase engagement and generate interest in final activities. The project's outputs have a strong legacy, and the consortium demonstrated a commitment to sharing knowledge and promoting the use of project findings.

The SAFEPATH project successfully achieved its objectives, contributing to the development of smart safe highways. Lessons learned highlighted the importance of effective communication, resource allocation, and helping NRAs to participate.

The ***Safe Smart Highways programme final conference***, hosted by Wallonie Mobilité et Infrastructures (pictured in Figure 3) presented the findings, impact, and recommendations of SHADAR and SAFEPATH.

Day 1 focused on high-level presentations and discussions for policy and strategic audiences, summarising objectives, achievements, and technical outcomes. SHADAR presented its findings, while SAFEPATH covered systems analysis, research, safety analysis, and main project outputs.

Day 2 engaged practitioners and decision-makers, using the Practitioners' Guide to Safe Smart Highways and the SHADAR process to demonstrate real-world applications. Both projects facilitated a collaborative workshop to work through a scenario, utilising the Practitioners' Guide and incorporating SHADAR's stopped vehicle detection and SAFEPATH's measures database and Safety Impact Indicator Tool.

Throughout the conference, participants actively engaged in discussions, role-plays, and interactive sessions, supported by the conference venue's conducive environment and amenities. The collaboration between the SHADAR and SAFEPATH project teams was seamless, highlighting the complementarity of their approaches. The conference fostered open dialogue, future work planning, and opportunities for CEDR and NRAs, ensuring a lasting legacy for the programme.

The project's outcomes align with the goals of the European Union, supporting economic, social, and territorial cohesion, combating social exclusion, and protecting the environment. The SAFEPATH project, along with other CEDR projects like SHADAR, will contribute to improving the flow of goods and services across Europe and fostering solidarity among member countries.

Figure 3. Image of the conference in progress in Namur.

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1 Introduction to Call 2019 Safe Smart Highways Projects

Safe Smart Highways was one of three research programmes funded by CEDR in 2019.

CEDR Call 2019 Safe Smart Highways called for research into:

1. Preventing collisions with stopped vehicle in a live traffic lane
2. Increasing capacity of highway without compromising road safety.

SHADAR and SAFEPATH were two complementary projects within this programme. SHADAR was concerned with the hazard presented by stopped vehicles on highways, and SAFEPATH addressed the need to increase highway capacity while neither compromising safety nor increasing land take.

All project outputs are available on the CEDR website at: https://www.cedr.eu/peb-call-2019-safe-smart-highways

1.1 SHADAR

SHADAR – Stopped vehicle Hazards – Avoidance, Detection, And Response – aimed to reduce the risk of collision with stopped vehicles through research on three areas: detection and reporting, response by traffic managers, and the behaviour of road users before and after these incidents.

1.1.1 Project team

SHADAR was delivered by a consortium led by Mott MacDonald and included MAP Traffic Management, Navtech Radar, Factum, and Chiltech Limited.

1.1.2 Methodology

The SHADAR research methodology (Figure 4) was to consider the main strands of detection, response, and road user behaviour, starting by establishing the current international state-of-the-art then progressing to consider potential improvements.

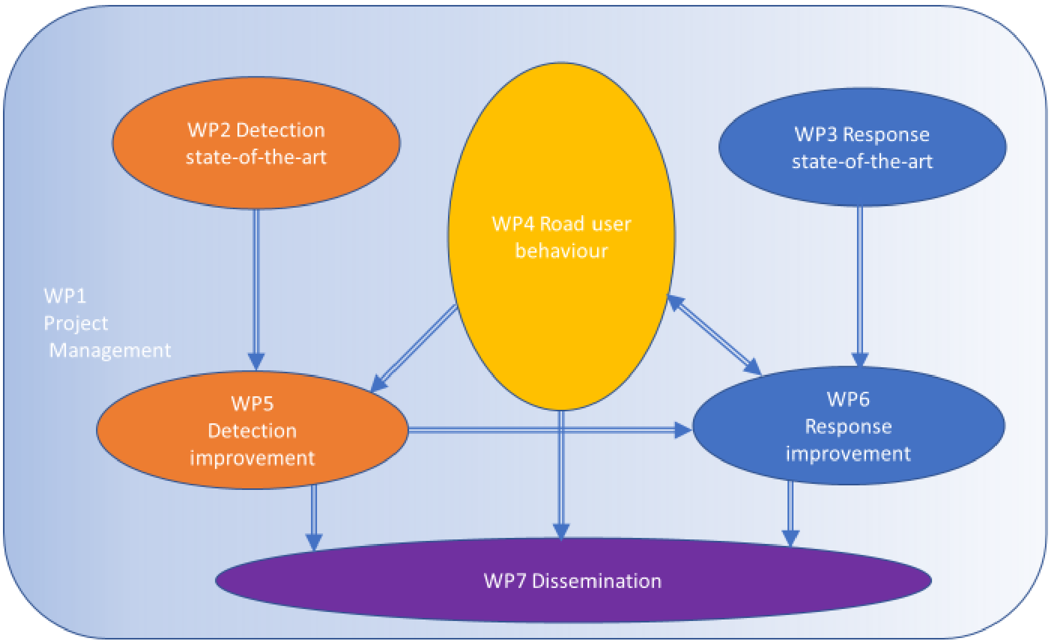

Figure 4. SHADAR research methodology expressed as work packages.

The project produced the following research reports:

- Stopped vehicle detection and reporting – current methods.
- Response current practices.
- Results of behavioural simulation study.
- Stopped vehicle detection and reporting: research results.
- Stopped vehicle detection and reporting: Summary of research results.
- Improving responses to stopped vehicle incidents.
- SHADAR Project final report.

1.1.3 Key findings

The key findings of SHADAR are described in the following sections.

1.1.3.1 Stopped vehicle hazards

Stopped vehicle hazards have been found to be common, with breakdowns varying in the range from thousands to tens of thousands per year per country. Breakdowns are just one reason why a vehicle may stop; others include collisions, obstructions, and even unjustifiable personal decisions by drivers. Past analysis showed stopped vehicles to be the source of 1.6% of all fatal and serious accidents.

1.1.3.2 Stopped vehicle detection – current state

A study on the current state-of-the-art of detection showed that almost all countries use various types of fixed sensors that can detect stopped vehicles – but dedicated stopped vehicle detection on open highways is limited, with some coverage of radar and video analytics. Detection through connected vehicles is less widely applied, although Waze is used operationally in a few countries.

Stopped vehicle detection equipment, systems, methods, or services can be characterised by metrics including detection rate, false alarm rate, time-to-detect, and coverage of the network and the vehicle fleet. There is commonly a trade-off between these metrics, and performance can be influenced by various conditions. Little quantitative evaluation of detection technology has been published, other than from limited trials. Detection rates achieved in trials of dedicated stopped vehicle solutions are relatively high (>80%), while anecdotal evidence on other methods suggest relatively lower rates. Methods exploiting connected vehicles for direct detection currently have relatively low coverage in the vehicle population so produce relatively lower detection rates, but coverage and therefore usefulness for stopped vehicle detection is increasing.

eCall, because it is fitted to all newly type-approved cars and light vans, is increasing rapidly in coverage of the vehicle population. In addition to the voice calls, eCall sends a data packet that can be processed automatically, eliminating delays, yet few countries currently use this data in traffic operations.

1.1.3.3 Stopped vehicle response – current state

A study on the current response methods showed that processes in each consulted country have a similar pattern of discovery, warning, verification, firm response action, and communication, but with differences in detail. Of the various organisation, cognitive and physical factors that support control room response, the organisational factors have the greatest influence, shaping how the control room operates, with consistency of incident management processes. Integrated stopped vehicle detection increases situational awareness and shortens the time to respond.

Figure 5. Control room success factors.

1.1.3.4 Road user behaviour

A set of interviews with road users in three countries gathered information on the range of relevant behaviours. Virtual reality simulations were then designed and developed, in which participants encountered a stopped vehicle in different positions, weather conditions and traffic situations. When the participants had no prior indication that the incident was known to authorities or services, they indicated a wide range of behaviour. Although most participants would try to pass by the stopped vehicle in a safe manner, others would exhibit dangerous behaviour such as driving at walking speed and trying to get in contact with the person in the stopped car when passing by or stopping in front or next to the stopped vehicle. There was no common knowledge about how to behave when a stopped vehicle is unexpectedly encountered. There was no unanimous opinion on whether to call for help in the event of a stopped vehicle, or who to call in such a case. Weather and traffic conditions seemed to have little impact on behaviour.

Figure 6. Screenshots from virtual reality simulations with driver warnings.

A further set of virtual reality simulations provided the participants with some kind of warning about the stopped vehicle: message sign settings, on-board display, radio traffic news, and an impact protection vehicle upstream of the stopped vehicle. The information via message signs was favoured by participants. Nearly all participants respected the information and intentions of stopping to help and report the incident almost disappeared due to participants understanding that the incident is already known.

Participants considered that warning information should be short, precise, repeated, multi-channel, and multi-sensory. Warning given at 700m or less before a stopped vehicle tended to be considered insufficient notice.

The lack of awareness of how road users should behave if no warning is given suggests that further investment in road user education could be worthwhile, for example through including the topic in standard driver education, running a safety campaign, and publicising the preferred phone number for reporting.

1.1.3.5 Stopped vehicle detection – new and improved methods

Several new and improved methods are available for stopped vehicle detection, including:

- eCall

eCall activations designated as automatic indicate a very strong likelihood of a real incident. Manual eCall activations have a higher false alarm rate, but this can be improved by processing to filter out alarms from faulty units and from irrelevant locations. eCall data can facilitate lookup and presentation of additional vehicle data such as vehicle type and propulsion type, which can improve the efficiency of response.

- Radar

The azimuth resolution of rotating radar should support the determination of the lane of a stopped vehicle, not for the full operational range of the radar, but for approximately 150m of range. A small set of experimental results support this.

The usefulness of pre-stop and post-stop radar measurements was explored, but so far not with sufficient populations to clearly demonstrate correlation that could be used to support stopped vehicle detection.

It was demonstrated that radar systems can identify and track pedestrians at the site of a stopped vehicle, which could identify potentially higher risk situations that may be worth prioritisation by the operators.

- Waze

Analysis of a large Waze dataset from the Netherlands showed that detection rate is high: 93% of stopped vehicle events recorded by the national traffic data access point were found to have a matching Waze alert, and most Waze alerts were issued before the corresponding national access point alerts – suggesting it to be a valuable source. Waze also raises many additional alerts on the nationally monitored network, which may represent very short stops, stops on the hard shoulder, or false alarms.

- Other connected vehicle sources

Standardised cooperative ITS capabilities include stationary vehicle identification and warning, but in most countries C-ITS still has low uptake beyond pilot projects. Meanwhile several data providers offer traffic data commercially, and now the Data for Road Safety initiative aims to make safety-related traffic information available for all road users in Europe. Coverage may vary across Europe, but a study in the Netherlands showed that coverage is substantial, and integration of the data can produce faster detection of stopped vehicles.

- Aerial imagery

Images from unmanned aerial vehicles and satellites could provide more accurate information both on location and vehicle type but have practical disadvantages such as availability, mechanical reliability, and sensitivity to weather conditions.

- Data fusion

Given the number of different fixed and mobile detection sources, each with their own strengths and limitations, there is potential for data fusion to achieve better overall performance than can be provided by any one source. SHADAR has shown how the performance of a stopped vehicle detection fusion system can be characterised, using probability theory, so that a road authority can understand the value of investment in the sources and their fusion. Better performance comes by fusing sources that behave independently.

Fusion can be used to avoid presenting too many false alarms to an operator, or without withholding any information it could be used to enrich and prioritise information for operators. SHADAR showed how the confidence of a fused alert can be calculated using a combination of probability theory and empirical data.

SHADAR conducted a study on real stopped vehicle data from two sources that were operational on the same stretch of road. The detection data sources were not designed to support data fusion analysis so unsurprisingly were not ideal for that purpose. Correlating the sources required assumptions. Data fusion would be simplified if reporting and logging were designed with a requirement to support data fusion. Before the study, the detection rates of these sources were unknown. The fusion study showed that each source was missing true stopped vehicle events that were detected by the other source, and the maximum detection rate of each source could be calculated. Even without the expense of a full ground truth study, the analysis of two sources together provides knowledge about the performance of each source which was not otherwise apparent. One source appeared to be more sensitive than the other on average. If these sources had been used together in a data fusion system, rather than using only the more sensitive source, then not only would the detection rate have increased but the false alarm rate would have reduced due to the low false alarm rate of the less sensitive source.

Data fusion also enables comparative technology performance reporting, so that technology managers can better understand the relative value that each source has delivered.

1.1.3.6 Stopped vehicle response – improvement and best practice

SHADAR demonstrated through a series of scenarios and user interface mock-ups how the fusion of new and existing sources could be presented to traffic management operators. Representatives of operators confirmed that the use of colour, position and numeric confidence are all useful tactics to support response prioritisation. Information about which sources have and have not detected the event is considered useful, as is the additional vehicle information that can be derived from some sources. Integrated CCTV is considered useful, integrated measurements (traffic/weather/surface conditions) less so.

Figure 7. Reporting fused data to traffic management operators.

Outside the control room, addressing the knowledge and understanding of drivers can help reduce the hazards from stopped vehicles, and could provide greater compliance with traffic management measures.

Connected vehicles and devices can provide an additional channel to disseminate information, but consistency with road operator information is important. Specific cooperation patterns for public-private cooperation have been proposed, but our research suggests that the patterns that go beyond data exchange are likely to require ongoing funded effort to provide benefit.

1.1.4 Dissemination

SHADAR dissemination included:

- A special interest session at the ITS World Congress 2021 Hamburg.
- Conference papers at: Transport Research Arena (TRA) 2022, International Co-operation on Theories and Concepts in Traffic safety (ICTCT) Györ 2022, ITS European Congress 2023 Lisbon (2 papers).
- Journal papers submitted to: Zeitschrift für Verkehrssicherheit, Transactions on Transport Sciences (TOTS).

1.1.5 Conclusion

SHADAR improved knowledge on stopped vehicle detection, response, and road user behaviour, by creating new knowledge and by sharing existing knowledge. It was considered by the Programme Executive Board to have achieved all its objectives. It also recorded in its final report a set of lessons about the process of running such a research project.

Road authorities can now use the key findings reported in section 1.1.3 to consider use of the most valuable techniques – such as implementing a data fusion system, harnessing various connected vehicle sources, or educating drivers – according to the needs and priorities of the country.

The following areas were identified for possible further research:

- Find the most effective methods of driver education on stopped vehicle hazards, which will maximise compliance with the best safe practices.
- Use a significant quantity of real eCall data to validate the estimates in SHADAR research and therefore confirm the value of automated eCall MSD processing.
- Acquire larger volumes of real radar stopped vehicle data with full context and use to confirm the significance of techniques explored by SHADAR.
- (For countries other than Netherlands where SHADAR focussed its Waze study) Capture Waze data sets and perform similar tests to confirm the value of the data source.
- (For countries other than covered by the reported DfRS study) Capture Data for Roads Safety data sets and test to confirm the value of the data source.
- Conduct ground truth studies on stopped vehicle detection performance, especially using multiple sources covering the same place and time and share results with further insights into the usefulness of combinations of kinds of sources.
- Investigate the feasibility and value of post-eCall communication between emergency responders and affected vehicles.
- As part of growing partnerships with in-vehicle service providers, explore the feasibility of cooperation patterns beyond reciprocal data exchange, but consideration of the ongoing funding pattern should not be deferred.

1.2 SAFEPATH

SAFEPATH – a consortium led by AECOM and including Royal HaskoningDHV, White Willow Consulting, and Eindhoven University of Technology – conducted research to identify good practice on increasing capacity while improving safety through smart safe highways.

The aim of the call was to identify, consider, and gain an overview and greater understanding of existing measures to increase the capacity of highways within National Road Authorities (NRAs), without compromising road safety or using more physical space.

1.2.1 Project overview

NRAs are facing many challenges with growing congestion and the need to increase capacity, together with the demand for safety improvements, better quality information to meet the needs of drivers, and wider issues including environmental improvements such as air quality. This is with a backdrop of political, financial, and operational opportunities and constraints, in a world in which technology is constantly evolving.

For several years, industry, academia, and road operators have been developing and evaluating measures to increase highway capacity – that is, to increase both maximum potential traffic flow (basic capacity), and the proportion of time for which the highway can deliver that maximum.

Project management followed a proven approach, with an Advisory Group consisting of industry experts providing strategic guidance. Participants reported to the Programme Executive Board, made up of members of the organisations sponsoring this work.

Alongside the project management and final report work packages, SAFEPATH achieved its aims using the following five main work packages:

- *System Analysis* dealt with stakeholder engagement and modelling the highway system.
- *Empirical research* conducted the literature and stakeholder surveys to identify measures to increase capacity.
- *Road safety analysis* conducted road safety analysis of these measures.
- *The Practitioners' Guide* brought together work from WP3000 and WP4000 to compile The Practitioners' Guide to Safe Smart Highways.
- *Dissemination* performed activities throughout the project to share the knowledge learned and to promote the use of the project outputs.

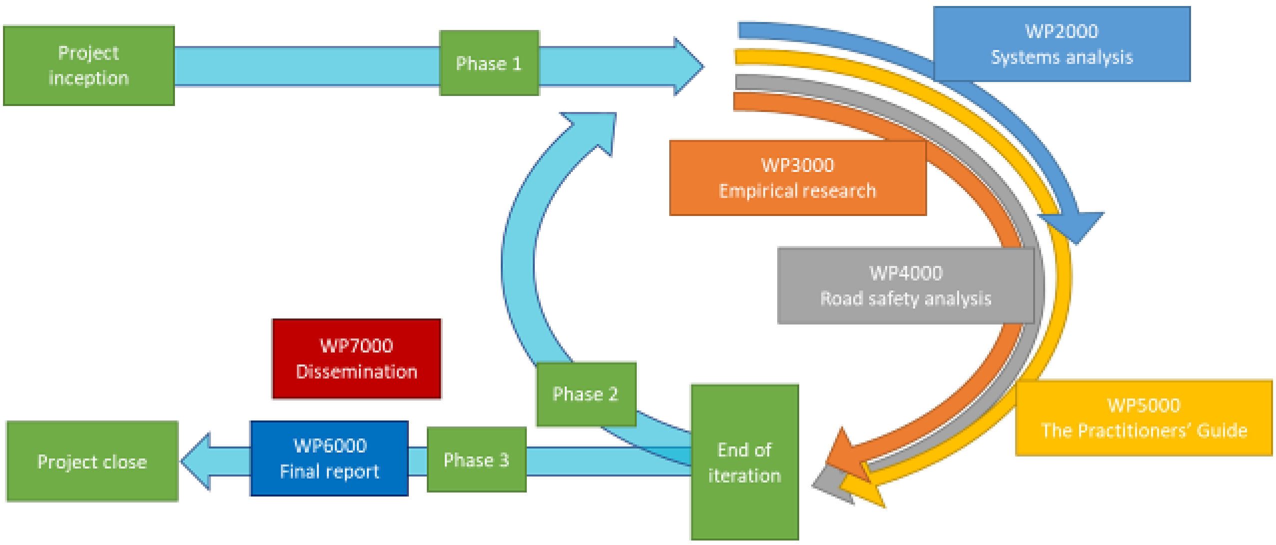

Figure 8. Schematic of agile methodology used in SAFEPATH.

Figure 8 illustrates the agile methodology used to deliver tangible outputs at the end of the first year in phase 1. Early delivery of quick wins aimed to allow NRAs to take practical, real-world advantage of the research sooner. The research continued into Phase 2, performing a second iteration to finesse and improve the quality of the outputs.

The project produced several formal reports, but the three primary external outputs were:

- The Practitioners' Guide to Safe Smart Highways.
- The SAFEPATH measures database website.
- The SAFEPATH-IIT Road safety Impact Indicator Tool.

Screenshots from these three outputs are shown in Figure 9.

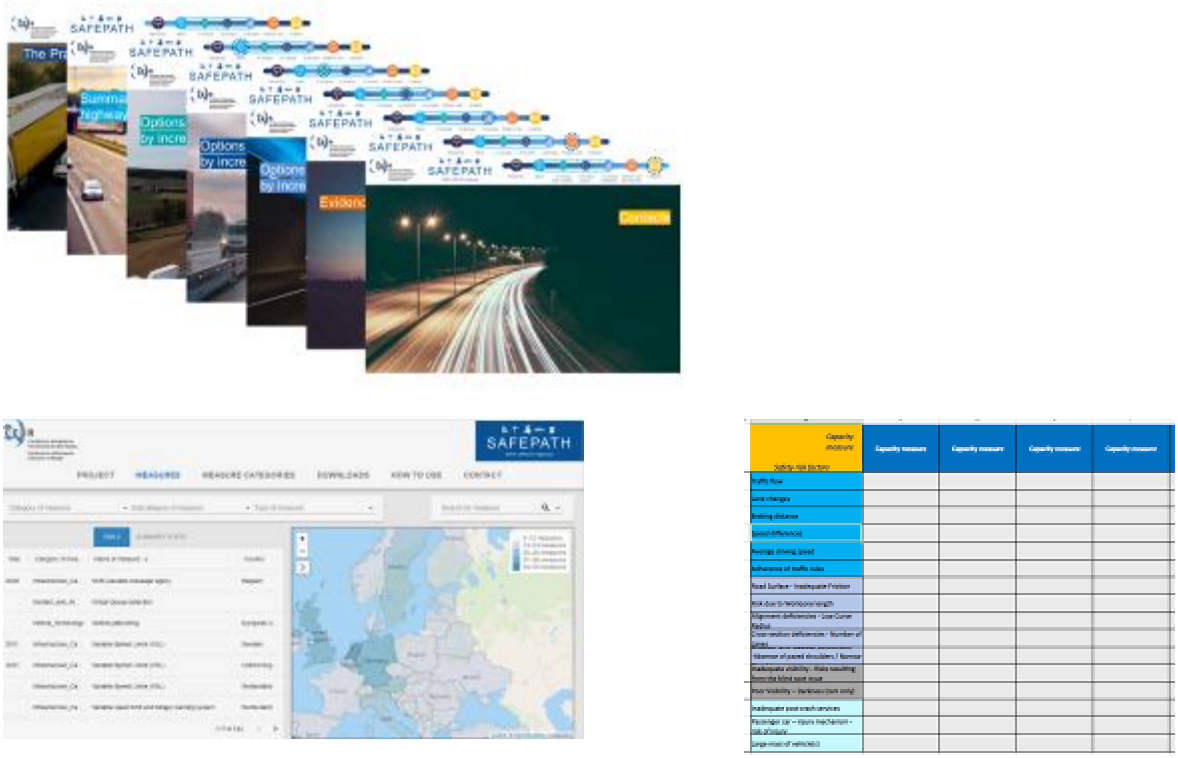

Figure 9. Example screenshots of the Practitioners' Guide to Smart Safe Highways (top), the SAFEPATH measures website (bottom left), and the SAFEPATH Road Safety Impact Indicator Tool (bottom right).

The project started with ambition to engage end-users (for knowledge gathering), but this proved harder than initially expected. It was difficult to engage with NRAs beyond those who were already implementing capacity improvement measures. This was less of a problem in the initial, information-gathering stage, but more an issue for dissemination. However, this difficulty highlights the need for such a project to stimulate knowledge sharing for this subject.

SAFEPATH worked hard to build engagement momentum, and as a result much interest was shown in the final dissemination activities, showing the project has a strong potential legacy.

1.2.2 Key findings

1.2.2.1 Systems Analysis

The process of systems analysis involved 4 steps as described below. This work was written up in the report Problem and Systems Analysis (Deliverable: D2.1, D2.2, & D2.3).

1.2.2.1.1 Step 1: Problem demarcation and determining level of analysis

The first step of systems analysis produced the means-ends diagram (shown in Figure 10) that provided a broad spectrum of the objectives and means from strategic to tactical level. The means-ends diagram placed 'increasing highway capacity' as the focal objective of this research. Four means to increase highway capacity – increase infrastructure capacity; Improve driver behaviour; Improve vehicle technologies; and Improve road safety – were identified as means for the core level of analysis.

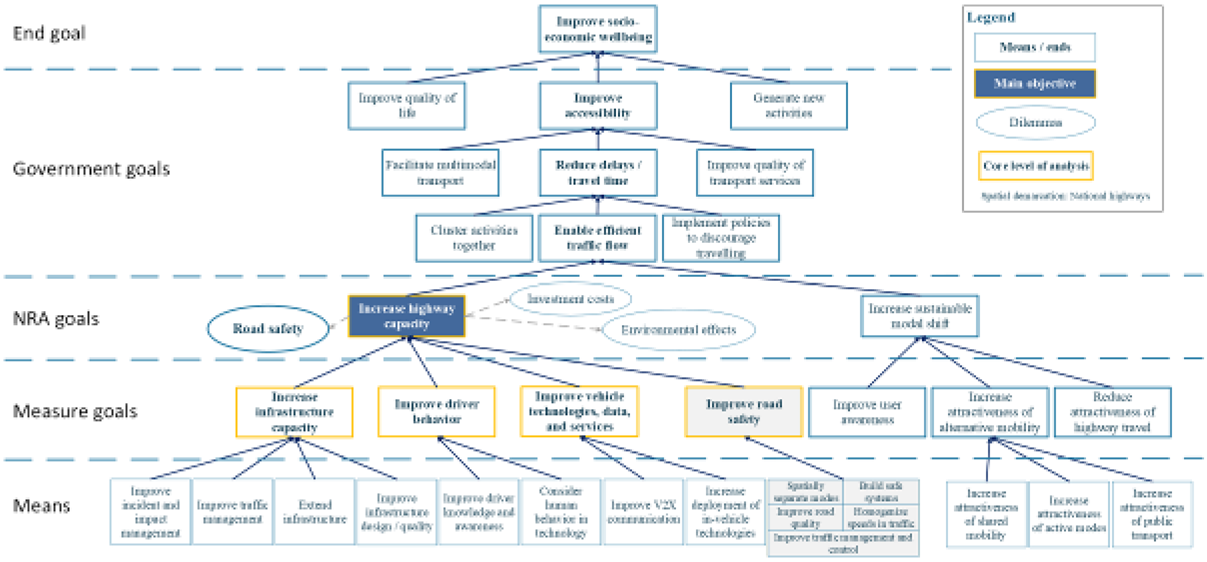

Figure 10. SAFEPATH means-ends diagram determining the level of systems analysis.

From the means-ends diagram, three dilemmas were identified in increasing highway capacity. These were:

- Road safety.
- Investment costs.
- Environmental effects.

1.2.2.1.2 Step 2: Specifying objectives and criteria

In the second step of systems analysis, the main objective was divided into three sub-objectives: increase highway capacity; improve user experience, and do not diminish road safety. For these sub-objectives, a total of six criteria were identified which can quantify their effect on highway capacity and road safety. The identified criteria were:

- Congestion severity.
- Collision risk.
- Traffic flow.
- Delays.
- Travel time reliability.
- Collision severity.

These criteria provided a set of reliable KPIs to assess the effect of different measures which may be implemented to increase highway capacity. These objectives and measurable KPIs are shown in Figure 11.

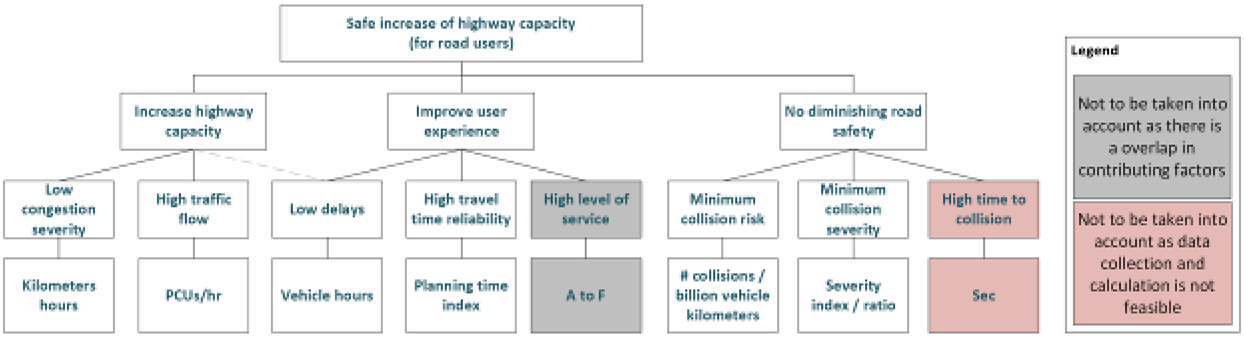

Figure 11. SAEFPATH objective tree diagram indicating the main objectives and measurable KPIs.

1.2.2.1.3 Step 3: Identifying influencing factors and mapping out causal relations

The third step of the systems analysis was to identify the factors that influence the criteria identified in step two and map the causal relationships between them. The outcome of this step was the causal relation diagram.

1.2.2.1.4 Step 4: Creating the systems diagram.

In the fourth and final step of systems analysis, all the findings from the first three steps were combined along with findings on external factors to gain a full overview of the complete system.

This step resulted in the systems diagram (shown in Figure 12), the main product of the Systems analysis work package, which formed the basis for further analysis within this and other work packages and could also be used by NRAs.

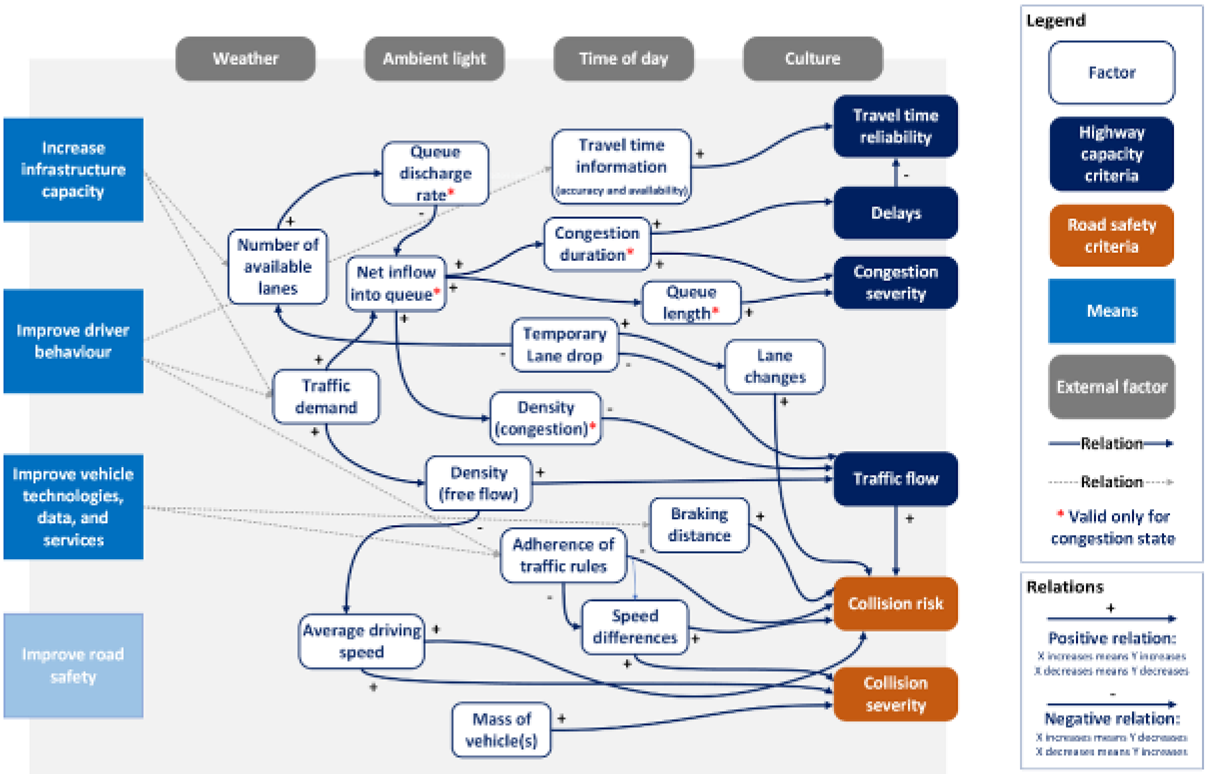

Figure 12. Completed systems diagram for the SAFEPATH project.

1.2.2.2 Empirical research

This work package involved construction of a database of projects and measures to increase highway capacity without diminishing road safety or building new physical infrastructure that have been implemented in countries including but not limited to CEDR member countries. The data includes information on the impact of measures on highway capacity and safety, along with various supplementary information such as user acceptance, challenges in implementation, and other relevant environmental, financial, and societal factors.

A stakeholder engagement plan was developed to identify key experts to engage via workshops, interviews, and questionnaires and collect more direct (and unpublished) information about these measures. This included effectiveness, any challenges faced in implementation, impacts on safety, and behavioural factors such as user acceptance. The interviews, workshops, questionnaires, and literature review outputs are also stored in the database.

The database can be accessed via the website at https://project-safepath.azurewebsites.net/ and illustrated in Figure 9.

An accompanying report – the Solutions Report – provides an overview of several measures that were found during the empirical research to have the most comprehensive evidence base. For a NRA, the findings of this review suggest that there may be future tools to deploy to increase capacity, but they are yet to be proven and investigated to the same extent as direct traffic management measures using road infrastructure. Some will also require other organisations such as vehicle makers and vehicle buyers to be involved. NRAs will need to keep up to date in this emerging and dynamic field.

This work package identified several gaps in knowledge:

- Robust quantification of the success or otherwise of many of the measures was lacking.
- There is very little reliable information on the transferability of measures, i.e. whether the success (or failure) in one country or region be used to predict results in another.
- Many assessments of the impact on capacity do not provide evidence on the likelihood or otherwise of induced demand.

The findings in *Empirical research* along with *Road safety analysis* provided the base for the Practitioners' Guide which will enable NRAs to make informed decisions when selecting which measures to deploy.

An agile approach to delivery was applied in this work package, with an Interim report being published once the more obviously beneficial measures for safely increasing capacity had been identified. These were then presented to the Programme Executive Board and other stakeholders for comments while further material was gathered for the final version of the report.

The interim and final versions of the Solutions Report were deliverables D3.1 and D3.2 respectively.

1.2.2.3 Road safety analysis

The objective of this work package was to investigate the safety impact of existing and evolving highway capacity measures.

The most relevant KPIs for road safety were identified as collision likelihood and collision severity, in line with the findings in *Systems analysis*. In this work package, two approaches to analyse the safety impact of capacity measures were used. The first approach focused on finding evidence on each capacity measure's safety impact using existing studies in the literature. In the second approach, the systems analysis was performed to create a model that was used to estimate the potential safety impact of a specific capacity measure.

To collect evidence on each capacity solution's safety impact and lessons learned from similar highway capacity projects, this work package began with reports such as those from CEDR, ESTC, PIARC, and AASHTO, which have already published analysis findings and recommendations on highway safety. A literature review was conducted on those scientific studies that emphasise pre-post analysis and surveys from NRAs.

Several measures, such as ITS and C-ITS services, are evolving, so their results are mostly derived from simulation data or controlled experiments instead of real-world data. Therefore, the findings contain evidence both from real-time analysis and simulation analysis. Providing evidence of both types is valuable for understanding capacity measures' safety performance level and the likely impacts of measures yet to be deployed at scale.

This work package proved more complex than initially expected, and additional labour resource was deployed. The reports from this work package constituted deliverables D4.1 and D4.2 respectively.

1.2.2.4 The Practitioners' Guide

This work package consolidated the research performed in earlier work packages to produce an accessible guide aimed at anyone involved in the planning, designing, or implementation of measures to increase highway capacity. The *Practitioners' Guide to Safe Smart Highways* can be consulted at any stage of the infrastructure life cycle.

The Practitioners' Guide is aimed at NRAs managing highways in Europe (strategic or major roads) but includes appropriate measures from around the world. It presents measures to increase highway capacity that are well established or have a good evidence base. It also aims to highlight the future operational impact of new technologies such as automated and connected vehicles on capacity measures.

It is produced as an interactive PDF. This allows it to be shared widely and easily. The document is designed to be accessed primarily via a digital medium – thus it is produced as a landscape document and includes links and hyperlinks to ease navigation.

It takes advantage of the availability of the SAFEPATH measures database website (accessible at https://project-safepath.azurewebsites.net), by providing a relatively high-level overview of measures from which the user can quickly determine whether a particular measure is applicable to their situation. Should the user require more detailed information, they can delve deeper by using the information provided on the website.

To help compare the various measures, they have been divided into three categories:

- Measures which increase basic capacity.
- Measures which increase up-time of basic capacity.
- Measures which increase compliance.

Each measure has a dedicated page summarising its main points and an indication of its impact on increasing capacity and improving safety. Summary tables and other decision support tools are available to help users in the choice of measures.

SAFEPATH were keen to present measures that had been implemented and were supported by available evidence for other road authorities to use or adapt for their own means.

An interim version of the Guide, a Phase 2 Plan, and final version of the Guide were the deliverables D5.1, D5.2, and D5.3 respectively.

1.2.2.5 Final report

This work involved the production of the final report following the CEDR template. The final report provided an overview of the methodology of the project, described the key findings, a review of the project against the original objectives, and recommendations for further dissemination and future work.

This report constituted deliverable D6.1.

1.2.2.6 Dissemination

The SAFEPATH consortium were conscious from the start of the project that the project outputs are of little practical purpose if the relevant people and institutions remain unaware of them. The project plan included extensive dissemination activities starting at month 18 – providing 6 months of effort to provide a strong legacy for the project. Dissemination activities started even earlier, with a prominent position at the ITS European Congress in Toulouse at month 12.

Dissemination occurred first among the SAFEPATH stakeholders, including CEDR PEB members and NRAs. Publication of the SAFEPATH outputs was widely advertised during any interaction, to allow potential end-users to factor the use of the outputs into their future plans.

SAFEPATH project members also presented at and attended several high-profile events. These included:

- Presenting a paper at the ITS European Congress in Toulouse, in May 2022.
- Hosting a Special Interest Session at the ITS European Congress in Toulouse, in May 2022.
- Presenting at the UK National Road Safety Conference in Harrogate, in November 2022.
- Presenting a paper at the Transport Research Area in Lisbon, in November 2022.
- Submission for a Special Interest Session at the ITS European Congress in Lisbon, May 2023.

Throughout the project, the SAFEPATH team hosted virtual workshops and meetings with stakeholders and potential end-users. Attracting attendees to initial meetings proved more difficult than anticipated, but by using the project's agile approach and utilising the risk contingency, additional effort was deployed to increase engagement. By the end of the project, the SAFEPATH dissemination workshops realised the benefits of this extra effort as each meeting involved approximately 30 attendees from various NRAs.

Deliverable D7.1 – the dissemination Portal – can be found on the website: https://project-safepath.azurewebsites.net/, while the dissemination activities mentioned above constitute Deliverable D7.2.

1.2.3 Key external outputs

The three external outputs of SAFEPATH were the Practitioners' Guide to Safe Smart Highways, the online measures database, and the Impact Indicator Tool (IIT).

1.2.3.1 Practitioners' Guide to Smart Safe Highways

This interactive PDF provides a relatively high-level overview of measures that allow the user to quickly determine whether it is applicable to their situation. It includes single-page illustrations of each measure, and a decision support tools to assess which of the measures may be most appropriate.

The title page of the Practitioners' Guide is shown in Figure 13.

Figure 13. Title page of The Practitioners' Guide to Safe Smart Highways.

1.2.3.2 Online measures database

The SAFEPATH website (accessible at https://project-safepath.azurewebsites.net), hosts a searchable database of all the measures identified, during the course of the project, which have been implemented by NRAs throughout Europe and the rest of the world in an attempt to reduce congestion while neither compromising safety nor increasing land take.

1.2.3.3 SAFEPATH-IIT safety assessment tool

This interactive spreadsheet enables each proposed measure to be assessed on safety grounds, using four categories of risk factors. These categories are traffic conditions, highway conditions, visibility, and incident characteristics (including incident response.)

Each column of the spreadsheet is headed by a capacity-enhancing measure which the user chooses from a drop-down list. Each row corresponds to a safety risk factor (for example, 'average driving speed'). When the user chooses a capacity-enhancing measure for a column, cells in that column change to indicate an increase or decrease in each safety risk factor.

For example, selecting 'Queue tail warnings' for the first column will cause the cell in that column and in the row 'Average driving speed' to display the word 'decrease' – meaning that given warnings of a queue ahead, drivers will naturally slow down. The eight columns enable up to eight measures to be assessed and compared.

1.2.4 Conclusions

The SAFEPATH consortium completed research to deliver information on good practice on increasing capacity whilst maintaining or improving safety through smart safe highways.

The project produced the Practitioners' Guide to Safe Smart Highways, supported by an online SAFEPATH measures database, and an Excel-based safety assessment tool called SAFEPATH-IIT, which enables NRAs to identify and assess the effectiveness of measures for safely increasing highway capacity.

The project was able to take an agile approach, publishing 'quick wins' relatively early in the timeline, for stakeholder comment and feedback into the final deliverables.

The project achieved its objectives as set out in the DoRN.

Lessons learned included:

- As with SHADAR, it is important to establish the best way of inter-group communication, including file sharing, as early as possible in the project.
- Allocation of resources needed to be re-assessed due to one of the work packages proving more resource-intense than had been predicted. This proved successful but the process of re-allocation could have been streamlined.
- Many NRAs were initially reticent about taking part, due to their own lack of resources. Consideration of this issue in future projects may learn from what activities worked well in SAFEPATH.

The following areas were identified as possible subjects for future research:

- There was a lack of pre-post performance data (traffic flow, congestion, collisions) for many of the measures itemised in the Guide. More of this type of data are needed.
- Case studies and data on the transferability of one measure to a different country were almost completely absent. It would be useful to identify the criteria that make a measure more transferable.
- Except for All-Lane Running in the UK, there is little data on road users' attitudes to the various measures.

SAFEPATH complements other CEDR projects such as SHADAR, and ultimately will help the flow of goods and services throughout the territory and thus contribute to aims of the European Union which include enhancing economic, social, and territorial cohesion and solidarity among EU countries, combating social exclusion and discrimination, and protecting and improving the quality of the environment.

2 Programme final conference

The conference was hosted by Wallonie Mobilité et Infrastructures on May 31 and 1 June 2023, at the Service public de Wallonie, 8, Boulevard du Nord – 5000 Namur, Belgium.

2.1 Aim and agenda

The aim of the Safe Smart Highways programme final conference was to present the findings, impact, and recommendations of the two projects (SHADAR and SAFEPATH) to members of the Programme Executive Board and invited guests. The intended outcome is the successful dissemination and implementation of the project outputs throughout the participating member states.

Day 1 of the conference was a formal presentation including simple demonstrations of key deliverables, with time for audience questions and discussion, aimed at a higher level, policy or strategic audience. It included in-person and virtual attendees and summarised what each of the projects set out to do, what was accomplished, how successful it was, and what were the key technical outcomes.

Day 2 was designed for engagement with practitioners, planners, and detailed decision makers. The aim was to get the audience actively involved, and our objective was that they would remember it and be more likely pass on or to use the outcomes of our work. It included only in-person attendees, set out as a collaborative workshop hosted by partners from both projects. The concept was to work through, step by step, examples of practitioners using the outputs of the two projects – primarily the Practitioners' Guide to Safe Smart Highways and the SHADAR process and outcomes. It was to also touch on the SAFEPATH measures database website and the SAFEPATH Safety Impact Indicator Tool. A use case was outlined to demonstrate how the various outputs and findings from both projects would help practitioners, as well as identifying where future research and international collaboration may benefit the highways ecosystem.

2.2 Day 1

Day 1 was planned to provide an overview of the two projects of the programme. The host (Belgium – Wallonia) provided an introduction and welcome.

SHADAR presented the findings of the project, with a focus on the detection strand. The content of the presentation reflected the information provided in Section 1.1 and the project Final Report (available here: https://www.cedr.eu/peb-call-2019-safe-smart-highways).

SAFEPATH presented on the three work packages that provided the foundation of the research (systems analysis, empirical research, and safety analysis) as well as the three main outputs of the project (the Practitioners' Guide to Safe Smart Highways, the measures website, and the SAFEPATH-IIT). The content of the presentation reflected the information provided in Section 1.2 and the project Final Report (available here: https://www.cedr.eu/peb-call-2019-safe-smart-highways).

2.3 Day 2

The second day of the conference was held entirely in-person, as audience feedback and real-time use of the Practitioners' Guide comprised an essential part of the activities.

2.3.1 Introduction

The facilitator of the session presented the delegates with a fictitious scenario (although inspired by real-life road layouts), requiring consideration of congestion and future increased traffic load on a busy highway junction.

The Practitioners' Guide to Safe Smart Highways was used to help steer participants through the process of evidence gathering to support decision-making. The 5-stage implementation process provided in the guide, illustrated in Figure 14, was used to structure the session.

Each of the five stages comes with its own non-exhaustive checklist of factors to consider when implementing a measure to increase capacity on highways, from identifying relevant factors in the present situation, through planning, design, implementation (i.e. construction), and finally evaluation of the resulting effects.

The outputs of SHADAR were integrated within this session by identifying stopped vehicle detection as one of the possible measures available to increase highway capacity for the scenario.

In addition, knowledge and experience from the delegates' own countries was elicited, so that all could benefit from hearing others' experiences, including any challenges they faced.

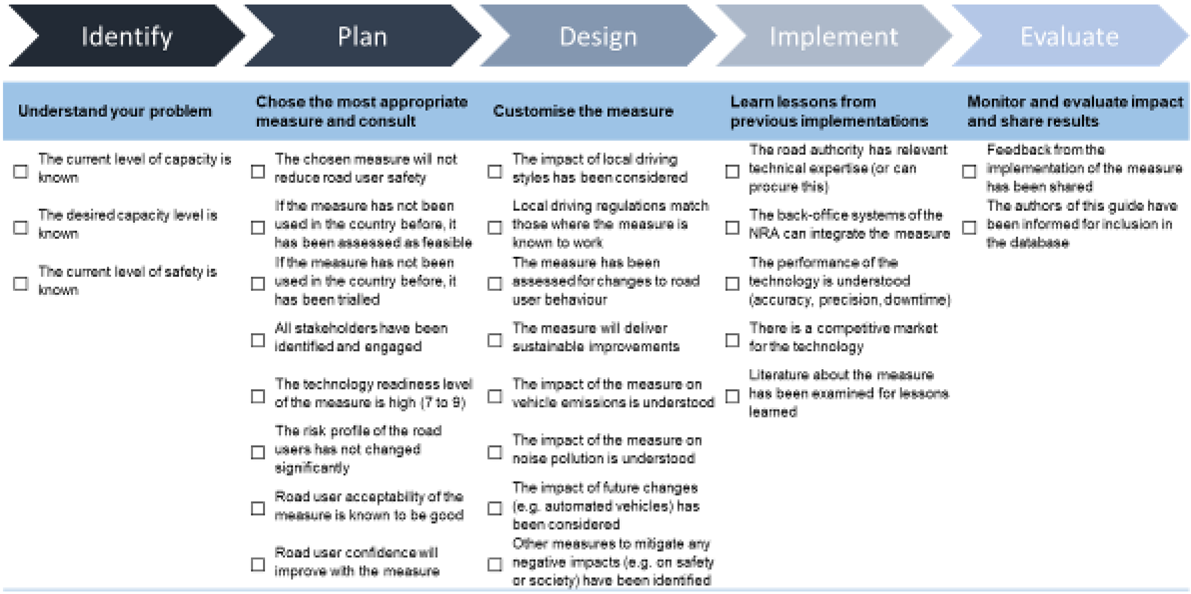

Figure 14. The Implementation Checklist – things to consider during the implementation of a measure to increase capacity on highways.

2.3.2 Scenario scene setting

The scenario used considered a busy highway junction requiring a reduction of congestion during peak hours. The layout of the scenario was described as similar to those found on the M62 in the UK, the A3 in Belgium, and the E31 in the Netherlands. An example of the road layout provided is shown in Figure 15.

Figure 15. Example road layout for the scenario.

The characteristics of the scenario were also provided. Illustrative figures were provided for the current and desired statistics of the junction related to capacity and safety. Likewise, the characteristics of the junction were also described. These details can be found in Figure 16.

Scenario:
Local – Congested highway junction

	Current	Desired
Traffic	1800 PCU/hr	+15%
Congestion	2 km-hrs	-50%
KSI incidents	1 ksi per year[1]	<1 ksi per year

Characteristics	
Existing infrastructure	Overhead gantries, power supply, communications, CCTV, constrained road space
Budget	Large capital and operational
Government strategy	Reduction of congestion during peak hours
Culture	Young vehicle fleet, compliant drivers.

Figure 16. Full description of the scenario.
[1]ksi – number killed and seriously injured per year – was assumed in line with similar roads.

Setting the scene like this ensured the audience were contributing to the discussion from the same or similar perspective.

2.3.3 *Scenario discussion*

At this point the Implementation Checklist (shown in Figure 14) was consulted so that the participants could work their way through each of the stages, considering each issue raised.

2.3.3.1 *Identify*

The implementation checklist was used to describe types of things needed at this stage. The checklist at this point only requires three questions be answered. However, discussions at this point raised some interesting extra issues when the audience was asked:

'*Is anything else required at this stage? To understand the problem.*'

- Issues raised and discussed included: clarification of the budget available and the timeframe; how recent the figures were from the monitoring; and the timeslots available for work (nights, weekends, or was a solid block of time available).
- Further issues the participants raised as relevant included whether the congestion was a seasonal issue (for example caused by holidaymakers); whether there were future developments planned nearby, and whether the highway itself was the problem or whether it might be the adjoining roads.

2.3.3.2 *Plan*

This stage is when the most appropriate measure is identified, and consultation really starts.

Participants worked their way through the implementation checklist to describe some of the activities and questions that might be required to be answered.

Participants were asked to consider planners' initial reactions to the problem, in the form of the question:

'*What is the tendency for solutions at this stage?'*

- Discussion agreed that there was a tendency to stay with the most familiar solutions, as new technology introduces risk – especially in the realms of cost and fitness for purpose.
- For example, something new might be found not fit the purpose, necessitating prolonged tests and trials. This meant that if cost and time constraints are present, then new options are not preferred.
- Technological readiness level affects risk-taking behaviour. Some are willing to take risks, whereas in other countries political constraints apply.

'*How can end-users use the Guide, website, and tool to complete actions at this stage?*'

- Participants agreed that the Guide could be useful in that they understand if a measure works elsewhere, it may give them a good starting point.
- Some also suggested showing the guide to politicians in the event of their being hesitant to implement an unfamiliar new measure.
- It was pointed out, however, that there is a need to be careful that too many people are not seeing all the options and becoming overwhelmed. The job of the practitioner is to help narrow down the possible measures to consider.
- The reactions of road users to the introduction of unfamiliar technology may also need to be considered.

'Will the Practitioners' Guide support wider consideration?'

- Yes: if a measure has been implemented elsewhere, then the guide will provide insight and a starting point.
- In the case of a very new measure, happy to take the risk but would prefer to investigate further how it has been used elsewhere, and how successfully.
- Practitioners are happy to take the risk involved in the use of a new measure, but politicians are not.

'Would the guide help discussions with politicians?'

- This might not always be helpful as politicians, offered the full range of options, may fail to agree, or may not choose the best option from an engineering point of view. A better approach may be to use the guide to scope and design a range of options before presenting these refined options to politicians.

After this discussion, a model set of results of the 'Plan' stage was presented. The resulting options, shown in Figure 17, included one which necessitates stopped vehicle detection (SVD). This introduced a session to consider the technologies and issues involved in SVD via the findings of SHADAR.

Options (measures)	CCTV	VSL	Ramp metering	SVD
Impact on safety?	tbc	tbc	tbc	tbc
Used in country already?	✓	✓	□	✓
Feasible?	✓	□	□	✓
Stakeholders identified?	✓	✓	✓	✓
Technology readiness level?	✓	✓	✓	✓
Impact on road user risk profile?	✓	✓	✓	✓
Acceptable to road users?	✓	□	✓	✓
Impact on road user confidence?	✓	□	□	✓

Figure 17. Table of options, with criteria by which they are assessed. CCTV (Closed Circuit Television), VSL (Variable speed limits), Ramp metering, and SVD (stopped vehicle detection)

2.3.3.2.1 Special session on stopped vehicle detection

An online question and answer service was used during the conference to gather opinions on a variety of topics.

What, if any, stopped vehicle detection technologies do you think are worth introducing to an existing base of queue detection loops and CCTV cameras, on a busy stretch of motorway?

- Each participant had unlimited votes. The poll results, displayed in Figure 18, show connected vehicle sources (any kind) were highest, although not chosen by over a third of participants; next were radar and automated video analytics, each selected by about half the participants; higher density loops were proposed by one quarter of participants.

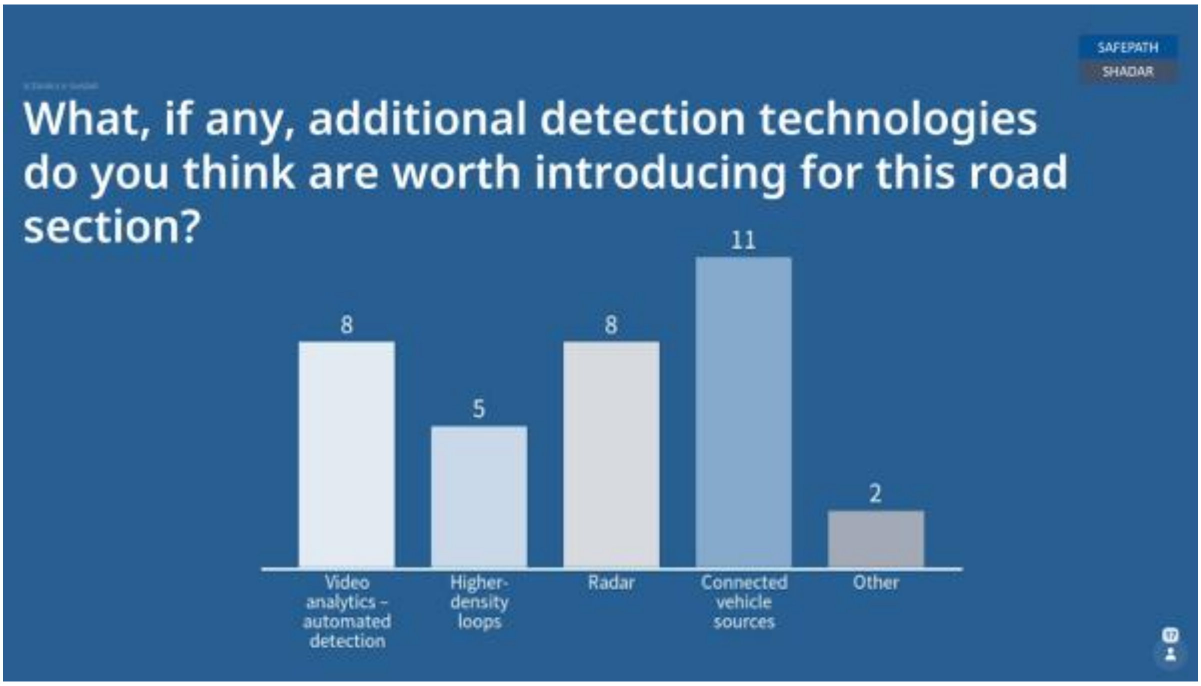

Figure 18. Poll: What, if any, additional technologies do you think are worth introducing on this road section?

- Amongst the ‘other’ category of detection technologies, the most promising for further investigation was considered (by all participants, not just those who voted ‘other’) to be drones, followed by thermal detection.
- Of various ways to get alerts from connected vehicles, Waze had the highest vote, closely followed by eCall data processing, then C-ITS, then commercial floating vehicle data, with involvement of the Data for Road Safety consortium quite far behind. The results are shown in Figure 19.

Figure 19. Poll: What, if any, connected vehicle services do you think are worth harnessing for this road section?

- We therefore drilled into reasons for the lack of votes for use of the Data for Road Safety consortium. A common theme in responses was a lack of knowledge, but there were also suggestions that more vehicle coverage is needed for it to become more useful.
- Having noted the need for public and private sector to be consistent when informing other vehicles about stopped vehicle hazards, the newly updated TM2.0 public/private cooperation levels were presented, and participants were asked which levels can be achieved in their countries in the next 5 years. The largest group thought that private sector route guidance in line with public policy could be achieved. A small number were more optimistic, thinking that public orchestration of all traffic management stakeholders could be achieved (funding may be an issue here), while another smaller number were more pessimistic, thinking that only in emergencies would the private sector acknowledge public sector constraints.

‘What additional radar detection capability would be worth investigating?’

- The radar detection capability that was considered most worth further research was specific lane determination. Other ideas suggested by participants were mobile radar devices (the calibration challenge was noted) and status reports that acknowledged blind spots created by large vehicles. In the case of a line-of-sight device such as a camera, one may have to rely upon extra information such as the build-up of traffic queues, to deduce the presence of a stopped vehicle.

2.3.3.2.2 Special session on stopped vehicle alert fusion

Participants took part in a role-play exercise to help further explore the topic of multi-source stopped vehicle detection and the fusion of alerts.

Participants were asked to imagine for the purpose of the exercise that they were operational traffic management staff. They were shown a series of stopped vehicle alerts and related information and had to record their thinking about whether they would wait for more information, actively investigate, or initiate an incident response. Participants were advised that they didn't have enough time to investigate every single case.

The potential detection sources were radar, video analytics, Waze, loop-based queue detectors, and eCall. The series of alerts were presented in two separate shifts, and between these shifts the imagined traffic management operators were trained in a new alert data fusion system used in the second shift. Although the participants were not informed, the same set of 8 scenarios were repeated in each shift, with the use or lack of alert fusion meaning that the alerts from the same scenarios were presented in a different way in each case.

The participants, although professionals in the road traffic domain, were not traffic managers; the exercise had limited realism, and the sample size of 17 people with recorded decisions is relatively small, so the results are far from scientific, but they do seem interesting. For example:

- In one scenario where two sources detected the event, but radar did not, there was *much* higher (4/17 became 12/17) positive activation of incident response with fusion than without. Just seeing that the 2 sources had alerted did not give the confidence to initiate a response but seeing that statistically this means a 97% confidence in being a real event appears to have persuaded many people to initiate a response.
- In the two scenarios where 4 sources all alert, where understandably the decision to initiate response was extremely common, with the introduction of fusion there was less investigation before committing to a response.
- In the scenarios where our intention was a false alarm from one source, with fusion there was a reduction in ultimately unnecessary (though procedurally sound) investigation. This is likely to have been because the fusion engine displayed the low probability of a real event based on the absence of indications from other detection sources. In these cases there was also an increase in waiting to see if further indications would emerge.

Subsequent discussion by participants noted the following:

- Some participants considered that the introduction of explicit confidence reports in the second shift helped their decision-making.
- The SHADAR study of stopped vehicle response had noted that well-defined procedures limit the scope for individual decision-making. It was suggested that the traffic management system, not the human individual, should either recommend or even implement a course of action, yet human sense-checking was also valued.
- Such procedures could, however, simply form a framework to support human decisions. It was noted that this might be complex for alert fusion.
- When using multiple data sources, it was considered important to know about the time left before the *lack* of detection from any source becomes significant. A visible countdown was suggested (or as explored in the SHADAR research, a more sophisticated profile of alert timing could even be used to update confidence continually).
- In the case of eCall, at least one participant's organisation policy was always to investigate (and respond if necessary).

2.3.3.3 Design

The Design stage involves customising the measure to the situation. The design stage checklist raises the following conditions:

- The impact of local driving styles has been considered.
- Local driving regulations match those where the measure is known to work.
- The measure has been assessed for changes to road user behaviour.
- The measure will deliver sustainable improvements.
- The impact of the measure on vehicle emissions is understood.
- The impact of the measure on noise pollution is understood.
- The impact of future changes (e.g. automated vehicles) has been considered.
- Other measures to mitigate any negative impacts (e.g. on safety or society) have been identified.

'*What does your organisation consider at this stage?'*

- ➢ Regarding driver behaviour:
  - This affects the adoption of measures. It was highlighted that in the Netherlands, Red X signs are used, and they achieve near 100% compliance. In France, they use concrete barrier and move it physically to change priority.
  - It is important to inform all drivers of new regulations. For example, the different speed limits for driving in rain. Overall, regulations need to be understandable to international drivers.
- ➢ When considering sustainability:
  - Increasing capacity could have a detrimental effect on other factors. For instance, for air quality issues, National Highways has reduced speed limits for more urban areas where there are Clean Air Zones and Rijkswaterstaat is providing controlled speeds, which avoids flow breakdown and maintains throughput, but the capacity is compromised.
  - A workshop attendee described how some NRAs are earlier in the journey towards greater sustainability and congestion is currently the greatest issue. Adoption of air quality and other aspects are improving but not well developed yet. Others added that a systems approach is needed to balance safety, sustainability, and the need for mobility. There is a balance needed as people demand reliability of journey time and low congestion but also complain about increased air quality issues.
- ➢ Future changes to the highways system also need to be considered:
  - Those envisioned by the participants included electric vehicle charging lanes (dynamic vehicle charging) and a need for VMS and gantry signals, as they improve safety, which is a top priority.
  - It was further pointed out that methods for enforcing speed limits would have to be updated if everything moved in-vehicle.
  - One participant noted that, as regards certain new technologies, 'the future is always 5 years away.'

2.3.3.4 Implement

The implementation checklist involves learning lessons from previous improvements. It raises the following requirements:

- The road authority has relevant technical expertise (or can procure this).
- The back-office systems of the NRA can integrate the measure.
- The performance of the technology is understood (accuracy, precision, downtime).
- There is a competitive market for the technology.
- Literature about the measure has been examined for lessons learned.

'*What does your organisation consider at this stage?'*

- ➢ There are a lot of regulations.
- ➢ Compliance is the biggest issue and needs to be considered.
- ➢ Bans on certain vehicles on certain roads on certain days could affect the design.
- ➢ Higher capacity could lead to reduced sustainability. Sustainability is now a major priority for most countries in Europe.
- ➢ Induced demand is a further aspect that is not always factored in at the Design and Implementation stages.
- ➢ People skills: People tend to stick to what they know and are often reluctant to change how they do things.
- ➢ The current understanding of the technology market proved a major issue for discussion.
    - o Some participants believed that this is the responsibility of the market to promote.
    - o There needs to be a competitive procurement route.
    - o Some participants had an issue with always ending up with local suppliers, possibly limiting the pool of knowledge.
    - o New trials do open opportunities, but also create bias towards incumbent suppliers.
    - o The data marketplace is very open and could adopt framework type approach, but specific technologies are more focussed and limited in competitive arena.

2.3.3.5 Evaluate

This stage involves monitoring and evaluating the impact of the measure and sharing the results. Discussion about this stage was understandably limited as nothing had been implemented for real. The checklist for this stage raises only two issues:

- Feedback from the implementation of the measure has been shared.
- The authors of the Practitioners' Guide have been informed for inclusion in the database.

'*What does your organisation consider at this stage?'*

- ➢ Participants agreed that some operator training and workshops with NRA subject matter experts would be beneficial to share knowledge and promote the lessons learned.

2.4 Lessons learned

Following the completion of the conference, the project team convened to reflect on the achievements of the event and share ideas about how it could be improved. A survey was also distributed amongst attendees for their feedback.

The following sections summarise what went well, and what could have been better. All comments made here should be considered as opinions.

2.4.1 What went well?

A well-considered agenda was designed and circulated in advance. However, the project team prepared content that relied on audience participation. Given this is not always guaranteed, the conference *presentation material was designed to be flexible* – allowing for instance, an ad-hoc presentation about how stopped vehicle detection is implemented by one of the NRA's representatives.

Generally, there was *active participation from attendees*. This included general discussion within the room, digital interaction using mentimeter, and role play using a paper-based form.

The *role play exercise was particularly memorable*. It was well planned and executed by the SHADAR team, did well to demonstrate the benefits and challenges of sensor fusion, and provided a common talking point amongst attendees. It also highlighted the challenges operators face in decision making.

The hosts of the meeting (SPW) provided *excellent refreshments*, lunch, and evening meal. Certainly, this helped to stimulate participation. Likewise, the *venue and the layout* provided a comfortable and welcoming environment to facilitate discussions and idea sharing.

The conference involved a *broad range of speakers* from the SHADAR and SAFEPATH projects. This helped to keep the content fresh.

Although the projects were not similar in approach, there was *excellent collaboration between the two project teams* before and during the conference. The *projects appeared complementary*, and the transition back and forth between them during the conference was relatively seamless.

For the SAFEPATH project, there was *good focus on the three project outputs*, rather than the process used to create them. The process has been covered in detail in previous meetings involving many of the attendees.

There was good time during the conference *focused on future work and opportunities for CEDR and NRAs*. This included how the outputs from the projects could be utilised, as well as other actions that should be taken to ensure there is *legacy from the programme*. This meant the attendees left the conference with fresh ideas.

Overall, the attendees were *relaxed and comfortable* during the conference.

2.4.2 What could have been better?

The conference did suffer from some *minor technical issues*: The Wi-Fi did not seem to cope very well with the number of devices requiring service (although an ethernet connection was quickly found to provide a strong connection to remote attendees); there were not sufficient power sockets for all the laptops and other devices requiring charge; and the contrast settings on the overhead projector meant some of the charts shown during the presentations were not very clear (although remote attendees did not suffer this issue).

There was *no time for virtual reality demonstration* for the SHADAR project. This was partly due to delays caused by the above technical issues, and partly due to the extended discussion, particularly on eCall.

A small number of participants were *more vocal than others* during the discussions. This is quite common in events requiring participants to speak publicly but may have been exacerbated by the mix of native languages. More effort could have been made provide opportunities for all participants to contribute, such as more use of interactive functions.

During refreshment breaks, there was a noticeably high level of discussion taking place between attendees about the conference theme. At times, this was cut short to return to the agenda. In future, it may be worth including *longer refreshment breaks* or *specific networking sessions* to allow these discussions to grow.

Interaction with virtual attendees could have been improved. Although no complaints were raised about the quality of the audio or visual systems, there is still learning to be done regarding hybrid meetings.

There were some excellent discussions being held that would have been more impactful earlier in the projects. This was understandable, though, given that the projects started during a period when travelling was either restricted or undesirable. However, it serves as a reminder how useful and generative in-person meetings can be. A group photo of some of the presenters and attendees is shown in 20.

Figure 20. Group photo of some of the presenters and attendees at the conference in Namur.

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Final Programme Report from CEDR Research Programme Call 2019 Safe Smart Highways

Conférence Européenne des Directeurs des Routes

Conference of European Directors of Roads

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