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Smart infrastructure access policy: a highway towards more efficient road freight transport

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Abstract

This paper describes interim results of the ongoing CEDR-funded “FALCON” project, which aims to introduce a step improvement in transport efficiency in Europe through the definition of a new performance-oriented legislative framework for road freight transport, thus ensuring a proper match between vehicles and the infrastructure. A Smart Infrastructure Access Policy (SIAP) is being developed as the primary method of regulation, in which policy explicitly specifies the performance level required from the road freight vehicle with respect to safety, manoeuvrability, infrastructure loading, and environmental impact, while giving consideration to national topologies and operational conditions. This method is fundamentally different to the prescriptive approach which mandates mass and dimension limits of vehicles. The prescriptive approach indirectly and often ineffectively ensures acceptable vehicle performance, as is the case of current, mainly prescriptive oriented, European legislation (96/53/EC).

Keywords: Smart Infrastructure, Decarbonization, ITS and Traffic Management, Regulatory Framework.

Nomenclature

PBS	Performance Based Standards
CO ₂	Carbon dioxide
EU	European Union
GDP	Gross Domestic Product
SIAP	Smart Infrastructure Access Policy
HCV	High Capacity Vehicle
RSC	Roll Stability Control

1. Introduction

The European Commission has set ambitious emission targets for the transport sector in its Transport White Paper (2011). The transport sector currently contributes to about a quarter of CO₂ emissions in the EU and is the only sector with an increasing trend according to European environment Agency (2017). One of the major drivers behind this trend is the growing demand for freight transport resulting from vertical disintegration and globalization. Road transport in EU accounts for about 75% of goods transport on land today, and is projected to increase in the forthcoming decades. It is expected that by 2030 the total freight transport volumes will grow further by approximately 38% with respect to 2011, while distributed over the transport modes, see Fig. 1.

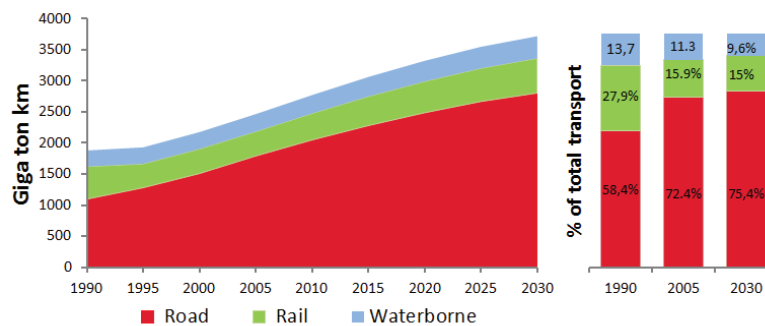


Fig. 1 Transport Demand Prognosis, European Commission (2011)

Moreover, as can be seen in Fig. 1, the road segment will remain a dominant transport mode in EU in the future with the highest energy consumption, and therefore biggest impact on the environment and society. Furthermore, this represents an increasing load on existing European infrastructure which cannot accommodate an additional 38% of transport demand. Expanding the capacity of current European infrastructure by nearly 40% is simply not viable within next decade due to the enormous financial investments required. Therefore, the risk of severe traffic congestions in the future seems unavoidable, when using current legislative framework that allows very limited design of commercial vehicle combinations. Based on the latest numbers from the European Commission (2013), the current costs associated with traffic congestions in the EU already correspond to approximately to 100 billion euro, representing 1% of the EU GDP.

Hence, the increasing demand for transport and mobility together with the congestion problem explicitly calls for intrinsically more efficient transport system. As proved by practice in number of countries all around the world, a Smart Infrastructure Access Policy (SIAP) has significant potential to optimize the use of limited infrastructure, while ensuring infrastructure protection, vehicle safety and societal benefit. A Performance-Based Standards (PBS) framework has been shown to be a highly effective form of SIAP. The biggest advantage of PBS compared to prescriptive policy, is that PBS is more pragmatic and ensures a better fit between the vehicle and infrastructure. This may result in allowing vehicle combinations operating outside of current directive 96/53EC which will be more suitable for intermodal logistic operations, will better match particular segments of the infrastructure network, will be more environmentally friendly in terms of emissions OECD/ITF (2011), and will be more profitable Kraaijenhagen (2014), all of which significantly contribute to enhancing overall transport efficiency. This paper outlines current efforts of the FALCON|CEDR project to assess the feasibility of a PBS framework for Europe and is organized as follows. Firstly, the formal problem definition is stated. Next, the fundamentals of

Performance Based Standards are discussed and followed subsequently by implementations and experiences from number of selected countries. In section 4, the paper continues by summarizing the interim results of the FALCON|CEDR project. The paper is ended by the description of the upcoming research tasks and conclusions.

2. Objective definition and methodology

In order to substantially enhance road transport efficiency in Europe, the primary objective of the ongoing FALCON|CEDR project is to compile a Smart Infrastructure Access Policy (SIAP). The policy is being defined for both current and future commercial vehicle combinations that excel in intermodal applications on selected segments of the European infrastructure network. The policy framework will adopt a Performance-Based Standards methodology. Furthermore, segments of the road network from selected European countries will be categorized into a number of levels. For the infrastructure categorization, the design criteria in different countries are crucial, especially for tunnels, bridges, and pavement design, as well as geometrical constraints, multimodal accessibility or geographical position.

The performance of each commercial vehicle combination is subsequently used as an access criteria to specific segments of the infrastructure network according to their categorization. It ensures a proper match between the vehicle and categorized segments of infrastructure network in terms of safety, bearing capacity of the infrastructure and the sustainability, which may substantially simplify and stimulate the cross-border transport. Moreover, it provides flexibility in the design of vehicles, that is not directly limited by dimensions, and stimulates the implementation of novel technologies that improve the performance of the vehicle combination, for example trailer steering or powertrain hybridization. The methodology consists of a number of distinct steps:

- Define a representative fleet of commercial vehicle combinations, employing standardized loading units that are highly suitable for intermodal transport.
- Compile a representative European infrastructure catalogue consisting of various pavements, bridges and tunnels in selected countries.
- Conduct a thorough review of current European policy related to vehicle and infrastructure on a national and federal basis.
- Define the SIAP framework based on representative fleet performance, representative infrastructure catalogue capacity and current EU policy.
- Validate the proposed SIAP framework to ensure a proper scaling of performance criteria as a function of road access.
- Conduct a set of case studies quantifying the impact of SIAP on congestions, aging and deterioration of an infrastructure, and modal choice.

3. Performance Based Infrastructure Access Policy in the World

A Performance-Based Standards framework for heavy vehicle regulation has been successfully implemented in Australia and Canada, and is on trial in South Africa. This approach explicitly defines the performance levels required from the vehicle combination with respect to safety, manoeuvrability, and infrastructure loading, rather than by mandating prescriptive dimensional limits. The performance of a commercial vehicle is subsequently used as an access criterion to specific segments of the infrastructure network that is previously assessed and categorized into number of levels according to design criteria, geographical position, or bearing capacity.

3.1. Australia

In Australia, a PBS scheme has been formally adopted into national transport legislation, and participation is voluntary. The scheme permits longer and/or heavier goods vehicles on designated subsets of the road network, provided they have undergone a comprehensive simulation-based assessment to prove acceptable vehicle dynamics performance, road wear impact and bridge loading impact. Additional requirements include special accreditation of the operator, smart access control and tracking of the vehicles, and special requirements for loading control and driver training. The Australian PBS scheme NTC (2008) consists of a set of twenty performance standards, against which all participating vehicles must be assessed, and which must all be passed. There are sixteen safety standards and four infrastructure related standards. Compliance of a vehicle with these standards is assessed either via physical testing or computer simulation. Computer simulation has proved very effective, and is the most common form of assessment due to the cost and effort involved in testing a prototype vehicle.

Thirteen of the sixteen safety standards are summarised in Table 1. with a description of each standard and a description of the associated test or manoeuvre. The three remaining standards – overtaking provision, ride quality and handling quality – are under review and are not likely to form part of the scheme in the short term. The four infrastructure standards are: pavement horizontal loading, pavement vertical loading, tyre contact pressure distribution and bridge loading. These standards are predominantly prescriptive due to the nature of the vehicle-infrastructure interaction. For each of the standards there are quantitative criteria against which the vehicle must be assessed. These will form an important aspect of the current work, as they will be dependent on many factors which are potentially unique to Australia or Europe. For example, to comply with the static rollover threshold (SRT) standard, that is the steady-state level of lateral acceleration that a vehicle can sustain during turning without rolling over, the vehicle must exhibit an SRT of at least 0.35-g, where g is the gravitational acceleration.

In some of the standards, the criterion is not universal and its value depends on the type of road access the vehicle will utilise. For this purpose, the PBS scheme has four defined road access Levels 1-4. Level 1 represents unrestricted access to the Australian road network, with the most stringent performance criteria. Levels 2, 3 and 4 represent subsets of the road network, in increasing order of route restriction, that have been deemed fit for the operation of longer vehicle combinations that meet less stringent performance criteria.

A fundamental pillar of the Australian PBS scheme is the associated National Heavy Vehicle Accreditation Scheme (NHVAS) and Intelligent Access Programme. Operators participating in the PBS scheme must be accredited with the NHVAS, a self-regulated compliance scheme. This ensures that operators meet a minimum set of requirements, over and above what is required by normal legislation, which address good practise in terms of vehicle maintenance, driver training and wellness, fatigue management and loading control. This ensures that operators of PBS vehicles, which are typically longer and or heavier than conventional trucks, are operated professionally and with the highest regard for safety and road network preservation. Participation with the IAP scheme is mandatory in some cases and is equally important for the PBS programme. This ensures that vehicles operate on the routes which they have been designed and approved for. This also enables transparency between operators and regulators, as real-time tracking information is available to regulators for all participating.

Table 1. Australian performance standards and manoeuvres (NTC 2008)

Maneuver	Safety Standard	Description
Accelerate from rest on an incline	1. Startability	Self-explanatory
Maintain speed on an incline	2. Gradeability	Self-explanatory
Cover 100m from the rest	3. Acceleration capability	Intersection/rail crossing clearance times.
	4. Low-speed swept path	'Corner cutting' of vehicle combination
	5. Frontal Swing	Swing out of the vehicle's front corner
	5a. Maximum of difference	The difference in frontal swing-out of adjacent vehicle units where one of them is semitrailer.
Low-speed 90 degree turn	5b. Difference of maxima	
	6. Tail swing	Swing-out of the vehicle's rear corner.
	7. Steer-tyre friction demand	Maximal friction utilized by steer-tyres.
Straight road of specified roughness and cross-slope	8. Tracking ability of a straight path	Total road width utilized by a vehicle as it responds to the uneven road at speed.
Constant radius turn (increasing speed) or tilt-table testing	9. Static rollover threshold	The maximum of steady lateral acceleration a vehicle can withstand before rolling over.
	10. Rearward amplification	'Whipping' effect as lateral accelerations are amplified in trailing units.
Single lane-change	11. High-speed transient off tracking	Overshoot of the rearmost trailing unit.
Pulse steer input	12. Yaw damping coefficient	The rate at which the yaw oscillations settle.
Brake from 60 km/h to rest	13. Directional stability under braking	Directional stability and controllability of the vehicle under heavy braking.

3.2. South Africa

South Africa have been operating a trial PBS scheme since 2008, largely based on the Australian scheme, and using similar methods of smart access policy. There is also an equivalent self-regulation scheme in place (the Road Transport Management System), accreditation with which is mandatory for all participating operators. As of February 2017, the trial includes 215 participating vehicles, transporting commodities such as mining ore, timber, fuel, coal and sugar, with vehicles ranging in length from 22 to 40 m, and in mass from 56 to 148 tonnes. To date, performance data for 92.4 million truck kilometres have been accumulated, together with data from conventional vehicles performing the same freight task on identical routes (the “baseline” vehicles).

The data show that the demonstration vehicle fleet has yielded significant savings in terms of truck trips, fuel consumed, and CO₂ emitted versus baseline vehicles (traditional trucks performing the same transport task operating under normal transport regulations) CSIR (2017). At the same time the trucks have yielded between a third and a half of the crash rate of the baseline vehicles, and have significantly fewer incidents of overloading, poor maintenance and other incidents as a result of the over-arching SIAP, CSIR (2017).

3.3. Sweden

The existing legislation in Sweden allows heavy vehicle combinations with a maximum length of 25.25m and maximum weight of 64t on the road network. Currently, the Swedish government is undertaking a large research program to investigate the use of HCVs in Sweden, part of which is the project “PBS for high capacity transport in Sweden”. The project objective is to investigate the applicability of PBS in Sweden and to propose a regulatory framework based on PBS by identifying a set of performance based standards suitable for Sweden, with attention to winter road conditions. The project started at the end of 2013 with reviewing the existing regulations, PBS approaches in other countries and other relevant literature. All the three domains of safety, infrastructure and environment were considered in this review. The gathered information is available as a public report, see Kharrazi et al. (2015). Though the project will be fully finalized in autumn 2017, the Swedish government recently decided for opening of a designated part of the road network for 74t vehicles from summer 2018 onwards. The regulations related to 74t road network were formulated upon long term results obtained from aforementioned research program.

During the project, a candidate set of performance measures was identified and examined. One of the investigated issues in the project is the required level of modelling details for assessing different performance measures. For instance, the carried investigation for the traction related performance measures showed that the model complexity could potentially be kept relatively low, without a significant loss in accuracy. However, for winter/low friction conditions a higher level of complexity might be required, see Bruzelius et al. (2016). A primary outcome of the project is the results of a study on the correlation between heavy vehicles performance in summer and winter conditions, which can be used for assigning required performance levels that also ensure safety in winter conditions. Results can be found in (Kharrazi 2016). Development of an open PBS tool has also started during the project, results of which are published in a public report (Jacobson et al. 2017). There have been several trials with HCVs, as part of the HCV program in Sweden. Since 2009, 50 vehicles have been operating in the program, saving about 10 million litres of diesel and a 25000 tons of CO₂, see Skogforsk (2017).

3.4. Netherlands

Although Netherlands have not operated a PBS scheme to the extent of the Australia or Sweden, there has been a continual effort to increase the efficiency of the road freight transport through the implementation of High Capacity Vehicles (HCVs). This started in 2000 with four experimental vehicles, each 25.25 m in length and up to a maximum operational mass of 60 t using standardized loading units. Those vehicles were allowed to operate on highways, and primary roads from highways to distribution centres. The vehicles were forced to satisfy most of the European prescriptive safety regulations except the one on low speed cornering where more space was provided in terms of national exception. It implied that those vehicles could not be employed for a cross-border transport. Over the years the number of HCVs increased based on very positive results in terms of profitability and sustainability, which in 2013 resulted in legalization of HCVs on national basis.

Since then, the national heavy vehicle regulator (RDW) has provided an open-access digital map of the infrastructure network segments, which were granted by the exception to allow HCVs operation (see Fig. 2). In

practice, if an operator requires an HCV to operate on a certain segment of the infrastructure, a request must be submitted to RDW to assess required infrastructure section. RDW will use a standard assessment procedure defined by CROW (2013), which reflects on the infrastructure and vehicle dimensions and vehicle maneuverability. If the proposed infrastructure segment satisfies the criteria, the road is “opened” and added to the map of allowable roads for HCVs to operate on (in green). In case of assessment failure, the segment is marked red, and no HCVs are granted access to this segment.

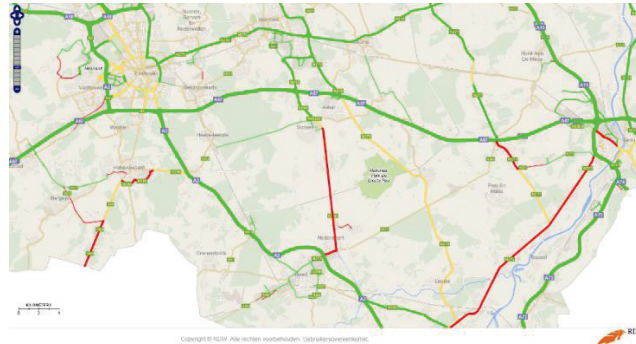


Fig. 2 Infrastructure network in Netherlands, indicating open and restricted access segments for HCV in green and red respectively

4. FALCON|CEDR interim results

The FALCON|CEDR project is scheduled to be finalized in the fall of 2018. As some interim results have already been obtained, they are herewith presented.

4.1. Representative fleet

The SIAP will be primarily developed for vehicle combinations which have good potential for multimodal transport through using standardized loading units that can be employed in other transport modes such as rail or water. Namely, we are considering 20ft and 45ft containers, and the 7.82m “swap body”, to be most frequently employed in the future because of their high utilization pallet ratio. Combinations of these loading units are utilized to define feasible vehicle combinations that are able to accommodate them. This resulted in a fleet of 27 unique vehicle combinations, that differ in terms of configuration, volumetric capacity, and operational weight. Some of them are depicted in Fig.3, where the operational weight of each vehicle combination as a function of the overall vehicle combination length is provided.

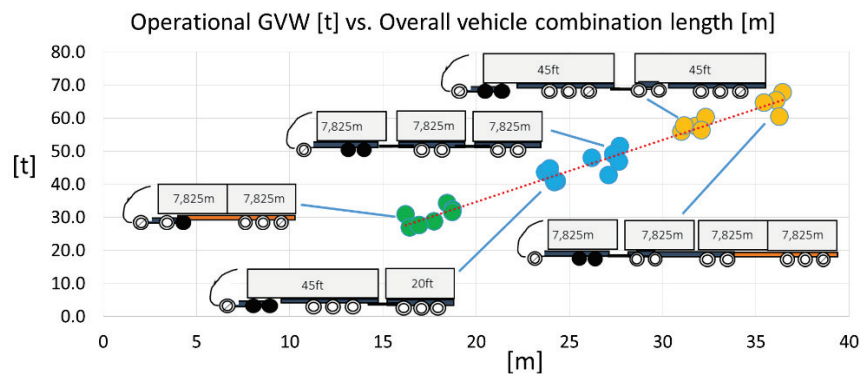


Fig. 3 FALCON|CEDR representative vehicle fleet

The operational weight of the vehicle combinations is governed by the representative loading condition that is also decisive for the infrastructure loading, and the vehicle dynamical behavior. As shown in numerous studies, most of the European long haul road transport is exerted on volumetric basis, meaning the space utilization of the loading unit is superior to its maximal weight limits (being approx. 26t for the common Tractor-Semitrailer combination).

In Fig.4 it can be seen that average load factor for EU is approximately 60% of maximum load capacity. In comparison, according to Davydenko (2015) and Lumsden (2009), volumetric and floor utilization loading factor is typically utilized with considerably higher rates while reaching 82% and 92%, respectively. This is very favorable for the potential future utilization of HCVs within a SIAP scheme, as their impact on the infrastructure network in terms of bridge and pavement loading will be comparable to current limits.

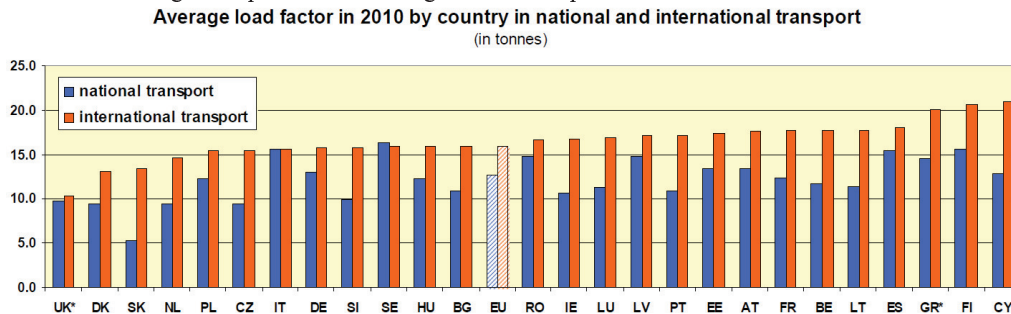


Fig. 4 Representative loading condition in EU as reported by European Commission (2011)

4.2. Representative Infrastructural Catalogue

The representative infrastructure catalogue is a compiled library of infrastructural components whose design depends on expected traffic load and volume. The library is organized through the categories of infrastructure elements that have been used in the various European studies of HCVs, such as for example European Commission (2009), OECD (2011), Kharrazi & Karlsson (2015), Walloon region DGO1(2016) as well as in European research projects dealing with the development of new road freight vehicles, TRANSFORMERS (2017). These categories are as follows:

- Pavements (existing types of pavement structures, design criteria, deterioration mechanisms etc.)
- Bridges (existing bridge structures, static load effects, fatigue, design criteria etc.)
- Tunnels (outer dimensions, axle load limits, calorific power of the truck payload, etc.)
- Horizontal geometry of the road (different road classes, road alignment, cross section, longitudinal profile, skid resistance characteristics, etc.)
- Road equipment (safety barriers, and parking lots)
- Services (intermodal terminals)

For each of these categories, an overview of the existing infrastructure is given in the catalogue. Subsequently the link between the design criteria of particular infrastructure category and the traffic load is elaborated. Finally, a methodology for assessment of this infrastructure category is proposed in order to quantify potential impact of vehicles operating within SIAP, and thus outside directive 96/53/EC, on the selected infrastructure segments. The catalogue will be mainly used as a representative source to create operational routes for of the case studies that are used as validation of the SIAP.

4.3. Policy review

As part of the FALCON project, relevant European legislation for commercial heavy vehicles, and the corresponding regulations implemented in the countries involved in the FALCON project, namely Sweden, Norway, Netherlands, Germany, UK, France and Belgium are reviewed and compared. It should be noted that there are two types of European legislations: regulations and directives. Regulations have general application and are applicable in all member states, while directives set out general rules to be transferred into national law by each country as they deem appropriate.

Here a brief comparison of the length and weight limits in the considered European countries are presented. The Length of motor vehicles in the EU is regulated in the R (EU) No 1230/2012 which is also applied in the studied countries (EC 2012). However, in Norway it is not applied to timber transport, and in Sweden it is only applicable to modular vehicles. The length of vehicle combinations in Europe are regulated in the Dir 96/53/EC, which is 16.5m for articulated vehicles and 18.75m for road trains. Due to the article 4 of the directive gives each member country the possibility to use longer vehicle combinations in its territory, if they are based on the modular system.

A modular combination is a vehicle combination that consists of vehicle units defined in Annex I of the directive (EC 1996).

In Belgium, UK, France, Germany and Netherlands, the European length limits are applied, but for EMS vehicles in the Netherlands and Germany, which are allowed on parts of the road network, a maximum length of 25.25 m is applied. In Sweden the overall length limit is 25.25 m for a modular vehicle combination and 24 m for other combinations. The length limit of a vehicle combination in Norway depends on the road category; the largest value is 19.5 m with exception of 24 m for timber transport and 25.25 m for modular vehicles which are allowed on parts of the road network.

The single axle load limits are very similar in the studied countries and comparable with the EU limits for international traffic stated in the Dir 96/53/EC; only France has a marginally higher single axle load limit. For a bogie, the load limits are comparable, but the reference axle distances for setting the bogie load limit are slightly different for some countries. For instance, in Norway 0.8 m and in France 0.9 m are used as the axle distance, below which the lowest load limit is applied, while in other countries 1 m is used which is the same as the EU regulations for international traffic. It is a similar case with triple axles loads, i.e. the load limits are comparable but the reference axle distances are not uniform. France has higher triple axles load limits in comparison with other countries, and Norway has the lowest load limit for an axle distance below 1 m.

The weight limit for a motor vehicle depends on its number of axles in all the considered countries and is quite similar to the European limits for the international traffic (the Netherlands is an exemption with higher limits). The EU limits are 18/25/32t for a motor vehicle with 2/3/4 axles respectively; a two axle motor vehicle can weigh 26t if driving axle is fitted with twin tyres and air suspension or equivalent. For regulation of the weight limits of trailers and semitrailers different approaches are used in each country. Commonly the weight limits are regulated based on features such as the axle distances, number of axles and the vehicle type. For instance, in Sweden the weight limit depends on the axle distance between the foremost and rearmost axles in the vehicle/vehicle combination, while in the Netherlands, the axle load limits and the total weight limit of the vehicle combination determine the weight limits on the constituent units, i.e. trailers and semitrailers.

The total weight limits for a vehicle combination in Germany, France and UK are same as the international traffic in EU, which is 40t, or 44t in case of carrying a 40ft ISO container. In Norway and the Netherlands, the total weight limit is 50t, and it is 64t in Sweden. Furthermore, in Norway and the Netherlands, as well as in Belgium, EMS vehicles up to 60t are allowed.

4.4. An approach to define and validate SIAP for Europe

One of the main pillars of the FALCON project is to determine the precise definition of a suitable SIAP for Europe. Given the proven success of the PBS approach to this in other countries, this has been selected as the basis for the planned pan-European SIAP framework. The Australian PBS scheme is arguably the most comprehensive and advanced example of a national SIAP. It is hence attractive to use this as the basis for a European PBS framework. However, it is very important to take into consideration the obvious differences in operating environment between Europe and countries such as Australia, and how these will impact the changes and refinements which would need to be made to the Australian framework in order for it to be suitable for Europe. Differences to consider include but are not limited to:

- Climate and geography conditions, e.g. the possibility for icy conditions, or mountainous terrain
- The existing Australian conditions which influenced their choice of performance standards and criteria, including:
 - Existing Australian vehicle and road design legislation
 - Existing common vehicle combinations operating in Australia
 - The PBS performance of the existing Australian fleet of vehicles
 - Existing road network characteristics
- Existing conditions in Europe which will affect which standards and criteria are suitable, including the conditions as per the above point.
- The requirements for and availability of vehicle active safety technologies such as Roll Stability Control.

By studying these differences between Australia and Europe, suitable decisions may be made about which standards are applicable and which are not, what the specific pass/fail criteria should be for each standard, and how the road network should be segmented to grant access to different categories of HCV. Other standards may also be introduced where the Australian standards are thought to not adequately address issues important to the European context. For example, the effects of low friction conditions do not feature in the Australian standards for good reason, but these will be very important for the European context. New standards which assess vehicle performance under low friction should therefore be introduced.

This process has been undergone to an extent in South Africa, where the Australian PBS system has been changed and updated to suit the conditions of South Africa. A simple example is the difference in vehicle width legislation, which is 2.5 m in Australia and 2.6 m in South Africa. Some performance standards are directly affected by vehicle width, and so the pass/fail criteria for these standards have been suitably optimised for South Africa conditions. The lessons learnt from the South African experience will be useful here. Preliminary findings of the work are:

- The pass/fail criteria of the Australian standards will need to be modified to suit the European context. These changes will be based on studies of climate and geography, existing legislation, existing vehicles, and existing road networks.
- Low friction performance standards will need to be introduced which are not addressed in the Australian framework
- A roundabout turn manoeuvre will need to be added to address EU requirements
- Certain standards will be simplified or replaced where comparable and familiar standards already exist in Europe
- The split of road classification categories will need to be reviewed, and redefined for Europe
- A universal approach to assessing bridge loading and road wear impact will be sought, which is acceptable to all member states.

The sub-objectives of this work are as follows:

1. Define SIAP (from Australia, Canada, EU regulations, other)
2. Define and quantify access criteria
3. Define road categories
4. Define any other standards and prescriptive requirements

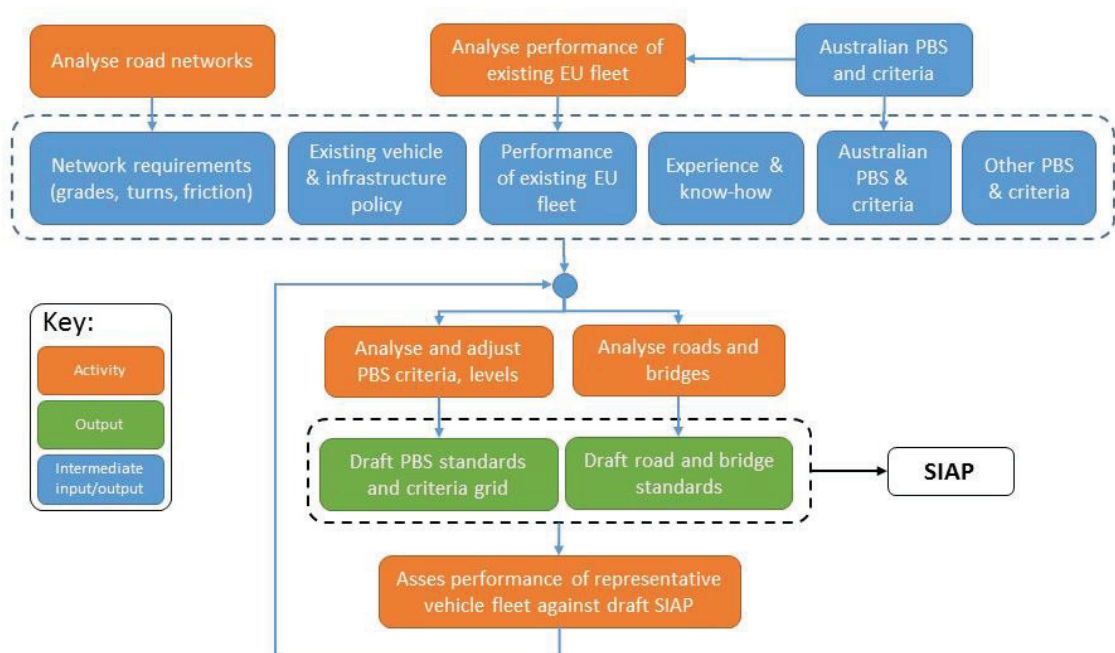


Fig. 5 Methodology to define SIAP

The planned methodology for the above is shown in Fig. 5. Starting inputs will include a pre-defined representative set of potential European HCVs, existing Australian and Canadian performance standards and criteria and the characteristics of existing European roads and legislation. From this, a draft set of performance standards will be defined. Then an iterative process will follow, where the draft set of standards is used to assess the representative fleet against vehicle safety and infrastructure standards and criteria. The results of this analysis will shed important insights into both the feasibility of certain existing HCV designs, and also the appropriateness of the draft set of standards. Through two or three iterations of this process the set of PBS and criteria will be defined, together with any other prescriptive requirements which may be deemed necessary. Once the SIAP has been developed, it will be virtually implemented in number of case studies quantifying the impact on road deterioration, congestions, environment and intermodal transport.

5. Conclusions and Upcoming Steps

In preparation for the definition of the SIAP, a number of important steps have been completed, including the definition of a representative fleet, the identification of important existing performance standards and schemes from which to build on, and the identification of important aspects of existing European legislation which will affect the feasible SIAO outcome. The next steps will be to prepare a draft PBS framework (standards, pass criteria, road segmentation), and to develop the simulation models of the representative fleet to use in the iterative assessment process.

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