THE DESIGN OF WEIGHT ENFORCEMENT STRATEGIES FOR OVERLOADED HEAVY-GOODS VEHICLES ON COMPLEX ROAD NETWORKS

Master Thesis

Martijn van Velzen

The design of weight enforcement strategies for overloaded heavy-goods vehicles on complex road networks

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Martijn van Velzen

Student number: 4229207

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Graduation committee

Chairperson	: Prof.dr. G.P. (Bert) van Wee,	Engineering Systems and Services
First Supervisor	: Dr. J.A. (Jan Anne) Annema,	Engineering Systems and Services
Second Supervisor	: Dr. M.L.C. (Mark) de Bruijne,	Multi Actor Systems
External Supervisor	: Ir. I. (Inge) Blommers,	Provincie Zuid-Holland
External Supervisor	: P. (Patricia) van der Holst,	Provincie Zuid-Holland

COLOPHON

AUTHOR

Author:	Martijn van Velzen
Email:	martijn_van_velzen@hotmail.com
Course:	SEN2331 CoSEM Master Thesis
Master Program:	Complex Systems Engineering and Management
Domain:	Transport and Logistics
Specialisation:	Infrastructure and Environmental Governance
University:	Delft University of Technology
Faculty:	Technology, Policy and Management

GRADUATION COMMITTEE

Chairman:	Prof. dr. G.P. (Bert) van Wee Section of Transport and Logistics Department of Engineering Systems and Services Faculty of Technology, Policy and Management Delft University of Technology g.p.vanwee@tudelft.nl
First supervisor:	Dr. J.A. (Jan Anne) Annema Section of Transport and Logistics Department of Engineering Systems and Services Faculty of Technology, Policy and Management Delft University of Technology j.a.annema@tudelft.nl
Second supervisor:	Dr. M.L.C. (Mark) de Bruijne Section of Organisation and Governance Department of Multi-Actor Systems Faculty of Technology, Policy and Management Delft University of Technology m.l.c.debruijne@tudelft.nl
External supervisor:	Ir. I. (Inge) Blommers Eenheid Advies Beheer Assets Dienst Beheer Infrastructuur Provincie Zuid-Holland i.blommers@pzh.nl
External supervisor:	P. (Patricia) van der Holst Eenheid Advies Beheer Assets Dienst Beheer Infrastructuur Provincie Zuid-Holland p.vander.holst@pzh.nl

PREFACE

This thesis forms the final step on my road towards the degree of Master of Science in Complex Systems Engineering and Management (CoSEM) at Delft University of Technology, within the Faculty of Technology, Policy & Management (department of Transport and Logistics). The past seven months, the province of Zuid-Holland offered me the opportunity to conduct this research under their guidance. In this period of time I was able to delve deeper into one single subject than I could ever imagine, which resulted in a report which I'm very proud to present. I would however not have been able to write this thesis without the support and contribution of some people, whom I would like to thank in this section.

First of all, I would like to thank my TU Delft supervisors. To start I owe many thanks to Jan Anne Annema, who was always there when needed and helped me with his enthusiasm, realism and his constructive and to the point feedback. This helped me to structure the report, to get confidence in my thesis and motivated me to keep on improving. Furthermore, I want to thank Bert van Wee and Mark de Bruijne for their supportive and enthusiastic feedback during the kick-off and green-light meeting.

I also like to thank my colleagues at the Province of Zuid-Holland. Despite the rather specific nature of my research, even within the DBI, I felt welcomed in the team. In particular thanks to my two supervisors, Inge Blommers and Patricia van der Holst. I thoroughly enjoyed our numerous discussions, which helped me to structure my own thinking process. Without your relativations, humour and feedback this thesis and my graduate process would not have been the same.

Thirdly, I would like to thank the eleven participants on the focus group session and the seven interview respondents for their contribution to my research. Their input, based on many years of experience with the topic, allowed me to understand the complexity of the problem within a short period of time.

Finally, I want to thank my friends for their support and company at the Leiden and Delft University Libraries. Special thanks as well to Isabel, for your endless patience and support.

Enjoy the read!

Martijn

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EXECUTIVE SUMMARY

On the Dutch national road network, around 15 percent of the heavy-goods vehicles (HGVs) is overloaded, yearly resulting in around 34 to 300 million euros in social costs (Hersbach et al., 2011; Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). Given the additional pavement damage, unfair competition and road safety reduction associated with HGV overloading, it is defined as an economic crime. The deployment and cost-effectiveness of weight enforcement in a broader context, within a dense and tightly interwoven infrastructural systems consisting of national, regional and local roads administered at multiple governmental layers, has not been addressed in the current literature. A second knowledge gap relates to the possibilities and effects of combining individual weight enforcement measures. Therefore, the following main research question will be answered:

How can the problem of overloaded heavy-goods vehicles on Dutch national and regional road networks be addressed in a cost-effective way, to reduce the social costs of heavy-goods vehicle overloading?

To answer the main research question, a Design Science Approach is used. Based on a literature study on enforcement, analysis of the current legislation, weight enforcement and governance situation and considerations and motivations for transporters to overload, four comprehensive weight enforcement strategies are designed. From the literature study, it is concluded that the enforcement strategy should consist of both compliance stimulating and violation deterring measures, applied both bureaucratically and strategically, allowing the inspector to vary in enforcement style and deal with various groups of conscious and unconscious violators. Furthermore, the strategies allow for responsive regulation, based on portfolio management. In this way, the inspector can scale up enforcement activities based on data retrieved from enforcement activities.

The analysis of the current weight enforcement situation shows that the financial benefits of overloading, which include a better competitive position, form a strong motivation to overload. Given the lack of social control and the extremely low chance of being checked and sanctioned, for 15 percent of the transporters the compliance stimulating effect of the current enforcement activities is too low. It is estimated that 80 percent of the offenders deliberately non-complies, while 20 percent is classified as unconscious violators. To avoid over- or underregulation, it is of importance that the inspector addresses both groups in the right way.

The four designed enforcement strategies are based on their main enforcement measure: Weigh-in-Motion (WiM) or On-Board Weighing (OBW), for pre-selection or direct enforcement. In the two WiM-based strategies, weight detection equipment is installed in the pavement, while in the two OBW-based strategies weight data is digitally retrieved from axle load sensors on the vehicle, by road-side systems. While for the two pre-selection strategies, reweighing on calibrated scales is needed in order to fine a transporter, in the two direct enforcement strategies, the WiM or OBW measurement serves as court-proof evidence. The strategies are complemented with strategic manual enforcement in WiM strategies and OBW handheld device-based enforcement in OBW strategies. Additionally, persuasive communication measures are taken, covenants will be closed and a prohibition on overloading in contracts in which the government serves as a client are included in the strategies.

Based on analysis using the Table of Eleven, it is concluded that the strategy *On-Board Weighing for automated enforcement* is estimated to have the largest compliance motivating effect, leading to the largest reduction of overloaded HGVs on the Dutch road network. Especially the advantages of strategic deployment of enforcement activities and possibility of directly sanctioning overloaded vehicles without reweighing, make this an effective strategy. Due to the complex relation between enforcement and compliance, it cannot be said whether this strategy will be cost-effective. However, especially compared to the basic enforcement strategies, the internal efficiency of strategy *OBW for automated enforcement*, expressed in euros per detected sanctionable HGV, is relatively high. It is therefore recommended to deploy this strategy and further research the exact composition of the strategies and its quantitative effect on the compliance level.

MANAGEMENTSAMENVATTING

15 procent van de zware vrachtwagens (HGV's) op het hoofdwegennet is overbeladen, jaarlijks goed voor 34 tot 300 miljoen euro aan maatschappelijke schade (Hersbach et al., 2011; Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). Gezien de door overbelading veroorzaakte extra wegschade, oneerlijke concurrentie en verkeersveiligheidsreductie, wordt overbelading gedefinieerd als een economisch delict. In de literatuur is de inzet en kosteneffectiviteit van handhaving op overbelading binnen een dicht en verweven wegennetwerk bestaande uit wegen die op meerdere overheidslagen worden beheerd, nog niet geanalyseerd. Een tweede kennislagune betreft de mogelijkheden en effecten van het combineren van individuele handhavingsmaatregelen. Daarom wordt volgende hoofdonderzoeksvraag beantwoord:

Hoe kan het probleem van overbeladen vrachtwagens op Nederlandse nationale en regionale wegennetten op een kosteneffectieve manier worden aangepakt, om de maatschappelijke kosten van overbelasting van vrachtwagens te verminderen?

Om de hoofdvraag te beantwoorden wordt een Design Science Approach gevolgd. Een literatuurstudie naar handhaving, analyse van de huidige wetgeving en handhavingspraktijk en overwegingen en motivaties van transporteurs voor overbelading vormen de input voor het ontwerp van handhavingsstrategieën. De literatuurstudie laat zien dat de handhavingsstrategie moet bestaan uit zowel nalevingsbevorderende als overtredingsafschrikkende maatregelen, op zowel bureaucratisch als strategische wijze toegepast. Op deze wijze kan de inspecteur variëren in handhavingsstijl en omgaan met verschillende groepen bewuste en onbewuste overtreders. Daarnaast dienen de strategieën responsieve regulering mogelijk te maken. Op basis van gegevens uit handhavingsactiviteiten kan de inspecteur indien nodig opschalen naar meer afschrikwekkende maatregelen.

De analyse van de huidige handhavingspraktijk toont aan dat de financiële voordelen van overbelading, waaronder een betere concurrentiepositie, een sterke motivatie vormen voor overbelading. Het gebrek aan sociale controle en de extreem lage kans om te worden gecontroleerd en gesanctioneerd leidt ertoe dat voor 15 procent van de vervoerders het nalevingsbevorderende effect van de huidige handhavingsactiviteiten onvoldoende effect sorteert. Geschat wordt dat 80 procent van de overtreders opzettelijk de regels overtreedt en 20 procent dit onbewust doet. Om over- of onderregulatie te voorkomen, is het van belang dat de inspecteur beide groepen op de juiste manier kan benaderen.

De vier ontworpen handhavingsstrategieën vloeien voort uit vier uitvoerbaar geachte hoofdmaatregel: Weigh-in-Motion (WiM) of On-Board Weighing (OBW) voor directe handhaving of voorselectie. In de twee WiM-strategieën wordt detectieapparatuur geïnstalleerd in het wegdek, terwijl in de twee OBW-strategieën de voertuiggewichten digitaal worden verkregen, gemeten via aslastsensoren gemonteerd op het voertuig. Om een transporteur te bekeuren, dient in beide preselectie strategieën naweging op gecalibreerde weegschalen plaats te vinden, terwijl bij de andere twee strategieën de eerste meting zelf al dient als voldoende bewijs. Strategische handmatige handhaving, al dan niet gebruikmakend van OBW detectieapparatuur, didactische communicatiemaatregelen, convenanten en een verbod op overbelading in overheidscontracten vormen de andere maatregelen binnen de strategieën

Dit onderzoek toont aan dat de strategie *OBW voor geautomatiseerde handhaving* naar verwachting resulteert in de grootste afname van overbeladen vrachtwagens op het Nederlandse wegennet. Met name de voordelen van strategische inzet van handhavingsinstrumenten en de mogelijkheid om overbeladen voertuigen direct te sanctioneren maken dit een effectieve strategie. Vanwege de complexe relatie tussen handhaving en naleving kan niet met zekerheid worden gezegd of deze strategie kosteneffectief is. Vergeleken met de basale handhavingsstrategieën, is de interne efficiëntie van de strategie *OBW voor geautomatiseerde handhaving*, uitgedrukt in euro per gedetecteerde goed te keuren zware vrachtwagen, relatief hoog. Het wordt aanbevolen om deze strategie in te zetten en verder onderzoek te doen naar de optimale kwantitatieve verhouding van de strategieën ten opzichte van elkaar en het kwantitatieve effect hiervan op het nalevingsniveau.

SUMMARY

In the Netherlands, yearly 630 million tons, equal to 82 percent of the domestic transport, is transported via road. Additionally, fifteen percent of the goods entering and twenty-one percent of the goods leaving the country are transported via road (Centraal Bureau voor de Statistiek, 2016). These goods are mainly transported by heavy-goods vehicles (HGVs), characterized by their gross vehicle weight of over 3,5 tons.

The economic benefits of transport activities for the transport sector and society as a whole are considerable. However, on the Dutch national road network, around 15 percent of the trucks is overloaded, yearly resulting in around 34 to 300 million euros in social costs (Hersbach et al., 2011; Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). Due to their weight, overloaded HGVs have a negative impact on the pavement and structures like bridges and culverts (Ministerie van Verkeer en Waterstaat, 2002; Mulyono, Parikesit, Antameng, & Rahim, 2010). Research estimates that 30 percent of the pavement damage can be related to overloaded trucks (Ministerie van Verkeer en Waterstaat, 2002). The theoretical calculated life cycle of roads could decrease by up to 30 percent, equal to several years (Vennix, 2016). Secondly, violating the maximum weight restrictions generates unfair financial benefits and increased competitiveness for noncomplying businesses, at the expense of the competitive position of their complying competitors. Lastly, overloading could result in reduced instability and braking capacity and a loss in motivity and manoeuvrability, especially in unexpected movements, swerving or bad weather (Jacob & Feypell-de La Beaumelle, 2010). Given these three consequences, in the Netherlands, overloading is defined as an economic crime.

A literature study on weight enforcement comes up two knowledge gaps in the existing literature. Firstly, the deployment and cost-effectiveness of weight enforcement in dense and tightly interwoven infrastructural systems consisting of national, regional and local roads administered at multiple governmental layers, has not been addressed in the current literature. A second knowledge gap relates to the possibilities and effects of combining individual weight enforcement measures. Therefore, the following main research question will be answered:

How can the problem of overloaded heavy-goods vehicles on Dutch national and regional road networks be addressed in a cost-effective way, to reduce the social costs of heavy-goods vehicle overloading?

To answer the main research question, a Design Science Approach will be used. At the start of the research, theoretical success factors for future weight enforcement are derived from a literature study. Analysis of the current legislation and weight enforcement situation and transporters' considerations and motivations for overloading are derived from empirical research, using desk research and the Table of Eleven, a scientific tool to assess future compliance. A compliance estimation provides insight in the magnitude of various groups of conscious and unconscious violators and compliers. The analyses are used to formulate requirements and constraints for future weight enforcement. Subsequently, in four design steps, the strategies are designed. For the deployment of measures on regional road networks, a case study of the road network of the province of Zuid-Holland is used. Next, the estimated effectiveness and cost-effectiveness of the strategies is assessed by the Table of Eleven and an estimation of costs and benefits. The design of the strategies is evaluated by stakeholder and expert interviews.

LITERATURE STUDY AND CURRENT ENFORCEMENT AND GOVERNANCE SITUATION

Based on the literature study, is it concluded that future weight enforcement strategies should have a generic preventive working rather than a specific preventive working. In other words, the risk of being checked and sanctioned should persuade transporters to comply, rather than an actual check or a sanction itself. The strategy should consist of both measures having a compliance stimulating effect, based on pedagogy, and measures having a violation deterring effect, based on sanctions. This allows the inspector to vary in enforcement style and deal with various groups of conscious and unconscious violators. Since the inspector has no complete insight in whether the inspectee is deliberately violating relevant regulations or not, responsive regulation should be applied. Responsive regulation allows the inspector to increase the pressure on transporters by scaling up enforcement activities in the direction of more sanction-based enforcement, when compliance stimulating enforcement does not have the desired result. Future enforcement measures should be deployed both bureaucratic-standardized and strategically. Bureaucratic enforcement activities are in general less expensive, but easier to anticipate on by inspectees. Costlier strategic enforcement activities are needed to address specific subgroups or to deploy less anticipatable enforcement activities. Using portfolios, the inspector gains insight in the type of inspectee (deliberately noncomplying or not aware of what it is doing) and the amount of social damage the inspectee is responsible for.

The analysis of the current weight enforcement situation in the Table of Eleven shows that the financial benefits of overloading, which include a better competitive position, form a strong motivation for companies to overload. This is visualized in Figure 2 on page XI, in which the compliance or violation stimulating nature of all eleven dimensions is visualized by blue dots on a continuous scale between ‘strong violation stimulating’ and ‘strong compliance motivating’. Given the lack of social control and the extremely low chance of being checked and sanctioned, the compliance stimulating effect of the current enforcement activities is too low for 15 percent of the transporters. Of these 15 percent violating regulations, about 25 percent is overloaded on gross vehicle weight and 75 percent is overloaded on one or more axles. Considering the fact that the nature of a large share of transport activities does not allow for overloading, the amount of overloading in subsectors sensitive for overloading is way higher. It is estimated that 80 percent of the offenders deliberately non-complies, while 20 percent is classified as unconscious violators. To avoid over- or underregulation, it is of importance that the inspector addresses both groups in the right way.

Based on the focus group session, it is concluded that all key stakeholders strive to decrease the number of overloaded HGV transports on the Dutch network. Where the sector mainly aims to reduce the number of HGVs overloaded on gross vehicle weight and argues not to focus on axle overloading, road administrators argue that both gross vehicle weight and axle loading should be enforced, since they both cause infrastructural damage.

An important constraint for future weight enforcement is found in European Directive (EU) 2015/719, amending Council Directive 96/53/EC, which states that all European Union Member States should take measures to at least pre-select heavy-goods vehicles for manual inspection, by means of weight sensors built in the pavement structure (Weigh-in-Motion) or weight sensors built in the heavy goods vehicle itself (On-Board Weighing).

FUTURE WEIGHT ENFORCEMENT STRATEGIES

Based on the literature study and analysis of the current enforcement and governance situation, four enforcement strategies are designed. The strategies consist of an interwoven package of measures. An overview of measures within the strategies can be found in Figure 1.

I. *Weigh-in-Motion for basic enforcement* includes the deployment of Weigh-in-Motion accuracy class B systems, accompanied with Automatic Number Plate Recognition Cameras. Since accuracy class B does not allow for direct sanctioning, suspicious vehicles will be selected for reweighing on certified static scales and sanctioning, based on the pre-selection by the Weigh-in-Motion system. Additionally, cease and desist orders can be imposed, solely based on the Weigh-in-Motion measures.

II. *Weigh-in-Motion for automated enforcement* includes the deployment of Weigh-in-Motion accuracy class A systems, accompanied with Automatic Number Plate Recognition Cameras. Accuracy class A allows for direct sanctioning, solely based on the Weigh-in-Motion measurements.

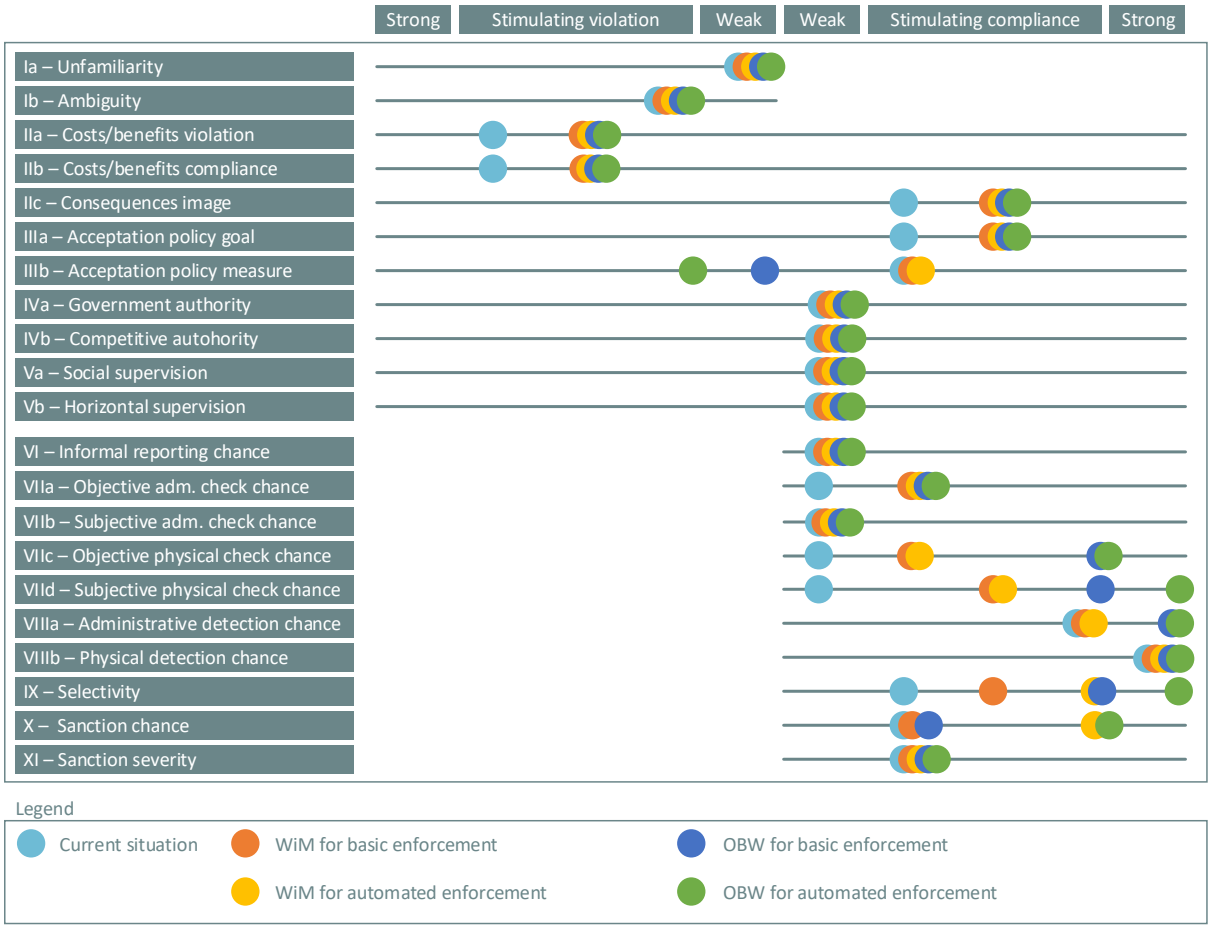
III. *On-Board Weighing for basic enforcement* includes the installation of accuracy class B axle load sensors and an On-Board Unit on new HGVs. Road side systems retrieve the axle load information from the On-Board Unit, making use of Dedicated Short-Range Communication (DSRC). Since accuracy class B does not allow for direct sanctioning, suspicious vehicles will be selected for reweighing on certified static scales and sanctioning, based on the pre-selection by the DSRC system. Additionally, cease and desist orders can be imposed, solely based on the DSRC measures.

IV. *On-Board Weighing for automated enforcement* includes the installation of accuracy class A axle load sensors and an On-Board Unit on new heavy-goods vehicles. Road side systems retrieve the axle load information from the On-Board Unit, making use of DSRC. Accuracy class A allows for direct sanctioning, solely based on the DSRC measurements.

In a case study for the regional road network administered by the province of Zuid-Holland, it is concluded that the two WiM-based main enforcement measures are not expected to be feasible, due to a lack of locations for reweighing, extensive opportunities for strategic avoidance behaviour and low expected internal efficiency. Therefore, only the deployment of OBW-based strategies is considered feasible on the regional road network.

Summary, Figure 1 – Overview of enforcement measures in strategies

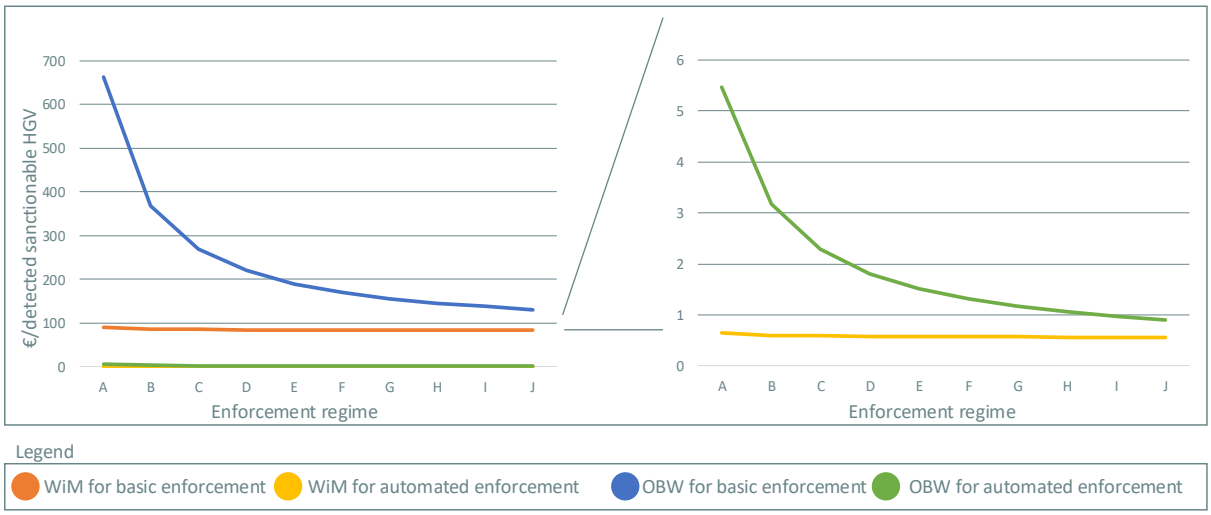
The effect of the four strategies on the spontaneous and enforced dimensions of compliance is visualised with four different colours of dots in Figure 2. For each of the strategies and each of the eleven dimensions, the violation or compliance stimulating effect is visualised by a dot on a continuous scale, ranging from 'strong violation stimulating' to 'strong compliance stimulating'. It should be noted that overlapping dots all represent the same violation or compliance stimulating effect. Based on the analysis, it is concluded that the strategy *On-Board Weighing for automated enforcement* is estimated to have the largest compliance motivating effect, leading to the largest reduction of overloaded HGVs on the Dutch road network. Especially the advantages of strategic deployment of DSRC units (Dimension VIId) and possibility to directly sanction overloaded vehicles without reweighing (Dimension X) makes this an effective strategy.



Summary, Figure 2 – Estimated effects of designed enforcement strategies on the nature of dimensions in the Table of Eleven

Due to the existence of a broad range of conscious and unconscious complying and noncomplying inspectees in various subsectors, for each of which the effects in terms of compliance level of different enforcement measures are different, the geographical layout of the road network influencing the effectivity of enforcement and the presence of a number of other, more external factors influencing compliance levels, it appeared not to be feasible to perform a full quantitative estimation of the effect of enforcement activities on the number of overloaded HGVs on a given road network.

The costs of the designed strategy combined with the estimated number of performed checks provide however insight in the internal efficiency of the violation-deterring enforcement measures within the strategies. In Figure 3, the costs per check are visualised for various numbers of checked vehicles. The figure shows that for a lower number of checked vehicles (in Figure 3 in the direction of enforcement regime A), the WiM-based strategies have a higher internal efficiency. As the required number of checks increases (in Figure 3 in the direction of enforcement regime J), the cost per check decreases for the OBW-based strategies. For a higher number of checks, the high initial investment in axle load sensors can be divided over more checks, lowering the costs per check. Within this research, due to the earlier mentioned complex relation between enforcement activities and their effects, the amount of required checks to achieve a certain reduction in the number of overloaded HGVs, cannot be defined.



Summary, Figure 3 – Internal efficiency of designed enforcement strategies

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the strategy *OBW for automated enforcement*, based on main enforcement measure *OBW for direct enforcement* is expected to result in the highest compliance level, at reasonably low costs per sanctionable overloaded HGV detection. Advantages of this strategy include the deployment of DSRC portable tripods and handheld devices, making regional road enforcement feasible and enforcement in general more unpredictable. Secondly, no time-consuming manual reweighing is needed, increasing the efficiency of the enforcement and transport operation. On the other hand, the yearly process of axle load sensor calibration could be time consuming. Integration with the general periodic inspection (APK) could possibly reduce the additional time needed for calibration.

For road owners, it is recommended to include an explicit prohibition on overloading in contracts in which they act as client. This provides them the opportunity to apply contract management and perform administrative and physical checks. It is recommended to require contractors to deliver weighing notes themselves and to integrate the physical checks in enforcement measure *Strategic OBW DSRC-based selection*.

Further research is needed to define the most effective employment of *OBW for automated enforcement*. Firstly, the amount of digital (anticipable) and manual (random) checks to reach a certain compliance level should be defined. Therefore, the relation between enforcement activities and compliance level should be further researched. Quantitative model- or scenario studies could provide these insights.

For regional road owners, anticipating the introduction of OBW portable tripods, it is recommended to define locations having a high risk on overloaded HGVs. This could for example be done by systematically mapping road damage potentially caused by overloaded HGVs and mapping business parks with a high amount of HGV movements.

SAMENVATTING

In Nederland wordt jaarlijks 630 miljoen ton, 82 procent van het binnenlands transport, via de weg vervoerd. Ook worden vijftien procent van de goederen die worden ingevoerd en eenentwintig procent van de goederen die Nederland verlaten via de weg vervoerd (Centraal Bureau voor de Statistiek, 2016). Deze goederen worden hoofdzakelijk vervoerd door zware vrachtvoertuigen (HGVs), gekenmerkt door hun brutogewicht van meer dan 3,5 ton.

De economische baten van deze vervoersactiviteiten zijn aanzienlijk, zowel voor de transportsector zelf als de samenleving als geheel. Op het Nederlandse wegennet is echter ongeveer 15 procent van de vrachtwagens overbelast, jaarlijks resulterend in ongeveer 34 tot 300 miljoen euro aan sociale kosten (Hersbach et al., 2011; Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). Overbeladen HGVs hebben een negatieve invloed op de levensduur van de deklaag en fundering van de weg en kunstwerken zoals bruggen en duikers (Ministerie van Verkeer en Waterstaat, 2002; Mulyono et al., 2010). Onderzoek laat zien dat 30 procent van de wegdekschade te maken heeft met overladen vrachtwagens (Ministerie van Verkeer en Waterstaat, 2002). De theoretische levensduur van wegen neemt af met maximaal 30 procent, gelijk aan meerdere jaren (Vennix, 2016). Ten tweede levert het schenden van de maximale gewichtsbeperkingen oneerlijke financiële voordelen op en verbetert het de concurrentiepositie van overtredende bedrijven, ten koste van die van nalevende concurrenten. Ten slotte kan overbelading zorgen voor verminderde instabiliteit, remvermogen en manoeuvreerbaarheid, vooral bij onverwachte bewegingen, uitwijkingen of slecht weer (Jacob & Feypell-de La Beaumelle, 2010). Gezien deze drie uitingen van maatschappelijke schade wordt overbelading in Nederland gedefinieerd als een economisch delict.

Een literatuurstudie naar de handhaving van gewichtsbeperkingen toont twee kennishiaten in de bestaande literatuur. Ten eerste is de inzet en kosteneffectiviteit van handhaving van gewichtsbeperkingen binnen een dicht en nauw verweven infrastructureel systeem bestaande uit nationale, regionale en lokale wegen die op meerdere overheidslagen worden beheerd, in de huidige literatuur niet geadresseerd. Een tweede kenniskloof werd gevonden in de mogelijkheden en effecten van het combineren van individuele maatregelen voor handhaving op gewichtsbeperkingen. Daarom zal de volgende hoofdonderzoeksvraag worden beantwoord:

Hoe kan het probleem van overbeladen vrachtwagens op Nederlandse nationale en regionale wegennetten op een kosteneffectieve manier worden aangepakt, om de maatschappelijke kosten van overbelasting van vrachtwagens te verminderen?

Om de hoofdvraag te beantwoorden, wordt een Design Science Approach gebruikt. Een literatuurstudie geeft inzicht in de theoretische succesfactoren voor toekomstige handhaving. De huidige wetgeving en handhavingssituatie en de overwegingen en motivaties van transporteurs om over te beladen zijn afgeleid van empirisch onderzoek, gebruikmakend van bureau-onderzoek en de Tafel van Elf. Dit is een wetenschappelijk instrument om toekomstige naleving van regelgeving in te schatten. Daarnaast is een nalevingsschatting opgesteld, welke inzicht biedt in de omvang van verschillende groepen bewuste en onbewuste nalevers en overtreders. Aan de hand van de inzichten verkregen met deze analyses worden eisen en beperkingen voor toekomstige gewichtshandhaving geformuleerd. Vervolgens worden in vier stappen een aantal handhavingsstrategieën ontworpen. Een case study van het provinciale wegennet in Zuid-Holland geeft inzicht in de mogelijke toepassing van handhavingsinstrumenten op regionale wegennetten. Vervolgens wordt de geschatte effectiviteit van de strategieën kwalitatief geschat met de Tafel van Elf. Een schatting van de kosten en baten van de strategieën geeft inzicht in de interne kosteneffectiviteit ervan. Het ontwerp van de strategieën wordt geëvalueerd middels interviews met belanghebbenden en experts.

LITERATUURSTUDIE EN HUIDIGE HANDHAVINGSSITUATIE

Op basis van de literatuurstudie wordt geconcludeerd dat toekomstige strategieën voor gewichtshandhaving een generiek preventieve werking moeten hebben in plaats van een specifiek preventieve werking. Met andere woorden, het risico om te worden gecontroleerd en gesanctioneerd, moet transporteurs overhalen om te regelgeving na te leven, in plaats van de daadwerkelijke controle of sanctie zelf. Een toekomstige handhavingsstrategie dient zowel te bestaan uit maatregelen met een nalevingsbevorderend effect en maatregelen die een afschrikkende werking hebben. Zo kan de inspecteur variëren in handhavingsstijl en omgaan met verschillende groepen van bewuste en onbewuste nalevers en overtreders. Omdat de inspecteur geen volledig inzicht heeft in de vraag of de inspectee opzettelijk een regel overtreedt, moet responsieve handhaving worden toegepast. Dit stelt de inspecteur in staat de druk op vervoerders te vergroten door handhavingsactiviteiten op te schalen in de richting van meer op sancties gebaseerde handhaving, wanneer nalevingsbevorderende activiteiten niet het gewenste resultaat hebben. Toekomstige handhavingsinstrumenten dienen zowel bureaucratisch-gestandaardiseerd als strategisch te worden ingezet. Bureaucratische handhavingsactiviteiten zijn over het algemeen minder duur, maar gemakkelijker op te anticiperen door de inspectee. Kostbare strategische handhavingsactiviteiten zijn nodig om specifieke subgroepen aan te pakken of om minder anticipeerbare handhavingsactiviteiten te kunnen inzetten. Aan de hand van portfolio's krijgt de inspecteur inzicht in het type inspectee (bewust niet-conform of niet op de hoogte van eigen gedrag) en de hoeveelheid maatschappelijke schade die de inspectee veroorzaakt.

De analyse van de huidige handhavingssituatie in de Tafel van Elf laat zien dat de financiële voordelen van overbelading, waaronder een betere concurrentiepositie, een sterke motivatie vormen voor bedrijven om de regels te overtreden. Dit wordt gevisualiseerd in Figuur 2 op pagina XVII, waarin het nalevings- of overtredingsbevorderende karakter van alle elf dimensies wordt gevisualiseerd met azuurblauwe stippen op een continue schaal tussen 'sterk overtredingsbevorderend' en 'sterke nalevingsbevorderend’. Het gebrek aan sociale controle en de extreem lage kans om te worden gecontroleerd en bestraft leidt tot een te laag nalevingsbevorderend karakter van de huidige handhavingsactiviteiten, voor 15 procent van de vervoerders. Van de 15 procent die de regels overtreedt is ongeveer 25 procent overbeladen op het voertuiggewicht en 75 procent op een of meer assen. Rekening houdend met het feit dat een groot deel van de transportactiviteiten geen overbelading toelaat, is het percentage overtreders in subsectoren die gevoelig zijn voor overbelading nog veel hoger. Op basis van ILT gegevens en gesprekken met verschillende stakeholders wordt geschat dat 80 procent van de overtreders dit opzettelijk doet en de overige 20 procent de regels onbewust overtreedt. Om over- of onderregulatie te voorkomen, is het van belang dat de inspecteur beide groepen op de juiste manier benadert.

Tijdens de focusgroepsessie werd duidelijk dat alle belangrijke stakeholders ernaar streven het aantal overbelaste HGV-transporten op het Nederlandse netwerk te verminderen. De sector zelf streeft voornamelijk naar vermindering van het aantal op het totaalgewicht overbeladen HGVs, omdat dit de meeste concurrentievervalsing met zich meebrengt. Anderzijds vinden met name wegbeheerders dat zowel het totaalgewicht van het voertuig als de asbelasting moeten worden gehandhaafd, omdat beiden infrastructurele schade veroorzaken.

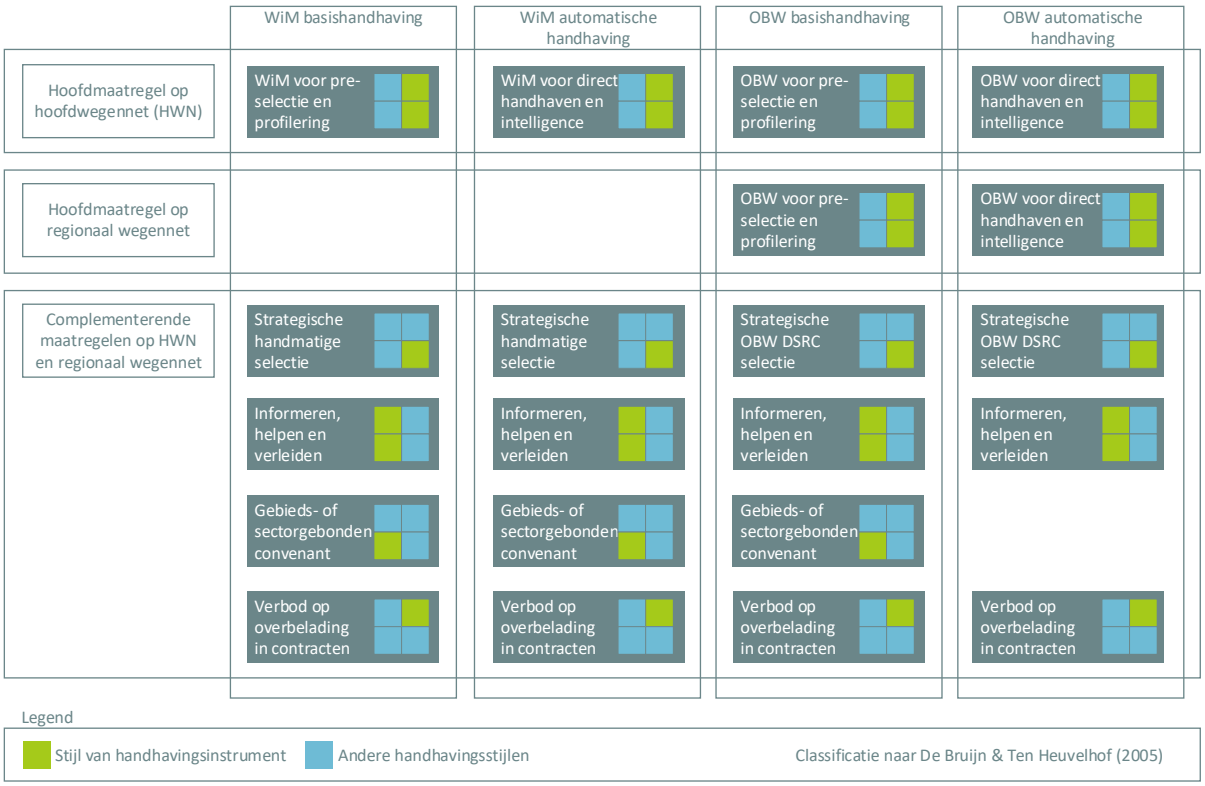
Een belangrijke randvoorwaarde voor toekomstige handhaving is te vinden in Europese Richtlijn (EU) 2015/719, een wijziging op Richtlijn 96/53 / EG van de Raad. Hierin wordt gesteld dat alle lidstaten van de Europese Unie maatregelen moeten treffen om op zijn minst handmatig te inspecteren, op basis van voorselectie door middel van gewichtsensoren die zijn ingebouwd in de wegdekstructuur (Weigh-in-Motion) of gewichtssensoren die zijn ingebouwd in het zware vrachtvoertuig zelf (On-Board Weighing).

TOEKOMSTIGE STRATEGIEËN VOOR HANDHAVING OP VOERTUIGGEWICHTEN

Op basis van de literatuurstudie en analyse van de huidige handhavings- en governancesituatie zijn vier handhavingsstrategieën ontworpen. De strategieën bevatten een geïntegreerd pakket aan instrumenten. Een overzicht van de handhavingsinstrumenten binnen de strategieën is te vinden in Figuur 1

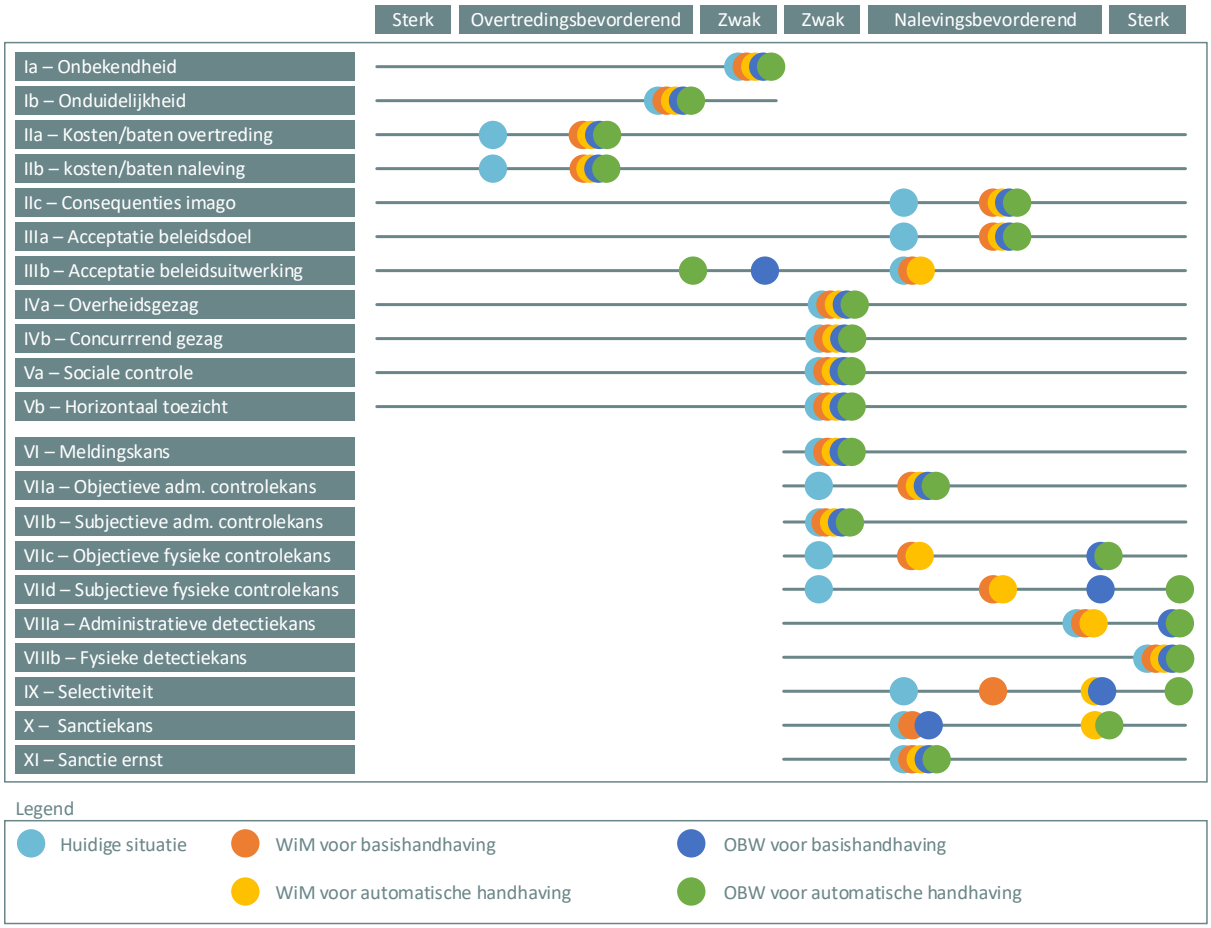
I. *Weigh-in-Motion voor basishandhaving* behelst de inzet van Weigh-in-Motion nauwkeurigheidsklasse B-systemen, vergezeld van automatische kentekenherkenningscamera's. Aangezien nauwkeurigheidsklasse B geen directe sanctionering toelaat, worden verdachte voertuigen op basis van de WiM metingen geselecteerd om op gecertificeerde weegmatten opnieuw te worden gewogen. Op basis daarvan worden bekeuringen uitgedeeld. Daarnaast kunnen dwangsommen worden opgelegd, uitsluitend op basis van de Weigh-in-Motion metingen.
II. *Weigh-in-Motion voor geautomatiseerde handhaving* omvat de inzet van Weigh-in-Motion nauwkeurigheidsklasse A-systemen, vergezeld van automatische kentekenherkenningscamera's. Nauwkeurigheidsklasse A maakt directe sanctionering mogelijk, uitsluitend op basis van de Weigh-in-Motion-metingen.
III. *On-Board Weighing voor basishandhaving* omvat de installatie van nauwkeurigheidsklasse B aslastsensoren op nieuwe HGVs. De aslast wordt digitaal verkregen via portalen langs de weg, gebruikmakend van Dedicated Short Range Communication (DSRC). Aangezien nauwkeurigheidsklasse B geen directe sanctionering toestaat, worden op basis van de voorselectie door het DSRC-systeem verdachte voertuigen opnieuw gewogen op gecertificeerde weegmatten. Op basis daarvan worden bekeuringen uitgedeeld. Daarnaast kunnen dwangsommen worden opgelegd, uitsluitend op basis van de metingen met aslastsensoren.
IV. *On-Board Weighing voor geautomatiseerde handhaving* omvat de installatie van nauwkeurigheidsklasse A aslastsensoren op nieuwe HGVs. De aslast wordt digitaal verkregen via portalen langs de weg, gebruikmakend van Dedicated Short Range Communication (DSRC). Nauwkeurigheidsklasse A maakt directe sanctionering mogelijk, uitsluitend op basis van de DSRC-metingen.

In een case study voor het regionale wegennet zoals beheerd door de provincie Zuid-Holland, wordt geconcludeerd dat de twee op WiM gebaseerde hoofdmaatregelen naar verwachting niet haalbaar zijn, door een gebrek aan locaties om geijkt te herwegen, de aanwezigheid van uitgebreide mogelijkheden voor strategisch vermijdingsgedrag en een lage verwachte interne efficiëntie. Daarom wordt alleen de inzet van op OBW gebaseerde strategieën haalbaar geacht op regionale wegennetwerken.



Samenvatting, Figuur 1 – Overzicht van handhavingsinstrumenten in strategieën

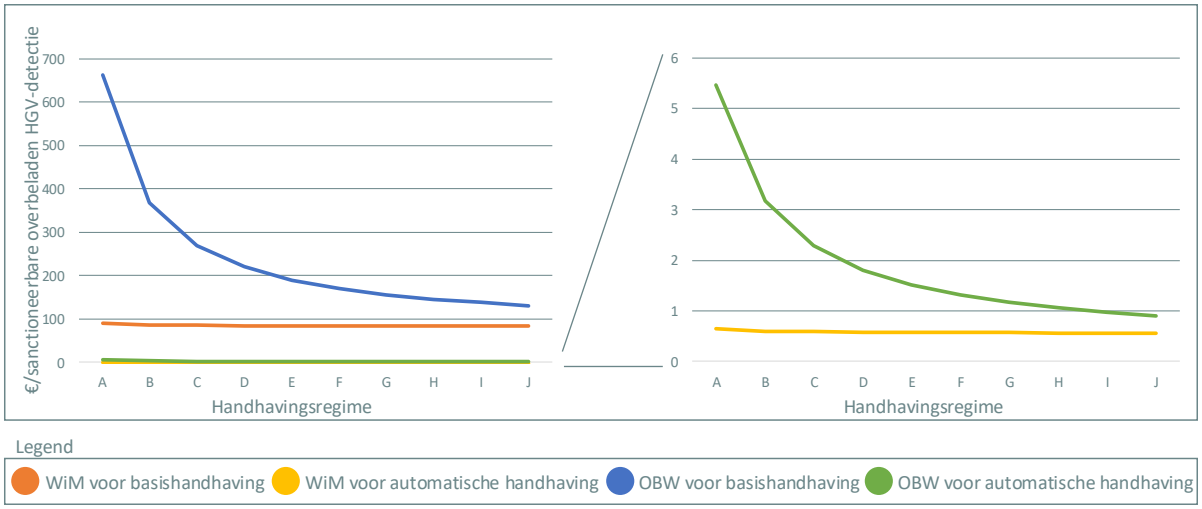
Het effect van de vier strategieën op de spontane en afgedwongen nalevingsdimensies in de Tafel van Elf wordt gevisualiseerd met vier verschillende kleuren stippen in Figuur 2. Voor elk van de strategieën en elk van de elf dimensies wordt het overtredings- of nalevingsbevorderende effect gevisualiseerd door een punt op een continue schaal, variërend van 'sterk overtredingsbevorderend' tot 'sterk nalevingsbevorderend'. Opgemerkt moet worden dat overlappende stippen hetzelfde overtredings- of nalevingsbevorderende effect vertegenwoordigen. Op basis van de analyse wordt geconcludeerd dat de strategie *On-Board Weighing voor geautomatiseerde handhaving* naar verwachting het grootste nalevingsbevorderende effect heeft en zal resulteren in de grootste reductie van overbeladen HGVs op het Nederlandse wegennet. Vooral de voordelen van strategische inzet van de DSRC-technologie (Dimensie VIId) en de mogelijkheid om overbeladen voertuigen direct te sanctioneren zonder opnieuw te wegen (Dimensie X), maken dit een effectieve strategie.



Samenvatting, Figuur 2 – Geschatte effecten van ontworpen strategieën op dimensies in de Tafel van Elf

Het bleek niet haalbaar om een volledige kwantitatieve schatting uit te voeren van het effect van handhavingsactiviteiten op het aantal overbeladen HGVs op een bepaald wegennet. Dit vanwege de aanwezigheid van een breed scala aan bewuste en onbewuste nalevende en overtredende inspectees in verschillende subsectoren, voor elk waarvan de effecten qua nalevingsniveau van verschillende handhavingsinstrumenten verschillend zijn. Ook de exacte geografische indeling van het wegennetwerk en de aanwezigheid van een aantal andere, meer externe factoren die de nalevingsniveaus beïnvloeden, maken het niet mogelijk een kwantitatieve effectschatting uit te voeren.

De kosten van de ontworpen strategieën in combinatie met het verwachte aantal uitgevoerde controles bieden echter wel inzicht in de interne efficiëntie van de handhavingsinstrumenten. In Figuur 3 zijn de kosten per sanctioneerbare detectie gevisualiseerd voor verschillende aantallen gecontroleerde voertuigen. De figuur laat zien dat voor een lager aantal gecontroleerde voertuigen (in Figuur 3 in de richting van handhavingsregime A) de op WiM gebaseerde strategieën een hogere interne efficiëntie hebben. Naarmate het benodigde aantal controles toeneemt (in Figuur 3 in de richting van handhavingsregime J), nemen de kosten per controle af voor de op OBW gebaseerde strategieën. Voor een groter aantal controles kan de hoge initiële investering in onder andere aslastsensoren worden verdeeld over meer controles, waardoor de kosten per controle dalen. Binnen dit onderzoek kan, vanwege de eerdergenoemde complexe relatie tussen handhavingsactiviteiten en hun effecten, het aantal vereiste controles om een bepaalde vermindering van de hoeveelheid overbelaste vrachtwagens te bereiken, niet worden gedefinieerd.



Samenvatting, Figuur 3 – Interne efficiëntie van ontworpen handhavingsstrategieën

CONCLUSIES EN AANBEVELINGEN

Geconcludeerd wordt dat de strategie *OBW voor geautomatiseerde handhaving*, gebaseerd op hoofdmaatregel *OBW voor directe handhaving*, naar verwachting zal resulteren in het hoogste nalevingsniveau, tegen redelijk lage kosten per sanctioneerbare overbeladen HGV-detectie. Voordelen van deze strategie zijn de inzet van verplaatsbare DSRC-statieven en DSRC handheld-apparaten, waardoor handhaving op het regionale wegennet haalbaar is en handhaving in het algemeen onvoorspelbaarder wordt. Ten tweede is er geen tijdrovende handmatige herweging nodig, waardoor de efficiëntie van zowel handhaving als transportoperatie wordt verhoogd. Anderzijds kan het jaarlijkse proces van kalibratie van de aslastsensoren tijdrovend zijn. Integratie met de Algemene Periodieke Keuring (APK) kan mogelijk de extra tijd die nodig is voor kalibratie verminderen.

Voor wegbeheerders wordt aanbevolen om een expliciet verbod op overbelading op te nemen in contracten waarin zij als opdrachtgever optreden. Dit biedt hen de mogelijkheid om contractmanagement toe te passen en administratieve en fysieke controles uit te voeren. Het wordt aanbevolen om van aannemers te vereisen dat zij zelf de aanlevering van data via het DSRC-systeem verzorgen.

Verder onderzoek is nodig om de meest effectieve inzet van OBW voor geautomatiseerde handhaving te bepalen. De hoeveelheid digitale (anticipeerbare) en handmatige (willekeurige) controles om een bepaald nalevingsniveau te bereiken moet worden gedefinieerd. Hiervoor dient de relatie tussen handhavingsactiviteiten en het nalevingsniveau verder te worden onderzocht. Kwantitatieve model- of scenariostudies kunnen deze inzichten verschaffen.

Voor regionale wegbezitters wordt, anticiperend op de introductie van verplaatsbare OBW-statieven, aanbevolen locaties met een hoog risico op overbeladen HGVs te definiëren. Dit kan bijvoorbeeld worden gedaan door systematisch bedrijventerreinen met zware transportactiviteiten in kaart te brengen, evenals wegschade die mogelijk worden veroorzaakt door overbelaste vrachtwagens.

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LIST OF ABBREVATIONS

ORGANIZATIONS

DBI	Dienst Beheer Infrastructuur	Infrastructure Management Office
PZH	Provincie Zuid-Holland	Province of Zuid-Holland
RWS	Rijkswaterstaat	Rijkswaterstaat
TLN	Transport en Logistiek Nederland	Dutch Association for Transport & Logistics
ILT	Inspectie voor de Leefomgeving en Transport	Human Environment and Transport Inspectorate
RDW	Rijksdienst voor het Wegverkeer	Dutch Vehicle Authority

OTHER ABBREVATIONS

ANPR	Automatic numberplate recognition	Camera system able to read numberplates
DSRC	Dedicated short-range communication	Wireless communication system using DSRC road side beacons to obtain data from OBUs installed on HGVs
OBW	On-Board Weighing	Comprises the determination of the GVW/GTW of a moving HGV, by measuring the GVW or axle loads, using axle load sensors or similar systems installed on the vehicle.
OBU	On-Board Unit	Small box installed on the HGV, in which the information from the axle load sensors can be stored for a period of time up to 30 days
GVW	Gross vehicle weight	Maximum operating weight of an HGV, including the vehicle itself, driver, passengers and cargo
GTW	Gross train weight	Maximum operating weight of an HGV, including the vehicle itself and driver, passengers and cargo, including trailers. In this study, the term GVW is mainly used.
HGV	Heavy goods vehicle	The European Union (EU) term for a truck with a GVW or GTW of over 3,500 kilograms
WiM	Weigh-in-Motion	Comprises the determination of the GVW/GTW of a moving HGV, by measuring the GVW or axle loads, using sensors built in or under the pavement

1. INTRODUCTION

As the Netherlands is a classic trading country, trade and transport of goods play a prominent role in the Dutch economy. On a yearly basis, 630 million tons, 82 percent of the domestic transport, is transported via road. Additionally, fifteen percent of the goods entering and twenty-one percent of the goods leaving the Netherlands are transported via road. This results in 1.400.000 tons of goods passing the Dutch road networks on a daily basis, mainly transported by heavy-goods vehicles (HGVs)(Centraal Bureau voor de Statistiek, 2016).

Although the economic benefits for the transport sector and society as a whole are considerable, heavy goods vehicle transport has some drawbacks as well. On the Dutch national road network, around 15 percent of the trucks is overloaded, yearly resulting in around 34 to 300 million euros in social costs (Hersbach et al., 2011; Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). The negative external effects of overloaded trucks can be divided in three categories: besides the road condition-related effects, safety-related and market-related effects can be distinguished (Taylor, Bergan, Lindgren, & Eng, 2000). Given these consequences, in the Netherlands, overloading is defined as an economic crime.

Due to their weight, overloaded HGVs have a negative impact on the pavement and structures like bridges and culverts. With regard to the pavement, both rutting, track formation and partial or complete subsidence are consequences of overloading (Ministerie van Verkeer en Waterstaat, 2002; Mulyono et al., 2010). The road damage of one overloaded HGV could equal the damage caused by 400.000 passenger car movements (Hersbach et al., 2011). Research performed by the former Dutch Ministry of Transport, Public Works and Water Management, estimated that 30 percent of the pavement damage can be related to overloaded trucks (Ministerie van Verkeer en Waterstaat, 2002). The theoretical calculated life cycle of roads could decrease by up to 30 percent, equal to several years, due to overloaded HGVs (Vennix, 2016).

The relationship between vehicle type and road damage is displayed in Figure 1 (Cornelissen et al., 2016). The figure shows that regular HGVs, having a gross vehicle weight (GVW) between 3,5 and 50 tons, and exceptional transports, weighing over 50 tons, are accountable for less vehicle kilometres but cause nearly all pavement damage. Especially overloaded regular HGV's and exceptional HGV transports heavily impact the lifetime of the pavement, road foundation and infrastructural works like bridges and culverts (Cornelissen et al., 2016).

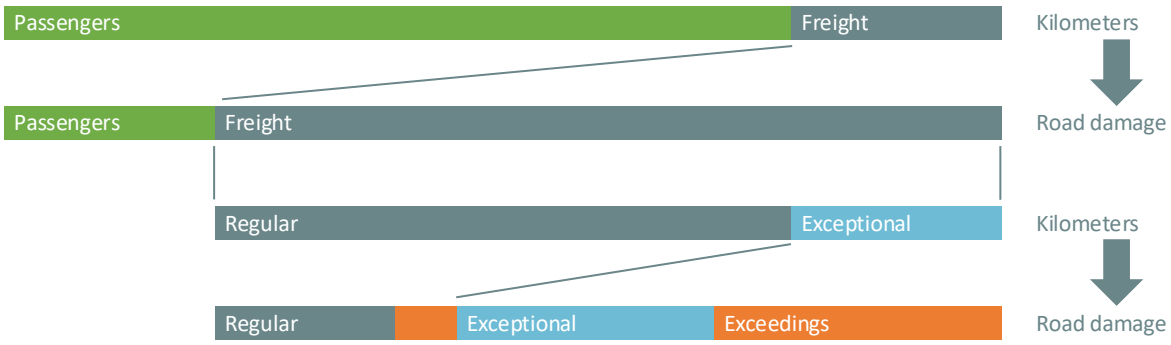

Figure 1 – Transport impact on pavement

Besides infrastructure-related consequences, violating the maximum weight restrictions generates unfair benefits for noncomplying businesses, in comparison to the rest of the industry, as well as that overloading results in unfair competition in the transport sector. Since noncomplying transporters can offer lower prices in tenders, their competitiveness increases. On the other hand, benevolent transporters are less likely to be awarded contracts. Furthermore, overloading could result in reduced instability and braking capacity and a loss in motivity and manoeuvrability, especially in unexpected movements, swerving or bad weather. This results in a higher chance of accidents (Jacob & Feypell-de La Beaumelle, 2010). The risks for trucks with a capacity higher than 3,5 tonnes are higher than for delivery vans with lower maximum weights (Andersson Elffers Felix, 2012).

1.1. RESEARCH PROBLEM

A literature study elaborated on in Section 3.1, shows that the technical relation between overloading and road infrastructure deterioration has been addressed in multiple studies. A number of studies on the cost-effectiveness of various enforcement measures on national road corridors has been found as well. However, the deployment and cost-effectiveness of weight enforcement in dense and tightly interwoven infrastructural systems consisting of national, regional and local roads administered at multiple governmental layers, has not been addressed in the current literature. Given the fragmented nature of regional and local road networks and relatively low volumes of traffic, enforcement can be costly. This makes weight enforcement in regional and local road contexts a complex challenge. A second knowledge gap relates to the possibilities and effects of technically and institutionally combining individual weight enforcement measures into enforcement strategies.

Given these two gaps in the existing literature, which are elaborated upon in Chapter 3, the problem statement for this research is formulated as follows:

There is a lack of knowledge on integrating individual weight enforcement measures on different geographical and institutional levels into coherent enforcement strategies, within complex road networks, consisting of multiple interwoven layers.

1.2. RESEARCH OBJECTIVE

Based on the research problem, the following research objective is formulated:

To develop and assess multi-level weight enforcement strategies dealing with the problem of heavy-goods vehicle overloading in a multi-levelled road network context.

The deliverable of this research is an advice on how to deal with HGV overloading in the complex Dutch national and regional multi-levelled road network context. In order to formulate this advice, a first version of coherent and balanced weight enforcement strategies will be designed and assessed on effectivity and efficiency. In a small case study for the road asset of the Dutch province of Zuid-Holland, the application of various enforcement measures on a regional road network is assessed.

1.3. RESEARCH QUESTIONS

The main research question of the research is as follows:

How can the problem of overloaded HGVs on Dutch national and regional road networks be addressed in a cost-effective way, to reduce the social costs of heavy-goods vehicle overloading?

The following set of research questions, based on the five phases of the Design Science Approach elaborated upon in the next section, will together lead to the answer of the main research question.

1. Which institutional, technical and social structures impact the functioning of weight enforcement in national and regional road networks?

   Deliverable: System description including list of factors impacting the choice of transporters to overload their vehicles and functioning of weight enforcement

2. What are the constraints and requirements for future weight enforcement focused on both national and regional road networks?

   Deliverable: Set of constraints and requirements for weight enforcement

3. What design alternatives for weight enforcement strategies on national and regional road networks can be adopted to reduce the social costs of overloading on regional road networks?

Deliverable: Set of technical and social feasible coherent weight enforcement strategies

4. What is the effectiveness and efficiency of the designed weight enforcement strategies on national and regional road networks?

Deliverable: Overview of effects and costs of designed future weight enforcement strategies

5. What is the added value of the designed weight enforcement strategies?

Deliverable: Opinion of stakeholders and expert on the extent in which the designed weight enforcement strategies fulfil the requirements for future weight enforcement

1.4. RELEVANCE AND CONTRIBUTION OF THE RESEARCH

To answer the main research questions, a Design Science Approach will be used. The choice for this approach is elaborated upon in Section 2.1. The societal and scientific relevance and contribution of Design Science research are displayed in Figure 2. According to Johannesson and Perjons (2014), Design Science research can be based on a local practice and contribute to that practice. In this research, empirical data on regional roads is derived from the Dutch road network. In a case study on the road network of the province of Zuid-Holland, the application of weight enforcement on regional road networks is assessed, contributing to solving the HGV overloading problem in this specific context. Johannesson and Perjons emphasize the need for a scientific basis in Design Science Projects. The scientific contribution of the project to the existing knowledge in the domain of weight enforcement is described in Section 1.4.2. The weight enforcement strategies designed in this research and the systems model in which they are evaluated form the contribution to global practice. Other road owners and administrators could use the insights derived in this research, enlarging the social contribution of the research (Section 1.4.2).

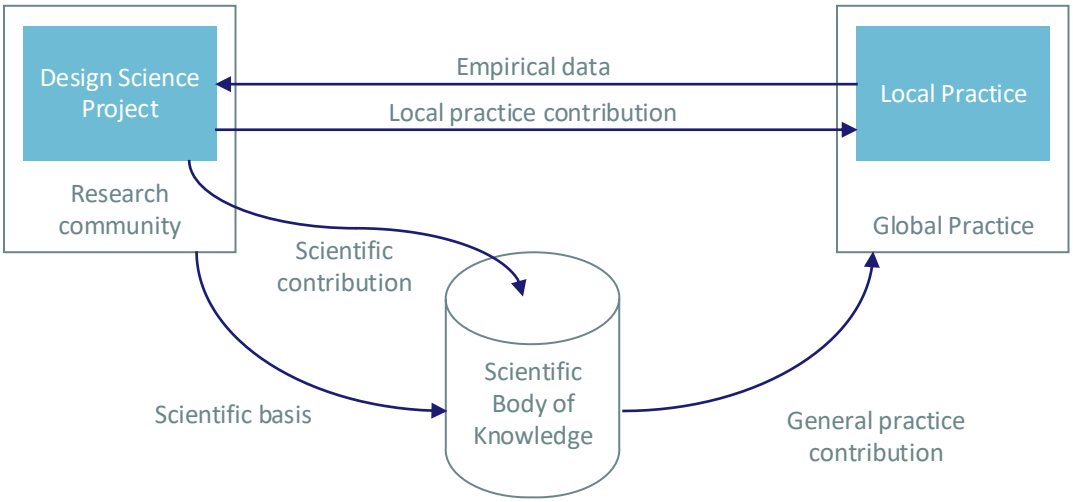

Figure 2 – Scientific and practical contribution of Design Science Research (Johannesson & Perjons, 2014, p. 9)

1.4.1. SOCIETAL RELEVANCE

Road administrators are focussed on retrieving more insight in how to predict the future condition of the road asset. Since the deterioration rate of pavement structures is partially influenced by the amount of load it has to process, HGV overloading has a strong impact on the road maintenance needed. The lifetime of pavement structures and infrastructural works like bridges and culverts decreases more rapidly and unequally by HGV overloading, in comparison to calculated expectations. This leads to additional maintenance costs and unexpected maintenance and road closures. From a societal perspective, a decrease in overloaded HGV vehicles would lead to more insight in and better prediction of the road assets condition, more effective maintenance scheduling and less road maintenance costs. Furthermore, the distortion of the level playing field in the transport sector, caused by HGV overloading would be reduced. Finally, a reduction of HGV overloading is expected to result in more road safety.

1.4.2. SCIENTIFIC RELEVANCE

Besides the societal relevance, this research is relevant from a scientific perspective as well. Two research gaps in current literature were found and will be addressed in this study, namely the scarce availability of literature on the integration of weight enforcement measures into coherent strategies and secondly the (cost-) effectiveness of weight enforcement in complex dense and tightly interwoven multi-layered road networks.

The most used technology in weight enforcement is Weigh-in-Motion (WiM), a system in which weight sensors are built in the road pavement. Current literature on the evaluation of WiM technology is focused on primary roads: highways, Build Operate Transfer projects and corridors. Most of the road networks however consist of a tightly interwoven system of concentrated national, regional and local roads, having lower intensities and different administrators. These characteristics make enforcement more challenging. Therefore, it is questionable whether weight enforcement is as (cost-)effective in complex road networks.

Although the technical relation between overloading and pavement distress and the effectiveness of individual weight enforcement measures have been addressed in multiple studies, the nature of the problem of overloaded HGVs on multi-layered road networks requires an integrated approach. The combination of enforcement measures on different networks and at different levels into coherent strategies has not yet been addressed in the existing literature.

This research addresses both knowledge gaps, decomposes the problem of overloading and comes up with coherent strategies from a behavioural science perspective. This has not yet been done in current literature.

1.5. SCOPE AND ORIENTATION

This research is conducted within the Infrastructure Management Office (DBI) of the province of Zuid-Holland, located in The Hague. Both the focus group session organized in the exploratory phase of the research and a part of the interviews held in the evaluation phase took place at the Provinciehuis.

Although the research is conducted at the province of Zuid-Holland, the scope of this research is broader than the province itself. The research will primarily focus on HGV overloading on national and regional roads with no additional weight restrictions, while considering the entire road infrastructure network. The outcomes of the research can therefore be applicable as well for other road administrators and enforcement authorities at all levels. The outcomes could even contribute to weight enforcement programming in other (European) countries, since the multi-levelled nature of the administration of roads in the Netherlands has many similarities with other European Member States. Additionally, all EU Member States face the choice between WiM and OBW, as obliged by the EU as enforcement measure on the national road network (which will be elaborated upon in Chapter 3).

As can be seen in Figure 1, both overloaded regular HGVs and exceptional transports generate a large part of the damage to the road network. Therefore, both overloading in regular HGV transport and exceptional transport are considered in this research. The report will not recommend on the administration of maximum weights for infrastructural works, since these activities are not considered to be part of the enforcement practice. For the same reason, nor the wider discussion on sustainability of longer and heavier transports, nor the creation of HGV corridors is elaborated upon in this research.

The problem of overloading will be addressed within its broader spatial, social and institutional context. Although strategies implementable by the relevant road administrator might at first sight seem to be the most reachable and logic, strategies in which the role of the road administrator in question is smaller or absent are explicitly considered as well. In other words, the most promising solutions for the problem might fall outside the geographical territory and/or legal capacity of regional road owner and administrator.

In this research, by law enforcement all activities aimed at increased compliance with governmental regulations by civilians are meant. Both traditional enforcement activities, based on a deterrence effect, and measures aimed at stimulating compliance by softer enforcement are considered. By heavy-goods vehicles, all vehicles with a gross vehicle weight over 3.500 kilograms are meant. Within the European Union, heavy goods vehicles are referred to as categories N2 and N3. For category N2, the gross vehicle weight lies between 3.500 kilograms and 12.000 kilograms. Category N3 includes all vehicles with a gross vehicle weight over 12.000 kilograms.

1.6. REPORT OUTLINE

The research is divided into five phases, according to the framework for Design Science Research of Johannesson and Perjons (2014), which will be elaborated upon in Chapter 2. In this chapter, the research methods will be explained as well. In the subsequent chapters, the five research questions will be answered, after which in the final chapter conclusions are drawn and recommendations are given. In each phase, a research question is answered. The research is visualised in Figure 3.

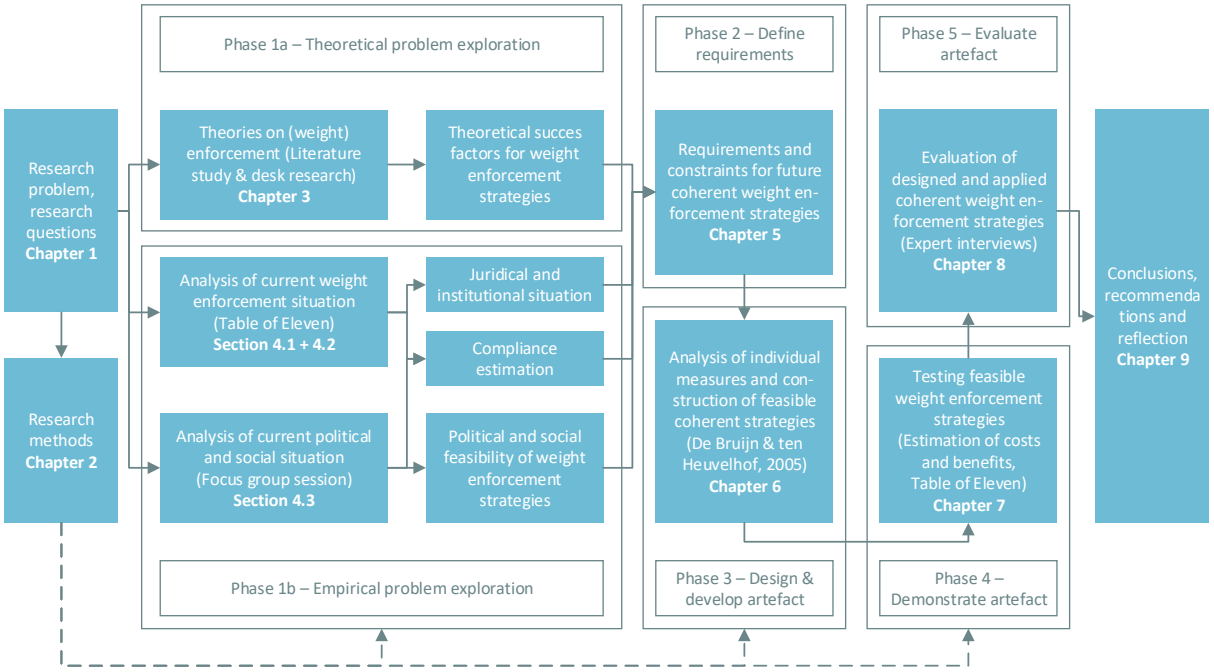

Figure 3 - Research flow diagram

2. METHODOLOGY

The approach that is taken to answer the research questions is elaborated upon in this chapter. The problem statement, research objectives and research questions as presented in the previous sections serve as the input for the research approach and methods. In the first Section of this section, the choice for a Design Science Research approach will be explained, after which in the second Section the methods used will be explained.

2.1. DESIGN SCIENCE RESEARCH APPROACH

A Design Science research approach is used, based on the method framework for Design Science Research by Johannesson and Perjons (2014). According to Johannesson and Perjons (2014), Design Science research "is the scientific study and creation of artefacts as they are developed and used by people with the goal of solving practical problems of general interest" (Johannesson & Perjons, 2014, p. 7). This approach is particularly suitable for the identified socio-technical problem of overloaded HGVs, since it concerns a practical problem in the transportation system, which is of large general economic and societal interest. Additionally, the identified problem requires an artefact, being some sort of enforcement, to solve it. In the proposed research, coherent enforcement strategies will be designed which addresses the problem of overloaded heavy-goods vehicles on complex road networks. Figure 4 shows the research outline and methods used, based on the framework for Design Science Research of Johannesson and Perjons (2014). In each phase, one research question is answered.

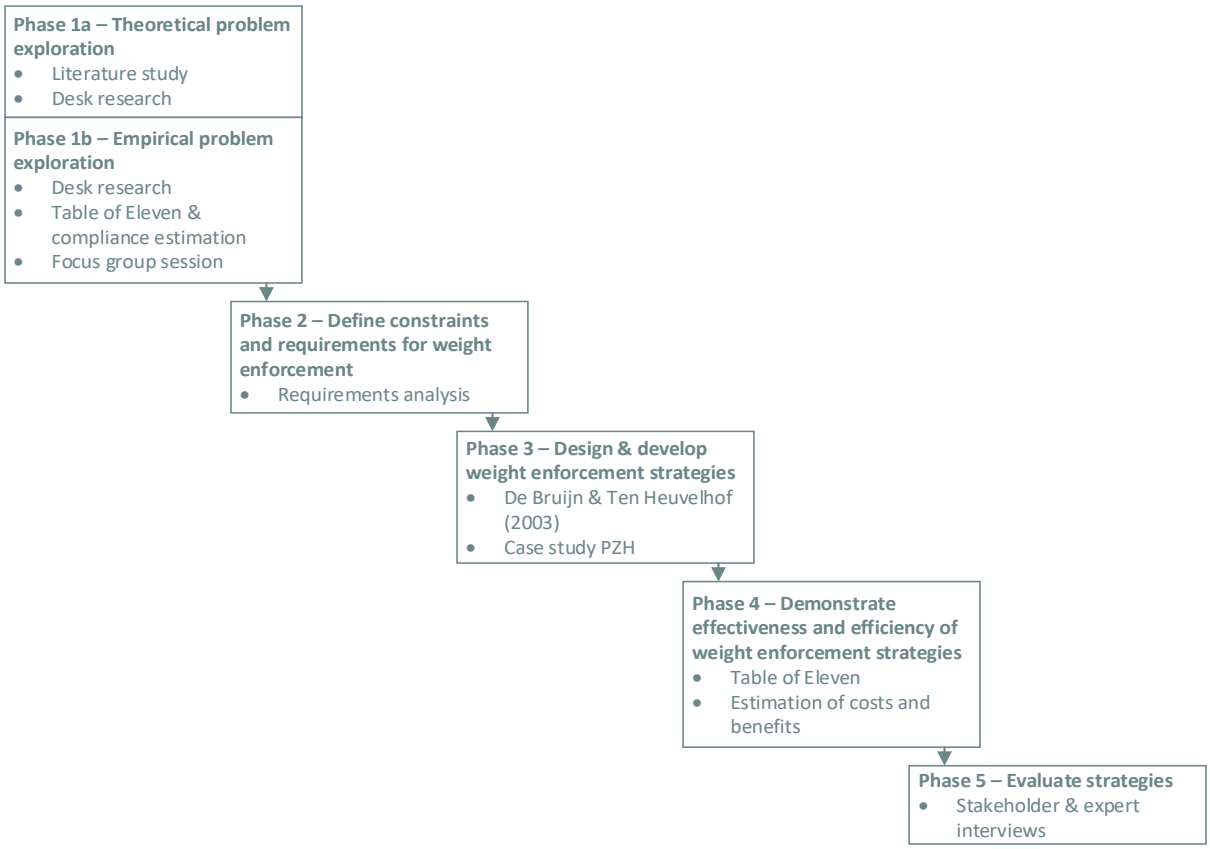

Figure 4 - Research framework, based on the Design Science Research framework in Johannesson and Perjons (2014)

The perspective on design in the Design Science approach includes both the social and organizational context as well as the theoretical and technical background (Johannesson & Perjons, 2014). The artefact design will as a result be based on both contexts. The Design Science perspective fits the research objectives, which concerns an artefact to be implemented in in a larger socio-technical and organizational environment. Therefore, the strategies will be designed in compliance with the requirements and constraints of various stakeholders and evaluated within a broader social and organizational setting.

To answer the research questions, the principle of triangulation will be applied (Jick, 1979). Different methods will be used together, to broaden the picture and improve accuracy. This allows for the author to view the problem from different perspectives and to obtain a complete overview of all dimensions of the problem.

2.2. RESEARCH METHODS

This section describes the research methods used in the different research phases (Figure 4).

PHASE 1A – SCIENTIFIC ANALYSIS OF HGV OVERLOADING AND ENFORCEMENT

The theoretical success factors for weigh enforcement countering the problem of overloaded HGVs on road networks are examined by means of a literature study.

LITERATURE STUDY

The literature study aims to provide insight in the theoretical success factors and optimum conditions for enforcement in general and weight enforcement in specific. The goal of the literature study is to present the relevant knowledge found in existing literature on enforcement in general and weight enforcement in specific. The literature study is divided in two phases. In the first phase, current literature on weight enforcement is presented, after which the knowledge gaps presented in Section 1.4.2 are elaborated upon. The second phase of the literature study focusses on enforcement theories in general, to come to theoretical success factors for weight enforcement.

Relevant literature was found using scientific databases like Scopes, ScienceDirect, Web of Science and Google Scholar. Additionally, in the second phase, a number of scientific studies performed by e.g. SWOV have been used as starting points in the literature study. Finally, the book 'Handhaving, het spel tussen inspecteur en inspectee' by de Bruijn and ten Heuvelhof (2005) is used. In all phases, both backward and forward snowballing has been applied in locating articles to be included in the literature study (Jalali & Wohlin, 2012). Key words used in the first phase of the literature study include 'weight enforcement', 'heavy-goods vehicle', 'overloading', 'weight regulation', 'Weigh-in-Motion' and 'On-Board Weighing'. In the second phase, 'law enforcement', 'responsive regulation' 'enforcement effects' and 'compliance' have been used.

PHASE 1B – EMPIRICAL EXPLORATION OF HGV OVERLOADING AND ENFORCEMENT

In a desk research, using the Table of Eleven, the motivations and considerations of transporters for overloading, the current enforcement situation and relevant legislation are assessed. A focus group session is organised, to gain insight in the interests and problem perspectives of key stakeholders and assess the political feasibility of various enforcement measures.

DESK RESEARCH, TABLE OF ELEVEN AND COMPLIANCE ESTIMATION

The Table of Eleven is in this research used as a method to retrieve insight in the root causes of overloading and actual considerations and motivations of companies to violate or comply with maximum weight regulations. It comprises all governmental activities that promote the compliance of regulations and distinguishes eleven dimensions of spontaneous and enforced compliance. Each of the eleven dimensions affects the compliance level. For the problem of overloaded HGVs, for all of the eleven dimensions the compliance or violation simulating character is analysed and ranked on a continuous scale, varying from 'strongly compliance stimulating' to 'strongly violation stimulating'.

The Table of Eleven is developed by mr. dr. D. Ruimschotel and the Ministry of Justice and is often used in the creation of enforcement policies, as a supportive tool (Centrum voor Criminaliteitspreventie en Veiligheid, 2010). The Table of Eleven is used as well by the Human Environment and Transport Inspectorate in deploying weight enforcement actively targeted at specific subsectors (Hersbach, 2018). Based on behavioural science, it supports in answering the following two key questions in designing enforcement strategies: 'Why does the target group live or do not follow a rule?' and 'What is the perception of the target group of enforcement?'. Each of the dimensions is based on supporting research, making the Table of Eleven the only comprehensive scientific tool to assess the complete working and (future) effectiveness of weight enforcement measures.

The violation or compliance stimulating nature of each of the eleven dimensions, together with empirical evidence forms the input of a so-called compliance estimation, which provides insight in the magnitude of different groups of conscious and unconscious complying and non-complying inspectees. The Table of Eleven and compliance estimation combined are used as an input for the formulation of requirements and constraints for coherent enforcement strategies in Chapter 5. The Table of Eleven will be used as well in the qualitative evaluation of the designed enforcement strategies in Section 7.2.

In contradiction to the existing Table of Eleven, in this research a distinction will be made between the objective and subjective chance of being checked. The difference between the objective and subjective chance of being checked is elaborated upon in Section 3.2.

FOCUS GROUP SESSION

A focus group was organised to retrieve insight in the interests and problem perceptions of key stakeholders in the problem (Section 4.3). Secondly, the focus group was used as input in the construction of constraints and requirements for future weight enforcement (Chapter 5). Additionally, a number of enforcement measures was already discussed, to retrieve some basic information on their political feasibility.

For the focus group session, participants from eight organisations were invited, of which a large number was already involved in one or more consultation structures on HGV overloading. Besides representatives from one local, three regional and the national road administrators, the Inspectorate ILT and the Vehicle Authority RDW, a representative from the transport sectors branch organisation TLN was invited and attended the focus group session. In Appendix III, the full list of participants is included.

The focus group was divided in three discussion rounds, preceded by a presentation of the intermediate research results by the author. During the first discussion round, the problem perceptions and interests of the involved actors were discussed. In the second round, the individual perceptions were used to identify the difference in interests between stakeholders, while discussing the bases and starting points for weight enforcement. Discussions on solutions, in the form of specific measures or strategies, were actively postponed to round three, in which enforcement measures were discussed based on the insights gained in the preceding rounds. The questions used to guide the discussion are presented in Appendix II.

The focus group session was held in Dutch, as this is the most convenient language for both participants and author to express themselves. A report of the focus group session was sent to the participants for verification (Appendix III). Within this explorative stage of the research and given the limited resources available, an impressionistic analysis of the focus group session was made. Advantages of this data collection method include the fast processing time. However, the quality and validity of data generated from the focus group depend on the skills and interpretation of the author.

Focus groups provide a number of advantages over other types of research method. Within focus groups as well as interviews, the researcher can communicate directly with the respondents. In this way, respondents can easily be asked follow-up questions or to clarify their responses. Furthermore, nonverbal communication and responses can be observed, that may be of interest. Compared with individual interviews, focus groups "allow

respondents to react and build upon the responses of other group members" (Stewart & Shamdasani, 1990, p. 16). Ideas, opinions or data that might have been uncovered in individual interviews or other research methods, may be discovered by this synergy.

The interaction between respondents in a focus group comes with some disadvantages as well. The focus group method involves the risk of dominant respondents, by which other respondents might not be heard (Johannesson & Perjons, 2014). To make sure that the opinion of all invited experts is voiced, the discussion was semi-structured, thoroughly prepared and moderated by the author. A second risk involves the dependency on the interests and perspectives of the participants (Johannesson & Perjons, 2014). This risk was partially mitigated by inviting experts of different organizations, having different perspectives. In the interpretation of the answers, this effect was considered. Finally, the generalizability of the focus group is limited, since respondents are dependent on each other. To mitigate this risk, existing consultation structures were only partly made use of.

PHASE 2 – DEFINING CONSTRAINTS AND REQUIREMENTS FOR WEIGHT ENFORCEMENT STRATEGIES

In the second phase of the research, constraints and requirements for future weight enforcement are formulated, based on the information retrieved from the literature study and desk research on enforcement and weight enforcement, the focus group session and the analysis of the current situation and resulting compliance estimation. The functional and non-functional constraints and requirements formulated in this phase of the research form the link between the analyses executed in the first phase of the research and the design, demonstration and evaluation of strategies in the subsequent phases of the research.

PHASE 3 – DESIGNING WEIGHT ENFORCEMENT STRATEGIES

For the design of the weight enforcement strategies, the constraints and requirements defined in the previous phase serve as the main input. The process of designing the strategies is divided in four steps, which are briefly described in this Section and elaborated upon in the introduction of Chapter 6.

Firstly, possible main enforcement measures on the national road network are assessed, forming the basis of the strategies to be designed. The selection of main enforcement measures results from a European obligation, which will be elaborated upon in Section 4.1.2 and included as constraint in Chapter 5.

Secondly, the implementation of the main enforcement measures on the regional road network will be designed. Therefore, a case study on the road asset of the Dutch province of Zuid-Holland is performed. The case study method is suitable to design the artefact, since the focus of the research is a contemporary problem the researcher has little control over (Yin, 2014). The case study will be designed holistically, consisting of a single case (Yin, 2012): the feasibility of the strategies will be tested on the areal of the province of Zuid-Holland.

Subsequently, promising complementing enforcement measures, selected based on the literature study, desk research and the focus group session, are assessed on feasibility.

Finally, for each strategy, the main enforcement measure is complemented with additional enforcement measures , based on the framework for classifying enforcement measures by de Bruijn and ten Heuvelhof (2005) and the requirements for future weight enforcement strategies defined in Chapter 5.

PHASE 4 – DEFINING THE EFFECTIVENESS AND EFFICIENCY OF THE DESIGNED STRATEGIES

The strategies designed in the third phase are qualitatively evaluated on effectiveness using the Table of Eleven (Centrum voor Criminaliteitspreventie en Veiligheid, 2010). In this phase, the Table of Eleven is used to estimate the effectiveness of future weight enforcement. Furthermore, an estimation of the costs is provided for each strategy, in order to estimate the efficiency of the violation-deterring measures in the strategies. Due to the fact that performing a full cost benefit analysis for the designed strategies appeared not to be feasible, the costs per performed check are used as a second order estimation of their possible effectiveness.

PHASE 5 – EVALUATING THE DESIGNED STRATEGIES

The construction of coherent enforcement strategies will be evaluated in a naturalistic ex-ante evaluation, using interviews. Within the limited resources for this research, ex-ante evaluation is used to obtain feedback on the design requirements, design principles and design itself, according to the guidelines for the evaluation of artefacts in Johannesson and Perjons (2014). Since a socio-technical artefact is designed, the naturalistic nature of the evaluation in which multiple stakeholders are involved, suits the goal of the evaluation. The evaluation goal is to assess whether the enforcement strategies designed in phase III meet the objectives, constraints and requirements and which improvements could be made.

The evaluation will be based on six interviews with six stakeholders and one expert. The interviewees all participated in the focus group session in the exploratory phase of the research and together represent different perspectives on the problem. Both RWS, the road administrator of the national road network, and PZH, the road administrator of a regional network, RDW and branch organisation TLN were interviewed. An expert on weight enforcement, working at the Human Environment and Transport Inspectorate was interviewed as well. The interviews were held in Dutch, as this is the most convenient language for both respondents and author to express themselves. The interviews were recorded by permission, worked out (Appendix XV - XIX) and sent to the interviewees for verification.

The main purpose of the interviews however was to evaluate the validity of the analysis and methods used and to retrieve insight in the validity of design requirements, design principles and choices made in the design process. The interview was based on informed argument, since it appeared difficult to let the stakeholders directly assess the effectivity and efficiency of the designed enforcement strategies.

The semi-structured interview style allowed the author to delve deeper into the views of the stakeholders, within the fixed topic of the question, by asking additional questions. An interview guide was made, in which the topics and basic questions were identified (Appendix XI). Per interviewee, the author added and removed interview questions when considered needed. Within the limited resources available in this research, an impressionistic analysis of the interviews was made. Advantages of this data collection method include the fast processing time. However, the quality and validity of data generated from the interviews depend on the skills and interpretation of the author.

3. WEIGHT ENFORCEMENT: A LITERATURE STUDY

In this chapter theoretical views on enforcement are discussed to derive insight in the success factors for enforcement in general, following the first step of the Design Science research framework by Johannesson and Perjons (2014). The research question answered in chapters 3 and 4 is:

Which technical, social and institutional structures impact the functioning of weight enforcement in national and regional road networks?

To answer this question, this chapter provides background information on weight enforcement, showing the relevance of this research and providing information for the formulation of constraints and requirements in the next chapter. The literature study provides insight in the existing research base (Section 3.1) and theoretical success factors and optimum conditions for enforcement in general (Section 3.2).

3.1. WEIGHT ENFORCEMENT

In general, three types of HGV overloading are distinguished:

I. Vehicles exceeding the GVW or GTW of 50 tons, as defined by law
II. Vehicles exceeding the GVW or GTW limit as defined in the registration certificate
III. Vehicles with one or more axle loads exceeding the axle load limit of 10 tons for non-powered axles and 11,5 tons for powered axles, as defined by law

GVW and GTW overloading, as defined in category I, mostly impacts the infrastructural works like bridges and culverts, while category III axle overloading mostly impacts the pavement structure. Since overloading on GVW/GTW in category I and II generally directly leads to overloaded axles, overloading on GVW/GTW affects both infrastructural works and pavement. Although the technical relationship between the number of overloaded HGVs and the amount of road damage falls out of the scope of this research, the differentiation in types of overloading is of interest a well for the deployment of enforcement activities, as will be described in Section 4.2.

3.1.1. INCENTIVES FOR OVERLOADING

An economic analysis of the incentives of companies to overload their HGVs is presented in a conceptual model by Jessup (1996). The study shows that overloading is expected to occur, when economic benefits exists and exceed the expected costs for fines. So, the decision whether or not to violate maximum weight restrictions, largely depends on the chance of being checked and the chance of being fined. A decrease in one of both leads to an increase in overloading, as will be elaborated upon in the Table of Eleven in Section 4.2.

The exact economic benefit of overloading depends on a number of factors, including the value of the transported good and the cost of additional vehicle maintenance and fuel. According to Jacob and Feypell-de La Beaumelle (2010), French research estimated that a yearly additional benefit of 25.000 euros was generated, for a 5-axle articulated truck at 20 percent overloading.

3.1.2. APPLICATION OF WEIGH-IN-MOTION

In a large part of Europe, fixed WiM equipment in the road is used to make a first selection of vehicles exceeding the weight limits (Haugen, Levy, Aakre, & Tello, 2016; Oskarbski & Kaszubowski, 2016). Pre-selected vehicles are directed to dedicated areas, where calibrated static scales are used to perform court-proof weighing. A study by Stanczyk and Klein (2012) describes the application of this method in France. The usage of High Speed WiM equipment for this purpose is further examined by Jacob and Feypell-de La Beaumelle (2010). The main advantage mentioned by the authors includes the possibility to weigh all vehicles, independent of their speed,

time of day or number of axles. Due to the required technology and man power needed for the calibrated reweighing, it is however a costly system.

When the accuracy of WiM is up to legal standards, direct enforcement could be adopted. In direct enforcement, vehicles can be fined solely based on the WiM measurement and no reweighing is needed. The challenges of modifying legislation and required technological and metrological improvements are described by Jacob and Cottineau (2016). The authors conclude that direct enforcement using WiM is promising but needs further development.

3.1.3. EFFECTIVENESS OF WEIGH-IN-MOTION

The effectiveness of WiM is assessed in several studies, including studies by Taylor, Bergan, Lindgren & Eng (2000) and Torres Martínez, Oliete Josa, Magrinyà, & Gauthier (2018). The effectiveness of WiM is defined by the decrease in social costs due to overloading, compared to the reference situation. However, the number of WiM's, the characteristics of the road network, the spreading of WiM's over the network and a large number of other factors influence the effectiveness as well. In developing countries with relatively high weight violation rates, the effect of weight enforcement is larger. Karim, Ibrahim, Saifizul, and Yamanaka (2014) focus specifically on the cost-effectiveness of weight enforcement in developing countries and propose indirect weight enforcement as a very cost-effective solution for countries such as Malaysia. Torres Martínez et al. (2018) even finds a benefit-cost ratio of 20 in a case study on a long corridor in Sub-Saharan Africa.

For more developed countries dealing with overloading, weight enforcement is recommended as well as a cost-effective method to address the overloading problem, according to the relevant literature. Taylor et al. (2000) examined WiM weight enforcement technology on USA's highways and consider it cost-effective, since the enforcement costs are expected to be lower than the pavement damage. The authors conclude furthermore that benefits can be gained from cooperation between different road owners and administrators in an integrated approach. Similar conclusions are drawn by Bagui, Das, and Bapanapalli (2013), who assessed the effectiveness of weight enforcement in Build, Operate and Transfer (BOT) projects, in general characterized by their extensive length. A system dynamics approach for evaluating truck weight regulations is applied by Hang & Li (2010). This unique approach makes it an interesting study, however focused as well on solely national roads. Different sorts of WiM technologies have been identified and assessed by Zhang (2007). The author points out the added value of a complete cost-benefit analysis, including costs for road asset users. In this way, the economic feasibility of Weigh-in-Motion systems could be defined.

The interaction between decision makers like road owners and administrators on the one hand and road users on the other hand is assessed in a bi-level approach study by Moreno-Quintero, Fowkes & Watling (2013). In this modelling approach, the carrier's objective and the road administrators' objective, are modelled as a bi-level interaction problem. The effects of weight enforcement inspection points can be made insightful in this way. Fekpe and Clayton (1994) identify the perceived probability of detection as one of the factors influencing weight enforcement effectivity. Furthermore, the author points out the difference in effectiveness between different WiM applications (fixed, dynamic).

Where Moreno-Quintero and Fekpe do not elaborate on the location-choice of inspection points, Mahmoudabadi & Seyedhosseini (2013) do. Using the shortest path algorithm, they defined the optimal spread of Weigh-in-Motion systems (WiM) over the road network of the Iranian province Fars. The validity of this study is questionable, since the possible avoidance of the fixed measuring points by overloaded vehicles is not addressed. Taylor et al. (2000) describes two studies in Idaho and Virginia which found that 14 percent of the traffic avoided weight measurement locations. It was found that transporters drove up to 160 miles to avoid weight measurement locations.

Finally, the impact of commercial vehicle pre-clearance programs in indirect weight enforcement situations is assessed in a study by Lee, Jaeckel, Choi, and Chow (2013). In this way, companies that have shown that they do not violate weight regulations, do not have to stop at weight inspection points. Time savings are considerable, and the author concludes that the programs increase the effectiveness of indirect weight enforcement.

3.1.4. KNOWLEDGE GAPS

The scientific knowledge base on the enforcement of maximum weight regulations is relatively small. The deployment and effectiveness of WiM, the most used weight enforcement technique is examined in different reviewed studies. The high implementation and maintenance costs are considered to be the largest limitations of this weight enforcement measure. Furthermore, achieving the desired accuracy level for the use of WiM for direct enforcement proves to be a challenge. The studies are consistent in their findings that WiM is a cost-effective weight enforcement strategy to address the problem of overloaded vehicles on highways. Newer technologies, like in-vehicle weighing systems, are not yet widely discussed in the literature.

Based on the conducted literature review, two important knowledge gaps can be identified:

I. *The cost-effectiveness of Weigh-in-Motion and other weight enforcement measures in multi-layered road networks*

The present literature on the evaluation of WiM technology is focused on primary roads: highways, large Build, Operate and Transfer projects and corridors. Given the specific characteristics of the Dutch road network, including strong variation in HGV intensities, higher road densities and different pavement structures, it is questionable whether WiM is as cost effective on local road networks as on national road networks.

II. *The cost-effectiveness of combining weight enforcement strategies, possibly combined with WiM weight enforcement*

The cost-effectiveness of other weight enforcement strategies, such as On-Board Weighing, special investigating officers equipped with weighing scales and more soft-governance based approaches, is not yet addressed in the current literature. Especially in a local road context, alternative and/or innovative weight enforcement strategies, whether or not integrated with WiM or weight enforcement programs of other road owners, could be a suitable solution.

This research will address both knowledge gap I and II and aims to define the cost-effectiveness of both WiM and other innovative weight enforcement strategies on integrated road networks. The results of the proposed study will allow for policy makers to make more substantiated decisions on weight enforcement programs.

3.2. ENFORCEMENT IN GENERAL

In this section, the results from a literature study on the general principle of law enforcement will be described. These theories are applicable on the problem of overloaded HGVs and are used to determine the theoretical success of future weight enforcement measures and strategies.

TYPES OF INSPECTEES

Effective enforcement contributes to the ‘successfulness’ of legislation. In order to achieve the desired policy outcomes, enforcement is needed in almost all cases (Gunningham, 2010). As will be elaborated upon in this section, it is of importance to gain insight in the willingness of the inspectee to comply with specific enforcement activities, to be able to deploy the right enforcement activities. Baldwin and Cave (1999) distinguish well-willing and malicious inspectees, aware or not aware of relevant regulations. The classification in Figure 5 is based on this distinction.

- *Unconscious compliers* are not aware of regulations, but do not violate relevant regulations, for example because the nature of their transport activities does not allow them to violate weight restrictions.
- *Unconscious violators* are not aware of regulations but do violate them. Sanctions or motivation based on persuasion could make them become compliers.
- *Spontaneous compliers* are aware of regulations and actively comply. This could be because the nature of their transport activities does not allow them to violate maximum weight regulations, because they want to act socially responsible or for other reasons not based on enforcement activities.
- *Conscious violators* are aware of regulations, but not willing to comply. The perceived benefit of violation stimulates them to violate and they are not deterred by current enforcement activities.
- *Inspectees deterred by enforcement* are aware of regulations, malicious, willing to violate, but comply because of deployed enforcement activities. This group is expected to fall back into violative behaviour when the pressure of enforcement activities on their behaviour is released.

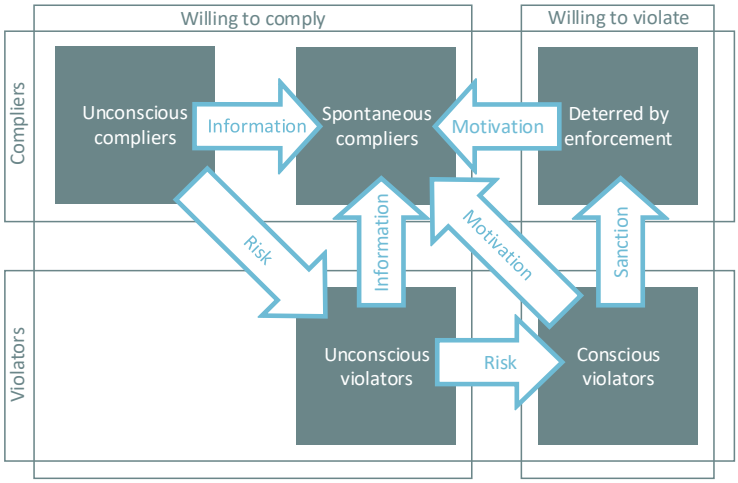

Figure 5 – Five types of inspectees

TYPES OF ENFORCEMENT STYLES

Broadly, two types of enforcement can be distinguished, a deterrence strategy and a compliance strategy (Gunningham, 2010; Hawkins, 1984; Sparrow, 2000). While the deterrence strategy focusses on penalizing violation of regulations and can therefore be seen as a confrontational strategy, the compliance strategy is more focussed on cooperation and conciliation. Proponents of the deterrent effect of regulation state that businesses will only invest in meeting public policy objectives, when they are obliged to do so by law and the detection chance and penalty are high (Becker, 1968; Stigler, 1971), while proponents of the compliance strategy argue that the complexity of enforcement in practice requires more cooperation and a more pedagogic enforcement style. de Bruijn and ten Heuvelhof (2005) provide the following overview of the two styles:

	Compliance strategy Pedagogic style	**Deterrence strategy Sanction style**
Central value	Relation-oriented enforcement	Goal-oriented enforcement
Most important control variable	Information and interaction	Information on norm-conformity
Relation inspector-inspectee	Versatile	One-sided
Enforcement context	Ambiguous	Unambiguous
Nature of enforcement process	Finding compromise	Sanctioning

Table 1 – Difference between compliance stimulating and violation deterring strategy (de Bruijn & ten Heuvelhof, 2005)

Enforcement styles can as well be classified in enforcement as bureaucratic or strategic activity. A more standardized, bureaucratic application of enforcement has a high level of predictability, which could contribute to a good relationship between inspector and benevolent inspectees (de Bruijn & ten Heuvelhof, 2005). On the

other hand, non-benevolent inspectees could strategically abuse the predictability of the enforcement activities. Strategic enforcement has a more unpredictable nature, in which anticipation and reaction on the behaviour of the inspectee plays a key role (de Bruijn & ten Heuvelhof, 2005).

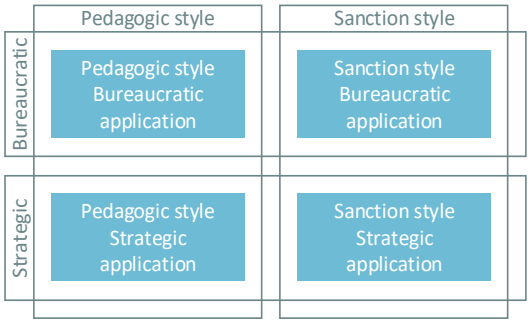

Figure 6 – Classification of enforcement measures (de Bruijn & ten Heuvelhof, 2005)

In Figure 6, the four resulting available enforcement styles are displayed. The figure shows that for both the sanction style, as well as the pedagogic style, a bureaucratic or strategic application can be chosen, by which four possible combinations of styles are available. de Bruijn and ten Heuvelhof (2005) argue that a larger variety of available styles makes it easier to match enforcement activities with the behaviour of inspectees.

The effectivity of enforcement depends largely on the position of the inspector in relation to the inspectee. Four important notions are distinguished by de Bruijn and ten Heuvelhof (2005), which play a key role in the effectiveness of enforcement strategies and will be used in the design of coherent enforcement strategies in chapter 5.

i. *Strategic selection* – A portfolio of inspectees and enforcement activities plays an important role in the identification of inspectees and the strategic selection of who to inspect and how to do so.
ii. *Information* – Redundancy of information enlarges the quality of the inspectors' intelligence, by which strategic behaviour of inspectees can be better discovered.
iii. *Context* – The use of context and the environment of the inspectee to stimulate compliance
iv. *Variety in enforcement style* – The inspector should have multiple enforcement styles available. A mix of compliance and deterrence provides the optimal strategy (Ayres & Braithwaite, 1992; Kagan, 1989; Wright, Marsden, & Antonelli, 2004). While the inspector can be pedagogic, helping the inspectee to comply with compliance, there must be sufficient threat from his enforcement activities. Vice versa leads a too large focus on the sanction style to over-enforcement, reduced information-sharing by the inspectee and more strategic behaviour. According to (Gunningham, 2010), "The challenge is to develop enforcement strategies that punish the worst offenders, while at the same time encouraging and helping employers to comply voluntarily."

THE USE OF THE ENFORCEMENT PYRAMID

Recognizing the limitations of applying only compliance or deterrence based enforcement styles and the need for a mix of these, Ayres and Braithwaite (1992) suggest to adjust the strategy to the variety of regulatees and their motivations. Conscious offenders should be successfully deterred, while at the same time unconscious or incompetent offenders should be encouraged to comply voluntarily. The distinction between different groups of regulatees is further worked out in the subsector analyses, elaborated upon in the next chapter.

The regulator should try to avoid two possible problems in regulating groups of regulatees. On the one hand, assuming all regulatees to be well-willing to comply with regulation could lead to a situation in which conscious offenders could use the freedom to perform strategic behaviour. The pedagogic, compliance strategy is not suitable to effectively deter those regulatees who are consciously violating regulations. On the other hand,

applying the deterrence, sanction-based strategy for all regulatees, even those who are willing to comply with regulations, could lead to resistance and strategic behaviour.

A widely applied mechanism to deal with the variety in regulatees and needed variety in enforcement styles is proposed by Ayres and Braithwaite (1992). An enforcement pyramid, as displayed in Figure 7, provides insight in the way in which regulators could apply responsive regulation. Progressive punitive strategies are applied when lower levels of intervention fail. The strategy should be communicated to the regulate in advance, to stimulate compliance in an early stage. The more persuasive measures can be found at the bottom of the pyramid, escalating towards sanctions at the top. Starting at the bottom, regulators can find out which regulatees are well-willing and for which regulatees more deterrence-based enforcement measures are suitable.

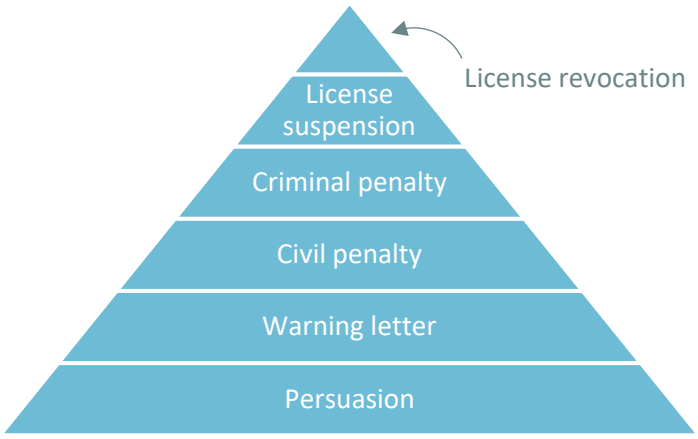

Figure 7 – Enforcement pyramid for responsive regulation (Ayres & Braithwaite, 1992)

THE OBJECTIVE VERSUS SUBJECTIVE PROBABILITY OF DETECTION

A distinction can be made between the generic and specific preventive effect of enforcement. Generic prevention includes the effect of inspectees changing their behaviour, based on avoiding the anticipated consequences of violation. Without being sanctioned themselves, inspectees adjust their behaviour. Specific prevention includes the effect of inspectees changing their behaviour, after being checked, detected or sanctioned. It is generally perceived that enforcement should be aimed at generic prevention instead of specific prevention, since by generic prevention the negative consequences of violation are already avoided. Generic prevention is largely influenced by the subjective risk of being checked (Goldenbeld & Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, 1994). In the end, the effectiveness of enforcement is determined by the improvement of the compliance rate of the enforced regulation (Fekpe & Clayton, 1994).

3.3. CONCLUSIONS

From the first part of the literature study on weight enforcement it is concluded that further research is needed to firstly define the cost-effectiveness of weight enforcement strategies such as WiM in a broader complex road network context and secondly define the possibilities and cost-effectiveness of combinations of strategies.

In the second part of the literature study, various theories on enforcement in general were elaborated upon. It can be concluded that insight in the behaviour and motivations of inspectees is expected to enlarge the chance on effective enforcement. The enforcement authority should use portfolio management to keep track of the inspectees behaviour. In order to be able to avoid under- or overregulation, the inspector should have various enforcement measures and styles at his disposal. In this way, enforcement can be specifically targeted at various types of inspectees, making use of the principle of responsive regulation.

4. CURRENT WEIGHT ENFORCEMENT AND COMPLIANCE LEVEL

The Human Environment and Transport Inspectorate (ILT) is, together with the Dutch police, appointed to enforce weight regulations. The enforcement activities in the past years, as deployed by the Inspectorate, provide valuable insights in the effectiveness of the used weight enforcement measures and the sensitivity of the sector for enforcement. Therefore, the current weight enforcement situation will be assessed by means of the Table of Eleven (Section 4.2.2) and compliance estimation (Section 4.2.3). Since the considerations and motivations to comply or violate differ per subsector, three of the subsectors in which the compliance level is exceptionally low, are further analysed in Section 4.2.4. Subsequently, in Section 4.3, the results of the focus group session are discussed. To start off, the impact of relevant legislation on future weight enforcement strategies will be discussed.

4.1. INSTITUTIONAL AND LEGISLATIVE SITUATION

The institutional and legislative situation shows the current possibilities enforcement authorities and road owners have in addressing the problem of overloaded HGVs. This section will show that the impact of national, but mostly European legislation on the future enforcement practice is considerable.

4.1.1. LEGAL PROHIBITION ON OVERLOADING

The prohibition on overloading is legally stated in the Road traffic Act 1994 (Wvw) and the Road freight transport Law (WWG). In Article 71 of the Wvw, the juridical basis of the overloading prohibition can be found. The maximum vehicle weight for trucks of 50 tons and for moving tools of 60 tons is stated in Article 5.18.17.a of the Vehicle Regulation. The maximum axle load is stated in Article 5.18.17.d and is set at 10 tons for normal axles and 11.5 tons for powered axles. The maximum axle load can be different, dependent on the amount of (powered) axles and the distance between axles (within axle groups). The axle road for moving cranes is 12 tons. In Article 2.6 of the WWG, the prohibition to carry out professional or own transport while violating the Wvw is mentioned. HGV overloading is defined as an economic crime in the Law on Economic Crimes in Article 1 sub 4. Within the European Union, legislation on maximum dimensions and weights for international traffic is set in Directive (EU) 2015/719 (which amends Directive 96/53/EC). The directive ensures the free movement of vehicles within the limits set in the Directive and ensures Member States cannot restrict this free movement.

If a road administrator considers it necessary to deviate from article 71 of the Wvw, leading to a limitation or expansion of the number of categories of road users that use a road or can use the road section, this can be done by means of a Traffic Decree, as defined in article 15 sub 2 of the Wvw. Traffic Decrees in which the maximum weight for the specified road section is lowered can guarantee the safety and/or extend the lifetime of instable dike roads, quays and older bridges.

4.1.2. JURIDICAL BASIS FOR SUPERVISING COMPLIANCE

Legal information on supervising the maximum vehicle weight compliance can be found in Wvw Article 158. A combination of Articles 2.6 and 5.1 of the WWG provides the legal base for government officials appointed by the Ministry of Infrastructure and Water Management to enforce weight regulations. Article 2.6 contains an independent prohibition to carry out professional transport or own transport with a truck in respect of which there is a violation of the loading instructions. In the “Decision to appoint ILT supervisors and investigating officers on transport legislation”, the ILT is appointed as supervising governmental body. No Decisions to appoint other supervisors and investigating officers were found in the legislation, by which the ILT is the only supervising governmental body on transport legislation, besides the National Police. In the current supervision practice, WiM systems are used to cary out the supervision on overloading. Article 5.1 of the WWG, combined with Article 5.11 and 5.19 form the juridical basis for the ILT to make use of WiM systems in its supervision practice.

EUROPEAN LEGISLATION ON ENFORCING MAXIMUM WEIGHT REGULATIONS

Directive (EU) 2015/719 (which amends Directive 96/53/EC) requires Member States to use either weighing system build in the road (WiM), or weighing systems build in the vehicle (OBW), for preselection purposes, before May 2021. Member States are furthermore required to carry out a minimum number of weight checks on HGVs, proportional to the total amount of vehicles checked on the Member States' territory. The Directive is also aimed at avoiding distortion of competition when performing national transport, making sure national operators cannot benefit from undue advantages, compared with competitors from other Member States. In the amendment it is furthermore stated that the communication of on-board data to road authorities and/or administrators should be defined by the existing CEN DSRC communication standards.

Compared to other European countries, the maximum GVW restriction for national transport in the Netherlands is relatively high, being 50 tonnes for most national and regional roads. The maximum GVW limits in Belgium and Germany are respectively 44 and 40 tonnes. Despite a lobby by the transport sector for higher weight limits, for international transport the GVW is set at 40 tonnes. According to the ILT, surrounding countries having lower maximum weight limits serve as some sort of buffer. On the other hand, the variation in maximum weights across the EU could reduce compliance, due to higher unfamiliarity.

4.2. CURRENT WEIGHT ENFORCEMENT PRACTICE

In this section, the current weight enforcement practice in the Netherlands is described and analysed. The current enforcement practice is described and assessed in the Table of Eleven, after which a compliance estimation and subsector analysis are presented.

4.2.1. DESCRIPTION OF CURRENT WEIGHT ENFORCEMENT PRACTICE

Rijkswaterstaat owns and operates 20 WiM points, strategically located on the national road network. Between 2014 and 2015, the ILT monthly summoned the 100 offending companies responsible for the largest economic damage. Within three months, these companies had to reduce their overloading with 37 percent. Otherwise, the ILT would issue them cease and desist letters up to 10.000 euros. The strategy is aimed at stimulating businesses to adjust their behaviour and can be categorized as responsive government. Due to the low accuracy of the used WiM systems, it was only possible to fine companies using static weighing bridges. The WiM system was therefore used as a method to pre-select the largest offenders. Since October 2015 the entire WiM system is out of order, due to technical problems.

Besides the WiM system, the ILT closed a few covenants with certain companies or in certain geographical areas as well. An interesting example is a covenant between Suiker Unie and ILT, to reduce overloading in sugar beet transport. The covenant, concluded in 2009, had a duration of three years. During this period, the police and Inspectorate did not carry out weight controls specifically on beet transport. In return, Suiker Unie annually supplied weight data from weighing scales to the enforcement department of the ILT. A second incentive for sugar beets not to offend the maximum weight regulations, was the maximum payment per HGV. Suiker Unie would only pay for the maximum amount of sugar beets according to weight restrictions. Additional weight would not be paid for by Suiker Unie, by which the economic incentive to overload was taken away. From measurements, it can be concluded that the covenant was effective in reducing the amount of overloading in the sugar beet transport.

4.2.2. ANALYSIS OF CURRENT WEIGHT ENFORCEMENT PRACTICE

The current weight enforcement practice in the Netherlands is analysed, using the Table of Eleven. The analysis results show the motivations for companies for violation or compliance and thus the effectiveness of current weight enforcement. Combined with desk research and the opinion of different experts, a compliance estimation is made, in which the magnitude of different groups of compliers and violators is visualised. As elaborated upon in Section 2.2, the Table of Eleven consists of five dimensions of spontaneous compliance (I-V) and six dimensions of enforcement compliance (VI-XI).

The compliance profile is visualised in Figure 8. On the left, the eleven dimensions are displayed. The horizontal axle represents a continuous scale in which the effect/nature of each dimension is ranked between strongly violation stimulating and strongly compliance stimulating. A mutual relationship between some of these dimensions exists. For example, the sanctioning dimensions (X and XI) strongly relate to the checking dimensions (VII and VIII). In the end, if the sanctions for a certain crime are extremely high, but the chance of being checked or detected extremely low, the enforcement will not lead to the desired reduction in crimes.

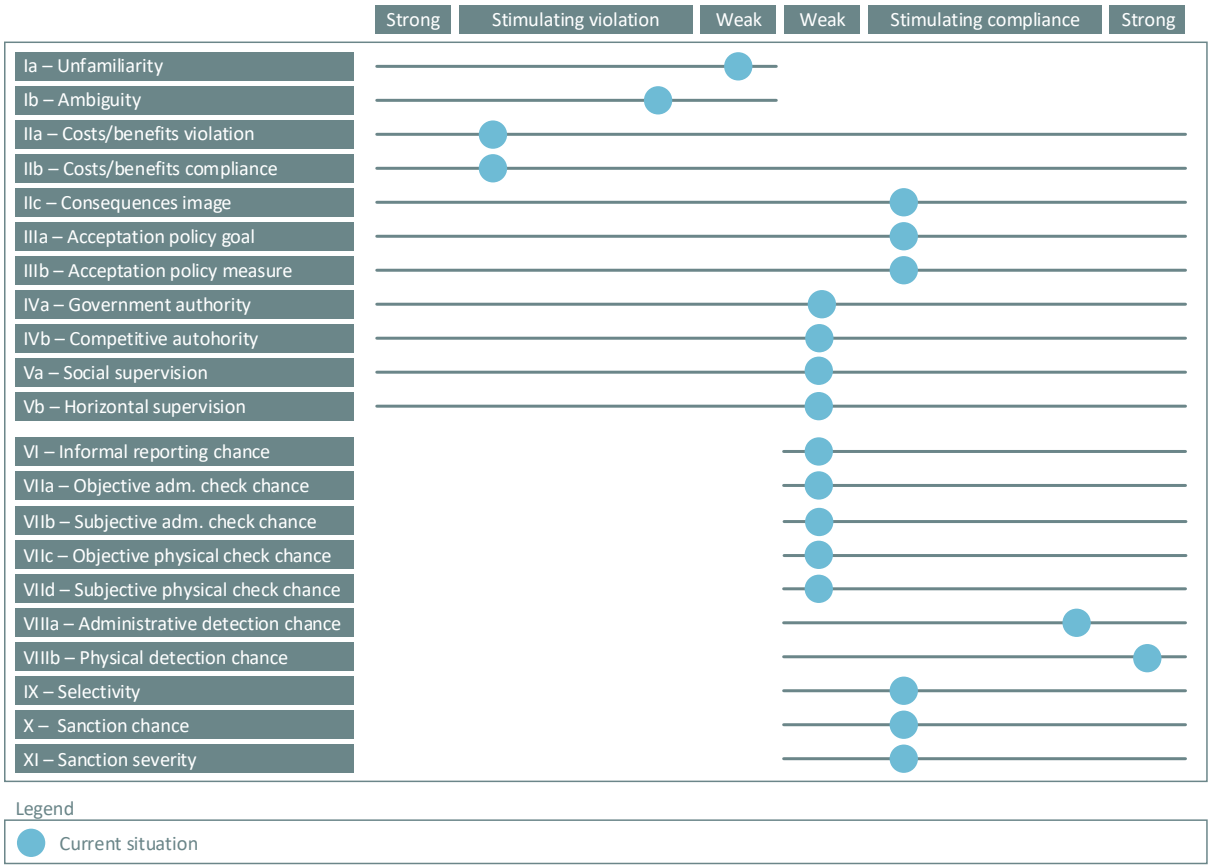

Figure 8 – Effects of current enforcement on the eleven dimensions of spontaneous and enforced compliance in the Table of Eleven

As can be seen in the compliance profile in Figure 8, within the spontaneous compliance dimensions, the benefits of violation and costs of compliance have a strong violation stimulating effect. Within the enforced compliance dimensions, the low objective and subjective chance of being checked have a low compliance stimulating effect. From this analysis, it can be concluded that future weight enforcement should lead to a reduction of the benefits of violation and/or reduction of the costs to comply and/or a higher probability of being checked. The results are discussed in this Section and elaborated upon in Appendix I.

DIMENSIONS OF SPONTANEOUS COMPLIANCE

Within the five dimensions of spontaneous compliance, as presented in the upper section of Figure 8, especially the costs and benefits of maximum weight regulation compliance and violation stimulate transporters to overload their vehicles. The level of competition in the transport sector is strong and depends on the economic tide. In Section 4.2.4, this effect is elaborated upon for three subsectors. For most clients, the price is still the most important factor in tenders. Transporters can offer lower prices in biddings when violating regulations, like driving and resting times and maximum weights. Additionally, investments in e.g. axle load sensors, weighing scales, side loaders, education and processes should be made to comply with regulations. Both the benefits of overloading and costs of complying have a violation stimulating character. This effect is elaborated upon in Appendix I.

The nature of the other dimensions is less violation stimulating. During the focus group session, it became clear that both ILT, RDW and TLN use multiple communication channels to communicate regulations and that the regulations are expected to be known by the largest part of the sector. As far as known, there is no social control between transporters in the sector on the subject of overloading.

DIMENSIONS OF ENFORCED COMPLIANCE

Since the WiM systems on the national road network were turned off, the amount of checks on overloading was reduced. According to the CJIB, in 2017 only 238 transporters were sanctioned for HGV overloading (Centraal Justitieel Incassobureau, 2018). Compared to the estimated total number of overloaded transports, the objective chance on being sanctioned is extremely small. As a result, the compliance stimulating effect of weight checks is missing. However, when being checked, the chance of being detected is close to 100 percent. Both the WiM systems and static weighing scales are relatively accurate, leaving little room to pass a weight check undetected while being overloaded. When being detected, an exceedance of the maximum gross vehicle weight of over 5 percent or an exceedance of the maximum axle load of over 10 percent leads to a sanction. In most of the cases, the sanction consists of a fine, but in cases of severe overloading the vehicle can receive a driving ban until the weight complies with regulations. The exact compliance or violation stimulating nature of the six dimensions of enforced compliance in the Table of Eleven is further discussed in Appendix I.

4.2.3. ANALYSIS OF COMPLIANCE LEVEL

Based on data on the amount of overloading, collected by the ILT and province of Zuid-Holland, the compliance profile and the opinion of experts during the focus group session and interviews, a compliance estimation is made. The estimation provides insight in the behaviour of the transport sector as a whole, and whether transporters violate or comply consciously or unconsciously. The compliance estimation forms an important input for the development of weight enforcement policies, since the different groups should be addressed in different ways.

From measurements by the WiM systems on the national road network, operated by the ILT, and the provincial network, operated by RWS, it is estimated that 15 percent of the HGVs on the Dutch road network is overloaded on GVW, GTW or axle load (Cornelissen et al., 2016; Inspectie Leefomgeving en Transport, 2015). The group offenders can be categorized in conscious and unconscious offenders. While unconscious offenders violate rules because they do not know or comprehend them, conscious offenders violate rules deliberately, knowing the rules ant taking the risk to get caught.

In the classification of the different groups of offenders, a distinction should be made between GVW/GTW overloading and axle overloading. Around 25 percent of the overloaded trucks is overloaded on GVW, the other 75 percent is overloaded on axle weight, was concluded during the focus group session. In the focus group, it was estimated that approximately all overloading on GVW is done intentionally, as well as the largest part of the overloading on axle loads.

Another group of transporters is deterred by the enforcement activities of the authorities and/or possible reputation damage. This group of actors would like to violate the maximum weight restrictions but does not do so because of the chance of being checked by random inspections or in other ways. For this group, the decision to comply with maximum weight regulations depends on an economic calculation, in which the chances of being checked, detected and sanctioned play an important role (Jessup, 1996).

The group of transporters complying with maximum weight restrictions can be categorized in spontaneous and unconscious compliers. Spontaneous compliers are aware of the regulations and live them by their selves, even in the case when no enforcement activities are performed. This could be because they want to act socially responsible, or because the nature of their transport activities does not allow them to violate the maximum weight restrictions. For example, a flower transporter is not likely to even have a chance to overload an HGV. Unconscious compliers are not aware of regulation and comply without realizing. Within this group again, a part might even not be able to overload their vehicles because of the nature of their transport activities. Based on the mentioned figures and the insights of the stakeholders and ILT expert, the compliance estimation in Figure 9 is made. The figure was shown for verification to all stakeholders and an ILT expert during both the focus group session and interviews. The results of this verification can be found in Chapter 8.

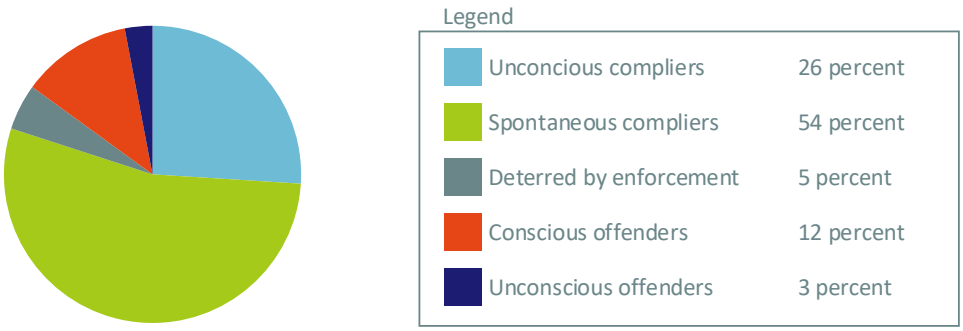

Figure 9 – Compliance estimation for current situation

4.2.4. ANALYSIS OF DIFFERENCES IN DIMENSIONS BETWEEN SUBSECTORS

According to the 2012 annual report of the Inspectorate and various experts in the focus group session, overloading is more present in the subsectors sea container transport, agricultural transport, fertilizer transport and construction material transport (Inspectie Leefomgeving en Transport, 2013b). In this Section, possible motives for (non-)compliance are further analysed for these subsectors. The analysis will show the differences and similarities in compliance- and deterrence-stimulating influences for the subsectors sea container transport, tipper transport and moving cranes. The analysis provide insight in the extent to which enforcement activities should be customized for different subsectors.

(SEA) CONTAINER TRANSPORT

The container road transport sector is part of a long transport chain, in which hinterland transport over road plays an important role. Most of the containers arrive at large sea ports, from where they are transported to their final destination via road, rail or barge transport. Inland terminals are used for intermodal transport, in which more than one modality is used in the hinterland transport. On the other side of the chain, at the beginning, vice versa hinterland transport is used to transport containers to the sea port. Within the hinterland transport, a large number of private companies are involved, including shipping lines, terminal operators, inland terminal operators, hinterland transport providers and forwarders. The transport chain is long and could consist of dozens of actors.

Containers are loaded from the ship or storage area on to tractor-trailer combinations in fully standardized and efficient processes, by for example the ECT. Even when the trailer is equipped with axle load sensors, the speed and standardisation of the process does not allow the transporter to check whether the vehicle is overloaded. The competition in the container transport market does not allow for the return of wrongly loaded or overloaded containers.

TIPPER LORRY TRANSPORT

Analysis of tipper transports, used in civil engineering, showed that 40 percent of the examined HGVs were overloaded on GVW (Hordijk, 2013). In the civil engineering, the transport chain is relatively short, compared to container transport. The market is growing but characterized by a high level of competition. 59 percent of the orders in the civil engineering sector are commissioned by governmental bodies, of which RWS is the largest one. According to a market analysis performed by ABN AMRO, the financial position of most civil engineering companies was bad in 2016. The margins were low and under pressure, due to increased costs (Buijs & ABN AMRO, 2016).

Clients, who can be contractors or 'regular' clients, set strict deadlines ad often choose for the lowest offer in tenders. Especially in economic downturn, when the number of transporters is relatively large, compared to the number of offered transport orders, contractors are forced to offer very low amounts to receive orders. One of the ways to reduce costs, is to overload vehicles.

Within the sector, other factors affect the amount of overloading as well. For example, within the asphalt transport towards infrastructural projects, overloading is not a problem. Since contractors buy asphalt from asphalt suppliers, asphalt plants are equipped with static weighing scales to determine the amount of asphalt loaded. Based on these measurements, the invoice is sent to the contractor. On the other hand, old asphalt, milled away from the old road construction, is dropped in tippers and transported away from the construction site without weighing. Given the tight contract agreements and high time pressure under which road construction projects take place, overloading could save time and money. Static weighing of all vehicles would cost money and a large amount of time.

TRANSPORT OF MOBILE CRANES

Mobile cranes are classified as exceptional transport, the transport of long, high, width and/or heavy load that falls outside of the standard legal frameworks. For performing exceptional transports, in most situations an exemption is needed. The RDW awards the exemptions, in which a difference is made between year exemptions and incidental exemptions. Year exemptions are based on a digital roadmap, on which the vehicle weight and size limitations for each road section and infrastructural work are visualised. For transports longer, wider, higher or heavier than the limits for year exemptions or incidental transports, an incidental exemption can be requested.

The time between the request for a year exemption and the award of the exemption generally not exceeds 5 working days. The processing time of an incidental exemption depends on the autonomous decision space the RDW received from the relevant road administrator(s) the route of the transport passes. The time between the request and award is dependent on the quality of the administration of maximum weights and dimensions by individual road administrators. For clients, hiring mobile cranes is expensive. According to TLN, in some situations transporters refusing to carry out the exceptional transport without exemption, are replaced by other transporters.

CONCLUSION ON SUBSECTOR ANALYSIS

A number of similarities between the subsectors are found. Firstly, all transport operators within the analysed subsectors operate within longer chains, in which mutual dependencies, contracts and other (market) forces play an important role in the decision to comply with or violate relevant legislation. The problem of overloading can be seen as a chain problem. Where in the civil engineering and mobile crane sector in most situations the transport chain is relatively short, in the sea container transport sector the transport chain could consist of dozens of players. The complexity and interdependencies within these chains make it difficult to take away the motivations to overload. Secondly, in all sectors overloading leads to distortion of the level playing field. Transporters complying with maximum weight regulations suffer from that wo do not comply and can offer lower biddings in tenders. This could be an incentive for other transporters to violate maximum weight regulations themselves as well, to bring in new orders.

Also, a number of differences between the subsectors were found. Specific market structures impact the probability on overloading. A good example is the transport of asphalt, at which the chance on overloading is virtually only present at the transport of old asphalt, since new asphalt is payed for per kilo by the contractor. So, while for old asphalt ignorance and imprudence might be causes for overloading, new asphalt overloading can only be done deliberately since the HGV loading process is closely monitored. For the inspector, these insights are needed to be able to apply more pedagogic measures. After all, pedagogic measures are not expected to have effect on the violator transporting new asphalt but could help violators transporting old asphalt change their business processes in order to comply.

4.3. POLITICAL AND SOCIO-ORGANISATIONAL ANALYSIS

During the focus group session, various stakeholders were invited to discuss with each other on their problem perceptions, interests and starting points for policy measures. In this section, the conclusions of the focus group session are presented. A report of the focus group session can be found in Appendix III.

4.3.1. PROBLEM PERCEPTIONS OF INVOLVED STAKEHOLDERS

During the focus group session, it was concluded by all stakeholders that the current weight enforcement situation and resulting compliance level is an undesired situation. A situation in which companies and transporters comply voluntarily with maximum weight regulations, would be desired but is considered unrealistic. It is perceived that there will always be financial considerations for companies and transporters, stimulating to overload their HGVs. The benefits of overloading, which include less trips, less man hours and consequently a better competitive position in tenders, are estimated to be considerable. At the other hand, the costs of overloading, which include higher tire wear and fuel consumption, are estimated to be low. Additionally, the chance to be checked is very low, according to the stakeholders.

Road owners at all levels benefit from effective weight enforcement. The road owners present at the focus group session, indicate to feel the impact of overloading on the road asset. However, road owners are dealing differently with the observation that overloading reduces the lifetime of their assets. The province of Overijssel concluded a covenant with the sector, in which the intention to increase the compliance level is stated. Water Board Rivierenland administers a number of dike roads, on which the maximum weight limit is set at 15 tons. The Water Board works together with the local police force, organising a small number of manual checks each year, to check whether HGVs are in the possession of an exemption which allows them to drive on the dike roads. In the weeks after the check, the number of requested exemptions increases, but this effect is highly temporarily, according to the Water Board. The province of Zuid-Holland tried to work together with the ILT, but this did not result in the intended increase in the number of manual checks on the road asset administered by the province.

According to branch organisation TLN, for companies complying with regulations, it is difficult and painful to see others consciously violating maximum weight regulations. The main interest of the sector as a whole is to create and maintain a level playing field, within the legislative boundaries. As a result, there should be no room for overloading. According to TLN, the possibilities to fine foreign companies should be expanded, again to create and maintain a level playing field for all companies.

With regard to the safety impact of overloaded HGVs, the views of the invited stakeholders differ. Although overloading possibly leads to a longer braking distance, the number of traffic accidents solely caused by overloading is estimated to be extremely low, by several stakeholders. Traffic accidents caused by human or technical failure could have a worse effect due to HGV overloading. At local roads and some regional roads, HGV safety is a larger issue, given the specific road conditions at some regional and local road networks; smaller roads, shared space for all types of users etc. The safety- and pavement impact of HGVs is larger, even if they are not overloaded. The impact of road accidents in which overloading plays a role could be greater on reginal and local roads, according to some of the stakeholders.

4.3.2. STARTING POINTS FOR DEALING WITH HGV OVERLOADING

An important starting point for future weight enforcement was found in Directive (EU) 2015/719, in which EU Member States are obliged to implement WiM or OBW for at least pre-selection. The current WiM systems are very sensitive for maintenance and malfunction, according to ILT. On the other hand, the ILT indicates that more knowledge on OBW is needed before OBW could be deployed. Both ILT and TLN acknowledge the possibilities of OBW, which include the possibility to be checked more frequently. ILT advocates solutions in which direct fining is possible, since this proved to have more effect.

According to the ILT, the stage of solely providing information has passed. It is expected that the largest part of the sector is aware of regulations. Instead, the ILT focusses on the stimulation of compliance, by incentivizing companies. The sugar beet covenant is cited as a successful incentive, in which transporters were only payed as much as the maximum GVW of their vehicle. The monopolistic position of Suiker Unie is perceived to be the major success factor. Closing covenants in other, more competitive sectors is not always supported. TLN welcomes more covenants but argues that smart enforcement should always be part of the enforcement strategy, to ensure the creation of a level playing field. The ILT strongly believes in a focus on subsectors, of which the container-, building- and civil engineering sector are the ones in which the percentage of non-complying transporters is the highest.

The need to focus on the entire transport chain is argued for by a number of stakeholders. In some situations, especially in highly competitive sectors, the position of the transporter is weak. If the transporter denies violating the regulations, clients search for another transporter not taking the regulations too seriously.

4.3.3. EXPLORING STRATEGIES FOR DEALING WITH HGV OVERLOADING

The importance of knowing the costs and benefits of enforcement is emphasized by a number of road owners. A tool that provides insight in the effect of a given configuration of HGVs on the maintenance of the road infrastructure is being developed within working group ‘Zwaartekracht’, in which representatives of RDW, ILT, RWS and PZH take place. This tool could be used to quantify the relationship between the number of (overloaded) HGVs and expected maintenance costs. It does however not include the relationship between enforcement activities and compliance level.

The role of governments at all levels as a client is widely perceived as a powerful tool to communicate the importance of the problem. The inclusion of an explicit prohibition on overloading in contracts in which the government operates as client is supported by all stakeholders. According to the ILT, this measure should be accompanied by sufficient administrative and physical checks, to sort effect.

The introduction of an Intelligent Access Program based on OBW, comparable to the system in Australia, is proposed by the RDW. In this approach, the transporter should retrieve a benefit, in exchange for sharing real time information via axle load sensors. The benefit could include the quicker issuing of weight exemptions. It is however believed by the Inspectorate that a direct translation of measures in other countries to the Dutch context is not always possible. In the case of an Intelligent Access Program, the practical implementation will be a major challenge, according to the ILT.

TLN emphasizes on the need for a higher chance of being checked, whether this is realised by the deployment of WiM, more manual enforcement or another smart enforcement system. Local road owner community of Zoetermeer argues that smart solutions are preferred over manual enforcement.

4.4. CONCLUSIONS

Based on the literature analysis, evaluation of the current enforcement situation and transport sector and the analysis of the political and socio-organisational context of the problem of overloaded HGVs, in this section the conclusions and key implications for the development of weight enforcement strategies will be described. The conclusions will serve as an input for the next chapter, in which the constraints and requirements for future weight enforcement strategies will be discussed.

Based on the analyses in the Table of Eleven and the insights of stakeholders on overloading, it is concluded that the benefits of overloading exceed the costs, in most cases. Especially in a competitive market, in which the lowest bidder is awarded the contract, overloading can be an attractive way to reduce costs. Within the transport sector, the amount of social control and chance of being reported on overloading is low. Especially since the use of WiM on several strategic locations in the Randstad and out there stopped, the risk of being checked became extremely low. The chance of actually being sanctioned is even lower, since physical weighing on certified scales is needed to do so. Based on the analysis of subsectors, it is concluded that in all sectors a strong amount of competition is a strong incentive for overloading. The structure of the total transport chain, in which the transporter operates and in which clients play an important role, has a strong impact on the tendency to overload. Given the position of transport companies within these larger chains, the competition in all subsectors and the market distortion associated with overloading, either an absolute waterproof enforcement system or a strategy focussed on the entire transport chain is needed. In priotising weight enforcement, a strong analysis per subsector provides insight in the strength of the dimensions of the Table of Eleven.

As described in relevant literature, the inspector should be able to deal with different groups of violators and compliers. While for unconscious violators providing information might be enough to get them complying, for deliberate non-compliers other, more sanction-based techniques could be needed. In these instances, the inspector should apply the principle of responsive regulation, in which enforcement activities are gradually build-up. A complicating factor in this is that the inspector is unable to identify who is overloading deliberately and who is doing this unconsciously. For all groups, the risk on over-enforcement and under-enforcement should be reduced. The availability of both compliance stimulating and violation deterring enforcement measures is needed.

All governmental and non-governmental parties involved in the focus group strive to reduce the number of overloaded HGVs. The choice between WiM and OBW is generally seen as a starting point for the implementation of a new weight enforcement policy. Road owners are highly dependent on the Inspectorate and National Police in enforcement on their asset, since they are the only appointed enforcement authorities for overloading. Given the high level of interconnectedness and high density of the Dutch road network and the fact that a large part of transport is longer distance and even international, solutions implemented by Rijkswaterstaat and other road owners could have an enormous impact on regional and local road owners.

5. CONSTRAINTS AND REQUIREMENTS FOR FUTURE WEIGHT ENFORCEMENT

In this chapter the constraints and requirements for future weight enforcement are presented, following the second step of the Design Science Research framework of Johannesson & Perjons (2014). The corresponding research question that will be answered in this chapter is:

What are the constraints and requirements for future weight enforcement focused on both national and regional road networks?

The constraints and requirements for future weight enforcement are based on the literature study, the analysis of the legislative situation, analyses of the current weight enforcement situation and compliance estimation and the focus group session or a combination of these, as can be seen in Table 2.

Requirement	Derived from
I	Focus group session, part I & compliance estimation
II	EU Directive 2015/719
III	Focus group session, part II
IV	Expert interviews
V	Focus group session, part II
VI	de Bruijn and ten Heuvelhof (2005) & compliance estimation
VII	de Bruijn and ten Heuvelhof (2005) & compliance estimation
VIII	Focus group session
IX	Focus group session
X	Focus group session, part II
XI	Focus group session, part II

Table 2 – Overview of bases for constraints and requirements for future weight enforcement

5.1. CONSTRAINTS

The enforcement strategy to be implemented addresses the problem of overloaded HGVs on the Dutch road networks and the resulting social damage. During the focus group session, it was concluded that all stakeholders strive for a reduction in the number of overloaded HGVs on the entire Dutch road network, including national, regional and local roads. All stakeholders agreed that enforcement of maximum weight regulations is needed to achieve the desired policy goal. The first constraint for future weight enforcement is therefore:

I. Future weight enforcement should lead to or contribute to a significant reduction in the number of overloaded HGVs on the Dutch road network

The requirement for European Union Member States in Directive (EU) 2015/719, to carry out a minimum number of checks, should be complied with before May 2021. Meeting European regulations requires the implementation of WiM or OBW on the national road network. It is not at all expected that this Directive will be adjusted, nor withdrawn. Therefore, this piece of European legislation is seen as an important constraint in the development of coherent future weight enforcement:

II. Future weight enforcement should comply with Directive (EU) 2015/719

The Dutch road network can be classified as highly complex, consisting of a tightly interwoven set of national, regional and local roads. Both the start and the end of most HGV trips fall within a local or regional road network. A complex system of local, regional, national and international road connections is used every day by millions of vehicles to get from point A to B. For 69 percent of the HGV movements, the travelled distance exceeds 60 kilometres, while only for 2 percent the travelled distance is shorter than 15 kilometres (Rijkswaterstaat, 2012). It can be concluded that a large part of the HGV movements goes through the national road network. Adjustments in weight enforcement on the national road network, will therefore have a considerable impact on

regional and local roads as well. During the focus group session, regional and local road owners argued that he designed weight enforcement strategy should be able to deal with this complexity and allow for collaboration between various stakeholders.

III. Future weight enforcement should fit within the physical and governance characteristics of the Dutch road network

The societal costs for overloading consist of additional road maintenance, level playing field distortion and road safety reduction. During the focus group session, it was concluded that the benefits in terms of societal costs reduction should outweigh the costs of weight enforcement. During the interviews, the difference between the governmental business case and the social cost benefit ratio was elaborated upon. When asked again for the need for cost-effectiveness, the largest part of the respondents indicated that future weight enforcement should be socially cost-effective. A cost-effective business case for the governments itself is not considered needed. This leads to the following constraint:

IV. The benefits of future weight enforcement in terms of social damage reduction should exceed the costs of future weight enforcement

5.2. REQUIREMENTS

The weight enforcement strategy to be designed should comply with European legislation, as mentioned in the previous section. Contrary to European legislation, national legislation is not seen as a constraint. The process of adjusting existing national legislation or creating new legislation could however, dependent on the legislative impact of the weight enforcement measure, still take a substantial amount of time and effort. It is of importance that an eventual integration of the regulations needed in the future weight enforcement strategy to be designed, can be added and integrated within the existing legislation. Therefore, the following requirement is formulated:

V. Future weight enforcement should be implementable in Dutch legislation

The compliance estimation shows that a group of violators deliberately violates the maximum weight regulations, while another group can be seen as unconscious violators. The two different groups require a different enforcement approach, as visualised in Figure 5. From these notions, it follows that the weight enforcement strategy to be designed should both consist of more compliance stimulating, pedagogic enforcement measures and more violation deterring and sanction-based enforcement measures. Additionally, this allows the inspector to deploy responsive regulation, by which deterrence-based enforcement activities can be gradually intensified based on the actual behaviour of the inspectee (Figure 7). Especially since it is not visible for the inspectorate whether companies are deliberately or unconsciously violating maximum weight restrictions, both styles should be available. Portfolio management should be used to track the behaviour and reaction on enforcement of the inspectee. This results in the following two requirements:

VI. The weight enforcement strategy should consist of both bureaucratically and strategically applied compliance stimulating and violation deterring enforcement measures

VII. The weight enforcement strategy should allow for portfolio management and responsive regulation

The social damage of incidental overloading is considerably less than structural overloading. During the focus group session, TLN argued that the weight enforcement companies responsible for the highest social costs should ideally be confronted with more enforcement activities. This opinion was shared by other participants and is reflected in the following requirement:

VIII. The weight enforcement strategy should be based on the amount of road damage transporters are accountable for

Road transport, as performed by transporters, is a link in a larger transport chain, in which clients and shippers play an important role. The subsector quick scans show the role of the transport chain in the decision of transporters to comply with or violate maximum weight restrictions. During the focus group session, all participants agreed that weight enforcement strategy should therefore not only be focussed on the transporter, but as well on taking away incentives in the chain to overload HGVs. This is reflected in the ninth requirement:

IX. The weight enforcement strategy should be focussed on the entire transport chain

Enforcement activities could seriously impact the business management of transporters, dependent on the exact completion of the enforcement strategy. For example, manual weighing could take up to one hour for one vehicle. According to branch organisation TLN during the focus group session, complying transporters should not be punished for the behaviour of their non-complying colleagues. This was agreed upon by a large number of participants. Therefore, the following requirement is formulated:

X. The impact of the weight enforcement strategy on the business management of complying transporters should be as low as possible

The ILT points out that foreign HGVs are less often overloaded than Dutch HGVs (Hersbach, 2018). It is expected that neighbouring countries, having lower maximum weights, form some sort of 'buffer'. Although the share of foreign overloaded trucks is not large, the level playing field between transporters is in disbalance, due to the inability to collect fines for maximum weight violations from a large part of the foreign transporters. In the context of the creation of a level playing field, fining foreign transporters should be made possible, according to the stakeholders invited at the focus group session (Section 4.3). This leads to the following requirement:

XI. Weight enforcement should be focussed on both Dutch as well as foreign transporters

5.3. CONCLUSIONS

Based on the constraints and requirements for weight enforcement, presented in the previous sections, it is concluded that the deployment of solely one weight enforcement measure will not result in the by all stakeholders desired reduction of overloaded transports. The research will therefore continue with the development and design of combinations of weight enforcement measures. The tight physical and institutional connection between the national road network and regional road network will form the base of the enforcement strategies to be designed. Coherent combinations of measures on both the national and regional road network will be designed. The choice between Weigh-in-Motion or On-Board Weighing as prescribed by the European Union will serve as first starting point.

6. DESIGN OF COHERENT WEIGHT ENFORCEMENT STRATEGIES

Based on the constraints and requirements presented in the previous chapter, a number of coherent weight enforcement strategies will be designed in this chapter. The corresponding research question that will be answered in this chapter is:

What design alternatives for weight enforcement strategies on national and regional road networks can be adopted to reduce the social costs of overloading on national and regional road networks?

The strategies will be designed in four subsequent phases, as visualized in Figure 10.

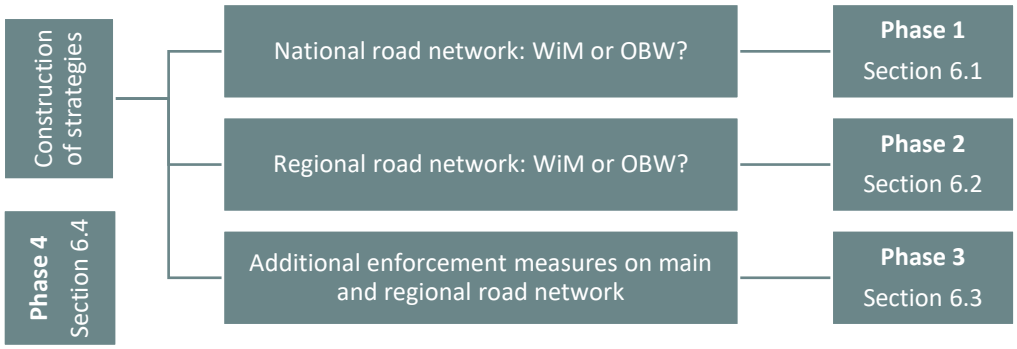

Figure 10 – Overview of design phases in design process

In the first phase, possible main enforcement alternatives on the national road network are discussed. The choice between WiM and OBW as main enforcement measure on the national road network (constraint II for future weight enforcement in the previous chapter), is used as a starting point in the design of the strategies. The impact of WiM on the regional and local road network and the design of a coherent strategy differs significantly from the impact of OBW and is dependent of the way in which the techniques are applied. The deployment options for WiM and OBW on the national road network are discussed in Section 6.1. Subsequently, in the second phase, the possibilities for deploying WiM or OBW as main enforcement strategy on the regional road network will be discussed in Section 6.2. Therefore, a case study is performed for the road asset of the province of Zuid-Holland. The full case study can be found in Appendix V.

In the third phase, covered in Section 6.3, additional enforcement measures on both national and regional level are discussed, which could complement the main enforcement strategy. Both WiM and OBW tend to be more sanction-based bureaucratic enforcement measures, which should be complemented with other measures, following requirement VI in the previous chapter. Finally, in Section 6.4, all of the four elements discussed in the previous four sections are combined into a set of coherent weight enforcement strategies.

6.1. NATIONAL ROAD NETWORK: WEIGH-IN-MOTION OR ON-BOARD WEIGHING

Both WiM and OBW can be implemented in multiple ways, varying from more compliance stimulating to more violation deterring deployment applications. Possible WiM applications will be discussed in Section 6.1.1. and subsequently OBW applications will be elaborated upon in Section 6.1.2. Finally, in Section 6.1.3, a conclusion on the choice for WiM or OBW on the national road network will be given.

6.1.1. WEIGH-IN-MOTION-BASED ENFORCEMENT MEASURES

WiM is used to estimate the axle loads and GVW of vehicles, by measuring the force of tires on the measuring system, which is built in the pavement. The maximum speed while measuring is dependent on the technique used and the required accuracy. The process of measuring the tire force, in combination with data on speed and longitudinal position allows to estimate the GVW, wheel load, axle load and axle group load of the static vehicle. WiM can be used in five different ways. Figure 11 shows these possible WiM applications and the subsystems needed for each application.

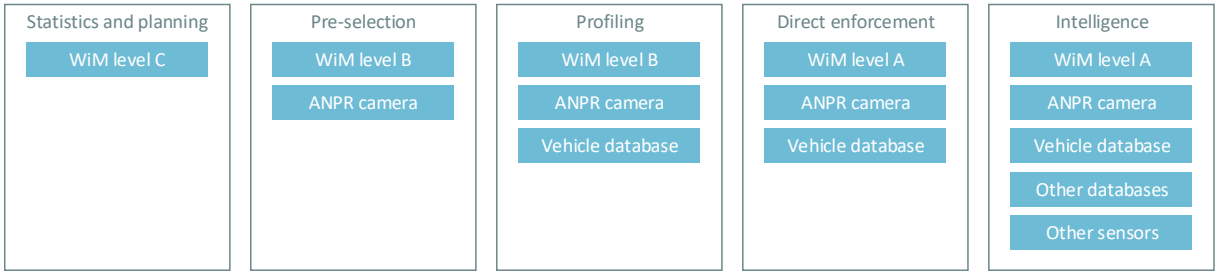

Figure 11 – Possible WiM applications and required subsystems

As can be seen in Figure 11, for different applications of WiM, different accuracy levels are needed, in which accuracy level A is the highest. In the Netherlands, for the deployment of WiM for direct enforcement or intelligence, no legislation is in force at this moment. The required accuracy classes in new legislation are expected to be similar to existing European standards. The accuracy class needed will be elaborated upon for each application in the next Sections.

When used for **statistics and planning**, WiM data provides road owners insight in the loading situation on their road asset. Since this does not contribute to enforcement, this application is not further considered.

When used for **pre-selection**, targeted vehicles are guided to areas where static weighing is performed. ANPR cameras are needed to be able to select the correct vehicle. Combined with vehicle databases, WiM can be used for **profiling**. Within the top-100 approach of the Inspectorate, HS-WiM systems were used for profiling and pre-selection.

When used for **direct enforcement**, the information retrieved from the WiM system serves as direct evidence for overloading. No static weighing is needed. The possibility of deployment of WiM for direct enforcement depends strongly on the accuracy of the used WiM system and relevant legislation. Combined with other data sources, WiM can be used for **intelligence**, data could enlarge the efficiency of enforcement activities

The use of WiM for pre-selection and profiling are merged into one enforcement measure, based on the current weight enforcement practice in the Netherlands and the required accuracy class of the used system. For this reason, WiM for direct enforcement is merged with intelligence into one enforcement measure as well. In the following Sections, these two applications of WiM on the national road network are further discussed and analysed, to be able to define which complementing measures are needed in forming enforcement strategies.

WEIGH-IN-MOTION APPLICATION – PRE-SELECTION AND PROFILING

For the application of *WiM for pre-selection and profiling*, each WiM site should be accompanied by an ANPR camera for each lane, to be able to identify the HGV corresponding with the identified weights. Based on the profile made with this data, suspicious vehicles can be guided to static weighing locations or imposed cease and desist orders. The Dutch 'Top 100' enforcement system, as deployed by the Inspectorate between 2014 and 2015, is an example of pre-selection and profiling based on WiM measurements.

Within the European Standard for Weigh-in-Motion, as prepared by the FEHRL institutes WiM initiative, it is defined that WiM accuracy class B(10) is needed for pre-selection and profiling. With a probability of 95 percent, the tolerance interval width of the GVW measurement should be 10 percent. These figures are based on the international COST 323 standard (COST, 2002).

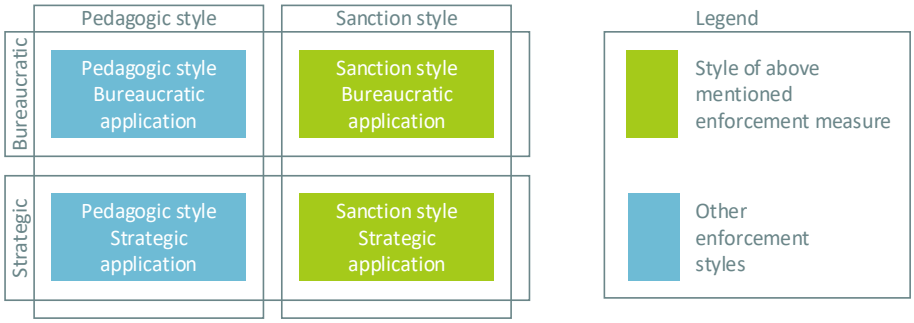

Figure 12 – Classification of Weigh-in-Motion for pre-selection and profiling according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, the system of pre-selection can be described best as a bureaucratic and strategic sanctioning style. In Figure 12, this is indicated by the green colour of the right two boxes. The application of WiM is highly standardized and inflexible. Since the weighing system is built in the road, and 24 hours a day operational, a large number of vehicles can be digitally checked fully automatically. However, company profiling allows for strategic enforcement activities, like cease and desist orders and targeted manual selection (Figure 12).

The benefit of the efficiency of the system, achieved by the standardized systems, is at the same time one of the major downsides. The phenomenon of WiM avoidance is recognized in a large number of researches (Richardson, Jones, Brown, O'Brien, & Hajializadeh, 2014; Taylor et al., 2000; Wermeskerken, 2005).

Accuracy class B(10) does not allow for direct enforcement. Therefore, suspicious HGVs should be reweighed once again on certified static scales at appointed locations, to impose fines. This process is labour intensive; during the focus group, the Inspectorate estimates the static weighing of one HGV to take up to two manhours, for selecting the vehicle, the weighing itself and filling in paperwork. The location at which selected vehicles are weighed, has to be in the proximity of the WiM site. Furthermore, a long and wide flat piece of road is needed for calibrated weighing and vehicle movements.

Finally, depending on the amount of manual weight checks performed, another deficiency of WiM for pre-selection is the low chance to be actually fined and the long time between the first notification of overloading and first fine.

The technological developments in the WiM industry and especially the improved accuracy of the available WiM systems make their deployment for direct enforcement possible. The use of ANPR cameras at WiM sites allows authorities to fine non-complying HGVs directly, without static weighing. The working of the direct enforcement system is then comparable to speed cameras, in which no manual re-check is needed to fine offenders.

Compared to WiM for pre-selection, a higher accuracy is needed since the WiM system is used as a direct way to fine non-complying transporters. According to the European Standard for Weigh-in-Motion, it is defined that WiM accuracy class A(5) is needed for direct enforcement. With a probability of 95 percent, the tolerance interval width of the GVW measurement should be 5 percent. These figures are based on the international COST 323 standard (COST, 2002). At this moment, legislation on the use of WiM for direct enforcement and the needed accuracy is not yet developed in the Netherlands. However, a number of international standards are available, which new legislation could be based on.

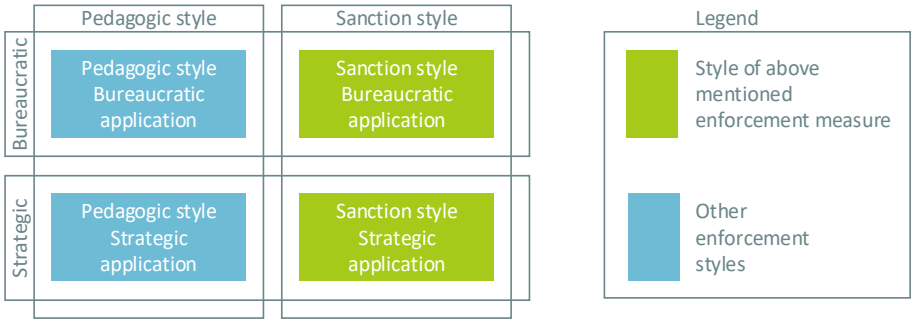

Figure 13 – Classification of Weigh-in-Motion for direct enforcement and intelligence according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, the system of pre-selection can be described best as a bureaucratic and strategic sanctioning style. In Figure 13, this is indicated by the green colour of the right two boxes. The application of WiM is highly standardized and inflexible. Since the weighing system is built in the road, and 24 hours a day operational, a large number of vehicles can be digitally checked fully automatically. However, the combined information retrieved via intelligence allows for strategic enforcement activities, like targeted manual selection (Figure 12).

The benefit of the efficiency of the system, achieved by the standardized systems, is at the same time one of the major downsides. WiM location avoidance could be expected, as indicated in the previous section. Since no research is available on this topic, the exact effect of the deployment of WiM for direct enforcement on the number of overloaded HGVs on avoidance routes is unknown. It is however clear that the need for strategically located manual enforcement activities is larger.

The WiM technology needed to achieve accuracy class A(5) is more expensive than the technology needed for class B(10). The higher purchase costs are on the other hand compensated by a reduction in costs for labour-intensive re-weighing, which is not needed anymore in direct enforcement conditions. However, the increased chance on being fined by the WiM system will likely result in more strategic WiM avoidance behaviour by deliberate non-complying companies and transporters.

6.1.2. ON-BOARD WEIGHING-BASED ENFORCEMENT MEASURES

On-Board Weighing comprises the determination of the GVW of a moving HGV, by measuring the gross vehicle weight (GVW) or axle loads, using axle load sensors or similar systems installed on the vehicle. Information from the system can be securely stored in a so-called On-Board Unit (OBU). In this unit, information on the total weight of the vehicle and corresponding weight recording time, axle weight is combined. The information stored in the OBU can be saved for 30 days and retrieved by authorities via static road portals provided with DSRC beacons, portable DSRC units or hand-held DSRC units. Similar to WiM, OBW can be used in different ways. Figure 14 shows these possible WiM applications and the subsystems needed for each application.

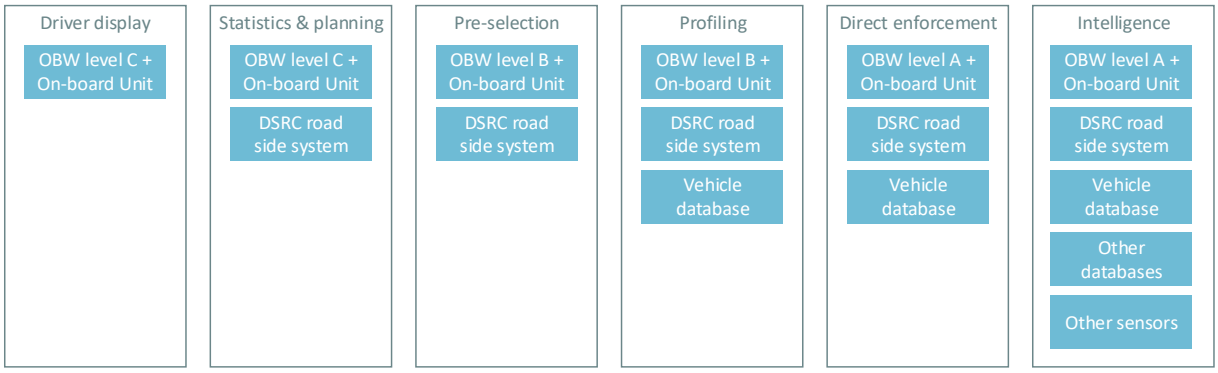

Figure 14 – Possible OBW applications and required subsystems

When used for **driver display**, real-time weight information retrieved from the OBW system could be displayed to the driver of the HGV, in the cabin of the vehicle or on displays located near the axles themselves. This is the most basic way of using OBW data, in which no data transfer to other parties or places is needed. When used for **statistics and planning**, OBW data provides road owners insight in the loading situation on their road asset. The information can also be used to evaluate manual enforcement activities. Since statistics and planning does not contribute to enforcement, this application is not further taken int account in this research.

When used for **pre-selection**, targeted vehicles are guided to areas where static weighing is performed. DSRC communication systems are needed to be able to select the correct vehicle. When DSRC units are combined with vehicle databases, OBW can be used for **profiling**.

When used for **direct enforcement**, the information retrieved from the WiM system serves as direct evidence for overloading. No static weighing is needed. The possibility of deployment of WiM for direct enforcement depends strongly on the accuracy of the used WiM system and relevant legislation. Combined with other data sources, WiM can be used for **intelligence**, data could enlarge the efficiency of enforcement activities

The use of WiM for pre-selection and profiling are merged into one enforcement measure, based on the current weight enforcement practice in the Netherlands and the required accuracy class of the used system. For this reason, WiM for direct enforcement is merged with intelligence into one enforcement measure as well. In the following Sections, these two applications of WiM on the national road network are further discussed and analysed, to be able to define which complementing measures are needed in forming enforcement strategies.

Given the significant investment and operational costs of the OBW system and the large share of foreign HGVs on the Dutch road network, the system is only considered successful in achieving a level playing field when implemented in surrounding Member States or the entire European Union as well. In the revision of Directive 96/53/EC, it is stated that Member States shall encourage the installation of OBW devices on new and existing HGVs. Furthermore, the European Parliament recommends the European Commission to consider the obligation to equip new HGVs with weight sensors (Oehry, van Driel, Haas, Dell, & Rapp, 2013).

ON-BOARD WEIGHING APPLICATION – DRIVER DISPLAY

Real-time weight information retrieved from the OBW system could be displayed to the driver of the HGV, in the cabin of the vehicle or on displays located near the axles themselves. This is the most basic way of using OBW data, in which no data transfer to other parties or places is needed.

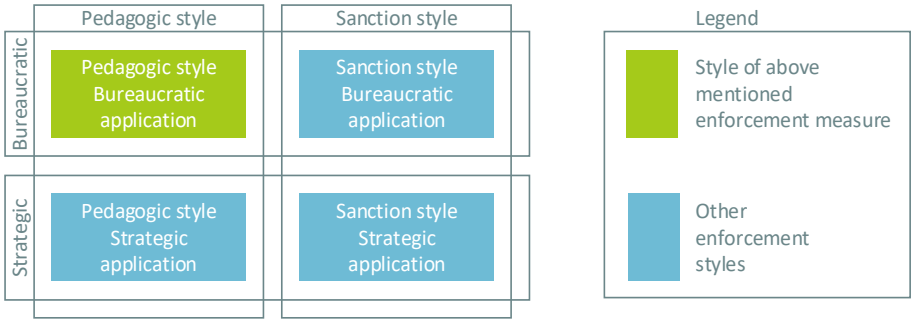

Figure 15 – Classification of OBW for driver display according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, the system of OBW for driver display can be described best as a bureaucratic pedagogic style. In Figure 15, this is indicated by the green colour of the top left box. The method is aimed at stimulating compliance via increased awareness in a standardized way. However, since the largest part of overloading is caused by deliberate non-compliance, the effectivity of this strategy is expected to be very low. Additionally, the chance exists that unconsciously complying inspectees become deliberately non-compliers by the introduction of OBW for driver display. Finally, given the large investments needed in axle load sensors, this application is not expected to be cost-effective. For these reasons, the use of On-Board Weighing solely for driver display will not be considered in this research.

ON-BOARD WEIGHING APPLICATION – VOLUNTARY ACTIVE DEMONSTRATION OF COMPLIANCE

Within this application, in return for actively sharing real-time weight information and compliance with weight regulations, drivers/companies receive certain benefits. These benefits could include access to special corridors or lanes or faster processing of weight exemptions for exceptional transports. Voluntary active demonstration of compliance is based on mutual benefits for both regulator and regulate and is already deployed in Australia (Intelligent Access Program) and the USA (PrePass). The Intelligent Access Program includes intelligent access to designated routes, when real-time data on the vehicle weight is shared with authorities (Žnidarič, 2015). In the PrePass system as deployed in the USA, vehicles communicating real-time weight information and compliance to authorities may pass manual inspection points without being stopped. In the USA, manual inspections are frequently set-up, by which the benefit of participation in the USA is relatively high.

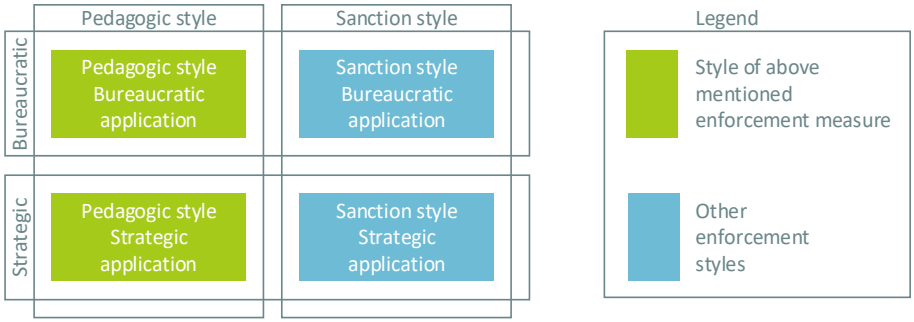

Figure 16 – Classification of OBW for voluntary active demonstration of compliance according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, the system of OBW for driver display can be described best as a bureaucratic and strategic pedagogic style. In Figure 16, this is indicated by the green colour of the two left boxes. The method is aimed at stimulating compliance via increased awareness in a standardized way.

Within a situation where manual inspection points are set-up less frequently, the incentive to participate in a voluntary compliance system might not be large enough. It is estimated that manual inspection points should be arranged every 100 kilometres, to put enough pressure on transporters to participate in a voluntary compliance scheme (Oehry, Haas, & Driel, 2013). Furthermore, "…requirements on setting up a harmonised incentive scheme across Europe, in introducing a calibration and certification regime, crating interoperable specifications for the DSRC interface and for the On-Board Weighing system security measures are quite high and challenging to implement." (Oehry, Haas, et al., 2013, p. 41)The lack of support for the system in Europe and the expected socio-organisational challenges in setting up such a system of Intelligent Access make it not feasible yet. Therefore, this method will not be considered in this research.

Enforcement authorities could be enabled to retrieve real-time weight information of HGVs, via static road portals provided with DSRC beacons, portable DSRC tripods or hand-held DSRC units. In this way, non-complying trucks could be selected for weighing on certified static scales or mats. Within the European Standard for Weigh-in-Motion, it is defined that WiM accuracy class B(10) is needed for pre-selection and profiling. With a probability of 95 percent, the tolerance interval width of the measurement should be 10 percent (COST, 2002).

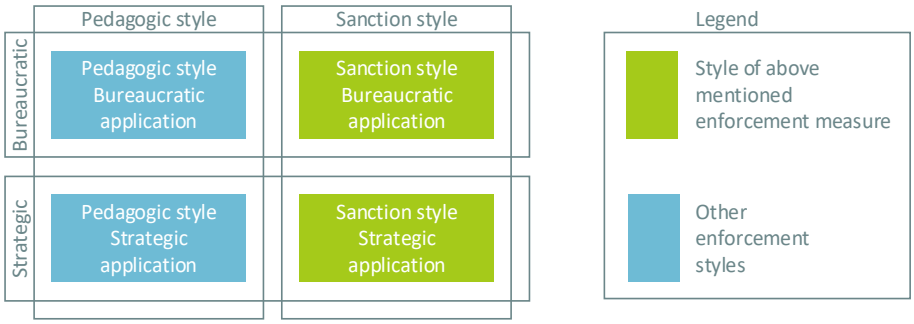

Figure 17 – Classification of OBW for pre-selection and profiling according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in 3.2, the system of pre-selection can be described best as a bureaucratic and strategic sanctioning style. Compared to WiM, the deployment of portable DSRC tripods and hand-held units allows for more strategic enforcement activities, since their deployment is not easily anticipated upon. Additionally, company profiling can be used to impose cease and desist orders and perform targeted manual selection (Figure 17). The application of the OBW portals and supporting systems will on the other hand be highly standardized. Since the weighing system is built on the side of the road, and 24 hours a day operational, a large number of vehicles can be digitally checked fully automatically.

The investments associated with OBW are large, compared to WiM, as will be elaborated upon in Chapter 7. Not only roadside systems are needed, but in-car systems as well. The installation of axle load sensors and OBU's on all trucks is expected to be a considerable investment.

The benefit of the efficiency of the system, achieved by the standardized systems, is at the same time one of the major downsides. Just like at WiM locations, it can be expected that deliberately non-complying inspectees will avoid OBW portal locations. The strategic deployment portable DSRC tripods overcomes this problem in a relatively easy and cheap way.

Accuracy class B(10) does not allow for direct enforcement. Therefore, suspicious HGVs should be reweighed once again on certified static scales at appointed locations, to impose fines. This process is labour intensive; during the focus group, the Inspectorate estimates the static weighing of one HGV to take up to two manhours, for selecting the vehicle, the weighing itself and filling in paperwork. The location at which selected vehicles are weighed, has to be in the proximity of the WiM site. Furthermore, a long and wide flat piece of road is needed for calibrated weighing and vehicle movements.

Finally, depending on the amount of manual weight checks performed, another deficiency of OBW for pre-selection is the low chance to be actually fined and the long time between the first notification of overloading and first fine.

ON-BOARD WEIGHING APPLICATION – DIRECT ENFORCEMENT

In On-Board Weighing for direct enforcement, various options could be considered. The system could have a preventive function, ex ante enforcement, or a corrective function, ex post enforcement.

The preventive direct enforcement function of On-Board Weighing could for example be realized by locking the vehicle in case of overloading. The system would in that case be comparable to the already known alcohol lock, used to avoid drunk people driving. This preventive application would rely heavily on the accuracy of the technique used and could be perceived as not proportionate. This application is however not expected to be politically feasible and will not be further considered in this research. In the past years, the application of an alcohol lock on all vehicles appeared not to be politically feasible either. Additionally, the implementation of a weight lock would cost far more due to expensive axle load sensors. Finally, the social costs of overloading are relatively low, compared to those of alcohol abuse.

For the corrective direct enforcement function of On-Board Weighing, within the European Standard for Weigh-in-Motion, it is defined that accuracy class A(5) is needed. With a probability of 95 percent, the tolerance interval width of the GVW measurement should be 5 percent (COST, 2002).

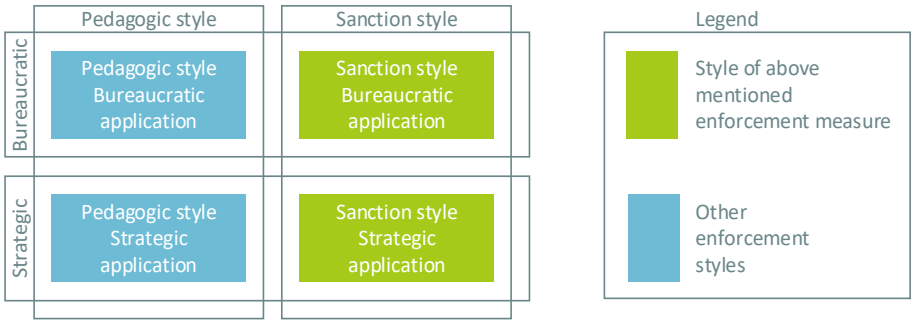

Figure 18 – Classification of OBW for direct enforcement and intelligence according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in 3.2, the system of direct, automatic enforcement can be described best as a bureaucratic and strategic sanction-based style. In Figure 18, this is indicated by the green colour of the right two boxes. The application of OBW is highly standardized and the location of OBW portals is inflexible. However, DSRC tripods and hand-held units could be deployed strategically. Additionally, the combined information retrieved via intelligence allows for strategic enforcement activities, like targeted manual selection.

The investments associated with OBW are large, compared to WiM. Not only roadside systems are needed, but in-car systems as well. The installation of axle load sensors and OBU's on all trucks is expected to be a considerable investment.

Accuracy class A(5) allows for direct enforcement. This allows the enforcement authority to fine inspectees solely based on the information retrieved from the axle load sensors, communicated via the OBU and DSRC communication system. Additional weight restrictions on e.g. bridges or dike roads could be enforced easily as well in this strategy.

6.1.3. CONCLUSION ON THE CHOICE BETWEEN WEIGH-IN-MOTION AND ON-BOARD WEIGHING

In the previous two Sections, various applications of OBW and WiM have been discussed. Although the main disadvantage of WiM, the ease in which the measurement locations can be avoided, is large, the effectivity of the method on longer corridors has been proved in multiple studies. However, the risk on avoidance becomes larger when more avoidance routes are available, which is the case in complex multi-layered road networks like the Dutch one. Also, when deployed for direct enforcement, the risk on strategic avoidance behaviour will be larger, requiring additional manual enforcement.

OBW overcomes the problem of avoidance partially, since the measurement is performed in the vehicle and portable and portable DSRC tripods and hand-held DSRC units can be deployed strategically. However, the investment costs of OBW are considerably larger than WiM, since axle load sensors and OBUs have to be installed at all HGVs.

Given the high implementation and operational costs of both systems and the considerable group of deliberately non-complying transporters, using one of the technologies for driver display or voluntary active demonstration only would not be effective nor efficient. The deployment of one of the technologies for pre-selection and profiling or direct enforcement and intelligence are perceived to be promising and effective in reducing the number of overloaded HGVs.

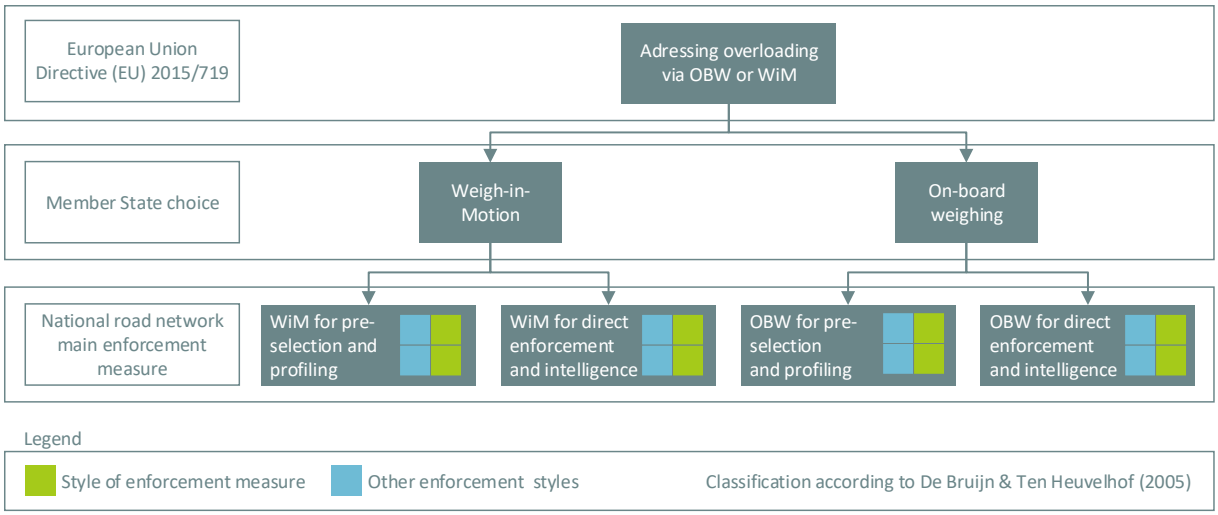

Figure 19 – Feasible main enforcement measures on the national road network

In Figure 19, the first level indicates the European Union taking the lead in countering overloading. The requirement for Member States to choose between WiM and OBW is visualised in the second layer. The four remaining main enforcement measures on the national road network are visualised in Figure 19. The classification of the measures according to the framework of de Bruijn and ten Heuvelhof (2005) is simplified displayed by four small square boxes, corresponding with Figure 6.

6.2. REGIONAL ROAD NETWORK: WEIGH-IN-MOTION OR ON-BOARD WEIGHING

In this section, the deployment of the four possible main enforcement measures (Figure 19) on the regional road network is assessed, based on a small case study for the road network of the province of Zuid-Holland (Appendix IV).

The province of Zuid-Holland is one of the largest regional road owners in the Netherlands. The administration of the provincial asset, among others consisting of 520 kilometres of main roads and 132 kilometres of side roads, is executed by the Infrastructure Management Office (DBI) (Blommers, Carton, & Provincie Zuid-Holland, 2017). Zuid-Holland has the most permits for professional transport and the total loaded and unloaded weight (domestic and bilateral) in Dutch freight transport is the largest in Zuid-Holland (Transport en Logistiek Nederland, 2017). The presence of some of the biggest Dutch cities, green ports Oost- en Westland, the Bollen-area and Boskoop, main port Rotterdam and a number of large business parks form the basis for the large number of freight transport movements in the province of Zuid-Holland.

In the case study, fourteen corridors at which the risk on a high absolute number of overloaded HGVs is large are identified. The corridors are selected based on information retrieved from counting loops. Based on the conducted case study, it is concluded that the deployment of WiM is not expected to be feasible on the regional road network. Due to the significantly lower HGV intensities on the regional road network and the high density and availability of avoidance routes, the application of WiM on the national road network will likely not result in a cost-effective decrease of the number of overloaded HGVs. For the same reason, the deployment of fixed DSRC portals is not expected to be cost-effective either. However, the deployment of portable OBW DSRC tripods is expected to overcome the problem of measurement location avoidance. The costs of one DSRC unit, which can be replaced every 2 months over a number of tripods, are considerably lower than WiM systems or DSRC portals. For drivers, it is not visible whether an OBW DSRC tripod is actively in use or not, by which one portable DSRC unit and a number of tripods have a more deterring effect.

Both for the application of WiM and OBW for pre-selection and profiling, the scarce availability of locations suitable for static calibrated reweighing proves to be problematic. The amount of locations at which WiM or OBW for pre-selection could be deployed for this reason, make the creation of a geographically well spread network difficult. The storage of data in the OBW On Board Unit overcomes the problem of static weighing location availability. Since the data could be stored for up to 30 days, the vehicle could be statically reweighed at another DSRC location on the national or regional road network.

The full case study can be found in Appendix V. Figure 19 is in Figure 20 extended with a fourth layer, in which the feasible main enforcement measures on the regional road network are visualised. Again, these are categorized according to the framework of de Bruijn and ten Heuvelhof (2005), which can be found in Figure 6.

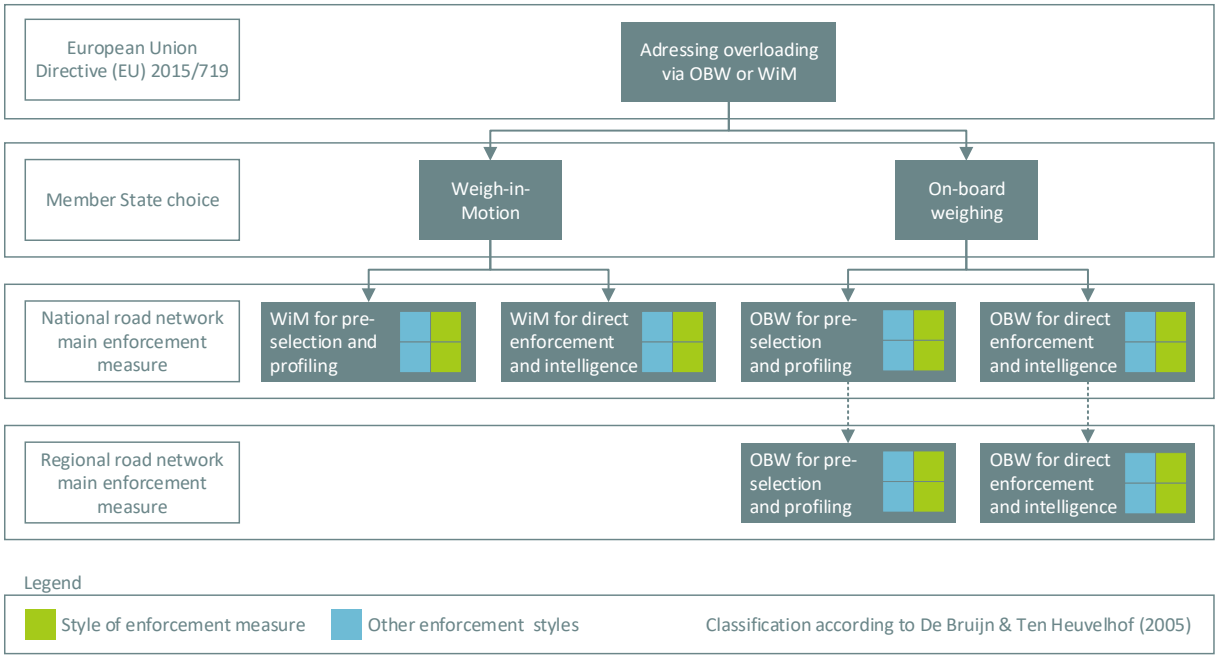

Figure 20 – Feasible main enforcement measures on the regional road network

6.3. MAIN AND REGIONAL ROAD NETWORK: ADDITIONAL ENFORCEMENT MEASURES

Although both WiM and OBW are feasible main enforcement measures, both of them are strongly focussed on sanctioning, in a more bureaucratic as strategic way. Following from requirement VI in Section 5.2, strategies should consist of both violation deterring and compliance stimulating measures, implemented both bureaucratic as well as strategic. This allows the government to vary in enforcement style (de Bruijn & ten Heuvelhof, 2005). Based on a number of governmental reports in and outside the Netherlands, the literature study conducted in the problem exploration and the focus group session, a number of additional enforcement measure are distinguished.

In Section 6.3.1, the deployment of strategic manual selection teams is discussed. In Section 6.3.2, methods based on information and persuasion are elaborated upon. A special form of information and persuasion, the covenant, is discussed in Section 6.3.3. Subsequently, the inclusion of the prohibition on overloading in contracts by governmental clients is elaborated upon in Section 6.3.4, after which conclusions are drawn in Section 6.3.5

6.3.1. STRATEGIC MANUAL SELECTION

A basic form of enforcement is selection and static weighing by enforcement officers, in which the selection of vehicles is based on visible characteristics of the vehicle. The officers' own judgement is based on field expertise, in which no technological tools are used. If available, the officer can use the profiling by the main enforcement method. Although no exact figures are available, it is expected that the hit rate of the officer increases drastically as the availability and quality of the profiling increases. Manually selected vehicles are escorted to areas equipped for static weighing, using axle weighers or wheel weighers. To obtain the required accuracy, those areas should consist of a large, flat piece of pavement.

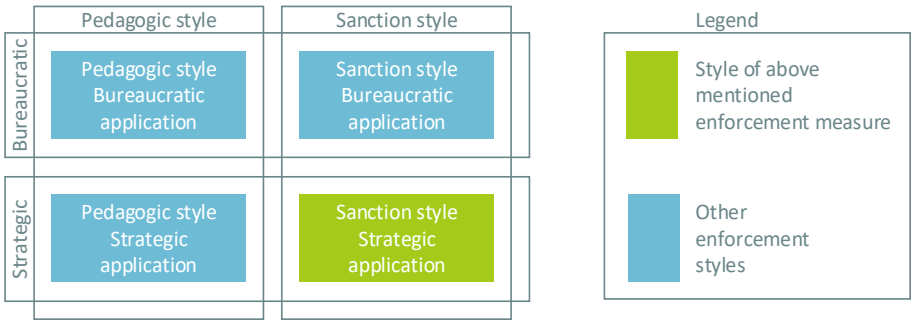

Figure 21 – Classification of manual enforcement according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, this measure can be classified as a strategic sanction-based style (Figure 21). Since the measuring can take place at a large number of locations, the measure allows for strategic enforcement, for example based on profiling by the main enforcement measure. Consequently, the avoidability of manual enforcement is low.

The hit rate of manual selection based on visual identification is expected to be 50 percent, which is relatively low compared to selection using WiM or OBW. Since the process of weighing one vehicle takes up to one hour, the impact of manual enforcement on the transporters schedule is considered large.

6.3.2. INFORMATION AND PERSUASION

This measure consists of a small spectrum of compliance stimulating enforcement measures, which are aimed at increasing awareness and persuading, supporting and informing the sector. Within the framework of de Bruijn and ten Heuvelhof (2005), these are typically characterized as pedagogic styles.

Although informing the sector is not considered very useful by a number of actors during the focus group session, the knowledge of maximum weight regulations is not present at the entire sector. Secondly, the mutual dependency between the Inspectorate and sector requires an enforcement style that is at least partially pedagogic and compliance stimulating. In case of (technical) failure of more sanction-based enforcement measures, the regulator can revert to the relationship built-up via more pedagogic-based enforcement. In this way, the regulator can vary between enforcement styles. Additionally, as can be seen in Figure 5, information could reduce the risk of unconscious compliers to become unconscious offenders.

More bureaucratic information-based measures include providing information on weight regulations via branch organisations, governmental websites and other governmental communication channels. More strategic information-based measures include the extensive communication of enforcement activities to the transport sector as a whole or subsectors in specific. According to the Dutch Institute for Road Safety Research, publicity increases the subjective chance to be checked (Goldenbeld & Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, 2005).

In publicity, a way of persuading companies to comply can be found. For example, whitelisting of complying companies, perhaps in combination with other enforcement authorities, could for a stimulation for companies to comply. Blacklisting could form this stimulation as well but is more based on the sanction style. By extensive communication of future enforcement and threatening to scale up enforcement activities, companies can be persuaded to comply as well.

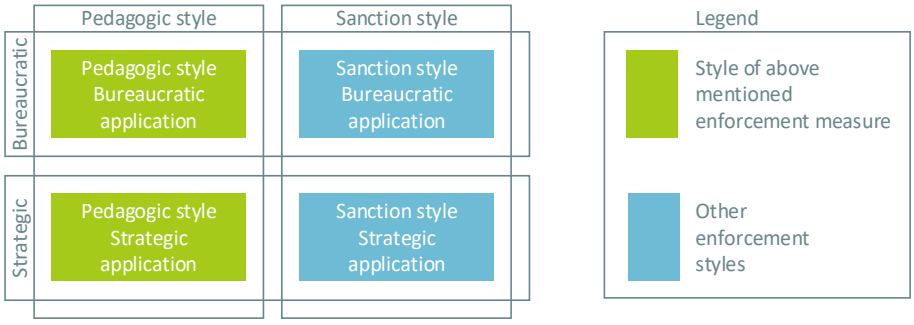

Figure 22 – Classification of information and persuasion according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, this measure can be classified as a both bureaucratic as well as strategic pedagogic style (Figure 22), dependent on the exact composition. The measure allows for variation between bureaucratic, standardized communication towards the entire sector, as well as strategically placed persuasive measures.

Since the effects of information and persuasion are dependent on different factors, such as the extent and way in which communication is applied and the sensitivity of the target group for persuading techniques, it is difficult to estimate the exact effect of the measures. The implementation of the measures could however be relatively simple and low-cost and is therefore considered to be well worth the effort.

6.3.3. COVENANTS

According to the Dutch Knowledge Center for Legislation and Legal Affairs, “A covenant is an agreement between the government and one or more parties aimed at realizing certain (policy) objectives. In a covenant, written agreements about the delivery of performances are recorded.” (Kenniscentrum Wetgeving en Juridische zaken, 2017, p. 1). The way in which the agreements in the contract are supervised is included in the covenant itself, as well as possible enforcement activities.

In recent years a small number of covenants was closed on the subject of overloading. Based on the experiences in these covenants, it is concluded that for each subsector a different approach is needed, including different incentives to join the covenant. Concluding covenants with monopolists or semi-monopolists, like in the case of the Dutch Suiker Unie covenant, is expected to be successful. In this specific covenant, the dependency of sugar beet transporters on the monopolist formed an entrance for the ILT to conclude a successful covenant. However, in more competitive markets, closing covenants could be though. In these cases, sanction-based enforcement is expected to be needed to persuade key players to join the covenant. In general, making overloading a shared problem is expected to help in concluding covenants. In the end, both for road owners and complying companies, overloading generates disadvantages.

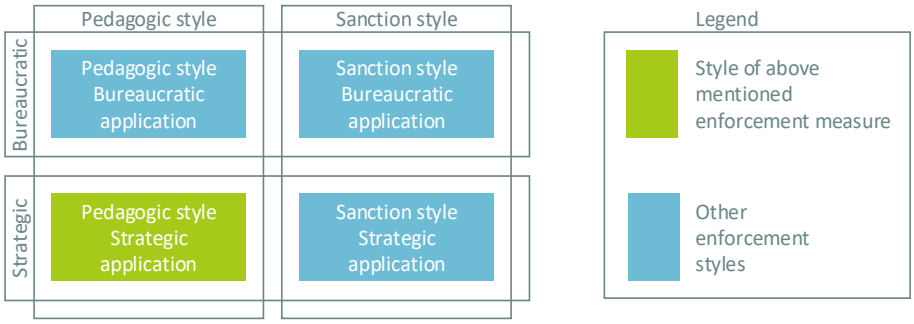

Figure 23 – Classification of covenants according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, this measure can be classified as strategic pedagogic style (Figure 23). The measure can be strategically applied on suitable subsectors, in which it is expected that closing covenants contributes to solving the problem of overloaded HGVs.

According to the ILT during the focus group session, the deployment of new covenants proved to be difficult. ILT has pointed on the possibilities of concluding covenants in various sub sectors, including the asphalt transport, but the rollout turned out not to be supported for competitive reasons. It can be expected that the willingness of transporters to conclude covenants gets larger, as the pressure following from enforcement activities increases.

6.3.4. PROHIBITION OF OVERLOADING IN GOVERNMENTAL CONTRACTS

Analysis of tipper transports, used in earthmoving showed that 40 percent of the examined HGVs were overloaded on GVW (Hordijk, 2013). Different governmental bodies together form the largest client for civil engineering transports in the Netherlands. Governmental clients, like RWS and other road administrators, could include special agreements on overloading in contracts.

Contract managers and jurists at various governmental clients question the profit of including agreements on overloading in contracts, since the prohibition on overloading is already included in contracts. Proponents argue that overloading is still a widespread phenomenon within the ground-, road- and water engineering sector, for which an extraordinary approach is needed. Including a prohibition in contacts allows the client to apply contract management, including administrative and physical enforcement. In public tenders, contractors would have to explain how to minimize the risk of overloading. The effectivity of the instrument is dependent on the way in which the supervision on compliance with the contract Section on overloading is arranged. Weighing letters, combined with RDW info on maximum vehicle weights, could be used to perform checks.

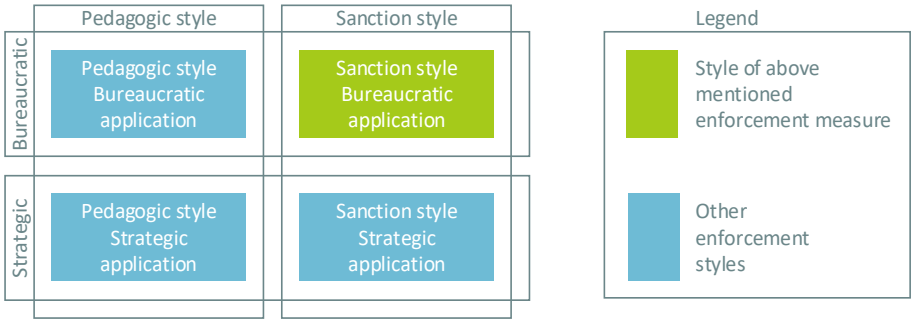

Figure 24 – Classification of prohibition on overloading in governmental contracts according to de Bruijn and ten Heuvelhof (2005)

Within the enforcement framework in de Bruijn and ten Heuvelhof (2005) as described in Section 3.2, this measure can be classified as bureaucratic sanction-based style (Figure 24). The measure can be strategically applied on suitable subsectors, in which it is expected that closing covenants contributes to solving the problem of overloaded HGVs.

Given the relatively low costs for the government as client to include a prohibition on overloading in contracts, at first sight the instrument seems very interesting in reducing the number of overloaded transports in governmental engineering projects. However, the reaction of the market could include an increase in the offered prizes in tenders, since extra costs for transport and administration have to be made to comply with the contract. A great part of the benefits, which include less pavement damage by overloading, could be coming out of the government's own pocket.

Since the average distance per loaded domestic trip in professional goods transport is the lowest for the transport of minerals and building materials, the chance of those transports using the national road network is low for this type of transport (Transport en Logistiek Nederland, 2017). This results in a lower chance of being checked on the national road network, by WiM of OBW. The inclusion of an explicit prohibition in contracts, together with an appropriate level of physical and administrative checks, could therefore be extra useful.

6.3.5. CONCLUSION ON THE DEPLOYMENT OF ADDITIONAL ENFORCEMENT MEASURES

In the previous four Sections, a number of additional enforcement measures is presented, analysed and categorised according to the framework in de Bruijn and ten Heuvelhof (2005). It is concluded that all four analysed measures could contribute to solving the problem of overloaded HGVs. Combined with the main enforcement measure, these could be deployed to form coherent strategies.

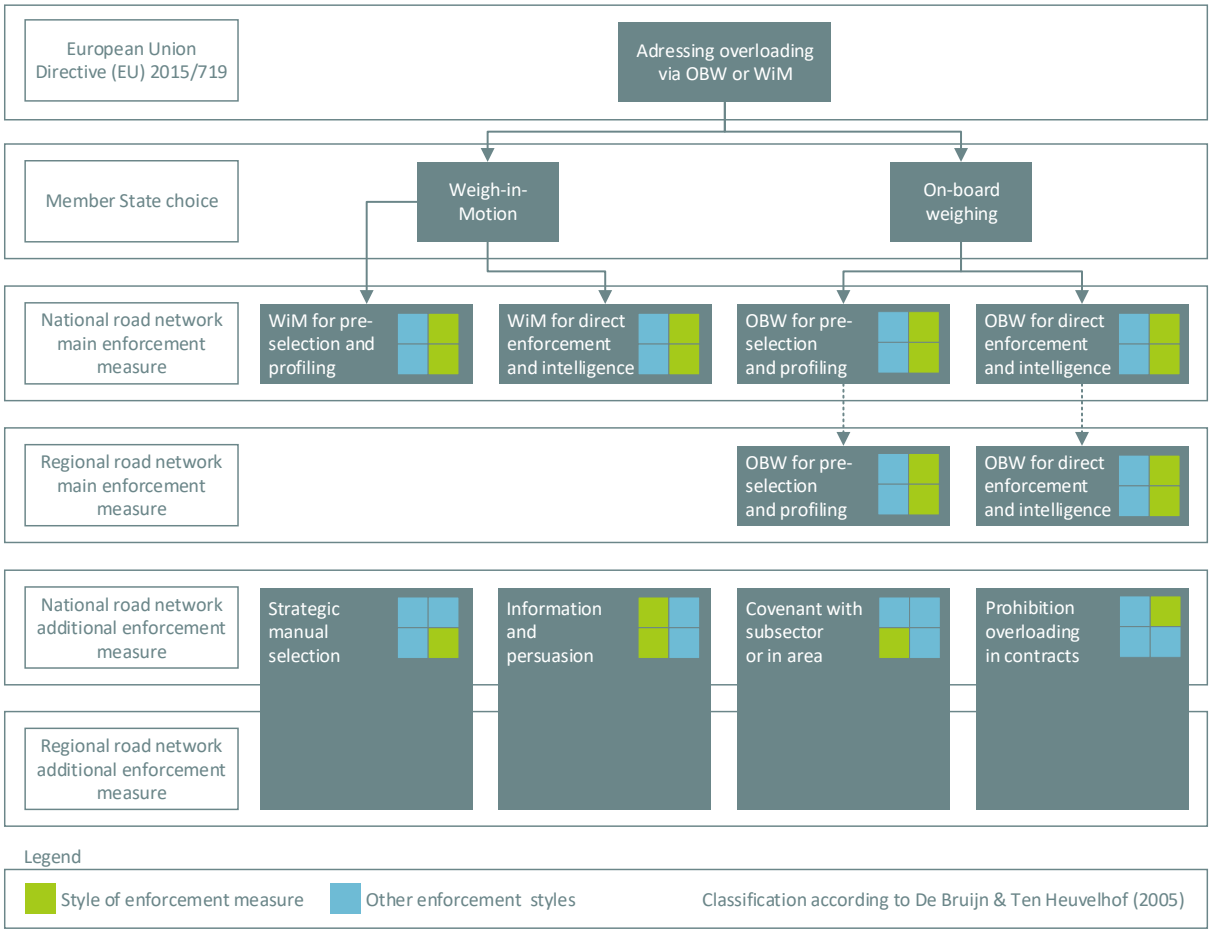

Figure 25 – Overview of feasible additional enforcement measures on the national and regional road network

Figure 20 is in Figure 25 extended with a fifth and sixth layer, in which the feasible complementing enforcement measures on the regional road network are visualised. Again, these are categorized according to the framework of de Bruijn and ten Heuvelhof (2005), which can be found in Figure 6. The figure shows all enforcement measures feasible and available for the government to reduce the number of overloaded HGVs on the Dutch road network. In Section 6.4, using the measures displayed in Figure 25 as building blocks, complete enforcement strategies will be designed.

6.4. INTEGRATION OF ENFORCEMENT MEASURES INTO COHERENT STRATEGIES

Based on the analysis of the main and additional enforcement measures in the previous section, in this section complementing enforcement measures will be integrated into four strategies. In the combination of measures into strategies, requirement VI and VII in Section 5.2 are used as starting points. These include that the enforcement authority:

a) should be able to vary in enforcement style;
b) should retrieve information from multiple sources;
c) should be able to use a portfolio to retrieve more insight in the behaviour of the regulate;
d) should be able to use context to influence the behaviour of the regulate;

In the next four Sections, four enforcement strategies are designed, which are displayed in Table 3. The four strategies consist of a combination of a main enforcement measure (WiM or OBW) and additional enforcement measures. The feasible main enforcement measures presented in Section 6.1.3 form the body of each strategy. Additional enforcement measures complement the strategies, enhancing their expected effectiveness.

Enforcement strategy	Main enforcement measure	Section
Weigh-in-Motion for basic enforcement	WiM for pre-selection and profiling	6.4.1
Weigh-in-Motion for automated enforcement	WiM for direct enforcement and intelligence	6.4.2
On-Board Weighing for basic enforcement	OBW for pre-selection and profiling	6.4.3
On-Board Weighing for automated enforcement	OBW for direct enforcement and intelligence	6.4.4

Table 3 – Main enforcement measures within enforcement strategies

For each strategy, both the design of the individual enforcement measures as well as the technical integration of the measures, systems and processes will be elaborated upon.

In Chapter 7, the strategies will be evaluated on effectiveness and cost-effectiveness.

6.4.1. STRATEGY – WEIGH-IN-MOTION FOR BASIC ENFORCEMENT

The design of the strategy *WiM for basic enforcement* is visualised in Figure 26. The figure shows the five enforcement measures the strategy consists of and the way in which these are deployed. The strategies are simplified illustrated on the right side of the figure.

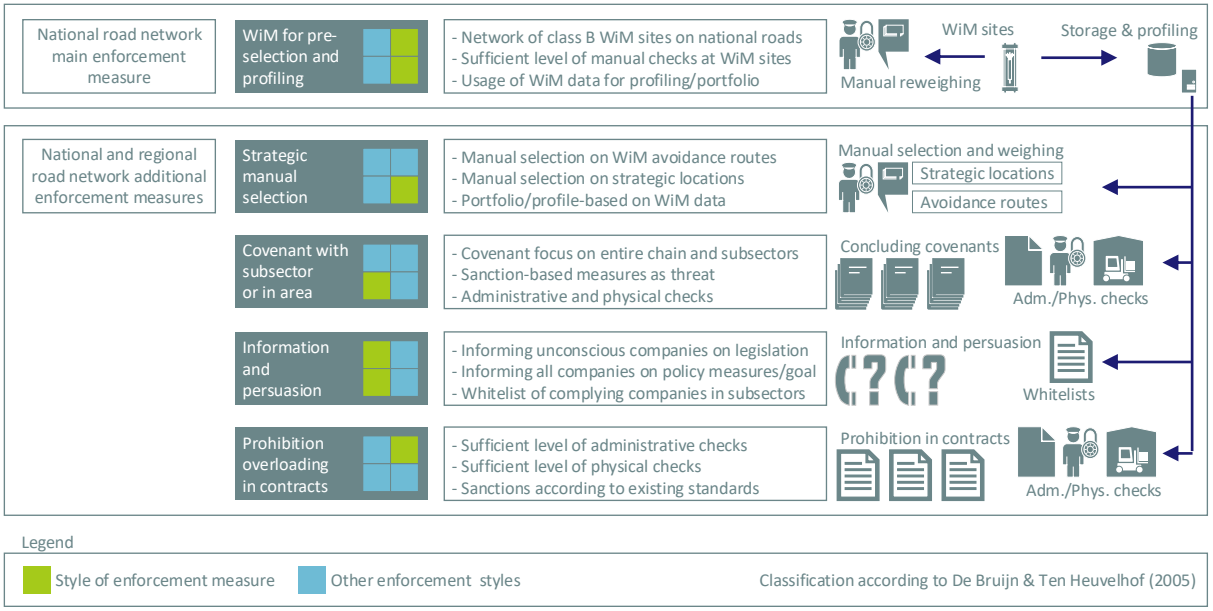

Figure 26 – Overview of strategy Weigh-in-Motion for basic enforcement

NATIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

For the deployment of **WiM for pre-selection and profiling**, the twenty existing WiM sites on the Dutch national road network could be used. The existing locations are already strategically located on the national road network and equipped with electricity, data cables and signing. Dependent on the required objective and subjective level of enforcement, additional locations could be added.

The information retrieved from the measurements at the WiM sites will be used for both pre-selection and profiling, comparable to the 'Top 100' approach as deployed by the ILT in 2014 and 2015. For pre-selection, a number of enforcement teams will be deployed. Using static scales, HGVs selected by the WiM system will be weighed again at designated locations. The data retrieved from the measurements will be used as well for profiling on sector, subsector, area and number plate level. Cease and desist letters will be imposed to noncomplying transporters. As can be seen in Figure 26, the database of WiM measurements forms the input for a number of other enforcement measures in the strategy, by which more synergy and efficiency can be achieved.

The deployment of WiM on the national road network is expected to result in a reduction in the number of overloaded HGV trips on the regional and local road network as well. This reduction is dependent on the number of WiM sites and the exact positioning of these sites in the network. Due to the fact that not all HGV trips use the national road network and not all HGV trips using the national road network will pass WiM measurement sites, the reduction on the regional and local road network is expected to be lower, compared to the national road network. Simultaneously, the deployment of WiM is also expected to result in WiM site avoidance by conscious violators. This form of strategic behaviour affects the number of overloaded HGVs on certain avoidance routes. The amount of WiM avoiders depends on the availability of detour routes, the length of the detour routes and the probability of being checked on the detour route.

REGIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

In the case study (Section 6.2), it was concluded that the deployment of WiM on regional road networks is not expected to be feasible. Therefore, only additional enforcement measures will be deployed on the regional road network.

MAIN AND REGIONAL ROAD NETWORK – ADDITIONAL ENFORCEMENT MEASURES

The deployment of **strategic manual selection** on avoidance routes contributes to the effectiveness of the WiM systems. Furthermore, manual enforcement could be applied in regions or on road sections where a high level of overloaded HGVs is expected, based on subsector, company profiling and road damage. For manual selection, a number of enforcement teams will be deployed. Using static scales, HGVs selected by the officers will be weighed again at appointed locations. Manual enforcement should be based on the insights derived from the WiM systems and corresponding database, to enlarge the hit rate and thus efficiency.

Besides the harsh line of deterring and sanctioning, for which WiM and manual enforcement are deployed, the ILT should operate in a benevolent way as well, to maintain a good relationship with the inspectees. Therefore, contact between the ILT and transporters is needed, according to de Bruijn and ten Heuvelhof (2005). Given the significant group of unconscious compliers and unconscious violators, significant amount of effort should therefore be put in **information and persuasion**. Regulations and compliance advice will be communicated via website, social media, branch organizations and other (digital) communication channels. Furthermore, enforcement results and general info on enforcement activities to be deployed will be extensively communicated via website, social media, newspaper and branch organizations. Additionally, whitelists of complying companies will be published to stimulate compliance.

The deployment of **covenants with subsector or in area**, focussing on the entire transport chain is expected to be effective in less competitive subsectors. In the process of concluding covenants, the inspector could gain more insight in the motivations and interests of the inspectee.

The inclusion of an explicit **prohibition on overloading in contracts** in which a governmental body serves as client, is an important signal to the sector and other clients. The contradiction in behaviour between the government as client on the one hand and the government as inspector on the other hand should be taken away in any enforcement strategy. In their role as a client, governmental bodies should pay attention to social sustainability in general and HGV overloading specifically.

6.4.2. STRATEGY – WEIGH-IN-MOTION FOR AUTOMATED ENFORCEMENT

The design of the strategy *WiM for automated enforcement* is visualised in Figure 27. The figure shows the five enforcement measures the strategy consists of and the way in which these are deployed. The strategies are simplified illustrated on the right side of the figure.

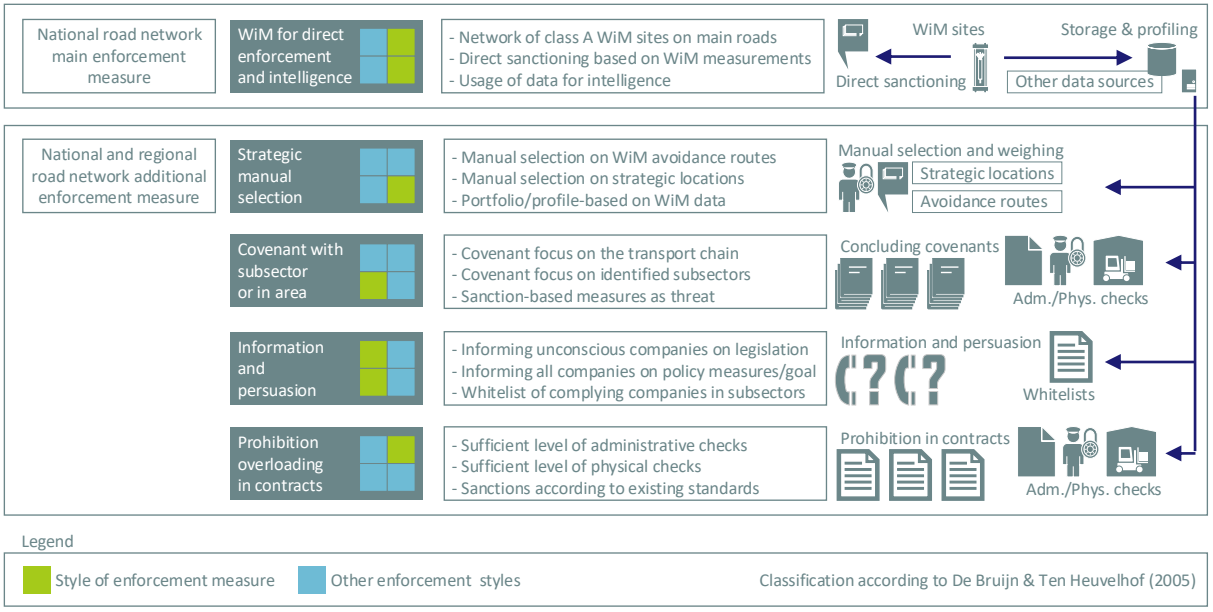

Figure 27 – Overview of strategy Weigh-in-Motion for automated enforcement

NATIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

Similar to the basic enforcement strategy, for the deployment of **WiM for direct enforcement and intelligence**, the twenty existing WiM sites on the Dutch national road network could be used or extended. Transporters will be fined directly based on the WiM measurements.

REGIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

In the case study (Section 6.2), it was concluded that the deployment of WiM on regional road networks is not expected to be feasible. Therefore, only additional enforcement measures will be deployed on the regional road network.

MAIN AND REGIONAL ROAD NETWORK – ADDITIONAL ENFORCEMENT MEASURES

The deployment of **strategic manual selection** on avoidance routes is needed to ensure the effectiveness of the WiM systems. Compared to WiM for pre-selection, the amount of avoidance behaviour by deliberate non-compliers is expected to rise significantly when WiM is used for direct enforcement. Therefore, for manual selection on avoidance routes, more manual enforcement teams will be deployed on avoidance routes. Furthermore, manual enforcement could be applied in regions or on road sections where a high level of overloaded HGVs is expected, based on subsector and company profiling.

Given the expectation of an increased amount of strategic behaviour, significant amount of effort should be put in **information and persuasion**. Compared to the WiM for basic enforcement strategy, a stronger focus on persuasion is expected to be needed since the risk of WiM avoidance is large. Regulations and compliance advice will be communicated via website, social media, branch organizations and other (digital) communication channels. Furthermore, enforcement results and general info on enforcement activities to be deployed will be

extensively communicated via website, social media, newspaper and branch organizations. Additionally, whitelists of complying companies will be published to stimulate compliance.

Since the main enforcement measure only covers a part of the national road network and possibly a small number of regional road sections, the deployment of **covenants in subsector or area** could still be useful. Focussing on the entire transport chain is expected to be effective in less competitive subsectors. In the process of concluding covenants, the inspector could gain more insight in the motivations and interests of the inspectee.

Again, the inclusion of an explicit **prohibition on overloading in contracts** is an important signal to the sector and other clients. The contradiction in behaviour between the government as client on the one hand and the government as inspector on the other hand should be taken away in any enforcement strategy. In their role as a client, governmental bodies should pay attention to social sustainability in general and HGV overloading specifically.

6.4.3. STRATEGY – ON-BOARD WEIGHING FOR BASIC ENFORCEMENT

The design of the strategy *OBW for basic enforcement* is visualised in Figure 28. The figure shows the six enforcement measures the strategy consists of and the way in which these are deployed. The strategies are simplified illustrated on the right side of the figure.

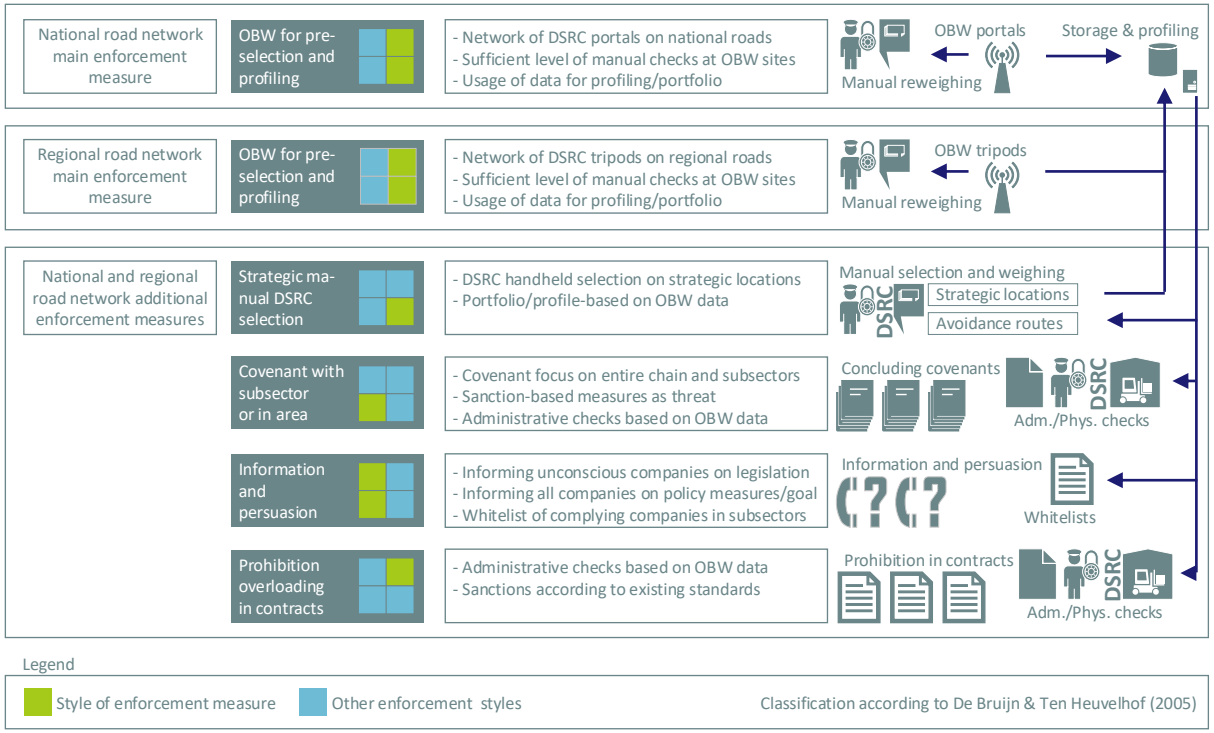

Figure 28 – Overview of strategy On-Board Weighing for basic enforcement

NATIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

As stated in Section 6.1.2, three possible deployments methods for **OBW for pre-selection and profiling** can be distinguished. The use of portable DSRC tripods and hand-held DSRC devices is expected to contribute significantly to the subjective chance of being detected, due to the randomness of enforcement activities and associated difficulty of avoiding enforcement. For profiling and pre-selecting suspicious HGVs using DSRC communication, the combined deployment of static DSRC road portals, portable DSRC tripod units and hand-held DSRC devices is expected to generate the optimum deterrence effectivity.

For the DSRC portals, initially the same locations as the existing WiM sites can be chosen. The portals will be equipped with one DSRC beacon per lane. The benefit of the system lies however in the strategic deployment of portable units and hand-held devices. Since the portable units can only cover up to one lane, they will be placed on strategic locations on the regional road network. The information retrieved from the measurements at the OBW sites will be used for both pre-selection and profiling. For pre-selection, a number of enforcement teams will be deployed. Using static scales, HGVs selected by the OBW system will be weighed again at designated locations. The data retrieved from the measurements will be used as well for profiling on sector, subsector, area and number plate level. Cease and desist letters will be imposed to noncomplying transporters. As can be seen in Figure 28, the database of OBW measurements forms the input for a number of other enforcement measures in the strategy, by which more synergy and efficiency can be achieved.

The deployment of OBW on the national road network is expected to result in a reduction in the number of overloaded HGV trips on the regional and local road network as well. This reduction is dependent on the number of OBW portals and their exact positioning in the network. Due to the fact that not all HGV trips use the national

road network and not all HGV trips using the national road network will pass OBW measurement sites, the reduction on the regional and local road network is expected to be lower, compared to the national road network. Simultaneously, the deployment of OBW portals is also expected to result in OBW portal site avoidance by conscious violators. This form of strategic behaviour affects the number of overloaded HGVs on certain avoidance routes. The amount of OBW avoiders depends on the availability of detour routes, the length of the detour routes and the probability of being checked on the detour route.

REGIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

On the regional road network, DSRC tripods will be placed on strategic locations. These include OBW portal avoidance routes and other locations defined by the OBW-based profiling. Of each couple of tripods, for example five, one will be equipped with a portable DSRC unit, detecting overloaded HGVs. The DSRC unit will be relocated every once in a while, as well as the tripods themselves. The randomness created in this way is comparable to the already known radar speed checks and enlarges the perceived randomness of enforcement.

MAIN AND REGIONAL ROAD NETWORK – ADDITIONAL ENFORCEMENT MEASURES

The deployment of manual **strategic OBW DSRC selection** on avoidance routes is needed to ensure the effectiveness of the static DSRC portals. Furthermore, manual enforcement could be applied in regions or on road sections where a high level of overloaded HGVs is expected, based on subsector and company profiling, using data retrieved by the system. Using static scales, HGVs selected by hand-held DSRC devices will be weighed again at appointed locations by ILT or road owner inspectors.

Given the large group of unconscious compliers and unconscious violators, significant amount of effort should be put in **information and persuasion**. Compared to the WiM for basic enforcement strategy, a stronger focus on persuasion is expected to be needed since the risk of WiM avoidance is large. Regulations and compliance advice will be communicated via website, social media, branch organizations and other (digital) communication channels. Furthermore, enforcement results and general info on enforcement activities to be deployed will be extensively communicated via website, social media, newspaper and branch organizations. Additionally, whitelists of complying companies will be published to stimulate compliance.

The deployment of **covenant with subsector or in area**, focussing on the entire transport chain is expected to be effective in less competitive subsectors. In the process of concluding covenants, the inspector could gain more insight in the motivations and interests of the inspectee.

The inclusion of an explicit **prohibition on overloading in contracts** is an important signal to the sector and other clients. Within this OBW-based strategy, transporters can be required to share axle load data with clients, via an OBW unit placed at the construction site. This makes the actual process of monitoring and contract management more efficient, compared to the first two strategies.

6.4.4. STRATEGY – ON-BOARD WEIGHING FOR AUTOMATED ENFORCEMENT

The design of the strategy *OBW for automated enforcement* is visualised in Figure 29. The figure shows the five enforcement measures the strategy consists of and the way in which these are deployed. The strategies are simplified illustrated on the right side of the figure.

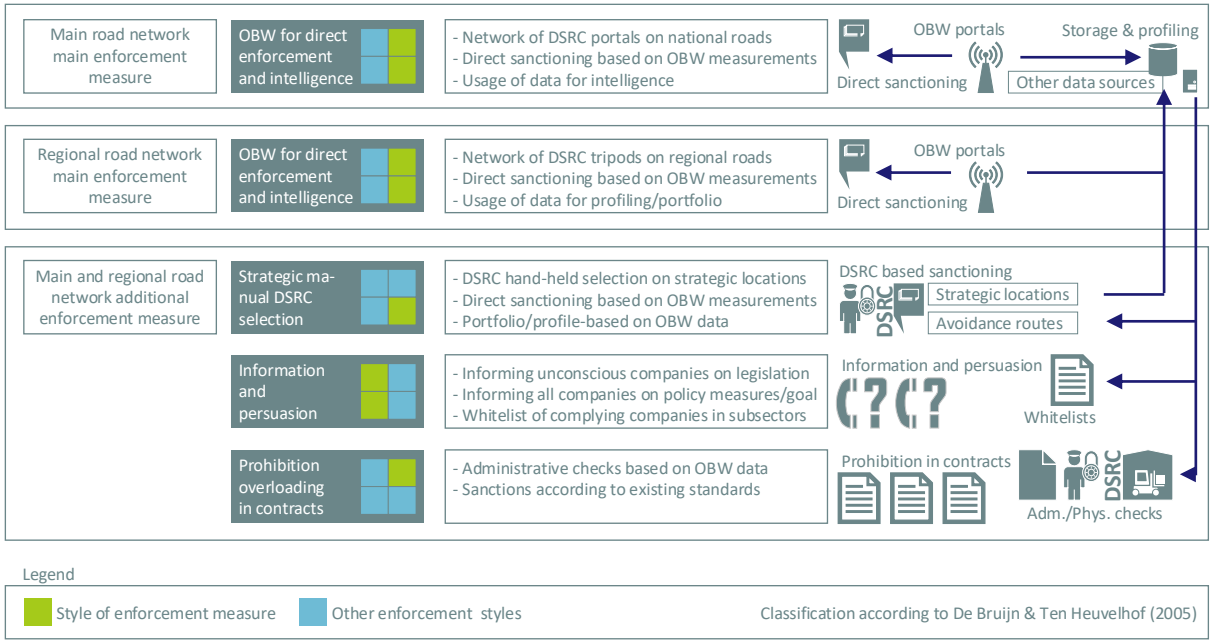

Figure 29 – Overview of strategy On-Board Weighing for automated enforcement

NATIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

As stated in Section 6.1.2, three possible deployment methods for **OBW for direct enforcement and intelligence** can be distinguished. For intelligence and direct enforcement of overloaded HGVs using DSRC communication, the combined deployment of static DSRC road portals, portable DSRC tripod units and hand-held DSRC devices is expected to generate the optimum deterrence effectivity.

For the DSRC portals, initially the same locations as the existing WiM sites can be chosen. The portals will be equipped with one DSRC beacon per lane. The benefit of the system lies however in the strategic deployment of portable units and hand-held devices. Since the portable units can only cover up to one lane, they will be placed on strategic locations on the regional road network. The information retrieved from the measurements at the OBW sites will be used to directly fine noncomplying transporters. Additionally, links with other sensors will be made, allowing for intelligent use of data and more efficient enforcement on several topics. As can be seen in Figure 29, the database of OBW measurements forms the input for a number of other enforcement measures in the strategy, by which more synergy and efficiency can be achieved.

The deployment of OBW on the national road network is expected to result in a reduction in the number of overloaded HGV trips on the regional and local road network as well. This reduction is dependent on the number of OBW portals and their exact positioning in the network. Due to the fact that not all HGV trips use the national road network and not all HGV trips using the national road network will pass OBW measurement sites, the reduction on the regional and local road network is expected to be lower, compared to the national road network. Simultaneously, the deployment of OBW portals is also expected to result in OBW portal site avoidance by conscious violators. This form of strategic behaviour affects the number of overloaded HGVs on certain avoidance routes. The amount of OBW avoiders depends on the availability of detour routes, the length of the detour routes and the probability of being checked on the detour route.

REGIONAL ROAD NETWORK – MAIN ENFORCEMENT MEASURE

On the regional road network, DSRC tripods will be placed on strategic locations. These include OBW portal avoidance routes and other locations defined by the OBW-based profiling. Of each couple of tripods, for example five, one will be equipped with a portable DSRC unit, detecting overloaded HGVs. The DSRC unit will be relocated every once in a while, as well as the tripods themselves. The randomness created in this way is comparable to the already known radar speed checks and enlarges the perceived randomness of enforcement.

MAIN AND REGIONAL ROAD NETWORK – ADDITIONAL ENFORCEMENT MEASURES

The strategic deployment of manual **strategic OBW DSRC selection** on avoidance routes is needed to ensure the effectiveness of the static DSRC portals and tripods. Furthermore, manual DSRC-based enforcement could be applied in regions or on road sections where a high level of overloaded HGVs is expected, based on subsector and company profiling, using data retrieved by the system. The deployment of accuracy class A axle load sensors and DSRC handheld devices makes reweighing unnecessary, e

Given the large group of unconscious compliers and unconscious violators, significant amount of effort should be put in **information and persuasion**. Compared to the WiM for basic enforcement strategy, a stronger focus on persuasion is expected to be needed since the risk of WiM avoidance is large. Regulations and compliance advice will be communicated via website, social media, branch organizations and other (digital) communication channels. Furthermore, enforcement results and general info on enforcement activities to be deployed will be extensively communicated via website, social media, newspaper and branch organizations. Additionally, whitelists of complying companies will be published to stimulate compliance.

The deployment of **covenants with subsector or in area** is not expected to contribute to the effectiveness of this strategy. Given the continuous awareness created by continuously displaying the GVW to the driver and associated direct enforcement, the both the compliance stimulating and violation deterring nature of this strategy are very strong. By information and persuasion, the inspector could remain in close contact with the inspectee.

The inclusion of an explicit **prohibition on overloading in contracts** is an important signal to the sector and other clients. The contradiction in behaviour between the government as client on the one hand and the government as inspector on the other hand should be taken away in any enforcement strategy. In their role as a client, governmental bodies should pay attention to social sustainability in general and HGV overloading specifically. Within this OBW-based strategy, transporters can be required to share axle load data with clients, via an OBW unit placed at the construction site. This makes the actual process of monitoring and contract management more efficient, compared to the first two strategies.

6.5. CONCLUSIONS

In the previous four sections, in a four-stepped design process, four enforcement strategies on the national and regional road network have been designed, consisting of multiple enforcement measures. Figure 30 provides an overview of the integration of measures in the four enforcement strategies. The four strategies are *WiM for basic enforcement, WiM for automated enforcement, OBW for basic enforcement* and *OBW for automated enforcement*.

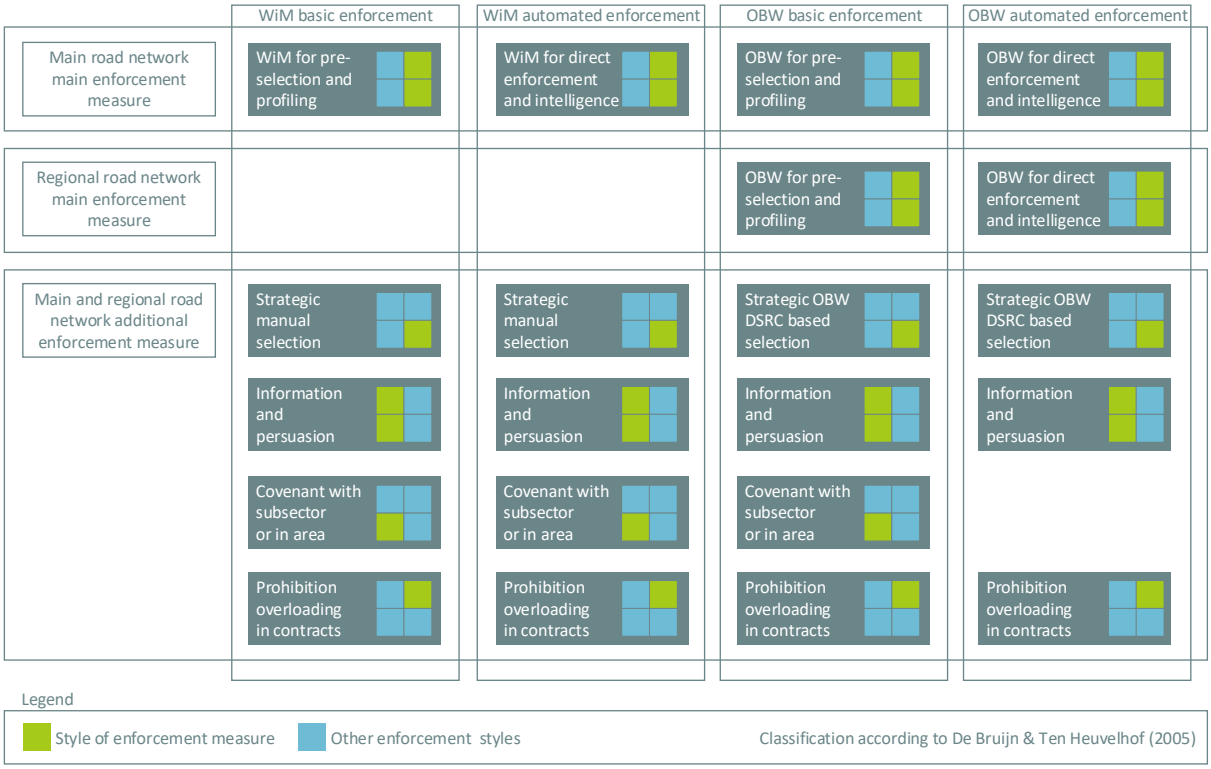

Figure 30 – Overview of weight enforcement strategies and weight enforcement measures

It can be concluded that the effectivity of the integrated deployment of multiple enforcement measures depends largely on the synergy created between them. Therefore, in all strategies, information derived from the main enforcement measure is used for profiling or intelligence. In this way portfolios can be created on regional, sector, company and numberplate level, retrieving more insight in the actual behaviour and reaction on deployed enforcement activities of the inspectee. Doing so, responsive regulation can be applied.

As can be seen in Figure 30, a number of measures is included in most of the designed enforcement strategies. The implementation of the measures within the strategy however differs significantly. In Figure 26, Figure 27, Figure 28 and Figure 29, the differences in application are visualised. Following requirement VI, the strategies include both compliance stimulating as well as violation deterring measures. This allows the government to adjust their style on the behaviour of the inspectee and the response of the inspectee on earlier enforcement activities.

In the next chapter, the effectiveness of the four designed coherent strategies will be evaluated.

7. THE EFFECTIVENESS AND EFFICIENCY OF DESIGNED STRATEGIES

Following the fourth step in the Design Science Research framework of Johannesson and Perjons (2014), the designed weight enforcement strategies will be evaluated on effectiveness and efficiency (cost-effectiveness), to answer the fourth research question:

What is the effectiveness and efficiency of the designed weight enforcement strategies on national and regional road networks?

In Section 7.1, the starting points for the estimation of costs and benefits are discussed, after which in Section 7.2 the expected effects of the strategies on the number of overloaded HGVs on the Dutch road network are elaborated upon. In Section 7.3, the internal efficiency of the four designed strategies is calculated, after which the designed strategies are reviewed on the constraints and requirements for future weight enforcement in Section 7.4. Finally, conclusions are drawn in Section 7.5.

7.1. ESTIMATING THE COSTS AND BENEFITS OF WEIGHT ENFORCEMENT

Following the fourth constraint for future weight enforcement (Section 5.1), the costs of enforcement activities should not exceed the benefits, which consist of a reduction of social costs that are due to violating behaviour. The costs of enforcement include costs for the implementation, operation and maintenance for all enforcement measures. The benefits of enforcement consist of a reduction of the number of overloaded vehicles on the road network, leading to a reduction of damage to infrastructure and unfair competition and increased traffic safety (Wermeskerken, 2005). Indirect benefits consist of a reduction of congestion costs caused by additional maintenance costs and road accidents due to overloading. Figure 31 shows the effects.

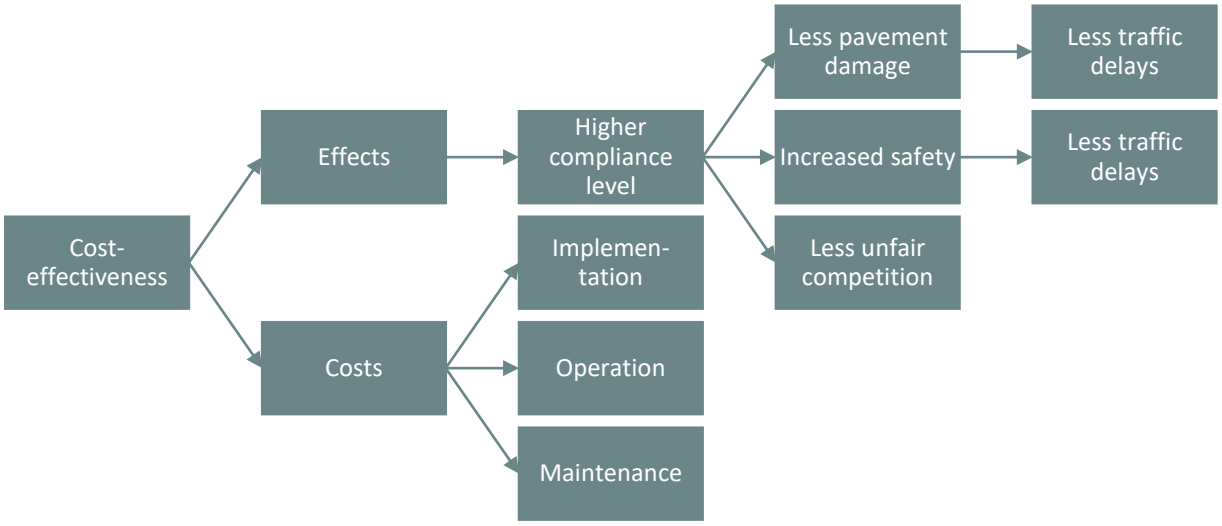

Figure 31 – Effects and costs of enforcement

Within the limits of this research, it appeared not to be possible to generate a full quantitative cost-benefit analysis. Four intangible factors affecting the effectiveness of enforcement are identified, which made the construction of a full cost-benefit analysis of the four designed enforcement strategies impossible:

- Firstly, the presence of a broad range of conscious and unconscious complying and noncomplying actors complicates the performance of a cost-benefit analysis. For each of these groups and each of the companies and individual drivers within these groups, the effects of various enforcement measures differ, increasing the complexity in performing a cost-benefit analysis. Especially for conscious offenders, the calculative behaviour in the decision whether or not to comply with legislation differs per company. For one, the introduction of a covenant and whitelists might already form enough stimulation to comply, while for another the benefits of overloading are so large, that only strategic sanction-based enforcement could generate this effect.
- Secondly, the existence of a broad range of subsectors and types of transports complicates performing a cost-benefit analysis. For each subsector, the characteristics of transport activities and benefit of overloading differs, as well as the reaction on different types of enforcement. For example, for long-haul international transport, a national network of WiM systems might be an optimal solution. At the same time, for shorter agricultural transports, the deployment of a WiM system on the national road network is illogical.
- Thirdly, the geographical layout of the road network influences the effectivity of enforcement. The effectiveness of static checks depends amongst others on the unavoidability of sanctions, thus the possibility to avoid checks. As a result, a dense and tightly interwoven road network leaves more room for control location avoidance than an open network consisting of longer corridors. The effect of network layout on the avoidance of checks is intangible and has not been addressed yet in the literature.
- Fourthly, a number of other, more external, factors is likely to affect the amount of overloading. For example, during economic crises, more pressure on transporters profit margins is placed, increasing the temptation to violate weight restrictions. Also, the general position towards governmental regulations of individual transporters affects the transporters willingness to comply.

Given these complexities, performing a full quantitative analysis of the effect of enforcement activities on the number of overloaded HGVs on a given road network appears not to be possible. It is however possible to calculate the costs of the enforcement strategies and estimate the number of checked HGVs. Based on these two pieces of information, the internal efficiency of enforcement activities can be calculated, providing a second order indication of their effectiveness. This will be done in Section 7.3.

First of all, in Section 7.2, based on the changes of the violation or compliance stimulating nature of the eleven dimensions in the Table of Eleven, a qualitative estimation of the effectiveness of the strategies will be given.

7.2. EFFECTS OF DESIGNED ENFORCEMENT STRATEGIES

The effects of the four designed enforcement strategies on the violation or compliance stimulating character of the dimensions of spontaneous and enforced compliance in the Table of Eleven are visualised in Figure 32. The scores are elaborated upon in Appendices VI, VII, VIII and IX. In this section, the Table of Eleven results are briefly discussed. Additionally, the effects on the dimensions in the Table of Eleven are used to come to reasoned estimations on the effectiveness of the strategies.

7.2.1. EFFECTS OF STRATEGIES ON TABLE OF ELEVEN DIMENSIONS

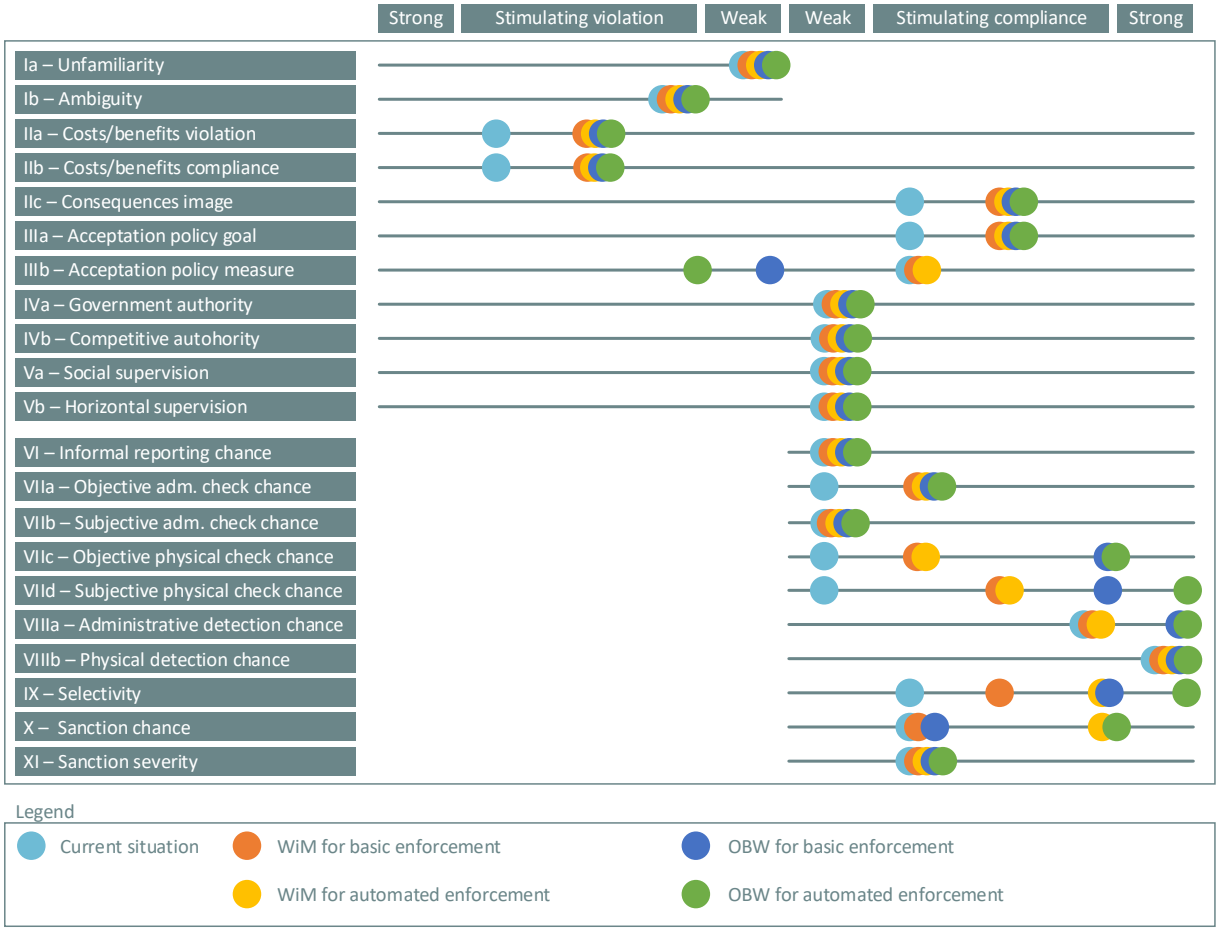

Figure 32 – Effects of designed strategies on the eleven dimensions of spontaneous and enforced compliance in the Table of Eleven

Figure 32 shows the impact of the four designed strategies on the compliance or violation stimulating nature of the eleven dimensions of spontaneous and enforced compliance in the Table of Eleven. The results are indicated by dots on a continuous scale, ranging between strongly violation stimulating and strongly compliance stimulating. It should be noted that overlapping dots represent the same level of violation or compliance stimulation.

In general, from Figure 32 it can be concluded that all four designed enforcement strategies are expected to result in a higher compliance rate. The nature of the majority of the eleven dimensions shifts towards more compliance stimulating. Especially the dimensions of enforced compliance (dimension VI – XI) are positively affected by the designed enforcement strategies. As can be seen, the designed strategies do not affect the nature of all dimensions. For example, the loyalty of the sector to regulations in general will not be affected by the designed weight enforcement strategies. Each of the dimensions of which the compliance or violating deterring nature changed, is elaborated upon in this Section.

DIMENSION II – COSTS AND BENEFITS

The effect of all four strategies on this dimension is the same: the prohibition on overloading in contracts in which a governmental body operates as client and the expected closure of covenants impact the violation stimulating character of this dimension. Additionally, information and stimulation-based measures affect the importance of a positive image for transporters, due to the introduction of whitelists and extensive communication of benevolent transporters.

The main benefit of HGV overloading, a stronger competitive position due to cost reduction, is reduced, by the inclusion of the prohibition on overloading in contracts and a stronger focus on societal responsible entrepreneurship in covenants within the entire transport chain. Instead, the benefit of compliance is larger, since companies actively showing compliance are more likely to be awarded governmental contracts.

DIMENSION III – LEVEL OF ACCEPTATION

It is expected that more communication, information and persuasion on the reason for weight enforcement leads to a higher acceptation of the policy goal. However, some of the measures require effort or investments from the transporter, which is expected to lead to a decreased acceptation of the enforcement measure. Especially the OBW-based enforcement strategies impact the business management, requiring the purchase of vehicles with axle load sensors, attending calibration sessions and additional actions and procedures, which impacts business management and leads to less acceptation of the measure.

On the other hand, despite an increase in the number of scheduled checks, the share of wrongly physically checked vehicles is expected to drop. Since in the current enforcement situation, only manual checks are deployed, the introduction of WiM or OBW as pre-selection method will significantly reduce the number of wrongly checked vehicles. In manual enforcement, the use of DSRC handheld devices ensures that no vehicles are wrongly checked in OBW-based strategies.

DIMENSION VII – PROBABILITY OF BEING CHECKED

All four strategies lead to a significantly higher objective and subjective chance of being checked. The deployment of WiM or OBW contributes the most to the objective probability of being checked, while the use of more strategic manual selection teams leads to a higher subjective chance of being checked. The expected closure of various covenants and prohibition on overloading in governmental contracts leads to a higher administrative chance of being detected.

By the deployment of WiM for pre-selection and profiling and OBW for pre-selection and profiling on 30 locations on the national road network, it is expected that approximately 230.000 HGVs will be digitally checked on a daily basis (Appendix VI). If two teams for manual selection based on the pre-selection are deployed, on a daily basis approximately 86 vehicles can be checked, of which the largest part will be sanctioned.

According to various studies, 15 percent of the checked HGVs is overloaded (Inspectie Leefomgeving en Transport, 2016; Ministerie van Infrastructuur en Milieu, 2015). It is expected that within WiM for direct enforcement or OBW for direct enforcement, daily 34.000 vehicles will be automatically fined. It should be noted that within these figures, the effect of enforcement is not included. In reality, these numbers will graduately decrease.

Additionally, the deployment of manual selection teams on both the national and regional road network is expected to result in a higher subjective chance of being checked. This is due to the randomness and unavoidability of manual enforcement.

DIMENSION IX – SELECTIVITY

Compared to the current enforcement situation, all alternatives lead to a higher chance of being checked for overloaded HGVs, compared to complying HGVs. Profiling based on respectively WiM or OBW data generates insight in the compliance rate of various forms the input for other enforcement activities. In this way, manual enforcement can be targeted at HGVs having a high risk of being overloaded, based on subsector, company or even number plate data.

DIMENSION X – PROBABILITY OF BEING SANCTIONED

The probability of being sanctioned depends strongly on the way in which the main enforcement is deployed, and which definition of sanctioning is used. While in terms of fines, the probability of being sanctioned will be close to 100 percent in *WiM for direct enforcement and intelligence* and *OBW for direct enforcement and intelligence*, the probability of being sanctioned is significantly lower for *WiM for pre-selection and profiling* and *OBW for pre-selection and profiling*. In the latter two, due to lower accuracy only cease and desist orders can be imposed, which can only be forfeited at manual checks.

7.2.2. EFFECTS ON COMPLIANCE LEVEL

As mentioned in Section 7.1, it appeared not to be feasible to fully quantify the effect of enforcement on compliance. In 2002, within the European ESCAPE project, it was concluded that "There is clearly a lack of factual knowledge about all facets of the association between enforcement and compliance." (Mäkinen et al., 2003, p. 120). Although a large amount of research has been performed on various enforcement topics, an interdepartmental policy research in the Netherlands confirms the finding of the ESCAPE project. The report concludes that for most measures, the effectivity on the Dutch roads and road users is unknown (Inspectie der Rijksfinanciën/Bureau Strategische Analyse, 2016). Given the relatively low social impact of overloading and low priority on the political agenda, the research base on the effect of weight enforcement in specific is even thinner.

Nevertheless, based on the analysis in the Table of Eleven, it can be expected that the enforcement strategy *On-Board Weighing for automated enforcement*, based on main enforcement measure 'On-Board Weighing for direct enforcement and intelligence', applied on both the national and regional road network, is expected to be the most effective. The strategy creates awareness, by continuously displaying axle loads to the driver of the vehicle. Additionally, both the objective and subjective risk on being checked increases drastically, due to the deployment of portable DSRC tripods and DSRC hand-held devices. Finally, direct enforcement allows for fining solely based on OBW measurements. Thus, the deployment of the combination of measures in this strategy is expected to achieve the largest decrease in the number of overloaded HGV movements on the Dutch road network.

7.3. INTERNAL EFFICIENCY OF DESIGNED ENFORCEMENT STRATEGIES

The enforcement costs of the four designed strategies are calculated in Appendices VI, VII, VIII and IX and are based on a number of governmental reports, key figures from other countries and a small number of reasoned assumptions. The starting points and assumptions for the estimation of the internal efficiency can be found in Appendix V. For each of the strategies, design choices are made as well on the exact composition of the enforcement measures, which can be found in Appendix V as well. Furthermore, assumptions are made on the needed amount of check locations. Further research on the relationship between the number of checks and perceived subjective risk of being checked and between the subjective risk of being checked and actual effect of the strategy is needed. Based on future research, the exact configuration of WiM and OBW sites, manual checks and other enforcement measures can be defined.

	WiM for basic enforcem.	WiM for automated enforcem.	OBW for basic enforcem.	OBW for automated enforcem.
Total yearly costs (x 1.000.000 €)	5,9	8,5	34	49,4
Costs per digital HGV check (€)	0,01	0,05	0,30	0,49
Costs per digital overloaded HGV detection (€)	0,09	0,33	2,04	3,32
Costs per manual HGV check (€)	48,01	48,01	48,36	0,18
Costs per manual overloaded HGV detection (€)	67,42	81,65	49,68	1,25
Costs per sanctionable overloaded HGV detection (€)	**86,68**	**0,60**	**367,54**	**3,17**

Table 4 – Overview of costs and efficiency of enforcement strategies, for enforcement regime B (figures per year)

Table 4 shows the total annual enforcement costs and internal efficiency of the four designed strategies:

- The internal efficiency, expressed as the enforcement costs per sanctionable overloaded HGV detection, differs significantly per strategy. Since in the two automated enforcement strategies, both digital and manual detections are sanctionable, the internal efficiency of these strategies is significantly higher.
- Due to the high investment and operational costs associated with OBW-based enforcement, the internal efficiency for these two strategies is lower.
- The costs per manual HGV check are equal for the two WiM-based strategies. For *OBW for basic enforcement* these are slightly higher, due to the purchase of DSRC handhelds. For *OBW for automated enforcement*, the costs per manual HGV check are significantly lower, since no weighing on calibrated scales is needed.

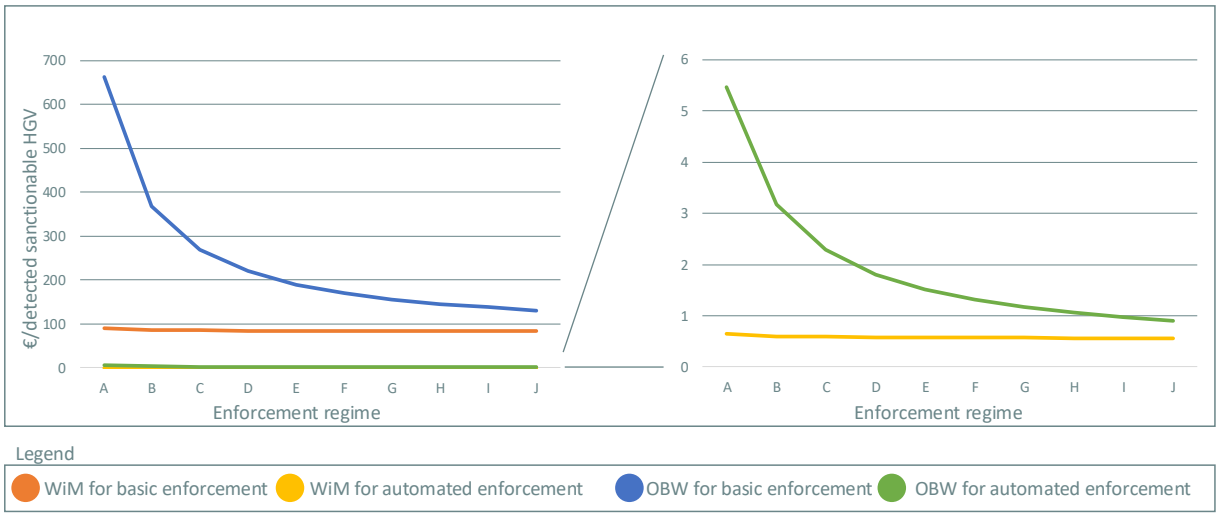

Figure 33 – Estimation of internal efficiency of designed enforcement strategies

Figure 33 shows the internal efficiency of the designed strategies for the enforcement regimes included in Appendix V. For tougher enforcement regimes, the internal efficiency of the OBW-based strategies increases rapidly, interpreted by the decreasing costs per detected sanctionable HGV. These results indicate that the two automated enforcement strategies are expected to be more efficient than the two basic strategies, indicated by lower enforcement costs per sanctionable HGV detection.

The figures presented in this section should be interpreted carefully. Firstly, the figures only provide insight in the violation-deterring enforcement measures, since the effect of compliance-stimulating measures could not be estimated. Secondly, the figures do not show the actual effect of the enforcement measures to be deployed, in terms of reduction of the number of overloaded HGV movements on the Dutch road network. They only provide insight in the efficiency of the violation-deterring enforcement measures within the various strategies. In reality, dependent on the exact deployment of enforcement measures, the compliance level will rise. Although the costs per checked HGV will stay the same, the costs per sanctionable overloaded HGV detection will increase.

7.4. REVIEWING STRATEGIES TO CONSTRAINTS AND REQUIREMENTS

In this section, the four strategies designed in the previous chapter are reviewed to the constraints and requirements presented in Chapter 5. An overview is included in Table 5.

Requirement		WiM basic	WiM automated	OBW basic	OBW automated
I	Future weight enforcement should lead to or contribute to a significant reduction in the number of overloaded HGVs on the Dutch road network	Yes	Yes	Yes	Yes
II	Future weight enforcement should comply with Directive (EU) 2015/719	Yes	Yes	Yes	Yes
III	Future weight enforcement should fit within the physical and governance characteristics of the Dutch road network	Yes/No	Yes/No	Yes	Yes
IV	The benefits of future weight enforcement in terms of social damage reduction should exceed the costs of future weight enforcement	Unknown	Unknown	Unknown	Unknown
V	Future weight enforcement should be implementable in Dutch legislation	Yes	Yes	Yes	Yes
VI	The weight enforcement strategy should consist of both bureaucratically and strategically applied compliance stimulating and violation deterring enforcement measures	Yes	Yes	Yes	Yes
VII	The weight enforcement strategy should allow for portfolio management and responsive regulation	Yes	Yes	Yes	Yes
VIII	The weight enforcement strategy should be based on the amount of road damage transporters are accountable for	Yes	Yes	Yes	Yes
IX	The weight enforcement strategy should be focussed on the entire transport chain	Yes/No	Yes/No	Yes/No	Yes/No
X	The impact of the weight enforcement strategy on the business management of complying transporters should be as low as possible	Yes/No	Yes/No	Yes/No	Yes/No
XI	Weight enforcement should be focussed on both Dutch as well as foreign transporters	Yes/No	Yes/No	Yes/No	Yes/No

Table 5 – Testing strategies to constraints and requirements

AD I: All strategies are expected to result in a higher compliance level. As discussed in Section 7.2.2, *OBW for automated enforcement* is expected to be the most effective strategy.

AD III: The small case study for the PZH road network in Appendix IV demonstrated that WIM is not expected to be feasible on the regional road asset.

AD IV: As discussed in Section 7.1, it appeared not to be feasible to define the cost-effectiveness of the designed strategies, due to the complex and intangible relation between enforcement and compliance.

AD V: Dutch legislation already allows for the use of WiM for pre-selection. For the other three strategies, legislation should be adjusted. Although this could be a time-consuming process, this is expected to be feasible for all three strategies.

AD IX: Although the conclusion of covenants is included as compliance-stimulating measure which addresses the entire transport sector, forming new covenants is challenging according to the ILT during the focus

group session. The additional pressure formed by additional enforcement activities could possibly ease and accelerate the creation of new covenants.

AD X: Due to extensive profiling, the probability of being checked while not being overloaded decreases, compared to the current enforcement situation. For the two basic strategies, it remains however needed to reweigh HGVs to obtain court-proof evidence. With regard to the OBW-based strategies, the calibration of axle load sensors could be time-consuming.

AD XI: The (im)possibilities for fining foreign transporters are not addressed in the strategies. All four strategies allow for sanctioning all transporters, so it depends on the political will of individual Member States to make agreements on this matter.

7.5. CONCLUSIONS

The strategy *OBW for automated enforcement* is expected to generate the largest effect in terms of reduction of the number of overloaded HGVs on the Dutch road network. The OBW system creates continuous awareness by displaying axle loads to the driver, while the static and portable DSRC units contribute to a high objective and subjective chance of being checked. Additionally, the principle of direct enforcement contributes to a 100 percent chance of being sanctioned. Combined, the high subjective chance of being checked, detected and sanctioned are expected to result in a higher compliance rate.

Two important advantages of *OBW for automated enforcement* over the other three strategies are distinguished. The first advantage of OBW over WiM in general relates to the extensive possibilities for strategic deployment of the system. Where WiM systems are built in the pavement and therefore not allocable, the deployment of portable DSRC tripods allows for strategic enforcement on specific corridors or geographical areas. This makes the enforcement less predictable, increasing the subjective chance of being checked. The use of DSRC handheld devices makes the pre-selection of suspicious HGVs in manual enforcement activities highly accurate, lowering the number of falsely checked HGVs. A second advantage of *OBW for automated enforcement* in specific relates to the possibility of sanctioning, solely based on the data retrieved from the OBW system. In this way, HGVs can be directly sanctioned, leading to a higher perceived chance of being sanctioned and higher compliance rate.

The internal efficiency of the two automated enforcement strategies is relatively high, compared to the two basic enforcement strategies. On the other hand, the two automated enforcement strategies require higher investments, especially for *OBW for automated enforcement*. The higher internal efficiency of the two automated enforcement strategies indicate that these are expected to be more cost-effective than the two basic strategies.

8. EVALUATION OF ANALYSIS AND ENFORCEMENT STRATEGIES

This chapter describes the evaluation of the analysis and designed strategies. Six stakeholders, representing road administrators at various levels, the vehicle authority and a transport branch organisation and one weight enforcement expert working at the ILT, were interviewed. In line with the guidelines for the evaluation of artefacts in Johannesson and Perjons (2014), they were asked to evaluate the starting points, effectiveness of the designed coherent strategies and the design of the strategies themselves. The fifth and last research question will be answered in this chapter:

What is the added value of the designed weight enforcement strategies?

An overview of interviewed stakeholders and experts can be found in Table 6.

Respondent	Organisation	Function
A	TLN	Secretaris Techniek, Deelmarkt exceptioneel vervoer en Autotransporteurs
B	RWS	Programmamanager Truck Platooning
C	PZH (2x)	Assetmanager Wegen
D		Adviseur verhardingen
E	PZH	Senior beleidsmedewerker kunstwerken
F	RDW	Manager ontheffingen
Expert	**Organisation**	**Function**
G	ILT	Projectleider Weigh-in-Motion en aanpak overbelading

Table 6 – Interviewed stakeholders and expert

The evaluation performed in this chapter is based on the opinions of a number of involved stakeholders. It is believed that together, these stakeholders represent the largest part of the actor field. It should however be noted that, except from the ILT representative, none of the interviewed stakeholders can be classified as expert in weight enforcement. Furthermore, it should be noted that respondent C & D are involved in overloading at a strategical level, while respondent E is involved in overloading at a more operational level.

Given the highly complex relation between enforcement and compliance, interviewees were not asked to directly evaluate the designed coherent weight enforcement strategies. Instead, the interviews were based on the principle of informed argument, in which the underlying analyses, design requirements, design principles and arguments are presented to the interviewees(Johannesson & Perjons, 2014). Based on the opinion of the interviewees on the arguments of the author, the effectiveness of the strategies was assessed. The risk on false positives in informed argument evaluations is very high. This risk is partially mitigated by asking follow-up questions when needed.

8.1. INTERVIEWS WITH STAKEHOLDERS AND EXPERT

Each of the seven interviewees was asked to evaluate the constraints and requirements for the design of the enforcement strategies and underlying analyses as presented in Chapter 3 & 4. In the interviews, it became clear that respondents have a different view on the size of groups of non-complying transporters. Since this analysis forms an important basis for the formulation of constraints and requirements, the discussion on this topic is elaborated upon in Section 8.1.1. Subsequently, the design constraints and requirements are evaluated in Section 8.1.2. With regard to the choice between WiM and OBW and their (dis)advantages as main enforcement strategy, the opinions between the respondents differed as well, which is elaborated upon in Section 8.1.3. In the following Section, weight enforcement is placed in a broader policy context, after which in Section 8.2 conclusions on the interviews are drawn

8.1.1. THE APPROACH FOR DIFFERENT GROUPS OF (NON)COMPLIERS

The interviewees recognize the target group consists of different types of violators and compliers and resulting need for the deployment of different enforcement styles. The compliance estimation (Figure 9), in which the size of the five groups of complying and violating transporters is visualised, is evaluated as an important step in the analysis. However, the respondents view on the size of the different groups differs. Respondents A (TLN) points out that within the group of non-complying transporters, a large part falls within the measurement ranges. While the maximum vehicle load is set at 50 tons, provided that the weight limit in the registration certificate equals 50 tons as well, the measurement range of 5 percent allows for 2,5 tons extra weight to be carried without being fined. TLN argues that a large number of transporters uses the extra margin 'in their favour'.

While GVW overloading is classified as conscious violation, the opinions of respondents differ on the classification of other violations in the groups mentioned in Figure 9. Respondent A (TLN) believes that category III axle load violators do not have a competitive advantage, since they do not exceed the maximum gross vehicle weight. On the other hand, respondent A argues as well that category III offenders regularly dealing with part load should invest in an extra axle, walking floor or side unloaders.

The added value of the Table of Eleven in analysing the underlying factors influencing the behaviour of the target group is recognized by the majority of the stakeholders and by the ILT weight enforcement expert. The ILT expert indicates that the Table of Eleven is used by the ILT as well to gain insight in the motivations for transporters in specific subsectors to comply or violate maximum weight regulations. The constructed compliance profile (displayed in Figure 8) is agreed upon by the stakeholders and expert.

8.1.2. THE EVALUATION OF DESIGN PRINCIPLES AND REQUIREMENTS

Based on the analyses, two main design principles by de Bruijn and ten Heuvelhof (2005) were used in the construction of coherent enforcement strategies and evaluated by all interviewees. Both the simultaneous use of deterrence-based and compliance-based enforcement activities and the simultaneous use of bureaucratic and strategic enforcement activities was considered to be needed, given the results of the performed analyses.

However, the proposed focus of the enforcement strategy on compliance-based or deterrence-based style differed amongst the respondents. Respondent B (RWS) argued that conscious violators should be deterred by sanction-based enforcement, while unconscious violators should be stimulated to comply by compliance-based enforcement. Respondent E (PZH) contributes to this line of reasoning. Respondent C suggests persuading deliberately-noncomplying companies to become spontaneous compliers, instead of enforcement deterred. The ILT weight enforcement expert made clear that information and communication are considered to be the most effective instruments, since these are expected to generate a change in behaviour. The expert argued that a strong focus on the sanction-based style could deter violators but does not stimulate them to become conscious compliers.

On the other hand, respondent A, TLN representative, made clear that weight enforcement should be focussed on deterring violators by increasing the chance to be checked. This opinion is shared by respondent F, RDW representative, who believes that more attention to sanction-based enforcement could contribute to the willingness of transporters to collect more information on maximum sizes and weights themselves. The RDW expects that the push of information from RDW to sector could be balanced in this way, since more companies will actively request information at the RDW.

All respondents were presented the eleven constraints and requirements presented in Chapter 5. All respondents agreed upon the three constraints, relating to the goal of the strategies, the technical feasibility and alignment with European legislation. The principle that the weight enforcement strategy should be based on the amount of social damage non-complying transporters are accountable for, was pointed out and supported by a large number of respondents, including the ILT expert. Respondent B, RWS representative, argued that the stimulation

of awareness of the policy goal by the sector and the reasons for weight enforcement contributes to the acceptation of the policy goal.

None of the respondents proposed additional design requirements. However, when asked further, for a number of respondents cost-effectiveness of enforcement activities did appear to be a starting point. For respondent F (RDW), the costs for a weight enforcement strategy should always be lower than the current social costs associated with HGV overloading. According to respondent E (PZH), the moment at which weight enforcement activities are not cost-effective anymore, the target of the policy is reached, independent on the corresponding number of overloaded HGVs. They argue that, for the society as a whole, costs should always be as low as possible, even if a small number of violations occurs. In addition, respondents C & D (PZH) point out the difference between social and internal cost-effectiveness of enforcement. They argue that weight enforcement should be socially cost-effective, but not necessarily internally cost-effective. In other words, all social benefits together should exceed the costs for enforcement, but the benefits for PZH itself should not. Based on these insights, the constraint 'The benefits of the weight enforcement strategy in terms of social damage reduction should exceed the costs of the weight enforcement strategy' is added to the list of constraints and requirements in Chapter 5.

8.1.3. THE CHOICE BETWEEN WIM AND OBW AS MAIN ENFORCEMENT MEASURE

The ILT weight enforcement expert made clear that a strong analysis of data, for example retrieved from the WiM site, should form the base of any enforcement strategy. In this way, the behaviour of transporters in different subsectors can be thoroughly analysed, on the basis of which targeted strategic enforcement activities can be deployed. Both WiM and OBW allow for the collection of large amounts of data for profiling. However, main enforcement measure 'WiM for direct enforcement' is not considered feasible by the majority of the respondents. The technical (accuracy) problems surrounding the existing WiM systems, used for pre-selection and profiling, form the basis for a highly sceptical attitude towards the deployment of accuracy class A WiM systems.

According to respondent A (TLN), B (RWS), C and D (PZH), *OBW for direct enforcement and intelligence* would be the ultimate main enforcement measure. Respondent F (RDW) argues that it would be more realistic to start with OBW for a small subsector only, instead of implementing OBW for the entire sector directly. Respondent A (TLN) stated that axle sensors for OBW should only be obliged for newly build HGVs, given the significantly higher installation costs for axle load sensors on existing HGVs.

The ILT expert does not consider automatic enforcement using OBW feasible, in a variant in which calibrated axle loads are actively shared with the enforcement authority. A variant in which can be detected whether axle load sensors are installed and working, is considered more feasible. This could be achieved by a network of DSRC road side systems. In this case, HGVs not equipped with working axle load sensors are considered violators already.

8.1.4. OVERLOADING IN A BROADER POLICY CONTEXT

Even though the routing of heavy transports falls outside of the scope of this research, policy decisions on weight enforcement and heavy goods transport routes should be made in conjunction with relevant other policy areas. Therefore, the comments of respondent B (RWS) and respondent F (RDW) on the cohesion between these policy decisions will be elaborated on in this Section. Respondent B indicates that RWS strives to decrease the number of transport movements on the national road network, to promote the traffic flow. Therefore, multimodal transport is stimulated, as well as the deployment of longer and heavier trucks. Besides a reduction in congestion, RWS argues that a reduction in transport movements contributes to the sustainability of the transport sector.

Respondent F (RDW) stresses that road owners should gain insight in the maximum weights allowed on their infrastructural works and pavements and should clearly communicate this to the sector, via the RDW road map. With regard to exceptional transports, the RDW believes that offering companies the information to make the

right choice could make it easier for transporters to comply. The respondent expects that, doing so, the compliance level will increase.

8.2. CONCLUSIONS

Although it appeared to be difficult for stakeholders to fully evaluate the designed coherent weight enforcement strategies, based on informed argument it is concluded that in all four strategies are generally expected to have the intended effect, according to the seven respondents. Especially the need for a higher chance of being checked, reflected in the design of all four strategies, is agreed upon by all respondents. Although the implementation of OBW-based strategies is expected to be challenging, most of the respondents expect OBW for direct enforcement to be the most effective enforcement strategy.

In addition to the focus group session, more insight is retrieved in the interests of various stakeholders. Both the sector and the interviewed road owners strive to maximize the chance of being checked, detected and sanctioned. Whereas for the transport sector the creation of a level playing field is the driving force behind the interest in the reduction of overloading, for road owners the infrastructural damage is the main issue. This difference in interest between the sector and road owners leads to a different view on how to address the problem of overloaded vehicles. For the transport sector GVW overloading is seen as a problem which distorts the market and axle overloading more as an incidental mistake, while for road owners axle overloading has an undesired impact as well on the lifetime of the infrastructure.

Despite the different interests of the interviewed stakeholders, the constraints and requirements for future weight enforcement strategies, formulated in Chapter 5, are widely recognized and accepted by all stakeholders and the ILT expert. Although the design principles underlying the construction of the four coherent strategies are widely accepted by all stakeholders and the weight enforcement expert, the opinion on the exact completion of the principles differed amongst the respondents. This results from a difference in opinion on how large the different groups of compliers and violators are, and how these should be addressed. According to the ILT expert, information and communication should be focussed on, since this is expected to result in the intended change in behaviour, from violator towards conscious complier.

As said, OBW-based enforcement is expected to be more effective than WiM-based enforcement, by the majority of the interviewees. The opinions on the exact deployment of OBW differ. Branch organisation TLN argues that the deployment of OBW for axle load display will not result in the intended reduction of overloaded HGVs, since TLN expects the largest part of the HGVs to be deliberately overloaded. On the other hand, the RDW believes that a system in which transporters retrieve certain benefits in return for sharing OBW-based weight data to be effective as well. The RWS and PZH respondents favour a system in which weights can be retrieved by DSRC road side systems and vehicles can be directly sanctioned. Despite this, a number of challenges in the implementation of OBW are distinguished. Besides the adjustment of legislation, a possible transition period towards OWB should be shaped.

9. CONCLUSIONS AND RECOMMENDATIONS

In this final chapter, the final results of this research are presented. This chapter answers the main research question, as presented in Chapter 1:

How can the problem of overloaded heavy-goods vehicles on Dutch national and regional road networks be addressed in a cost-effective way, to reduce the social costs of heavy-goods vehicle overloading?

The main findings of the research are presented in Section 9.1, after which in the subsequent section the results are discussed and limitations elaborated upon. Section 9.3 comprises the scientific contribution of this research, as well as recommendations for future research. Subsequently, the social contribution of the research is presented by recommendations for decision-makers on weight enforcement at different governmental levels in Section 9.4. Finally, in Section 9.5, a design for the policy making process with regard to future weight enforcement is proposed.

9.1. MAIN FINDINGS

This research demonstrated the need for a comprehensive weight enforcement strategy, by estimating the magnitude of various groups of conscious and unconscious violators and compliers and applying the framework for enforcement of de Bruijn and ten Heuvelhof (2005) on the research problem. The four weight enforcement strategies designed in this research therefore include a set of both compliance stimulating as well as violation deterring enforcement measures on the national and regional road network, applied both bureaucratically and strategically. The choice for a main enforcement measure is based on the choice for Weigh-in-Motion (WiM) or On-Board Weighing (OBW) as obliged for European Member States (European Parliament and the Council, 2015). For each of these technologies, two feasible ways of deployment were identified, namely as a selection tool for calibrated reweighing and profiling or as an automatic enforcement tool. A small case study for the areal of the province of Zuid-Holland demonstrated that the deployment of both OBW applications is expected to be effective on regional roads as well, since the OBW technology, in contradiction to WiM, offers possibilities for strategic enforcement as well.

Qualitative analysis using the Table of Eleven demonstrated that all four designed strategies are expected to result in a decrease in the number of overloaded HGVs. The strategy *OBW for automated enforcement*, which is based on main enforcement measure *OBW for direct enforcement*, is expected to result in the largest decrease in the number of overloaded HGV movements on both the national and regional road network. Static road portals and portable tripods equipped with Dedicated Short-Range Communication (DSRC) beacons are placed on the road network. These devices derive real-time and historical axle load data from all HGVs, which are obligatory equipped with axle load sensors and an on-board DSRC unit. The strategy is complemented with strategic manual DSRC-based enforcement, increasing the subjective probability on being checked. Additionally, by whitelisting and extensive communication of regulations and enforcement measures, transporters are further incentivized to comply. Finally, a prohibition on overloading should be included in contracts in which a governmental body acts as client. A risk profile based on an OBW measurement database serves as the input for all other enforcement measures.

The total enforcement costs of all measures in this strategy are estimated to be 49,4 million euros each year. For a moderate enforcement regime, the internal efficiency of strategy *OBW for automated enforcement* equals €3,17 per sanctionable overloaded HGV detection. The internal efficiency of the measure is dependent on the amount of checks required to achieve the desired reduction in the number of overloaded HGVs. It is concluded that the costs per checked, detected and sanctioned vehicle are significantly lower for WiM-based strategies, due to the high investment and maintenance costs associated with OBW-based strategies. However, as the number of scheduled checks increases, the costs per OBW-based check decrease drastically. The efficiency of

automated strategies is considerably higher, since both digital and manual overloaded HGV detections can serve as court-proof evidence. A major advantage of the OBW road side system could be the technical integration with the to be introduced kilometre charge for HGVs. In this way, the costs for the data system, road side systems and on-board system could be reduced.

9.2. LIMITATIONS AND DISCUSSION

Following a Design Science research approach, in this research a number of enforcement measures were designed and evaluated on effectiveness and internal cost-effectiveness. The research shows that a strategy using *OBW for automated enforcement* as main enforcement measure is expected to be feasible on both the national and regional road network and is expected to be the most effective in reducing the social damage caused by HGV overloading. It should be noted that this research does not provide quantitative insights in the effectiveness of the evaluated enforcement measures. As mentioned in Section 7.1, the relation between enforcement activities and compliance level is highly complex. The internal efficiency, expressed in enforcement costs per checked, detected and sanctionable HGV, serves however as a second order indicator of the cost-effectiveness of the strategy.

9.2.1. LIMITATIONS

Therefore, a first limitation of this research relates to the external efficiency or cost-effectiveness of the designed strategies. As elaborated upon in Section 7.1, the relation between enforcement activities and their effects on the number of overloaded HGVs is highly complex. The probability of various groups to comply with or violate maximum weight regulations differs from subsector to subsector and from transporter to transporter. This probability depends on a large number of factors, including the economic climate, competitive position and exact deployment of enforcement activities. It therefore appeared not to be possible to include all effects for all groups in a full quantitative cost-benefit analysis. However, the qualitative estimation of the effects of the four strategies provides insight in their relative effectiveness. Although based on the research outcomes it could be expected that all four strategies designed will result in a higher compliance level, the social damage reduction does not necessarily outweigh the enforcement costs.

The second limitation of this research is related to the small case study performed in Chapter 6. To determine the feasibility of the deployment of the main enforcement measures on the regional road network, the road asset of the province of Zuid-Holland was used in a small case study. It should be noted that the HGV intensities on this regional road network are high, compared to other provinces. This could have resulted in a higher cost-effectiveness of weight enforcement on this specific network. Secondly, the selected network is relatively dense, compared to other provincial road networks. For deliberately non-complying companies, having more opportunities to avoid check locations could result in a decreased violation deterring effect. The deployment of WiM on the road asset of the province of Zuid-Holland is not considered feasible, partially due to the network density. It could however be effective on other regional networks, where less accessible opportunities for avoidance behaviour are available. Therefore, it can be questioned if this case study is sufficient to generalise these conclusions to other regional road networks.

The third limitation of this research can be found in the evaluation of the designed strategies. Within the Design Science Approach, the interviews were intended to verify the research outcomes and evaluate the added value of the designed coherent strategies. It however appeared to be difficult to discuss the outcomes of the research in detail, especially within the time set for one interview. Instead, the respondents were guided through the research outcomes, based on the principles of informed argument. The associated high risk of false positives has been partially mitigated by the semi-structured nature of the interviews. However, possibly a number of false positives is noted. For example, during the interview several respondents indicated that no requirements were missing, while later on some of them indicated that societal cost-effectiveness was an important constraint for

enforcement to them. The responses should therefore be interpreted as a good, but not necessarily complete indication of the real opinion and interest of the participants and organisations they represented.

The fourth and final limitation of the research relates to the processing of the interviews. Given the complexity of the research problem and designed strategies and limited knowledge on the topic of the respondents, the interview question could not be formulated in such a way that coding was possible. Instead, an impressionistic approach was taken to process the focus group session and interviews. The reproducibility of the research could be increased, by coding the interviews. Although this change in approach is not expected to affect the research outcomes, it would increase the transparency and reproducibility of the interview processing.

9.2.2. DISCUSSION

It appeared not feasible to quantify the social damage caused by overloading in terms of road safety reduction and unfair competition. With regard to road safety, this was caused by a lack of data. Concerning unfair competition, it is estimated that the total economic benefit of overloading for violating transporters equals 613 million euros (Inspectie Leefomgeving en Transport, 2017a). The economic benefit however is not equal to the social costs other transporters and society encounter. It appears to be difficult, if not impossible, to fully quantify these effects. The intangible and challenging to quantify relations between enforcement, compliance and social damage limits policy makers in decision making on weight enforcement. The problem has a low political priority since individual governmental bodies do not feel responsibility to address the problem and do not actively feel the consequences of overloading.

Although the estimation of costs and benefits of weight enforcement provides valuable information on the magnitude of the problem and costs to solve it, other considerations could be taken into account in decision-making process as well. From a normative point of view, one could namely argue that it is the government's role to facilitate an equal playing field and fair competition and should therefore enforce maximum weight regulations independent of the costs to do so.

9.3. SCIENTIFIC CONTRIBUTION: RECOMMENDATIONS FOR FUTURE RESEARCH

At the start of this research, two knowledge gaps in the current literature were identified. Firstly, the deployment of WiM and other weight enforcement measures in a wider context, within dense, tightly interwoven multi-levelled road networks had not yet been addressed. Secondly, the possibilities and effects of combining various weight enforcement measures into complete strategies have not yet been explored and assessed in the existing literature.

Firstly, this research has expanded the knowledge on the integration of weight enforcement policy measures into strategies by applying the framework for enforcement measures by de Bruijn and ten Heuvelhof (2005), on the specific context of weight enforcement. Secondly, this research concluded that an integration of different enforcement styles is expected to result in a higher compliance level, since various groups of offenders can be addressed in this way. Additionally, while existing studies on weight enforcement are solely focussed on the implementation of one measure on corridors or highways, this research provided insight in how to address the problem of overloaded HGVs under 'Dutch conditions': in complex multi-levelled and dense road networks.

Within this research, reasoned assumptions are made on the composition of enforcement measures. Further research is needed to determine the optimum deployment of enforcement measures within the strategies. To be able to define the optimum number of digital checks, manual checks and communication moments, insight is needed in the relationship between the objective and subjective probability of being checked and compliance level.

Therefore, a recommendation for future research relates to the subjective chance of being checked and subjective chance of being sanctioned. The relationship between enforcement activities and compliance level is highly dependent on the subjective risk of being checked and being sanctioned. Improved knowledge on this highly complex relationship is needed to be able to define the number of fixed and random check locations required to achieve a certain compliance level. Existing literature shows that the subjective risk of being checked depends on the objective risk of being checked, the inescapability and unpredictability of checks, communication of enforcement measures and visibility of enforcement measures. Further research is needed to define the optimum mix between these factors, aimed at increasing the subjective risk of being checked. Quantitative model- or scenario studies could provide these insights.

9.4. SOCIAL CONTRIBUTION: RECOMMENDATIONS FOR POLICYMAKERS

Given the different role of various policymakers in weight enforcement, the recommendations in this section are for policymakers at various governmental bodies and levels. After some general recommendations, specific recommendations for respectively the Inspectorate for the Human environment and Transport Inspectorate (ILT) and regional road owners are made.

GENERAL RECOMMENDATIONS

The current level of weight enforcement does not result in the intended reduction of the number of overloaded transports on the Dutch road network. It could even be expected that the compliance level will decrease, due to the low enforcement level. It is therefore recommended for the Ministry of Infrastructure and Water Management to adopt a new enforcement strategy as soon as possible. Based on this research, it is recommended to scale up enforcement activities and deploy the enforcement strategy *OBW for automated enforcement* (Section 6.4.4). The analyses performed in this research indicate that, of the four examined strategies, the deployment of *OBW for automated enforcement* is expected to result in the largest reduction of the number of overloaded HGV movements. Policy makers should however acknowledge the need to make policy choices under the condition of incomplete information, to address the problem of overloaded HGVs. The relations between enforcement, compliance level and social damage are uncertain, intangible and highly complex.

The intangible relation between weight regulation compliance level and social damage should be made more insightful by the Ministry of I&W. Within one of the intergovernmental partnerships, working group Zwaartekracht, a first version of a calculation tool was developed. In the tool, which is still under construction, the impact of several vehicle-based parameters on the road infrastructure can be calculated. It should be noted that the major risk of such a tool is that it provides false certainty, since not all parameters can be fully included. It could however provide policy makers some feeling on the magnitude of the effects.

With regard to safety reduction by overloaded HGVs, it is recommended to actively registrate overloading as incident factor, to retrieve more insight in the safety aspect of overloading. Therefore, when overloading is suspected, heavy-goods vehicles involved in traffic accidents should be weighed to determine if overloading was one of the root causes of the accident or contributed to the severity of the accident. Based on this information, the social damage due to road safety reduction could be estimated.

RECOMMENDATIONS FOR THE ROAD OWNER

For regional road owners, it is recommended to systematically map out road damage possibly caused by HGV overloading, anticipating the introduction of *OBW for automated enforcement* and DSRC-based enforcement on regional road networks. Locations having a high risk of overloaded HGVs, suitable for the deployment of DSRC tripods, can be selected in this way.

Furthermore, as compliance stimulating measure within the *OBW for automated enforcement* strategy, it is recommended to include a separate contract Section including an explicit prohibition of overloading in contracts in which the road owner acts as a client. It is recommended to manage these contracts by the deployment of administrative and physical checks. With regard to the administrative checks, it is recommended to make the transporter responsible for providing relevant data on the weight of all performed transports. Additionally, physical checks should be deployed, in cooperation with the Inspectorate or not, to make sure the provided transport administration is correct.

9.5. MANAGERIAL IMPLICATIONS AND IMPLEMENTATION PROCESS

Given the amount of social damage caused by overloading each year and the malfunctioning of the current enforcement system, the Ministry of Infrastructure and Water Management should take a decision on the deployment of a new, comprehensive weight enforcement strategy as soon as possible. This research shows that all four designed weight enforcement strategies are expected to result in a significantly higher compliance level, compared to the current enforcement situation. In this section, a process design is suggested for the implementation of *On-Board Weighing for automated enforcement*. In this design, suggestions for the role and actions of various stakeholders are presented.

In Figure 34, four arenas are distinguished, in which various key stakeholders should take decisions on the implementation of future weight enforcement.

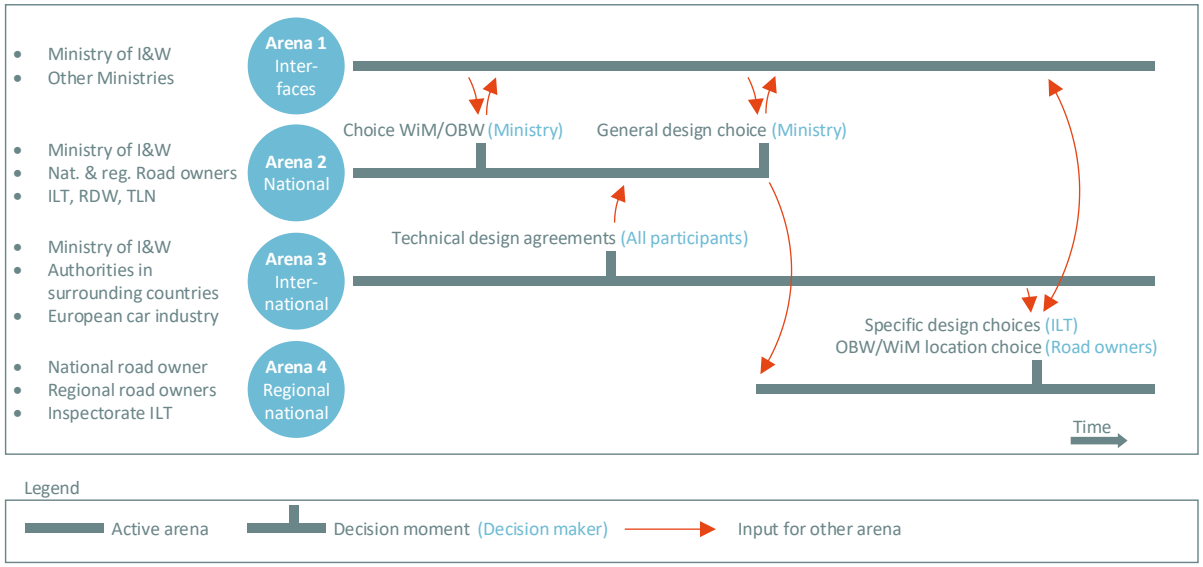

Figure 34 – Process design for future weight enforcement

1) Since choices concerning weight enforcement could impact other policy areas as well and synergy can be created between weight enforcement and other measures like road pricing, alignment with current affairs within the Ministry of I&W and other Ministries is desirable (Figure 34, Arena 1).
2) In the choice between WiM and OBW as main enforcement measure, the national and regional road owners, the Inspectorate, Dutch Road Authority and transport branch organisations should be consulted (Figure 34, Arena 2). Since the choice between WiM and OBW and exact design of future weight enforcement is decided upon at a strategical level, the Ministry of Infrastructure and the Environment should take the lead in this decision-making process.
3) Given the cross-border nature of heavy-goods transport, the Ministry of I&W should discuss the technical design of the proposed OBW strategy with relevant authorities from neighbouring countries (Figure 34, Arena 3). Doing so, two important advantages can be achieved. Firstly, the user interface of the technical systems can be aligned, improving the usability of the technical

systems for both transporters and enforcement authorities. Secondly, a cost reduction can be achieved by cross-border mass production of axle load sensors, on-board units and DSRC road-side beacons. Therefore, representatives from the European HGV building industry should be consulted in this arena as well.

4) When a general design decision on future weight enforcement is made by the Ministry, in which the outlines for future weight enforcement are determined, the national and regional road owners should work out the designed strategy into concrete plans (Figure 34, Arena 4). Not necessarily all regional road owners should be forced to participate in this process. This would slow down the decision-making process, while they could easily join later on. In this arena, close cooperation with the Inspectorate is needed, to align the different technical and managerial elements of the strategy.

During the implementation phase, a plan-do-check-act cycle should be followed. Continuously and closely monitoring the effect of the performed enforcement activities provides more insight in the complex relation between enforcement and compliance.

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OVERVIEW OF APPENDICES

APPENDIX I – ANALYSIS OF CURRENT WEIGHT ENFORCEMENT SITUATION

In this appendix, the analysis of the current weight enforcement situation is elaborated upon. In Figure 35, the analysis of spontaneous and enforced dimensions of compliance is displayed, according to the Table of Eleven (Centrum voor Criminaliteitspreventie en Veiligheid, 2010).

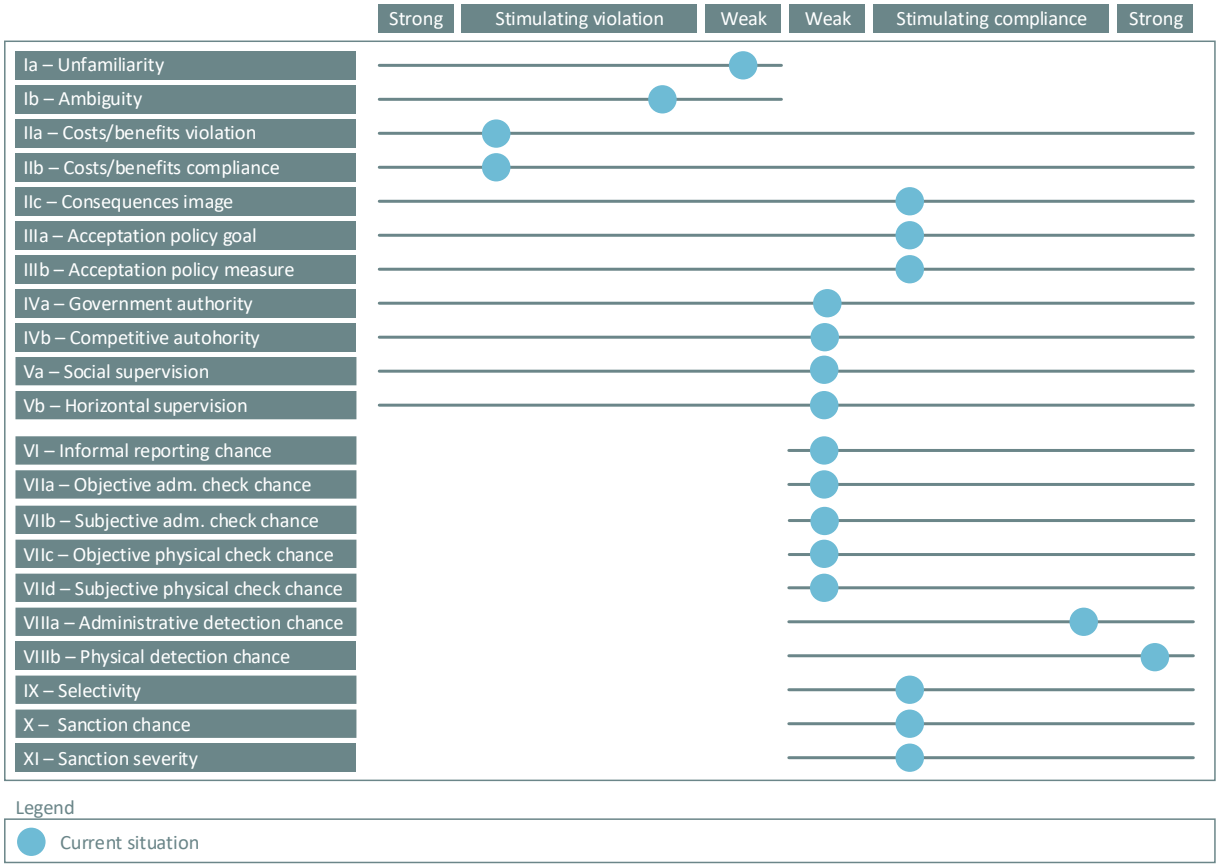

Figure 35 – Effects of current enforcement on the eleven dimensions of spontaneous and enforced compliance in the Table of Eleven

DIMENSIONS OF SPONTANEOUS COMPLIANCE

I. *Knowledge of rules*
II. *Costs and benefits*
III. *Level of acceptation*
IV. *Law abidance*
V. *Non-governmental control*

DIMENSIONS OF ENFORCED COMPLIANCE

VI. *Reporting probability*
VII. *Probability of being checked*
VIII. *Probability of being detected*
IX. *Selectivity*
X. *Probability of being sanctioned*
XI. *Sanction severity*

DIMENSIONS OF SPONTANEOUS COMPLIANCE

DIMENSION I – KNOWLEDGE OF RULES

The first dimension of spontaneous compliance concerns the knowledge and understanding of rules. The level in which applicable legislation and regulation is known and understood by transporters and shippers, as well as their clarity, can impact the level of compliance in two ways. On the one hand, more knowledge on legislation could lead to more compliance, for actors aiming to comply with the rules. On the other hand, more knowledge on legislation and regulation could lead to more strategic behaviour, since actors gain more insight in the possibilities to avoid regulation. From the perspective of the inspector, clear and unambiguous regulation are beneficial as well. More regulation and especially more complexity in regulation requires more enforcement capacity. In general, complex regulation requires complex enforcement activities (de Bruijn & ten Heuvelhof, 2005).

DIMENSION IA – UNFAMILIARITY

Knowledge of rules can be obtained during education or in practice. Information on the maximum load of HGV's is provided during the compulsory training for obtaining an HGV driving license. Additionally, an overview of maximum dimensions, GVW's and GTW's is provided by the RDW in a publication (Rijksdienst voor het Wegverkeer, 2012). The ILT published an info sheet on axle overloading, in which specific measures are presented that transporters could take to prevent axle overloading (Inspectie Leefomgeving en Transport, 2013a). On the website and application voertuiggewicht.nl, transporters can enter their license plate number to obtain information on the maximum weight of the corresponding HGV. According to TLN and ILT during the focus group session, the knowledge on maximum weight regulations in the transport sector is widespread. It is estimated by all parties that only a very small percentage, approximately 5 to 15 percent, of the transporters is not familiar with maximum weight regulations.

DIMENSION IB – AMBIGUITY

The maximum weight regulations in the Netherlands are relatively straightforward. According to the participants of the focus group session, it is the responsibility of transporters to familiarize themselves with these regulations and apply them on their business process. Although in this research no quantitative research is performed on this matter, it is not at all expected that misinterpretation of regulations leads to a lower compliance level.

DIMENSION II – COSTS AND BENEFITS

The second dimension of spontaneous compliance concerns the economic and immaterial costs and benefits of compliance with and violation of weight enforcement regulations. Four categories of costs and benefits are defined, visualised in Figure 36.

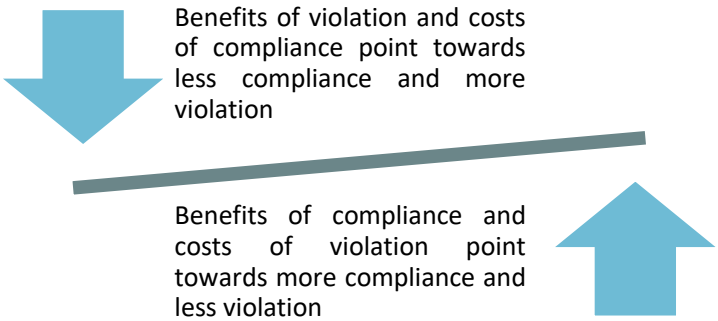

Figure 36 – Impact of costs and benefits of violation and compliance on compliance level

COSTS/BENEFITS OF VIOLATION

Violating the maximum weight restrictions comes with additional tire wear and increased fuel usage. In extreme cases of overloading, tire blowouts and broken axles could occur.

The benefits of violating the maximum weight restrictions are all economic and calculated in a confidential NEA report, commissioned by the Inspectorate. The economic benefits per ton overloading per ride are equal to €6,29 for GVW or GTW overloading over 50 tons, €5,98 per ton per ride for GVW or GTW overloading over the registration certificate and €6,12 per ton per ride for axle load overloading (NEA, 2011). The figures are averages, real costs depend on the exact axle configuration, length of the ride and several other factors.

In tenders by public and private clients, the price a contractor can offer plays a large role in the award of the contract. The economic benefit of overloading can be used to offer a sharper price to clients, to obtain a contract.

COSTS/BENEFITS OF COMPLIANCE

The costs of compliance with weight restrictions include costs for weight administration of goods, private weight scales and/or axle load sensors and/or training on correct HGV loading.

In general, the main benefit of compliance is to maintain a good company reputation. Within the recent covenants in the provinces of Limburg and Overijssel, companies participating and complying with weight restrictions are only checked in administration and not physically, which can be identified as an additional benefit. After all, physical weight checks could take up to an hour, seriously impacting the business management.

DIMENSION III – LEVEL OF ACCEPTATION

The third dimension of spontaneous compliance concerns the level of acceptation of policy goals and the level of acceptation of enforcement measures to achieve these policy goals. Research showed that regulatees accepting the policy measure are more likely to comply with the regulation (Kagan & T. Scholz, 1984). Although no specific research in the field of HGV weight enforcement has been executed, it is commonly agreed upon that cultural and individual factors strongly influence the effectiveness of enforcement. Individual aspects influencing the attitude towards enforcement include gender, age, work status, level of education, years of driving experience and exposure and accident history.

A number of researches has been performed to gain insight in the individual attitude towards traffic enforcement, including a research performed within the ESCAPE project, based on the SARTRE database covering drivers in 13 EU Member States. In this comparative research, it was shown “that drivers who are male, young, single, professionally independent, with high annual kilometrages, short-to-medium driving experience and reporting having had road accident(s), are more likely to be opposed to enforcement of traffic regulations” (Cauzard & Quimby, 2000, p. 2). Within the European Union, the population in northern countries is more in favour of traffic enforcement. In the Netherlands, 54 percent of the respondents was in favour of traffic enforcement, while respectively 30 and 16 percent were neutral or opposed to traffic enforcement. Compared to EU Member States in the south of Europe, like Portugal, Greece and France, in which up to 48 of the respondents was opposed to traffic enforcement, the acceptation rate is very high.

DIMENSION IV – LAW ABIDANCE

The fourth dimension of spontaneous compliance concerns the general extent to which the transport sector is willing to conform to the authority of the government or its own standards and values.

DIMENSION IVA – GOVERNMENT AUTHORITY

With respect to this dimension, the introduction of the digital tachograph provides interesting insights in the level of law abidance in the sector. According to Gerard Schipper, Acting General Delegate at Euro Contrôle Route, the cooperation of European road transport enforcement bodies, 20 to 30 percent of the digital tachographs are manipulated (Schipper, 2018). Although this is just one example and the level of willingness of

transporters to conform to the authority of the government has not been researched yet, it is expected that the compliance motivating nature of this dimension will be weak.

DIMENSION IVB – COMPETITIVE AUTHORITY

Competitive authority includes the own norms and values of the transport sector. The compliance or violation stimulating character of this dimension is expected to be relatively weak. For non-complying transporters, the habit to add a few tons to the gross vehicle weight might have a weak violation stimulating character.

DIMENSION V – NON-GOVERNMENTAL CONTROL

The fifth dimension of spontaneous compliance concerns non-governmental control. In this dimension, a distinction is made between social supervision and horizontal supervision. Social supervision is exercised by the social environment, for example by family, friends or competitors. Horizontal supervision is a formalized form of social supervision, in which for example external accountants perform supervision.

DIMENSION VA – SOCIAL SUPERVISION

According to TLN during the focus group session, the level of social supervision on overloading is extremely low, if not nil. This image was confirmed by other participants. The nature of transport activities does not really allow for social supervision,

DIMENSION VB – HORIZONTAL SUPERVISION

A form of horizontal supervision was found in the sand supply industry in the province of Limburg, were an external accountant supervised the compliance with a covenant. In general, however, the compliance stimulating nature of horizontal supervision is weak.

DIMENSIONS OF ENFORCED COMPLIANCE

DIMENSION VI – REPORTING PROBABILITY

The sixth dimension of enforced compliance concerns the perceived probability of someone in the close environment reporting violations of the maximum weight regulation to the authorities. According to TLN during the focus group session, the chance of being reported by another transporter or shipper is nil. This impression is confirmed by the ILT, who receives only a very limited amount of reports on overloading (Inspectie Leefomgeving en Transport, 2015).

DIMENSION VII – PROBABILITY OF BEING CHECKED

The seventh dimension concerns the probability for overloaded transports of being checked by an enforcement authority. The probability is defined by the number of checks performed by the ILT and police and the number of transports in the Netherlands. A distinction is made between administrative checks and physical checks and between the objective and subjective probability of being checked. The subjective risk of being apprehended is dependent on the regularity of checks, the amount of publicity accompanied with the checks, the randomness and visibility of checks and the possibility of avoiding checks (Stichting Wetenschappelijk Onderzoek Verkeersveiligheid, 2016).

DIMENSION VIIA – OBJECTIVE ADMINISTRATIVE CHECK CHANCE

Apart from a few covenants, no administrative checks are performed. Hence, the compliance stimulating nature of this dimension is weak.

DIMENSION VIIB – SUBJECTIVE ADMINISTRATIVE CHECK CHANCE

Apart from a few covenants, no administrative checks are performed. Hence, the compliance stimulating nature of this dimension is weak.

DIMENSION VIIC – OBJECTIVE PHYSICAL CHECK CHANCE

According to the 2015 annual report of the ILT, 4.700 physical weight checks were realized in that year (Inspectie Leefomgeving en Transport, 2016). The physical checks were partially based on a pre-selection by the WiM system on the national road network. The physical checks were performed using static weight scales. The Inspectorate concludes that the compliance with maximum weight regulations decreased slightly compared to the years before 2015.

The most recent data on the number of performed weight compliance checks was found in the 2016 annual report of the ILT. In that year, according to the multiannual planning, 3000 weight checks were scheduled. However, none of them were actually realized (Inspectie Leefomgeving en Transport, 2017b). Although no explanation is provided in the annual report, the malfunctioning of WiM systems on the national road network is expected to be the cause of this. All participants of the focus group session considered the probability of being checked to be extremely low, especially since the WiM systems are not used for enforcement purposes anymore.

DIMENSION VIID – SUBJECTIVE PHYSICAL CHECK CHANCE

Almost all of the manual checks are performed at highways. Although the checks are relatively random and not anticipated upon by transporters, their extremely low number still does not lead to a compliance motivating effect.

DIMENSION VIII – PROBABILITY OF BEING DETECTED

The eighth dimension of enforced compliance concerns the probability of being detected, when being checked.

DIMENSTION VIIIA – ADMINISTRATIVE DETECTION CHANCE

For administrative checks, the chance of being detected when being checked is close to 100 percent. The effect is strongly compliance motivating.

DIMENSION VIIIB – PHYSICAL DETECTION CHANCE

For the random checks using static weighing scales, the chance of being detected when being checked is close to 100 percent. The effect is strongly compliance motivating.

DIMENSION IX – SELECTIVITY

The ninth dimension of enforced compliance concerns the perceived probability of control and detection in the event of a violation, by selective control of certain HGV types, companies or areas. The ILT uses some sort of profiling in their enforcement activities, which has a moderate compliance stimulating effect.

DIMENSION X – PROBABILITY OF BEING SANCTIONED

The tenth dimension of enforced compliance concerns the probability of being sanctioned, when being detected. In the ‘top 100’ approach of the Inspectorate, as deployed in 2014 and 2015, the fictive social costs of overloading are calculated, per company. The 100 companies causing the highest fictive social costs, exceeding 10.000 euro, were sent letters to inform them they are being closely monitored by the Inspectorate.

With regard to manual checks, vehicles with a GVW or GTW over 50 tons are sanctioned starting at 5 percent overloading. Vehicles with a GVW or GTW exceeding the weight limit in the registration certificate are sanctioned starting at 5 percent overloading as well. Vehicles with one or more axle loads exceeding the axle load limit in the registration certificate are sanctioned starting at 10 percent overloading. Since at this moment only manual checks are deployed, the compliance stimulating nature of this dimension is moderate.

DIMENSION XI – SANCTION SEVERITY

The eleventh and last dimension concerns the sanction severity. Numerous researches confirm that the severity of a sanction impacts the compliance rate (Thornton, Kagan, & Gunningham, 2003).

A distinction should be made between the cease and desist orders, following on overloading detected in digital checks (between 2014 and 2015), and fines, following on overloading detected in physical checks. The Human Environment and Transport Inspectorate (ILT) monthly summoned the 100 offending companies responsible for the largest economic damage. Within three months, these companies had to reduce their overloading with 37 percent. Otherwise, the Inspectorate would issue them cease and desist letters up to 10.000 euros. The height of the cease and desist order is based on the confidential NEA-report 'Overloading in road freight transport, Determination of the economic profit of individual transport companies through overloading of the freight vehicle'. The height of the cease and desist order depends on the violation category:

I. Vehicles with a gross vehicle weight (GVW) or gross train weight (GTW) over 50 tons.
   (€ 100, - + (tonnes overloading x € 6,29)) x 5 with a maximum of €10.000
II. Vehicles with a gross vehicle weight (GVW) or gross train weight (GTW) exceeding the weight limit in the registration certificate.
   (€ 100, - + (tonnes overloading x € 5,98)) x 5 with a maximum of €10.000
III. Vehicles with one or more axle loads exceeding the axle load limit in the registration certificate.
   (€ 100, - + (tonnes overloading x € 6,12)) x 5 with a maximum of €10.000

The target of cease and desist orders is to stimulate offenders not to violate the maximum weight restrictions again (article 5:32, vijfde lid Awb). The cease and desist order can be forfeited, when the vehicle is weighed on a static scale. Fines are increased by 50 percent for second-time offenders and by 100 percent for third-time offenders. Fourth-time offenders are directly summoned and under specific circumstances the vehicle can be confiscated.

Transporters are obliged to directly reduce the load of their HGV when the GVW or GTW exceeding is more than 10 percent or when the axle load exceeding is more than 20 percent. The obligation to transfer the load to another vehicle, can have a large impact on the transporter, especially when deadlines cannot be met. It requires an extra investment and lost income.

APPENDIX II – FOCUS GROUP SESSION GUIDE

In this appendix, the focus group session as organised on 27 March 2018 is described. The session was held at the House of province in the Hague and had a duration of three hours. During the first part of the session, a presentation was given on the analyses so far. Both the compliance estimation as well as the analysis of the current enforcement situation in the Table of Eleven were presented, serving as a theoretical input for the three discussion rounds. The theoretical view on overloading stimulated the participants to approach the problem from a different perspective. During three discussion rounds, the individual perceptions of the participants on the problem were discussed, starting points for enforcement were elaborated upon and possible enforcement measures and combinations of measures were discussed. The discussion on possible solutions was deliberately and actively postponed to the third discussion round, to stimulate participants to discuss and reveal their own interests first.

The following questions served as starting points for the discussion rounds. During the rounds, several follow-up questions were asked by the author, to gain deeper insight in the interests and opinions of the different participants.

II. INDIVIDUELE PROBLEEMPERCEPTIES EN BELANGEN

- Vanuit eigen organisatie/werkveld geredeneerd
- Wat ziet u als 'het probleem overbelading' en wat is de impact ervan op uw organisatie?
- Wat is voor u de voornaamste reden waarom 'het probleem overbelading', zoals door u geschetst, nog aanwezig is?
- Wat zijn de belangen van uw organisatie/werkveld in 'het probleem overbelading'?

III. UITGANGSPUNTEN VOOR OMGANG MET OVERBELADING

- Binnen juridische kaders
- De grenzen waarbinnen oplossingsstrategieën gezocht moeten worden

IV. BEOORDELING OMGANGSSTRATEGIEËN

- Gegeven uw probleemperceptie en uitgangspunten voor handhaving
- Hoe staat u tegenover de volgende mogelijkheden tot handhaving?
- Combinatie van interventies/ duale handhavingsstrategie kan ook

APPENDIX III – FOCUS GROUP SESSION REPORT

DATUM & TIJD

27 maart 2018, 09.00 – 12.00

LOCATIE

Provinciehuis Provincie Zuid-Holland, Zuid-Hollandplein, 2596AW Den Haag

AANWEZIG

Kees Hersbach	Specialistisch adviseur Inspectie Leefomgeving en Transport (ILT)
Jeffrey Broeders	Sr. Beleidsmedewerker Gemeente Zoetermeer
Willy Hoogma	Rayoncoördinator Provincie Overijssel
Inge Blommers	Assetmanager Wegen Provincie Zuid-Holland (PZH)
Patricia van der Holst	Adviseur Verhardingen Provincie Zuid-Holland (PZH)
Nico Meininger	Sr. Beleidsmedewerker Kunstwerken Provincie Zuid-Holland (PZH)
Bert de Rooij	Manager Ontheffingen Rijksdienst voor het Wegverkeer (RDW)
Joris Cornellissen	Programmamanager Truck Platooning Rijkswaterstaat (RWS)
Jan Top	Adviseur Goederenvervoer Rijkswaterstaat (RWS)
Ambro Smit	Secretaris Techniek, Deelmarkt exceptioneel vervoer en Autotransporteurs Transport en Logistiek Nederland (TLN)
Martijn van Velzen	Afstudeerder Technische Universiteit Delft/Provincie Zuid-Holland (PZH)
Tonnie Roelofs	Adviseur Wegen Waterschap Rivierenland

UITGENODIGD

Remko Molenaar	Adviseur civieltechnische constructies Provincie Zuid-Holland (PZH)

OPENING EN WELKOM

Genodigden worden welkom geheten door Martijn. Het programma van de focus group sessie bestaat uit vier achtereenvolgende onderdelen, te weten

I. Wetenschappelijke benadering van overbelading
II. Individuele probleempercepties en belangen
III. Uitgangspunten voor omgang met overbelading
IV. Beoordeling omgangsstrategieën

waarvan het eerste onderdeel een presentatie is van de onderzoeksresultaten van het afstudeeronderzoek tot op heden en de overige drie onderdelen discussieronden zijn, waarvan de laatste wordt ingeleid met een korte uiteenzetting van het pallet aan omgangsstrategieën.

I. WETENSCHAPPELIJKE BENADERING VAN OVERBELADING

Zowel de juridische, technische als sociale context van het probleem overbelading worden beschreven door Martijn.

OPMERKINGEN BIJ DE PRESENTATIE

Met betrekking tot de harmonisatie van maximum toegestane gewichten in de Europese Unie: Maximum toegestane totaalgewichten voor nationaal transport verschillen in de Europese Unie per land. Maximum toegestaan totaalgewicht voor internationaal transport binnen de Europese Unie is wel geharmoniseerd en gelijk aan 40 ton.

Met betrekking tot het wel of niet uitgeschakeld zijn van de Weigh-in-Motion systemen op het Hoofdwegennet: Het is onduidelijk of de Weigh-in-Motion systemen zijn uitgeschakeld. Ze worden niet meer gebruikt in handhaving door de ILT.

Met betrekking tot de nalevingsschatting: *Spontane nalevers / Bewuste nalevers* zijn bekend met de regels omtrent overbelading en leven deze na, ook in het geval waarin er geen handhaving op overbelading zou plaatsvinden. *Onbewuste nalevers* kennen de regels omtrent overbelading niet, maar leven deze na zonder erbij stil te staan. *Handhavingsafgeschrikten* zijn bekend met de regels omtrent overbelading en zouden deze wel willen overtreden, maar worden afgeschrikt door handhavingsactiviteiten. *Bewuste overtreders* zijn bekend met de regels omtrent overbelading en kiezen er voor deze willens en wetens te overtreden. *Onbewuste overtreders* overtreden de regels omtrent overbelading omdat zij niet op de hoogte zijn van de regels of deze niet begrijpen. Door TLN wordt benadrukt dat er een verschil is tussen overbelading op totaalgewicht en overbelading op assen. Vanuit TLN is de indruk dat overbelading op totaalgewicht niet meer dan vijf procent van de vrachtwagens betreft. Overbelading op assen heeft een groter aandeel, en heeft vooral te maken met verschuivingen in aslast bij tussentijds herladen.

II. INDIVIDUELE PROBLEEMPERCEPTIES EN BELANGEN

Het convenant tussen de ILT en Suiker Unie, het zogenoemde suikerbietenconvenant, wordt aangehaald als voorbeeld van een succesvolle strategie om overbelading tegen te gaan. De prikkel voor de vervoerder om over te beladen is weggenomen omdat suikerij niet meer betaalt dan het maximum laadvermogen.

Voor veel ondernemers en opdrachtgevers lijkt geld toch de primaire prikkel te zijn om over te beladen. Opdrachtgever alsnog anders benaderen als ondernemer. Door veel overheden (grootste opdrachtgever) wordt in bestekken al meegenomen dat overbelading niet is toegestaan. Vanuit de werkgroep overbelading van het platform Wegbeheerders ontmoeten Wegbeheerders wordt deze gedachte en handelswijze verder verspreid onder overheden. Enerzijds kost het de opdrachtgever geld om dit in contracten op te nemen, anderzijds levert het geld op in de vorm van minder schade aan infrastructuur. In een ideale situatie zouden bedrijven zich uit zichzelf houden aan wet- en regelgeving rondom overbelading.

Volgens RWS zou het helpen als de overheid, via handhaving, zou uitstralen overbelading een urgent probleem te vinden, maar gebeurt dit niet. TLN sluit zich hierbij aan, en geeft aan dat het zeer pijnlijk is om te zien dat een grote groep zich aan de regels houdt en tegelijkertijd moet toezien hoe een kleine groep ermee wegkomt zich niet aan de regels te houden. TLN is sterk voorstander van landelijk Weigh-in-Motion (WiM) netwerk, om een level playing field te bereiken. Tekort aan handhaving is volgens TLN het probleem.

Link met buitenlandse kentekenregisters moet worden gelegd om ook buitenlandse overtreders te kunnen beboeten, volgens TLN, waar anderen zich bij aansluiten. Een goed deel van de buitenlandse vervoerders houdt zich wel aan regelgeving, maar het deel wat dit niet doet moet beboet kunnen worden. Vergelijking met milieuzones wordt gemaakt, waarin ook op verschillende schaalniveaus wordt gehandhaafd. Echter, een groot

deel van het transport is binnenlands, dus ook zonder Europese harmonisatie op het gebied van wet- en regelgeving en handhaving kan er veel worden bereikt.

Naast het belang van wegbeheerders om overbelading terug te dringen, gerelateerd aan infrastructurele schade, speelt ook het belang van verkeersveiligheid een rol. Op een lager schaalniveau speelt verkeersveiligheid in relatie tot overbelading een grotere rol. Waterschap Rivierenland geeft aan dat in hun areaal, voor een goed deel bestaande uit 15-tons wegen, met name overlast door trillingen en verkeersveiligheid van belang zijn. Er wordt geconcludeerd dat de afwegingen hierin op verschillende schaalniveaus anders zijn.

Van klapbanden en andere materiële schade door overbelading zijn volgens TLN enkele voorbeelden bekend. Door Martijn wordt benadrukt dat uit onderzoek blijkt dat doorstromingsproblemen als gevolg van extra onderhoud door een kortere levensduur van de weg een grotere impact hebben dan doorstromingsproblemen als gevolg van ongelukken door overbelading. Er wordt geconcludeerd dat met name op hogere schaalniveaus het veiligheidsbelang in de omgang met overbelading klein is.

Rijkswaterstaat benadrukt het belang van het inzichtelijk maken van de urgentie van het probleem overbelading, de omvang van het vrachtvervoer in relatie tot het beheer en onderhoud van het areaal. Het beter illustreren van die urgentie, bijvoorbeeld met behulp van de tool Zwaarteblik, ontwikkeld in de werkgroep Zwaartekracht, zou kunnen helpen het probleem overbelading hoger op de agenda te zetten.

Koffiepauze

III. UITGANGSPUNTEN VOOR OMGANG MET OVERBELADING

De vraag die volgens ILT gesteld zou moeten worden is welke activiteiten en prikkels er nodig zijn om stakeholders te bewegen tot andere actie (zijnde niet meer overbeladen). Het voorbeeld van de suikerbietenindustrie wordt aangehaald om te illustreren dat het belang van de stakeholder suiker Unie, Maatschappelijk Verantwoord Ondernemen, het startpunt was voor bereidheid om overbelading tegen te gaan.

Uit analyses van ILT op basis van WiM data blijkt dat de containersector, bouwsector en los gestort sector (grond-, weg- en waterbouw) de boventoon voeren bij overbelading. Vanuit ILT wordt benadrukt dat de overheid in laatstgenoemde sector de grootste opdrachtgever is en er moet worden gekeken hoe je in je contract omgaat in overbelading. ILT gelooft niet meer in voorlichting, maar meer in de aanpak van deelsectoren (voorbeeld bietensector).

Daarnaast worden lidstaten vanuit de Europese Unie opgedragen Weigh-in-Motion of aslastsensoren te gebruiken in controles. ILT geeft aan niet de beleidsmaker te zijn en dat huidige wegsystemen erg beheer- en onderhoudsgevoelig zijn. On-Board Weighing wordt door ILT beschreven als veelbelovende optie, maar plaatst ook daar kanttekeningen bij. Als dit in Nederland verplicht zou worden verwacht ILT niet dat de kunde en kennis aanwezig zal zijn die hiervoor nodig is. ILT geeft aan dat de pakkans een belangrijk punt is en dat uitleesbaarheid door de handhavingsautoriteit hier positief aan bijdraagt. Ook TLN ziet hier mogelijkheden.

De rol van de verlader wordt onderstreept door ILT en TLN en geïllustreerd met een voorbeeld bij de ECT, waarbij chauffeurs zien dat een container overbeladen/verkeerd beladen is, maar Europe Container Terminals (ECT) weigert de container terug te nemen. Tegen Nederlandse beladers en verladers kan nog wel worden opgetreden, richting buitenlandse verladers is dit niet mogelijk.

In vergelijking met andere landen wordt de mening dat Nederland het goed doet op het gebied van omgang met overbelading breed gedragen. Een Australisch Intelligent Acces Program, waarin extra (kortere) routes worden opengesteld als je je aslast via aslastsensoren real-time doorgeeft aan de handhaver, wordt genoemd als interessante optie. Positieve prikkels helpen, in een omgekeerd systeem, waarbij transporteur informatie

aanlevert aan autoriteit in ruil voor een voordeel. ILT waarschuwt dat buitenlandse systemen niet altijd één op één te vertalen naar de Nederlandse context. Het organiseren van slots is volgens ILT een grote opgave.

Een systeem waarbij aslasten worden gebruikt voor directe handhaving werkt alleen als ook daadwerkelijk wordt gehandhaafd. Gemeente Zoetermeer geeft aan dat het digitaler en slimmer moet kunnen dan met handhavers langs de weg. TLN benadrukt dat zij positief tegenover convenanten en afspraken met vervoerders in sectoren staat, maar dat we er niet aan ontkomen op een slimme manier te moeten handhaven, om een level playing field te creëren. Als opties worden WiM, gerichte handmatige controles of andere slimme toepassingen genoemd.

ILT pleit ten slotte voor een oplossing waarin directe beboeting mogelijk is. Uit trajectcontroles op snelheid is gebleken dat dit het beste werkt.

Door ILT is in diverse sectoren ruchtbaarheid gegeven aan de mogelijkheid tot het afsluiten van een convenant met de Inspectie. Het idee van convenanten werkte bij suiker Unie, omdat dit een monopolist is, maar een uitrol bij asfaltboeren blijkt uit concurrentieoverwegingen niet ondersteund te worden.

IV. BEOORDELING OMGANGSSTRATEGIEËN

Ter introductie van de laatste ronde wordt door Martijn een niet-uitputtend pallet aan omgangsstrategieën gepresenteerd.

OPMERKINGEN BIJ DE PRESENTATIE

Weigh-in-Motion wordt in Hongarije toegepast, met een andere techniek als in Nederland, waarvoor een vrij brede sleuf in het asfalt nodig is. Andere landen grijpen Weigh-in-Motion aan voor andere beleidsdoelen, zoals het tegengaan van belastingontduiking of tolbetaling naar gewicht.

Bij directe handhaving via aslastsensoren speelt privacy mee. Ter illustratie: de digitale tachograaf zendt wel informatie over of het apparaat aan staat en goed wordt gebruikt naar de autoriteiten, maar geen inhoudelijke informatie over rij- en rusttijden. ILT zou graag zien dat het privacy-aspect van directe handhaving op Europees niveau wordt afgehandeld. Provincie Zuid-Holland benadrukt dat met de juiste prikkels transporteurs wellicht kunnen worden overgehaald informatie te delen. ILT zet uit eigen ervaring vraagtekens bij deze prikkels. Volgens de gemeente Zoetermeer moet ook dit in Europees verband worden geadresseerd, om een gelijk speelveld te behouden.

DISCUSSIE

Provincie Zuid-Holland geeft aan de gevolgen van overbelading wel te ervaren en wel een belang te hebben bij de aanpak ervan, maar zich af te vragen wie aan de lat staat er iets aan te doen, te handhaven en tijd voor vrij te maken. ILT geeft aan dat gemeenten bijvoorbeeld wel de rol van toezichthouder hebben, door bijvoorbeeld bepaalde wegen open te stellen of te sluiten of routering aan te geven en verwijst als voorbeeld naar de afsluiting van de binnenstad van Delft als logistieke zone. Zuid-Holland geeft aan dat de moedwillige overtreders hier niet mee worden tegengehouden.

Volgens de Gemeente Zoetermeer zijn de kosten van handhaving en de effecten ervan van belang om te komen tot een politiek oordeel over wel of niet te handhaven. Hierop presenteert RDW Zwaarteblik, namens werkgroep Zwaartekracht. Dit is een tool voor het hoofdwegennet, waarmee de relatie tussen overbelading en beheer- en onderhoudskosten inzichtelijk kan worden gemaakt. Het effect van een bepaalde configuratie van vrachtwagens en mate van overbelading op beheer- en onderhoud voor zowel kunstwerken als verharding kan worden berekend. De tool geeft inzicht in de gebruiksafhankelijke kosten voor bestaande en nieuwe trajecten. Volgens RDW gaat het voor transporteurs heel erg over het verdienmodel, maar voor wegbeheerders juist ook over waar

je geld aan uitgeeft en waar je invloed op uit kunt oefenen. ILT benadrukt dat de belangen van de vervoerders met deze tool niet inzichtelijk worden.

ILT draagt als mogelijkheid aan weeglussen aan te leggen bij de in/uitgang van grote bedrijventerreinen, met bijbehorende prikkel om de infrastructuur er omheen te upgraden, maar de kosten ervan bij de bedrijven op het bedrijventerrein te leggen als overbelading plaatsvindt.

De provincie Zuid-Holland is geïnteresseerd in ontwikkelingen in de sector die in de komende jaren invloed zouden kunnen gaan hebben op de mate van overbelading. Door TLN wordt de elektrificering van vervoer in binnensteden genoemd als trend, met kleinere voertuigen. Dit zou voor de stad een positieve uitwerking kunnen hebben, in de vorm van minder zwaar transport bewegingen. Ook een toename van LZV's wordt verwacht. RWS benadrukt de duurzaamheid van LZV's. Platooning is volgens RWS nog toekomstmuziek, maar heeft wel potentie als innovatie. Door TLN wordt geopperd dat de LZV XL wellicht op speciale corridors in Nederland in de toekomst toegestaan kan gaan worden.

RWS benadrukt dat er al een breed pallet aan mogelijkheden is uitgeprobeerd en de oplossing ook gevonden zou kunnen worden in het nadrukkelijker uitvoeren van wat we nu al doen. Zwaarteblik wordt hierin gezien als een positieve tool met een grote duidingskracht om inzichtelijk te maken wat overbelading betekent voor beheer en onderhoud. ILT oppert de ondernemer bewust te maken van de schade die hij aanricht. Een koppeling tussen Weigh-in-Motion en de schade aan het wegdek zou, aldus ILT, een uitkomst zijn. Een fonds, waar alle vervoerders geld in moeten stoppen op basis van non-conformiteit met regels omtrent overbelading wordt als idee geopperd door ILT. Het veelvuldig informeren van overtreders zou op bestuursrechtelijke basis een ander handhavingsinstrument kunnen bieden, waarbij een Last onder Dwangsom kan worden opgelegd. Hierbij is het van belang dat het WiM systeem voldoet aan een aantal voorwaarden, welke niet zo strikt zijn als wanneer je WiM voor strafrechtelijke doeleinden wil gebruiken. Het verbeuren van de Last onder Dwangsom zou plaats kunnen vinden op basis van vooraf afgesproken condities. Volgens TLN is de top 100 aanpak, waarin brieven werden verstuurd naar overtreders, in de basis goed. TLN benadrukt wel dat de basis waarop dit gebeurt betrouwbaar moet zijn, want als dat niet zo is wordt het systeem aan alle kanten onderuitgehaald.

Een grote aansprekende groep koplopers in het bedrijfsleven zou het voortouw kunnen nemen in de strijd tegen overbelading, door het goede voorbeeld te geven, volgens RWS. Het bewustzijn zou hiermee kunnen worden vergroot, naast handhaving. TLN geeft aan dat hiermee de subgroepen waar het nu vaak mis gaat niet worden bereikt. RWS denkt dat de middengroep, die niet altijd even bewust bezig is met overbelading, hiermee wel bereikt zou kunnen worden. Volgens ILT zou het een grote stap voorwaarts zijn als de genoemde groep koplopers ook hun onderaannemers zou aanjagen conform hun standaarden te werken en niet meer over te beladen. Provincie Overijssel benadrukt dat ook de overheid als opdrachtgever het goede voorbeeld moet geven. Provincie Zuid-Holland draagt aan dat bij de Rijnlandroute, waarbij de overheid opdrachtgever is, geen controle op overbelading plaatsvindt. ILT geeft aan dat met Rijkswaterstaat is afgesproken dat in contracten boetes zouden worden opgenomen, maar dat niet op alle werken contractmanagement werd uitgevoerd.

AFSLUITING EN VERVOLG

Een korte uiteenzetting van het verdere afstudeeronderzoek wordt door Martijn gegeven, met als conclusie dat de bal uiteindelijk ligt bij de stakeholders die aan tafel zitten, maar ook andere partijen op verschillende schaalniveaus. Martijn geeft aan dat de notulen van de workshop binnen enkele dagen worden verzonden naar alle genodigden, en in een later stadium in het afstudeeronderzoek opnieuw contact plaatsvindt met genodigden.

APPENDIX IV – MAIN ENFORCEMENT MEASURES ON REGIONAL ROAD NETWORKS

In this appendix, the feasibility of the deployment of the four main enforcement measures (as presented in Section 6.1.3) on regional road networks is examined in a small case study for the regional road network administered by the Dutch province of Zuid-Holland.

The province of Zuid-Holland (PZH) is one of the largest regional road owners in the Netherlands. The administration of the provincial asset, among others consisting of 520 kilometres of main carriageways and 132 kilometres of side carriageways, is executed by the Infrastructure Management Office (DBI) (Blommers et al., 2017). The amount of HGV trips and additional maintenance costs for the province of Zuid-Holland are expected to be significant: Zuid-Holland has the most permits for professional transport and the total loaded and unloaded weight (domestic and bilateral) in Dutch freight transport is the largest in Zuid-Holland (Transport en Logistiek Nederland, 2017). The presence of some of the biggest Dutch cities, green ports Oost- en Westland, the Bollen-area and Boskoop, main port Rotterdam and a number of large business parks form the basis for the large number of freight transport movements in the province of Zuid-Holland. For the province of Zuid-Holland, it is estimated that 38 percent of the HGV trips starts and ends in the province (intern), 52 percent starts or stops in the province (extern traffic) and 10 percent neither starts nor stops in the province (through traffic)(Ecorys and Goudappel Coffeng, 2007).

In the first section, the magnitude of the problem on the PZH road network will be analysed, based on data retrieved from counting loops in the network. Sub sequentially, in Section 2, the deployment of the main enforcement measures on the regional network will be discussed, after which in Section 3 conclusions are drawn.

1. ANALYSIS OF THE PROBLEM OF OVERLOADING ON THE PROVINCIAL ROAD ASSET

Based on existing reports, the additional road maintenance costs of HGV overloading for the road asset of the province of Zuid-Holland are estimated. Subsequently, a number of transport corridors is identified at which the risk on a high number of overloaded HGVs is high.

1.1. ADDITIONAL ROAD MAINTENANCE COSTS ON THE PZH ROAD ASSET

It is estimated that on the entire Dutch national road network, the annual extra road maintenance costs due to HGV overloading are 34 to 100 million euros per year (Hersbach et al., 2011). Based on this analysis, the annual extra road maintenance costs for the province of Zuid-Holland are based on the following notions:

- The length of the road network as owned by the province of Zuid-Holland and administered by the DBI is equal to 520 kilometres, about seventeen percent of the length of the national road network as administered by RWS (main carriageways)(Blommers et al., 2017; Centraal Bureau voor de Statistiek, 2017)
- Data from PZH counting loops showed the average HGV intensity per day on the PZH road network to be equal to 745, about 20 percent of the average HGV intensity on the national road network (Rijkswaterstaat, 2017).
- The maintenance regime on the national road network is estimated to be slightly harder, resulting in earlier replacement (Hersbach et al., 2011)

Based on these notions, a rough estimation of the yearly additional maintenance costs due to HGV overloading on the PZH road network can be made. These costs are estimated to be 0,9 to 3 million euros per year.

1.2. IDENTIFICATION OF HIGH-RISK CORRIDORS

For the identification of corridors having a high risk on HGV overloading, three approaches are considered, being:

I. Estimation based on the actual road damage
II. Estimation based on area and company profiles derived from the WiM system on the national road network
III. Estimation based on the actual number of HGVs derived from counting loops, combined with SBI category data on business parks

It appeared not to be feasible to identify high-risk corridors based on the actual road damage (approach I), since no reliable data is available on this matter. Additionally, road damage is dependent on a large number of factors including soil, type of foundation and pavement and weather. It neither appeared to be feasible either to identify corridors based on WiM area and company profiles (approach II), nor to identify high-risk companies, since this data sources were not available to the author.

Based on data from counting loops, the road sections with the highest HGV intensities (>1300/day) are displayed in red in Table 7 and Figure 37. For most of these road sections, the share of HGVs is relatively high as well. For a small number of other road sections, the share of HGVs is relatively high as well, but the HGV intensity does not exceed 1300 per day. These are presented in orange in Table 7 and Figure 37. Both on the sections with a high HGV intensity and a high HGV share, the risk on rapid pavement deterioration is relatively high, compared to other road sections. Therefore, these fourteen sections are identified as having a high risk on lifetime shortening due to pavement damage caused by HGV overloading.

Road number	Start	End
N206	Katwijk-Noord	Connection A44
N209	Connection A13	Connection A12
N211	Connection A4	Kwintsheul
N213	Poeldijk	Naaldwijk
N215	Connection N59	Nieuwe Tonge
N217	Connection A29	Maasdam
N219	Connection A20	Connection A12
N211/N222	Connection A4	Naaldwijk
N223	Connection A4	Connection N213
N470	Connection A13 – Ruiven	Connection A13 - Ruiven
N214	Connection N482	Connection A27
N216	River Lek	Connection N214
N453	Coenecoop	Connection A12
N466	Naaldwijk	Kwintsheul

Table 7 – Road sections with highest HGV intensities and/or share of HGVs

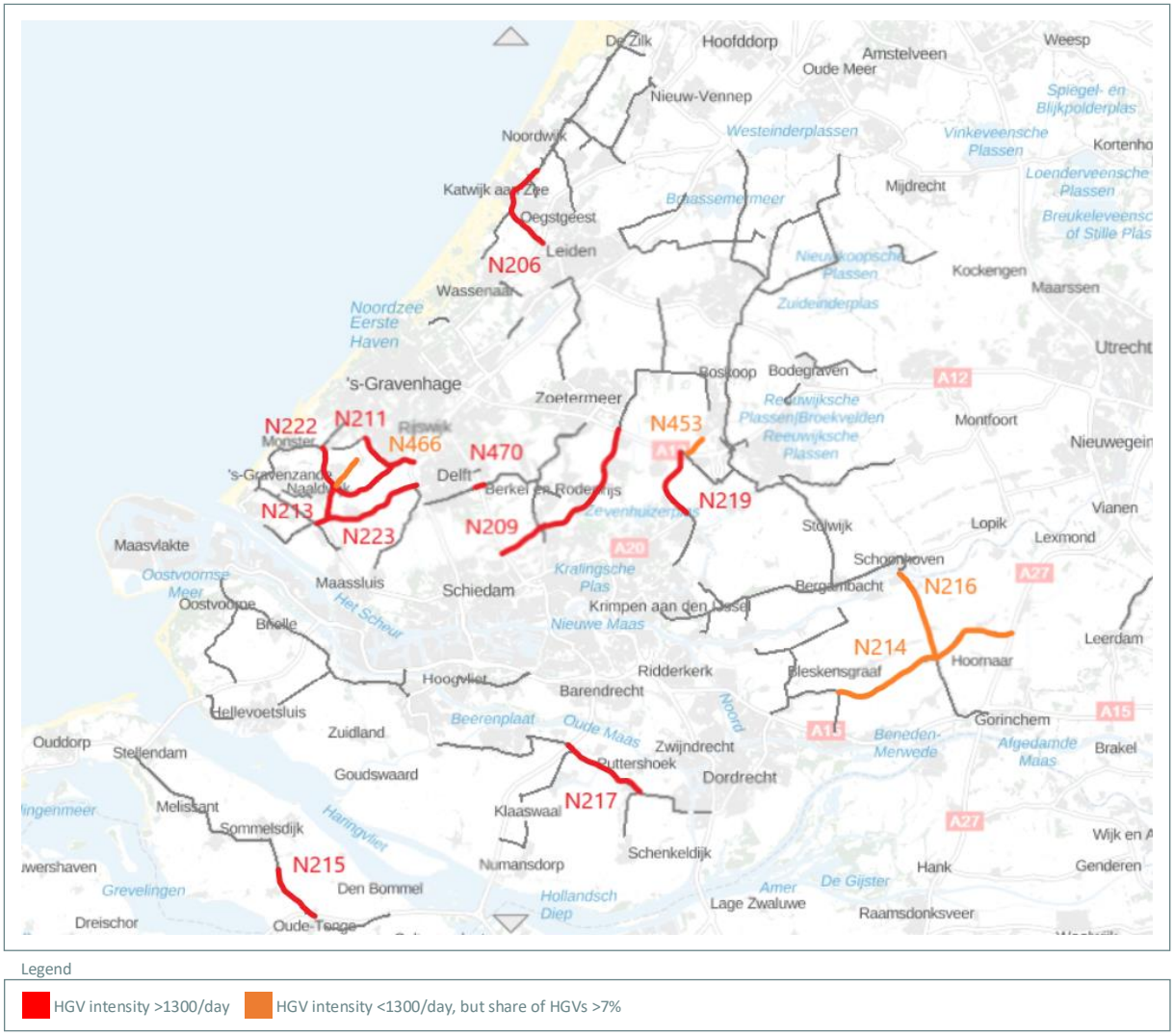

Figure 37 – Road sections with highest HGV intensities and/or share of HGVs

From Figure 37, it can be concluded that almost all road sections at which large absolute numbers of HGVs can be expected, are directly connected to the national road network, which underscores the need for an integrated approach.

2. EVALUATION OF MEASURES AT DEFINED CORRIDORS

In this section, the deployment of WiM and OBW main enforcement measure is qualitatively analysed.

2.1. WIM FOR PRE-SELECTION AND PROFILING

In addition to the network of WiM sites on the Dutch national road network, the deployment of additional WiM systems on the provincial road network is assessed. The WiM systems can be deployed for profiling only, for pre-selection only, or for a combination of profiling and pre-selection.

- When deployed for profiling only, the data retrieved from the WiM sites on the provincial road asset is combined with data retrieved from the WiM sites on the national road network. In this way, the national database is enriched with local transport movements. Cease and desist orders can be based on the measurements. The effectiveness of this approach depends on the amount of physical checks on the national road network. The added value of the WiM sites would however be limited, since the intensities

on the regional road network are low and the WiM system on the main road network is expected to generate more than sufficient input for manual reweighing.

- When deployed for pre-selection only, no connection between the national and provincial WiM systems is made. In this approach, the WiM system is only used to select suspicious vehicles for calibrated weighing. This would however be a missed opportunity, since the synergy between these data sources would in this way not be used.
- When deployed for both pre-selection and profiling, the two earlier mentioned functionalities are integrated. It however lacks locations suitable for calibrated reweighing. The province of Zuid-Holland owns a number of workstations which could be used for calibrated reweighing, but these are limited in number and not strategically located. New areas would have to be created or selected vehicles would have to be escorted over a long distance, leading to less internal enforcement efficiency, more pavement damage and loss time for the transporter.

For all three applications, the internal efficiency of the measure will be low. Compared to the national road network, the average HGV intensities are about five times lower. Given the high density and complexity of the road network as administered by the province of Zuid-Holland and the presence of an even denser underlying local road network, deliberate non-compliers are left many opportunities to perform strategic avoidance behaviour on the five to seven WiM sites. Additional manual enforcement would be needed on avoidance routes, further lowering the internal efficiency of this strategy. Based on this motivation, it can be concluded that the deployment of additional WiM systems for pre-selection and/or profiling on the regional network is not estimated to be effective nor efficient.

2.2. WIM FOR AUTOMATED ENFORCEMENT

In addition to the network of WiM sites on the Dutch national road network, the deployment of additional WiM systems for automated enforcement on the provincial road network is assessed. Since no calibrated manual reweighing is needed to obtain court-proof evidence, the problem of unavailable space for reweighing is irrelevant in this case. However, in order to achieve a cost-effective solution, in which the costs for enforcement on the provincial network do not exceed the estimated social damage of overloading on the provincial network, not more than roughly six to twenty-one-directional WiM systems for automated enforcement can be installed. Again, the number of road sections that can be covered is extremely low and the high density of the provincial and underlying road networks leaves deliberate non-compliers a great amount of opportunities to perform strategic avoidance behaviour. Therefore, it is concluded that the deployment of additional WiM systems for direct enforcement on the provincial network is not estimated to be effective nor efficient.

2.3. OBW FOR PRE-SELECTION AND PROFILING

In addition to the network of OBW portals on the national road network, the deployment of additional OBW systems for strategic selection and profiling on the provincial road network is assessed. The OBW system can be deployed for profiling only, for pre-selection only or for a combination of profiling and pre-selection. For the provincial road network, the deployment of portable tripod units is estimated to generate the most efficient enforcement situation. The DSRC installation can be placed within a case installed on the tripod. Per DSRC installation, five tripods are placed on the side of the road, in which the installation is variably placed. For the transporter, it is not visible whether the DSRC installation is placed or not, so all five locations have a deterring effect.

- When deployed for profiling only, the data retrieved from the OBW sites on the provincial road asset is combined with data retrieved from the OBW sites on the national road network. In this way, the national database is enriched with local transport movements. Cease and desist orders can be based on the measurements. The effectiveness of this approach depends on the amount of physical checks on the

national road network. The added value of the OBW sites would however be limited, since the intensities on the regional road network are low and the OBW system on the main road network is expected to generate more than sufficient input for manual reweighing.

- When deployed for pre-selection only, no connection between the national and provincial OBW systems is made. In this approach, the OBW system is only used to select suspicious vehicles for calibrated weighing. This would however be a missed opportunity, since the synergy between these data sources would in this way not be used.
- When deployed for both pre-selection and profiling, the two earlier mentioned functionalities are integrated. It however lacks locations suitable for calibrated reweighing. The province of Zuid-Holland owns a number of workstations which could be used for calibrated reweighing, but these are limited in number and not strategically located. New areas would have to be created or selected vehicles would have to be escorted over a long distance, leading to less internal enforcement efficiency, more pavement damage and loss time for the transporter.

Although the possibilities for reweighing are limited, the portable DSRC tripods however provide the opportunity to relocate them once in a while, by which the dense and splintered network can still be monitored. Given the low yearly costs of 37.000 euros for one DSRC + ANPR installation, five tripods and man hours for replacing the installation, the measure could be cost-effective as well.

2.4. OBW FOR AUTOMATED ENFORCEMENT

In addition to the network of WiM sites on the Dutch national road network, the deployment of additional WiM systems for direct enforcement on the provincial road network is assessed. Again, a DSRC installation can be placed within a case installed on a tripod. Per DSRC installation, 5 tripods are placed on the side of the road, in which the installation is variably placed. For the transporter, it is not visible whether the DSRC installation is placed or not, so all 5 locations have a deterring effect. The space needed for placing a tripod is limited and since no calibrated manual reweighing is needed to obtain court-proof evidence, the problem of unavailable space for reweighing is irrelevant in this case.

The high density of the provincial and underlying road networks leaves deliberate non-compliers a great amount of opportunities to perform strategic avoidance behaviour. However, in contradiction to WiM systems, the tripods could be placed almost everywhere. Strategic locations could be choosen, for example close to highway exits. Secondly, the tripods themselves can easily be replaced based on relevant information.

3. CONCLUSIONS

It is concluded that only the deployment of OBW for pre-selection and profiling and OBW for direct enforcement are expected to be feasible on the regional road network. Both strategies are characterized by their high level of flexibility, since the DSRC tripods can be placed nearly everywhere and can easily be relocated when needed. Especially the deployment of OBW for direct enforcement is expected to be suitable, since no room for manual reweighing is needed.

Due to the lack of available locations for manual reweighing, the limited flexibility of the WiM technology, the great amount of opportunities to perform strategic avoidance behaviour and the high operational costs especially for WiM for direct enforcement, the deployment of WiM on regional road networks is not considered feasible.

APPENDIX V – STARTING POINTS FOR INTERNAL EFFICIENCY ESTIMATIONS

In Appendix VI, VIII, X and XII, an estimation of the costs and efficiency of each enforcement strategy is presented, according to the overview in Figure 38. In order to compare the strategies, for each of them the same starting points and input parameters are used. These are presented in this appendix.

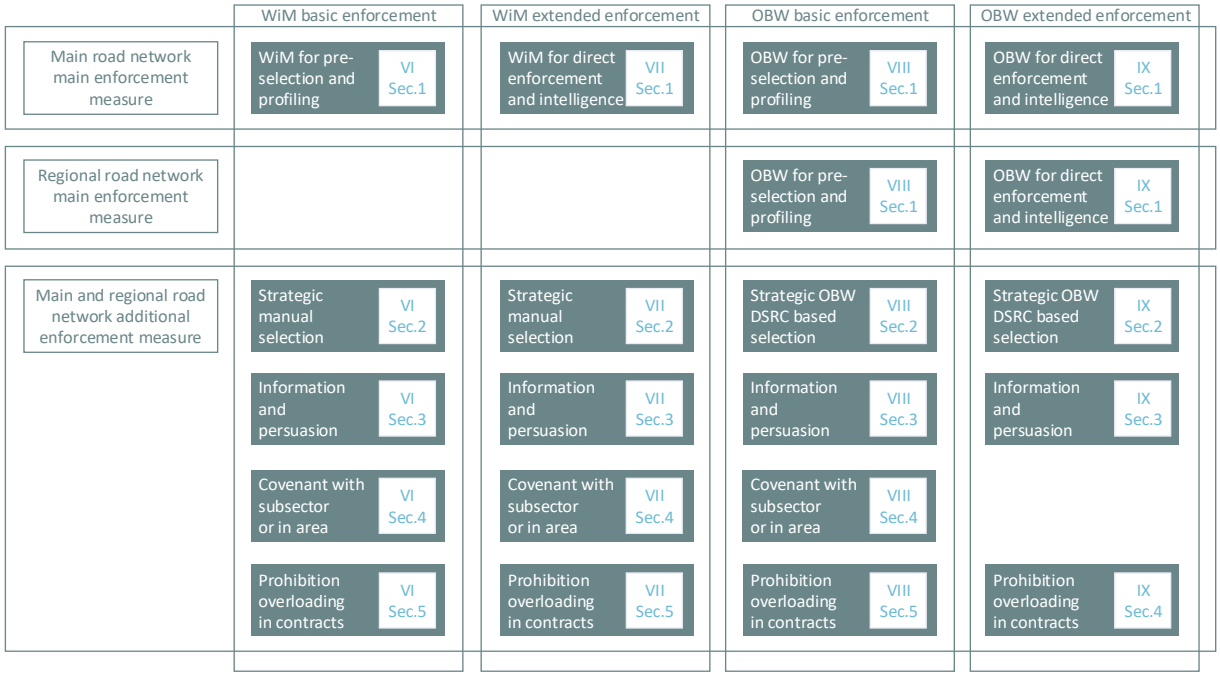

Figure 38 – Overview of Appendix VI, VII, VIII and IX

ENFORCEMENT REGIME

Since the relation between enforcement activities and compliance level is highly complex (Section 7.1), it is uncertain which enforcement regime is needed in order to achieve a certain effect in terms of overloaded HGV movement reduction. In order to be able to compare the enforcement strategies, ten enforcement regimes are designed and displayed in Table 8. These vary between light (regime A) and though (regime J). To demonstrate the calculation of the internal efficiency of the four strategies in Appendix VI, VII, VIII and IX, a moderate enforcement regime (B) is chosen.

Enforcement regime	A	B	C	D	E	F	G	H	I	J
WiM for basic enforcement										
- Number of WiM systems	15	**30**	45	60	75	90	105	120	135	150
- Number of reweighing teams	1	**2**	3	4	5	6	7	8	9	10
- Number of strategic selection teams	2	**4**	6	8	10	12	14	16	18	20
WiM for automated enforcement										
- Number of WiM systems	15	**30**	45	60	75	90	105	120	135	150
- Number of strategic selection teams	2	**4**	6	8	10	12	14	16	18	20
OBW for basic enforcement										
- Number of OBW portals on main road	15	**30**	45	60	75	90	105	120	135	150
- Number of OBW units on regional road	5	**10**	15	20	25	30	35	40	45	50
- Number of reweighing teams	1	**2**	3	4	5	6	7	8	9	10
- Number of strategic selection teams	2	**4**	6	8	10	12	14	16	18	20
OBW for basic enforcement										
- Number of OBW portals on main road	15	**30**	45	60	75	90	105	120	135	150
- Number of OBW units on regional road	5	**10**	15	20	25	30	35	40	45	50
- Number of strategic selection teams	2	**4**	6	8	10	12	14	16	18	20

Table 8 – Enforcement regimes

AVERAGE HGV INTENSITY ON NATIONAL AND REGIONAL ROAD NETWORK

Table 9 shows the average HGV intensities on the road sections currently provided with WiM systems. Within this research, it is assumed that the average HGV intensity on these road sections is equal to those at potential new WiM or OBW sites on the national road network. The average HGV intensities are derived from INWEVA (INtensiteiten op WEgVAkken), a database of the intensities on all Dutch national roads as administered by Rijkswaterstaat (Rijkswaterstaat, 2017)

Roadnumber	Average intensity one side	Percentage HGVs	Average intensity HGVs
RW1	47.500	14	6.650
RW2	47.500	13	6.175
RW4	95.000	9	8.550
RW12	75.000	12	9.000
RW15	39.000	16	6.240
RW16	62.000	14	8.680
RW27	40.000	16	6.400
RW28	60.000	16	9.600
RW50	52.500	15	7.875
RW67	32.500	26	8.450
Average HGV intensity one side			**7.762**

Table 9 – Average HGV intensities on national road network

In strategy *OBW for automated enforcement*, the number of HGVs that can be manually checked is not limited anymore on the availability of calibrated scales. Officers could simply take position on the road-side with a DSRC handheld device. In this way, the number of checked vehicles becomes equal to the average HGV intensity during checks, as calculated in Table 10. The figures are derived from RWS counting loops.

Periode	Total HGV intensity one side	HGVs/hour	Percentage of checks scheduled at this time
07.00-19.00	2575	215	76%
19.00-23.00	285	71	8%
23.00-07.00	545	68	16%
07.00-07.00	3400		
Average intensity one side during checks			**179**

Table 10 – Average HGV intensity at manual OBW DSRC-based enforcement on regional road network

The average HGV intensity per day (INWEVA) on the national road network is equal to 3400. The average HGV intensity between 07.00 and 19.00 on the national road network is equal to 2575, 215 per hour. The average HGV intensity between 19.00 and 23.00 is equal to 285, equals 70 per hour. The average HGV intensity between 23.00 and 07.00 equals 545, equals 68 per hour. It is estimated that enforcement activities are scheduled proportionally to the intensities: 75 percent during day time, 8 percent during evening time and 17 percent during night time. On average, the intensity during checks will be 180 vehicles per hour.

NUMBER OF HEAVY-GOODS VEHICLES

Data on the number of trucks, tractors and semitrailers are retrieved from the Dutch Central Bureau for Statistics and presented in Table 11 (Centraal Bureau voor de Statistiek, 2018). These figures are used in determining the costs for equipping trucks, tractors and semitrailers with OBW technology.

Indicator	Value
Number of trucks (1/1/2017)	62.155
Number of tractors (1/1/2017)	74.218
Number of semitrailers (1/1/2017)	149.030

Table 11 – Number of HGVs in the Netherlands

PERSONNEL COSTS

Data on the costs for personnel are based on the final report of the fourth work package from the European REMOVE project (Wermeskerken, 2005). The figures are slightly adjusted to the current Dutch labour market.

Cost entity	Costs (€/year)
System administrator	55000
Officer	30000
Communication officer	40000
Overhead personnel	30%

Table 12 – Personnel costs

SYSTEM COSTS

Data on the purchasing costs for axle load sensors on trucks are retrieved from Oehry, Haas, et al. (2013). Based on this, assumptions are made on the purchasing costs for axle load sensors on tractors and semitrailers. It should be noted that these figures are only rough estimations, since OBW technologies are relatively new. Furthermore, cost reduction by mass production in cooperation with other EU Member States is assumed.

Cost entity	Costs (€)	Depre-ciation	Figures based on
Purchase WiM for pre-selection	100000	5 yr	(Keulen, 2010; Wermeskerken, 2005)
Maintenance WiM for pre-selection	15000		(Keulen, 2010; Wermeskerken, 2005)
Purchase WiM for direct enforcement	350000	5 yr	(Keulen, 2010; Wermeskerken, 2005)
Maintenance WiM for direct enforcement	60000		(Keulen, 2010; Wermeskerken, 2005)
WiM data system (pre-selection)	300000	10 yr	Assumption
WiM data system (direct enforcement)	600000	10 yr	Assumption
Purchase OBW DSRC portal	185000	5 yr	(Huitink, Dieten, & Significant, 2009)
Maintenance OBW DSRC portal	32000		(Huitink et al., 2009)
Purchase OBW DSRC portable unit	110000	5 yr	(Huitink et al., 2009)
Maintenance OBW DSRC portable unit	15000		(Huitink et al., 2009)
Purchase OBW DSRC handheld	7500	5 yr	(Huitink et al., 2009)
Maintenance OBW DSRC handheld	1300		(Huitink et al., 2009)
Purchase axle load sensors truck	500	15 yr	(Oehry, Haas, et al., 2013)
Purchase axle load sensors tractor	200	15 yr	Assumption based on (Oehry, Haas, et al., 2013)
Purchase axle load sensors semitrailer	300	15 yr	Assumption based on (Oehry, Haas, et al., 2013)
Purchase costs OBU truck/tractor	280	15 yr	
Purchase static scale	30000	3 yr	(Wermeskerken, 2005)
Exploitation static scale	2000		(Wermeskerken, 2005)
Purchase weighing van	50000	5 yr	(Wermeskerken, 2005)
Exploitation weighing van	3500		(Wermeskerken, 2005)
Purchase selection vehicle	40000	5 yr	(Wermeskerken, 2005)
Exploitation selection vehicle	3000		(Wermeskerken, 2005)

Table 13 – System costs

DETECTION RATES AND HIT RATES

Table 14 shows the detection rates and hit rates for the violation deterring measures within the four strategies. The detection rate is specified as the chance of being detected when being checked. The hit rate is specified as the chance of an HGV being overloaded when being checked.

Indicator	Value (%)	Figure based on
Detection rate WiM for pre-selection	98	(Loo & ARCADIS Bouw/Infra B.V., 2001)
Detection rate OBW for pre-selection	98	Assumption
Detection rate strategic manual selection	98	Assumption
Detection rate strategic OBW DSRC-based selection	98	Assumption
Hit rate strategic manual selection	60	Assumption
Hit rate strategic OBW DSRC-based selection	100	Assumption

Table 14 – Detection rates and hit rates

It is assumed that the detection rates of OBW and weighing scales used for manual selection are similar to the detection rate of WiM.

STARTING POINTS FOR MANUAL ENFORCEMENT

Table 15 shows the starting points for manual enforcement. The design of the measure *strategic manual selection* is based on the REMOVE work package 4 final report and can be seen as an optimisation (Wermeskerken, 2005). In this research, it is assumed that each manual weighing team consists of nine pairs (sub teams) of two officers will be deployed. For each sub team, one officer selects the suspicious vehicle, while the other performs the static weighing process and administration. It is assumed that the effective length of one work day is equal to 6 hours and the length of one check is set at 45 minutes, of which 15 minutes is used for the weighing process. The other two hours of the eight-hour workday are used for movement and administration. Each team will use one static weighing scale and one weighing bus, in which other equipment is stored. Each pair of officers uses one motor vehicle for pre-selection. In this configuration, for 330 days a year, two shifts of eight hours (of which six hours effective) can be scheduled. In this way, the equipment (weighing bus, static scales and motor vehicles) is used as efficient as possible.

Indicator	Value	Figure based on
Effective length of workday (hours)	6	(Wermeskerken, 2005)
Length of one manual check (hours)	0,75	(Wermeskerken, 2005)
Number of sub teams per team	9	Design choice based on Wermeskerken (2005)
Number of checks per sub team per workday	8	(Wermeskerken, 2005)
Number of working days per year	220	(Wermeskerken, 2005)
Number of checks per team per year	15840	Follows from previous three starting points
Number of checks per team per day	43	Follows from previous starting point
Number of officers per team	18	Design choice based on Wermeskerken (2005)
Number of officers per team for OBW automated enforcement	9	Design choice
Static scales per team	1	(Wermeskerken, 2005)
Weighing vans per team	1	(Wermeskerken, 2005)
Selection vehicles per team	3	Design choice based on Wermeskerken (2005)
DSRC handhelds per team	3	Design choice based on Wermeskerken (2005)

Table 15 – Starting points for manual enforcement

APPENDIX VI – WIM FOR BASIC ENFORCEMENT – INTERNAL EFFICIENCY ESTIMATION

In this appendix, the internal efficiency of the first designed strategy, *WiM for basic enforcement*, is estimated. The yearly enforcement costs and benefits (in terms of checked, detected and sanctionable HGVs) for the five measures forming this strategy are calculated in sections 1 to 5. Finally, in Section 6, the total costs and benefits of the strategy are presented, and the internal efficiency is calculated.

1. MEASURE – WIM FOR PRE-SELECTION AND PROFILING

1.1. COSTS

The yearly costs for *WiM for pre-selection and profiling* are presented in Table 16 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of road side systems, data systems and personnel. Additionally, the costs for reweighing consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €2.672.500.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
WiM road system					**1050000**
- Hardware	30	3000000	5 years	600000	
- Maintenance				450000	
WiM data system					**101500**
- Hardware		300000	10 years	30000	
- System administrator	1			55000	
- Overhead				16500	
WiM reweighing team					**1404000**
- Officers	36			1080000	
- Overhead				324000	
Static scales					**24000**
- Hardware	2	60000	3 years	20000	
- Exploitation				4000	
Weighing van					**27000**
- Hardware	2	100000	5 years	20000	
- Exploitation				7000	
Selection vehicles					**66000**
- Hardware	6	240000	5 years	48000	
- Exploitation				18000	
Total yearly costs					**2672500**

Table 16 – Cost estimation for measure *WiM for pre-selection and profiling*

1.2. BENEFITS

The daily and yearly benefits for *WiM for pre-selection and profiling*, in terms of checked, detected and sanctionable HGVs, are presented in Table 17. On a yearly basis, over 85 million HGVs checks are performed by the WiM system. Due to the low accuracy of the system, vehicles can only be fined based on static reweighing. In this enforcement regime, on a yearly basis up to 32.000 vehicles can be checked.

Indicator	Value per day	Value per year
Number of digital HGV checks	232860	85052115
- Of which overloaded	34929	12757817
- Of which detected	34230	12502661
- Of which sanctionable	0	0
Number of manual HGV checks	87	31680
- Of which overloaded	85	31046
- Of which detected	83	30425
- Of which sanctionable	83	30425
- Of which wrongly stopped	2	634

Table 17 – Number of digitally and physically checked, detected and sanctioned HGVs for measure *WiM for pre-selection and profiling*

2. MEASURE – STRATEGIC MANUAL SELECTION

2.1. COSTS

The yearly costs for *strategic manual selection* are presented in Table 18 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €3.042.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
WiM strategic team					**2808000**
- Officers	72			2160000	
- Overhead				648000	
Static scales					**48000**
- Hardware	4	120000	3 years	40000	
- Exploitation				8000	
Weighing van					**54000**
- Hardware	4	200000	5 years	40000	
- Exploitation				14000	
Selection vehicles					**132000**
- Hardware	12	480000	5 years	96000	
- Exploitation				36000	
Total yearly costs					**3042000**

Table 18 – Cost estimation for measure *Strategic manual selection*

2.2. BENEFITS

The daily and yearly benefits for *strategic manual selection*, in terms of checked, detected and sanctionable HGVs, are presented in Table 19. In this enforcement regime, on a yearly basis over 63.000 vehicles can be checked.

Indicator	Value per day	Value per year
Number of manual HGV checks	173	63360
- Of which overloaded	104	38016
- Of which detected	102	37256
- Of which sanctioned	102	37256
- Of which wrongly stopped	69	25344

Table 19 – Number of physically checked, detected and sanctioned HGVs for measure *Strategic manual selection*

3. MEASURE – INFORMATION AND PERSUASION

3.1. COSTS

The yearly costs for information and persuasion are presented in Table 20 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel and budget for communication campaigns. The total yearly costs for this measure are equal to €152.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Communication budget				**100000**	**100000**
Communication team					**52000**
- Communication officer	1			40000	
- Overhead				12000	
Total yearly costs					**152000**

Table 20 – Cost estimation for measure *Information and persuasion*

3.2. BENEFITS

The measure will result in an increased subjective risk of being checked. The exact effect in terms of reduction of violation behaviour of this measure can however not be estimated.

4. MEASURE – COVENANT WITH SUBSECTOR OR IN AREA

4.1. COSTS

The costs for this measure include solely personnel and are assumed to be allocable within the current governmental administration.

4.2. BENEFITS

The benefits of including covenants include:

- Using the knowledge and creativity of the inspectees, by which the relationship between inspector and inspectee is improved and the acceptation of the policy goal is enlarged
- Using the knowledge of the inspectees, by which more realistic targets can be set
- Exchange of opinions leads to more feasible agreements

Since a covenant is a customized policy measure, the benefits depend on the content of the covenant, the amount of parties involved in the covenant and the level in which parties comply with the agreements made in the covenant. Therefore, the exact effect in terms of reduction of violation behaviour of this measure cannot be estimated.

5. MEASURE – PROHIBITION OVERLOADING IN CONTRACTS

5.1. COSTS

The costs for this measure include the costs of contract management, administrative checks and physical checks. The costs for contract management and administrative checks are assumed to be allocable within the current governmental organisation. Physical checks will be executed randomly by the manual selection teams on the national and regional road network. The costs for these checks are allocated at *strategic manual selection*.

5.2. BENEFITS

The benefits of this measure, in terms of checked, detected and sanctionable HGVs are allocated at *strategic manual selection*.

6. STRATEGY – WIM FOR BASIC ENFORCEMENT

6.1. COSTS

The yearly cost estimation for the strategy *WiM for basic enforcement* is displayed in Table 21. The yearly costs are estimated to be €5.866.500.

Policy measure	Yearly cost estimate
WiM for pre-selection and profiling (Section 1)	2.672.500
Strategic manual selection (Section 2)	3.042.000
Information and persuasion (Section 3)	152.000
Covenant with subsector or in area (Section 4)	0
Prohibition overloading in contracts (Section 5)	0
Total strategy costs	**5.866.500**

Table 21 – Cost estimation for strategy *WiM for basic enforcement*

6.2. BENEFITS

The daily and yearly benefits for this strategy, in terms of checked, detected and sanctionable HGVs, are presented in Table 22. On a yearly basis, over 85 million HGV checks are performed by the WiM system. Due to the WiM measurement system not meeting the legal requirements for direct enforcement, none of the detections are sanctionable. However, cease and desist orders can be imposed. Additionally, over 95.000 manual checks are performed, based on risk profiling based on the WiM measurements. Given the current compliance level, almost 68.000 fines will be imposed each year.

Indicator	Value per day	Value per year
Number of digital HGV checks	232860	85052115
- Of which overloaded	34929	12757817
- Of which detected	34230	12502661
- Of which sanctionable	0	0
Number of manual HGV checks	260	95040
- Of which overloaded	189	69062
- Of which detected	185	67681
- Of which sanctionable	185	67681
- Of which wrongly stopped	71	25978

Table 22 - Number of digitally and physically checked, detected and sanctioned HGVs for strategy *WiM for basic enforcement*

6.3. COSTS VERSUS BENEFITS

The internal efficiency of strategy *WiM for basic enforcement* is displayed in Table 23 and is equal to €86,68 per sanctionable overloaded HGV detection, for enforcement regime B (Appendix V). In order to calculate the internal efficiency, the total enforcement costs of all measures forming this strategy were divided by the number of sanctionable detections. It should be noted that within this strategy, only manual checks are sanctionable.

The costs per digital HGV check were derived by dividing the sum of all costs directly associated with the process of digitally checking the HGVs weight over the number of expected digital HGV checks. Similar, the costs per manual HGV check were derived by dividing the sum of all costs directly associated with the process of manually checking the HGVs weight over the number of expected manual HGV checks. Due to the high costs for personnel and lower number of checked HGVs, the costs for a manual HGV check are considerably higher.

Using the same cost base, the costs per detected overloaded HGV were calculated for both digital and manual enforcement. Due to the higher hit rate of manual enforcement, the difference between the costs per manually checked and manually detected HGV is relatively small, compared to digital enforcement.

Indicator	Costs (€)
Costs per digital HGV check	0,01
Costs per digital HGV detection	0,09
Costs per manual HGV check	48,01
Costs per manual HGV detection	67,42
Costs per sanctionable detection	**86,68**

Table 23 - Costs per checked, detected and sanctioned HGV for strategy *WiM for basic enforcement*

APPENDIX VII – WIM FOR AUTOMATED ENFORCEMENT – INTERNAL EFFICIENCY ESTIMATION

In this appendix, the internal efficiency of the second designed strategy, *WiM for automated enforcement*, is estimated. The yearly enforcement costs and benefits (in terms of checked, detected and sanctionable HGVs) for the five measures forming this strategy are calculated in sections 1 to 5. Finally, in Section 6, the total costs and benefits of the strategy are presented, and the internal efficiency is calculated.

1. MEASURE – WIM FOR DIRECT ENFORCEMENT AND INTELLIGENCE

1.1. COSTS

The yearly costs for *WiM for direct enforcement and intelligence* are presented in Table 24 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of road side systems, data systems and personnel. Since no reweighing is needed, no additional costs are made. The total yearly costs for this measure are equal to €4.174.500.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
WiM road system					**3900000**
- Hardware	30	10500000	5 years	2100000	
- Maintenance				1800000	
WiM data system					**274500**
- Hardware		600000	10 years	60000	
- System administrator	3			165000	
- Overhead				49500	
Total yearly costs					**4174500**

Table 24 – Cost estimation for measure *WiM for direct enforcement and intelligence*

1.2. BENEFITS

The daily and yearly benefits for *WiM for direct enforcement and intelligence*, in terms of checked, detected and sanctionable HGVs, are presented in Table 25. On a yearly basis, over 85 million HGVs checks are performed by the WiM system. The high accuracy of these systems allows for direct enforcement. All detected overloaded HGVs are sanctionable.

Indicator	Value per day	Value per year
Number of digital HGV checks	232860	85052115
- Of which overloaded	34929	12757817
- Of which detected	34230	12502661
- Of which sanctionable	34230	12502661

Table 25 – Number of digitally checked, detected and sanctioned HGVs for measure *WiM for direct enforcement and intelligence*

2. MEASURE – STRATEGIC MANUAL SELECTION

2.1. COSTS

The yearly costs for strategic manual selection are presented in Table 26 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €3.042.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
- WiM strategic team					**2808000**
- Officers	72			2160000	
- Overhead				648000	
Static scales					**48000**
- Hardware	4	120000	3 years	40000	
- Exploitation				8000	
Weighing van					**54000**
- Hardware	4	200000	5 years	40000	
- Exploitation				14000	
Selection vehicles					**132000**
- Hardware	12	480000	5 years	96000	
- Exploitation				36000	
Total yearly costs					**3042000**

Table 26 – Cost estimation for measure *Strategic manual selection*

2.2. BENEFITS

The daily and yearly benefits for strategic manual selection, in terms of checked, detected and sanctionable HGVs, are presented in Table 27. In this enforcement regime, on a yearly basis up to 63.000 vehicles can be checked.

Indicator	Value per day	Value per year
Number of manual HGV checks	173	63360
- Of which overloaded	104	38016
- Of which detected	102	37256
- Of which sanctioned	102	37256
- Of which wrongly stopped	69	25344

Table 27 – Number of physically checked, detected and sanctioned HGVs for measure *Strategic manual selection*

3. MEASURE – INFORMATION AND PERSUASION

3.1. COSTS

The yearly costs for *information and persuasion* are presented in Table 28 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel and budget for communication campaigns. The total yearly costs for this measure are equal to €304.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Communication budget				**200000**	**200000**
Communication team					**104000**
- Communication officer	2			80000	
- Overhead				24000	
Total yearly costs					**304000**

Table 28 – Cost estimation for measure *Information and persuasion*

3.2. BENEFITS

The measure will result in an increased subjective risk of being checked. The exact effect in terms of reduction of violation behaviour of this measure can however not be estimated.

4. MEASURE – COVENANT WITH SUBSECTOR OR IN AREA

4.1. COSTS

The costs for this measure include solely personnel and are assumed to be allocable within the current governmental administration.

4.2. BENEFITS

The benefits of including covenants include:

- Using the knowledge and creativity of the inspectees, by which the relationship between inspector and inspectee is improved and the acceptation of the policy goal is enlarged
- Using the knowledge of the inspectees, by which more realistic targets can be set
- Exchange of opinions leads to more feasible agreements

Since a covenant is a customized policy measure, the benefits depend on the content of the covenant, the amount of parties involved in the covenant and the level in which parties comply with the agreements made in the covenant. Therefore, the exact effect in terms of reduction of violation behaviour of this measure cannot be estimated.

5. MEASURE – PROHIBITION OVERLOADING IN CONTRACTS

5.1. COSTS

The costs for this measure include the costs of contract management, administrative checks and physical checks. The costs for contract management and administrative checks are assumed to be allocable within the current governmental organisation. Physical checks will be executed randomly by the manual selection teams on the national and regional road network. The costs for these checks are allocated at *strategic manual selection*.

5.2. BENEFITS

The benefits of this measure, in terms of checked, detected and sanctionable HGVs are allocated at *strategic manual selection*.

6. STRATEGY – WIM FOR AUTOMATED ENFORCEMENT

6.1. COSTS

The yearly cost estimation for the strategy *WiM for automated enforcement* is displayed in Table 29. The yearly costs are estimated to be €8.520.500.

Policy measure	Yearly cost estimate
WiM for direct enforcement and intelligence (Section 1)	4.174.500
Strategic manual selection (Section 2)	3.042.000
Information and persuasion (Section 3)	304.000
Covenant with subsector or in area (Section 4)	0
Prohibition overloading in contracts (Section 5)	0
Total strategy costs	**8.520.500**

Table 29 – Cost estimation for strategy *WiM for automated enforcement*

6.2. BENEFITS

The daily and yearly benefits for this strategy, in terms of checked, detected and sanctionable HGVs, are presented in Table 30. On a yearly basis, over 85 million HGVs are digitally checked by the WiM system. All detections by the WiM system are directly sanctionable. Additionally, over 63.000 manual checks are performed, based on risk profiling based on the WiM measurements. Given the current compliance level, over 37.000 fines will be imposed each year.

Indicator	Value per day	Value per year
Number of digital HGV checks	232860	85052115
- Of which overloaded	34929	12757817
- Of which detected	34230	12502661
- Of which sanctionable	34230	12502661
Number of manual HGV checks	173	63360
- Of which overloaded	104	38016
- Of which detected	102	37256
- Of which sanctionable	102	37256
- Of which wrongly stopped	69	25344

Table 30 – Number of digital and physical checked, detected and sanctioned HGVs for strategy *WiM for automated enforcement*

6.3. COSTS VERSUS BENEFITS

The internal efficiency of strategy *WiM for automated enforcement* is displayed in Table 31 and is equal to €0,60 per sanctionable overloaded HGV detection, for enforcement regime B (Appendix V). In order to calculate the internal efficiency, the total enforcement costs of all measures forming this strategy were divided by the number of sanctionable detections. It should be noted that within this strategy, both digital and manual checks are sanctionable.

The costs per digital HGV check were derived by dividing the sum of all costs directly associated with the process of digitally checking the HGVs weight over the number of expected digital HGV checks. Similar, the costs per manual HGV check were derived by dividing the sum of all costs directly associated with the process of manually checking the HGVs weight over the number of expected manual HGV checks. Due to the high costs for personnel and lower number of checked HGVs, the costs for a manual HGV check are considerably higher.

Using the same cost base, the costs per detected overloaded HGV were calculated for both digital and manual enforcement. Due to the higher hit rate of manual enforcement, the difference between the costs per manually checked and manually detected HGV is relatively small, compared to digital enforcement.

Indicator	Costs (€)
Costs per digital HGV check	0,05
Costs per digital HGV detection	0,33
Costs per manual HGV check	48,01
Costs per manual HGV detection	81,65
Costs per sanctionable detection	**0,60**

Table 31 – Costs per checked, detected and sanctioned HGV for strategy *WiM for automated enforcement*

APPENDIX VIII – OBW FOR BASIC ENFORCEMENT – INTERNAL EFFICIENCY ESTIMATION

In this appendix, the internal efficiency of the third designed strategy, *OBW for basic enforcement*, is estimated. The yearly enforcement costs and benefits (in terms of checked, detected and sanctionable HGVs) for the five measures forming this strategy are calculated in sections 1 to 5. Finally, in Section 6, the total costs and benefits of the strategy are presented, and the internal efficiency is calculated.

1. MEASURE – OBW FOR PRE-SELECTION AND PROFILING

1.1. COSTS

The yearly costs for *OBW for pre-selection and profiling* are presented in Table 32 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of road side systems, data systems and personnel. Additionally, the costs for reweighing consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €30.776.156.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
OBW road side system					**2440000**
- Hardware (DSRC-portals)	30	5550000	5 years	1110000	
- Maintenance				960000	
- Hardware (DSRC tripods)	10	1100000	5 years	220000	
- Maintenance				150000	
OBW data system					**101500**
- Hardware		300000	10 years	30000	
- System administrator	1			55000	
- Overhead				16500	
OBW in-car system					**26713656**
- Axle load sensors		90630100	15 years	6042007	
- On-Board Units		38184440	15 years	2545629	
- Calibaration every 2 yr				18126020	
Reweighing team					**1404000**
- Officers	36			1080000	
- Overhead				324000	
Static scales					**24000**
- Hardware	2	60000	3 years	20000	
- Exploitation				4000	
Weighing van					**27000**
- Hardware	2	100000	5 years	20000	
- Exploitation				7000	
Selection vehicles					**66000**
- Hardware	6	240000	5 years	48000	
- Exploitation				18000	
Total yearly costs					**30776156**

Table 32 – Cost estimation for measure *OBW for pre-selection and profiling*

1.2. BENEFITS

The daily and yearly benefits for *WiM for pre-selection and profiling*, in terms of checked, detected and sanctionable HGVs, are presented in Table 33. On a yearly basis, over 97 million HGVs checks are performed by the WiM system. Due to the low accuracy of the system, vehicles can only be fined based on static reweighing. In this enforcement regime, on a yearly basis up to 32.000 vehicles can be checked.

Indicator	Value per day	Value per year
Number of digital HGV checks	266910	97488878
- Of which overloaded	40037	14623332
- Of which detected	39236	14330865
- Of which sanctionable	0	0
Number of manual HGV checks	87	31680
- Of which overloaded	85	31046
- Of which detected	83	30425
- Of which sanctionable	83	30425
- Of which wrongly stopped	2	634

Table 33 – Number of digitally and physically checked, detected and sanctioned HGVs for measure *OBW for pre-selection and profiling*

2. MEASURE – STRATEGC OBW DSRC-BASED SELECTION

2.1. COSTS

The yearly costs for strategic *OBW DSRC-based selection* are presented in Table 34 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €3.075.600.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Strategic team					**2808000**
- Officers	72			2160000	
- Overhead				648000	
Static scales					**48000**
- Hardware	4	120000	3 years	40000	
- Exploitation				8000	
Weighing van					**54000**
- Hardware	4	200000	5 years	40000	
- Exploitation				14000	
Selection vehicles					**132000**
- Hardware	12	480000	5 years	96000	
- Exploitation				36000	
DSRC handhelds					**33600**
- Hardware	12	90000	5 years	18000	
- Exploitation				15600	
Total yearly costs					**3075600**

Table 34 – Cost estimation for measure *Strategic OBW DSRC-based selection*

2.2. BENEFITS

The daily and yearly benefits for *Strategic OBW DSRC-based selection*, in terms of checked, detected and sanctionable HGVs, are presented in Table 35. In this enforcement regime, on a yearly basis up to 63.000 vehicles can be checked.

Indicator	Value per day	Value per year
Number of manual HGV checks	173	63360
- Of which overloaded	173	63360
- Of which detected	170	62093
- Of which sanctioned	170	62093

Table 35 – Number of physically checked, detected and sanctioned HGVs for measure *Strategic OBW DSRC-based selection*

3. MEASURE – INFORMATION AND PERSUASION

3.1. COSTS

The yearly costs for *information and persuasion* are presented in Table 36 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel and budget for communication campaigns. The total yearly costs for this measure are equal to €152.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Communication budget				**100000**	**100000**
Communication team					**52000**
- Communication officer	1			40000	
- Overhead				12000	
Total yearly costs					**152000**

Table 36 – Cost estimation for measure *Information and persuasion*

3.2. BENEFITS

The measure will result in an increased subjective risk of being checked. The exact effect in terms of reduction of violation behaviour of this measure can however not be estimated.

4. MEASURE – COVENANT WITH SUBSECTOR OR IN AREA

4.1. COSTS

The costs for this measure include solely personnel and are assumed to be allocable within the current governmental administration.

4.2. BENEFITS

The benefits of including covenants include:

- Using the knowledge and creativity of the inspectees, by which the relationship between inspector and inspectee is improved and the acceptation of the policy goal is enlarged
- Using the knowledge of the inspectees, by which more realistic targets can be set
- Exchange of opinions leads to more feasible agreements

Since a covenant is a customized policy measure, the benefits depend on the content of the covenant, the amount of parties involved in the covenant and the level in which parties comply with the agreements made in the covenant. Therefore, the exact effect in terms of reduction of violation behaviour of this measure cannot be estimated.

5. MEASURE – PROHIBITION OVERLOADING IN CONTRACTS

6.4. COSTS

The costs for this measure include the costs of contract management, administrative checks and physical checks. The costs for contract management and administrative checks are assumed to be allocable within the current governmental organisation. Physical checks will be executed randomly by the manual selection teams on the national and regional road network. The costs for these checks are allocated at *strategic manual selection*.

6.5. BENEFITS

The benefits of this measure, in terms of checked, detected and sanctionable HGVs are allocated at *Strategic OBW DSRC-based selection*.

6. STRATEGY – OBW FOR BASIC ENFORCEMENT

6.1. COSTS

The yearly cost estimation for the strategy *OBW for basic enforcement* is displayed in Table 37. The yearly costs are estimated to be €34.003.800.

Policy measure	Yearly cost estimate
OBW for pre-selection and profiling (Section 1)	30.776.200
Strategic OBW DSRC-based selection (Section 2)	3.075.600
Information and persuasion (Section 3)	152.000
Covenant with subsector or in area (Section 4)	0
Prohibition overloading in contracts (Section 5)	0
Total strategy costs	**34.003.800**

Table 37 – Cost estimation for strategy *OBW for basic enforcement*

6.2. BENEFITS

The daily and yearly benefits for this strategy, in terms of checked, detected and sanctionable HGVs, are presented in Table 38. On a yearly basis, over 97 million HGVs are digitally checked by the OBW system. Due to the OBW measurement system not meeting the legal requirements for direct enforcement, none of these detections are sanctionable. However, cease and desist orders can be imposed. Additionally, over 95.000 manual checks are performed, based on risk profiling based on the OBW measurements. Given the current compliance level, almost 93.000 fines will be imposed each year. Compared to the strategy 'WiM for basic enforcement', the hit rate of manual enforcement is significantly higher due to the deployment of DSRC handheld units.

Indicator	Value per day	Value per year
Number of digital HGV checks	266910	97488878
- Of which overloaded	40037	14623332
- Of which detected	39236	14330865
- Of which sanctionable	0	0
Number of manual HGV checks	260	95040
- Of which overloaded	258	94406
- Of which detected	253	92518
- Of which sanctionable	253	92518
- Of which wrongly stopped	2	634

Table 38 – Number of digital and physical checked, detected and sanctioned HGVs for strategy *OBW for basic enforcement*

6.3. COSTS VERSUS BENEFITS

The internal efficiency of strategy *OBW for basic enforcement* is displayed in Table 39 and is equal to €367,54 per sanctionable overloaded HGV detection, for enforcement regime B (Appendix V). In order to calculate the internal efficiency, the total enforcement costs of all measures forming this strategy were divided by the number of sanctionable checks. It should be noted that within this strategy, only manual checks are sanctionable.

The costs per digital HGV check were derived by dividing the sum of all costs directly associated with the process of digitally checking the HGVs weight over the number of expected digital HGV checks. Similar, the costs per manual HGV check were derived by dividing the sum of all costs directly associated with the process of manually checking the HGVs weight over the number of expected manual HGV checks. Due to the high costs for personnel and lower number of checked HGVs, the costs for a manual HGV check are considerably higher.

Using the same cost base, the costs per detected overloaded HGV were calculated for both digital and manual enforcement. Due to the almost 100 percent hit rate of manual enforcement, the difference between the costs per manually checked and manually detected HGV is relatively small, compared to digital enforcement.

Indicator	Costs (€)
Costs per digital HGV check	0,30
Costs per digital HGV detection	2,04
Costs per manual HGV check	48,36
Costs per manual HGV detection	49,68
Costs per sanctionable detection	**367,54**

Table 39 – Costs per checked, detected and sanctioned HGV for strategy *OBW for basic enforcement*

APPENDIX IX – OBW FOR AUTOMATED ENFORCEMENT – INTERNAL EFFICIENCY ESTIMATION

In this appendix, the internal efficiency of the fourth and final designed strategy, *OBW for automated enforcement*, is estimated. The yearly enforcement costs and benefits (in terms of checked, detected and sanctionable HGVs) for the four measures forming this strategy are calculated in sections 1 to 4. Finally, in Section 5, the total costs and benefits of the strategy are presented, and the internal efficiency is calculated.

1. MEASURE – OBW FOR DIRECT ENFORCEMENT AND INTELLIGENCE

1.1. COSTS

The yearly costs for *OBW for direct enforcement and intelligence* are presented in Table 40 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of road side systems, data systems and personnel. Since no reweighing is needed, no additional costs are made. The total yearly costs for this measure are equal to €47.554.176.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
OBW road side system					**2440000**
- Hardware (DSRC-portals)	30	5550000	5 years	1110000	
- Maintenance				960000	
- Hardware (DSRC tripods)	10	1100000	5 years	220000	
- Maintenance				150000	
OBW data system					**274500**
- Hardware		600000	10 years	60000	
- System administrator	3			165000	
- Overhead				49500	
OBW in-car system					**44839676**
- Axle load sensors		90630100	15 years	6042007	
- On-Board Units		38184440	15 years	2545629	
- Calibaration every year				36252040	
Total yearly costs					**47554176**

Table 40 – Cost estimation for measure *OBW for direct enforcement and intelligence*

1.2. BENEFITS

The daily and yearly benefits for *WiM for direct enforcement and intelligence*, in terms of checked, detected and sanctionable HGVs, are presented in Table 41. On a yearly basis, over 97 million HGVs checks are performed by the WiM system. The high accuracy of these systems allows for direct enforcement. All detected overloaded HGVs are sanctionable.

Indicator	Value per day	Value per year
Number of digital HGV checks	266910	97488878
- Of which overloaded	40037	14623332
- Of which detected	39236	14330865
- Of which sanctionable	39236	14330865

Table 41 – Number of checked, detected and sanctioned HGVs for measure *OBW for direct enforcement and intelligence*

2. MEASURE – STRATEGIC OBW DSRC-BASED SELECTION

2.1. COSTS

The yearly costs for *OBW DSRC-based selection* are presented in Table 42 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel, static scales and vehicles. The total yearly costs for this measure are equal to €1.569.600. Compared to strategic manual selection in all other three strategies, the costs for this measure are lower in this strategy. Since HGVs can be fined solely based on DSRC data, the time-consuming processes of vehicle selection and calibrated weighing are not needed. This is reflected in the estimation of costs and benefits by a reduction in the number of officers needed per enforcement team.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Strategic team					**1404000**
- Officers	36			1080000	
- Overhead				324000	
Selection vehicles					**132000**
- Hardware	12	480000	5 years	96000	
- Exploitation				36000	
DSRC handhelds					**33600**
- Hardware	12	90000	5 years	18000	
- Exploitation				15600	
Total yearly costs					**1569600**

Table 42 – Cost estimation for measure *OBW DSRC-based selection*

2.2. BENEFITS

The daily and yearly benefits for *OBW DSRC-based selection*, in terms of checked, detected and sanctionable HGVs, are presented in Table 43. The number of vehicles that can be checked is dependent on the intensity of HGVs, when using DSRC handheld devices. Therefore, in this enforcement regime, on a yearly basis up to 8.5 million vehicles can be checked.

Indicator	Value per day	Value per year
Number of manual HGV checks	23307	8512939
- Of which overloaded	3496	1276941
- Of which detected	3426	1251402
- Of which sanctionable	3426	1251402

Table 43 – Number of checked, detected and sanctioned HGVs for measure *OBW DSRC-based selection*

3. MEASURE – INFORMATION AND PERSUASION

3.1. COSTS

The yearly costs for *information and persuasion* are presented in Table 44 and based on the starting points and assumptions presented in Appendix V. The costs for the measure consist of personnel and budget for communication campaigns. The total yearly costs for this measure are equal to €304.000.

Cost entity	Number	Purchase (€)	Depreciation	Costs (€/yr)	Costs (€/yr)
Communication budget				**200000**	**200000**
Communication team					**104000**
- Communication officer	2			80000	
- Overhead				24000	
Total yearly costs					**304000**

Table 44 – Cost estimation for measure *Information and persuasion*

3.2. BENEFITS

The measure will result in an increased subjective risk of being checked. The exact effect in terms of reduction of violation behaviour of this measure can however not be estimated.

4. MEASURE – PROHIBITION ON OVERLOADING IN CONTRACTS

4.1. COSTS

The costs for this measure include the costs of contract management, administrative checks and physical checks. The costs for contract management and administrative checks are assumed to be allocable within the current governmental organisation. Physical checks will be executed randomly by the manual selection teams on the national and regional road network. The costs for these checks are allocated at *strategic manual selection*.

4.2. BENEFITS

The benefits of this measure, in terms of checked, detected and sanctionable HGVs are allocated at *OBW DSRC-based selection*.

5. STRATEGY – OBW FOR AUTOMATED ENFORCEMENT

5.1. COSTS

The yearly cost estimation for the strategy *OBW for automated enforcement* is displayed in Table 45. The yearly costs are estimated to be €36.567.500.

Policy measure	Yearly cost estimate
OBW for direct enforcement and intelligence (Section 1)	47.554.200
Strategic OBW DSRC-based selection (Section 2)	1.569.600
Information and persuasion (Section 3)	304.000
Prohibition overloading in contracts (Section 4)	0
Total strategy costs	**49.427.800**

Table 45 – Cost estimation for strategy *OBW for automated enforcement*

5.2. BENEFITS

The daily and yearly benefits for this strategy, in terms of checked, detected and sanctionable HGVs, are presented in Table 46. On a yearly basis, over 97 million HGVs are digitally checked by the OBW system. All detections by the OBW system are directly sanctionable. Additionally, over 8.5 million manual checks are performed, based on risk profiling based on the OBW measurements. Given the current compliance level, over 15 million fines will be imposed each year.

Indicator	Value per day	Value per year
Number of digital HGV checks	266910	97488878
- Of which overloaded	40037	14623332
- Of which detected	39236	14330865
- Of which sanctionable	39236	14330865
Number of manual HGV checks	23307	8512939
- Of which overloaded	3496	1276941
- Of which detected	3426	1251402
- Of which sanctionable	3426	1251402

Table 46 – Number of checked, detected and sanctioned HGVs for strategy *OBW for automated enforcement*

5.3. COSTS VERSUS BENEFITS

The internal efficiency of strategy *OBW for automated enforcement* is displayed in Table 25 and is equal to €3,17 per sanctionable overloaded HGV detection, for enforcement regime B (Appendix V). In order to calculate the internal efficiency, the total enforcement costs of all measures forming this strategy were divided by the number of sanctionable checks. It should be noted that within this strategy, both digital and manual checks are sanctionable.

The costs per digital HGV check were derived by dividing the sum of all costs directly associated with the process of digitally checking the HGVs weight over the number of expected digital HGV checks. Similar, the costs per manual HGV check were derived by dividing the sum of all costs directly associated with the process of manually checking the HGVs weight over the number of expected manual HGV checks. Since the costs for in-car systems are accommodated with digital enforcement, the costs per digital check and detection are higher than for manual enforcement.

Using the same cost base, the costs per detected overloaded HGV were calculated for both digital and manual enforcement. Since the hit rate of digital and manual enforcement is expected to be roughly the same, the relative difference between the costs per check and per detection is the same for digital and manual enforcement.

Enforcement regime B	Costs (€)
Costs per digital HGV check	0,49
Costs per digital HGV detection	3,32
Costs per manual HGV check	0,18
Costs per manual HGV detection	1,25
Costs per sanctionable detection	**3,17**

Table 47 – Costs per checked, detected and sanctioned HGV for strategy *OBW for automated enforcement*

APPENDIX X – EFFECTS OF STRATEGIES

The effects of the strategy on the dimensions of spontaneous and enforced compliance are visualised in Figure 39. Changes in and elaborated upon in this appendix. The effects of the current enforcement situation on the dimensions of spontaneous and enforced compliance in the Table of Eleven are elaborated upon in Appendix I.

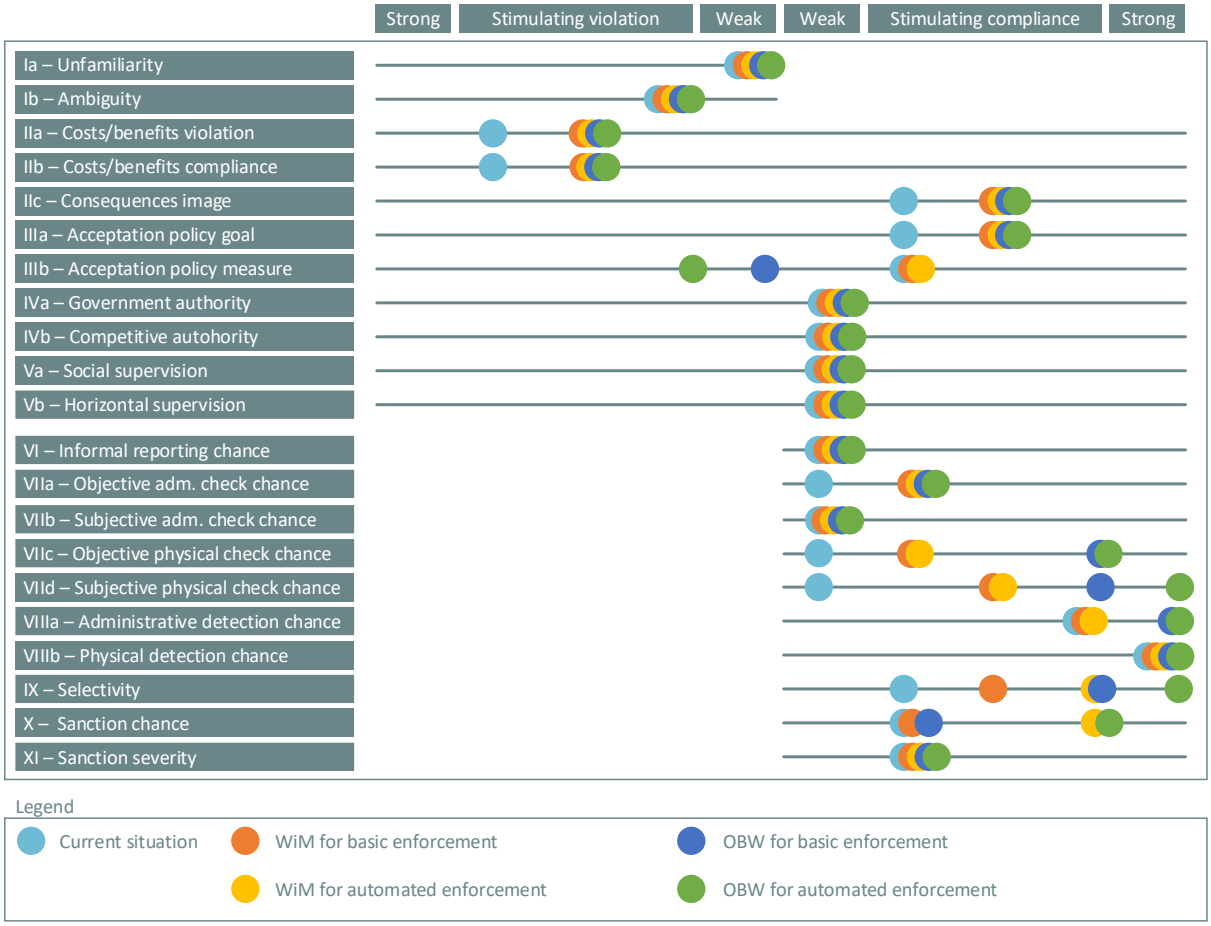

Figure 39

DIMENSIONS OF SPONTANEOUS COMPLIANCE

I. Knowledge of rules
II. Costs and benefits
III. Level of acceptation
IV. Law abidance
V. Non-governmental control

DIMENSIONS OF ENFORCED COMPLIANCE

VI. Reporting probability
VII. Probability of being checked
VIII. Probability of being detected
IX. Selectivity
X. Probability of being sanctioned
XI. Sanction severity

DIMENSIONS OF SPONTANEOUS COMPLIANCE

DIMENSION I – KNOWLEDGE OF RULES

DIMENSION IA – UNFAMILIARITY

The weak violation stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION IB – AMBIGUITY

The weak/moderate violation stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION II – COSTS AND BENEFITS

DIMENSION IIA – COSTS/BENEFITS VIOLATION

Due to the conclusion of various covenants with parties in the transport chain and the inclusion of the prohibition on overloading in governmental contracts, the benefit of violating maximum weight regulations decreases substantially, especially in the civil engineering sector. Overall, the cost/benefit ratio of overloading decreases slightly.

DIMENSION IIB – COSTS/BENEFITS COMPLIANCE

Due to the conclusion of various covenants with parties in the transport chain, the benefit of compliance increases slightly. In covenants can be arranged that clients and shippers award contracts to transporters that can demonstrate their compliance with maximum weight regulations.

DIMENSION IIC – CONSEQUENCES IMAGE

Due to the deployment of whitelists in subsectors with high percentages of non-compliers, the image of noncomplying transporters can be affected. The effect of this measure is expected to be relatively low.

DIMENSION III – LEVEL OF ACCEPTATION

DIMENSION IIIA – ACCEPTATION POLICY GOAL

The level of acceptation of the policy goal is expected to slightly increase by more extensive communication of policy measures and policy targets. Additionally, concluding covenants leads to higher acceptation as well, since overloading is made a shared problem in which parties join forces.

DIMENSION IIIB – ACCEPTATION POLICY MEASURE

The effects of the four designed enforcement strategies are expected to differ.

- The acceptation of the sector of *WiM for basic enforcement and WiM for automated enforcement* is not expected to differ from the acceptation of the sector of the current enforcement situation, since WiM is not expected to have a large impact on the regular business process.
- The acceptation of the sector of *OBW for basic enforcement OBW for automated* enforcement is expected to be lower than the acceptation of the sector of the current enforcement situation, since the impact of these strategies on the regular business process is expected to be larger. The feeling of being constantly monitored could lower the acceptation, as well as the need for axle load sensor calibration.

DIMENSION IV – LAW ABIDANCE

DIMENSION IVA – GOVERNMENT AUTHORITY

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION IVB – COMPETITIVE AUTHORITY

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION V – NON-GOVERNMENTAL CONTROL

DIMENSION VA – SOCIAL SUPERVISION

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION VB – HORIZONTAL SUPERVISION

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSIONS OF ENFORCED COMPLIANCE

DIMENSION VI – REPORTING PROBABILITY

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

DIMENSION VII – PROBABILITY OF BEING CHECKED

DIMENSION VIIA – OBJECTIVE ADMINISTRATIVE CHECK CHANCE

The inclusion of the prohibition on overloading in contracts will be checked both administratively and physically by the governmental client. In covenants, administrative checks could be performed by the client itself or a private third party. The chance on being administratively checked decreases significantly within the civil engineering sector and for parties involved in concluded covenants. Overall, the probability of being administratively checked increases slightly.

DIMENSION VIIB – SUBJECTIVE ADMINISTRATIVE CHECK CHANCE

The weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies, due to the fact that the administrative checks within covenants and contracts can easily be anticipated upon.

DIMENSION VIIC – OBJECTIVE PHYSICAL CHECK CHANCE

The effects of the four designed enforcement strategies are expected to differ.

- For the two WiM-based strategies, the objective probability of being checked increases, compared to the current enforcement situation, due to the deployment of the WiM systems on the national road network and manual enforcement teams on the regional road network.
- For the two OBW-based strategies, the objective probability of being checked increases even harder, due to the 30-day storage of axle load data in the OBU, deployment of DSRC portals on the national road network, deployment of DSRC tripods and OBW DSRC enforcement teams on the regional road network

DIMENSION VIID – SUBJECTIVE PHYSICAL CHECK CHANCE

The effects of the four designed enforcement strategies are expected to differ.

- For the two WiM-based strategies, the subjective probability of being checked increases, compared to the current enforcement situation, due to the deployment of WiM systems on the national road network and manual enforcement teams on the regional road network. Especially the amount and perceived randomness of locations of manual checks is likely to contribute to a higher subjective probability of being checked.
- For *OBW for basic enforcement*, the subjective probability of being checked increases slightly harder, due to the 30-day storage of axle load data in the OBU, deployment of DSRC portals on the national road network, deployment of DSRC tripods and OBW DSRC enforcement teams on the regional road network. Especially the randomness of locations of portable tripods and manual checks is likely to contribute to a higher subjective probability of being checked.
- For *OBW for automated enforcement*, the subjective probability of being checked increases the hardest. Compared to *OBW for basic enforcement*, the fact that only DSRC measurements can serve as court-proof evidence, combined with the fact that these can be deployed on and location, contribute to a very high subjective probability of being checked.

DIMENSION VIII – PROBABILITY OF BEING DETECTED

DIMENSION VIIIA – ADMINISTATIVE DETECTION CHANCE

The effects of the four designed enforcement strategies are expected to differ. For OBW-based strategies, the compliance stimulating effect of this dimension is expected to increase, since in these strategies administrative checks are (partially) based on OBW measurements. It is expected that these are less easily manipulable, compared to the weighing scales and letters used for administrative checks in WiM-based strategies.

DIMENSION VIIIB – PHYSICAL DETECTION CHANCE

The strong compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies. When being checked, the probability on being detected remains close to 100 percent for both WiM systems, axle load sensors, DSRC devices and weighing mats or scales.

DIMENSION IX – SELECTIVITY

The effects of the four designed enforcement strategies are expected to differ.

- Within the two OBW-based strategies, more data is collected than in the two WiM-based strategies. After all, data on the axle loads is stored for up to 30 days in the OBU. This data could be generalised and used by the inspector for extensive profiling.
- Within the two automated strategies, the combination of other data sources into enforcement could lead to more effective selection. After all, companies violating one specific rule are in general more likely to result other rules as well.

Together, these points make the selectivity for *OBW for automated enforcement* to have the most compliance stimulating effect and the selectivity for WiM for basic enforcement to have the least compliance stimulating effect.

DIMENSION X – PROBABILITY OF BEING SANCTIONED

The effects of the four designed enforcement strategies are expected to differ. For the two automated enforcement strategies, the probability of being sanctioned is considerably larger, compared to the two basic strategies (Appendix VI, VII, VIII, IX). After all, in the two automated enforcement strategies the initial WiM or

OBW measurement serves already as court-proof evidence, whereas in the two basic strategies these can only be used for cease and desist orders. Compared to the current enforcement situation, in which only manual checks are being scheduled, the compliance stimulating nature of this dimension increases drastically for all strategies.

DIMENSION XI – SANCTION SEVERITY

The moderate/weak compliance stimulating nature of this dimension is not affected by the deployment of one of the four designed enforcement strategies.

APPENDIX XI – INTERVIEW GUIDE

LIST OF RESPONDENTS

Table 48 shows the list of interviewed stakeholders and experts.

Interview date and time	Organisation	Function
May 22, 13.00-14.30	TLN	Secretaris Techniek, Deelmarkt exceptioneel vervoer en Deelmarkt autotransporteurs
May 23, 09.30-11.00	RWS	Afdeling synchromodaal vervoer en scheepvaart
May 24, 15.00-16.30	PZH (2x)	Assetmanager Wegen Adviseur verhardingen
May 25, 09.00-10.30	ILT	Projectleider Weigh-in-Motion en aanpak overbelading
May 28, 09.00-10.30	PZH	Senior beleidsmedewerker kunstwerken
May 28, 13.00-14.30	RDW	Manager ontheffingen

Table 48 – Interviewed stakeholders and expert

The interview guide is in Dutch.

DEEL A – ALGEMENE VRAGEN

1. INTRODUCTIE

1.1. Kunt u zichzelf kort voorstellen en uw functie beschrijven?
1.2. Kunt u iets vertellen over hoe u betrokken bent bij het probleem overbelading in het goederenvervoer over de weg?

2. EVALUATIE HUIDIGE SITUATIE

2.1. Hoe evalueert u de huidige handhavingssituatie op respectievelijk het hoofdwegennet en het regionaal wegennet in Nederland?
2.2. Hoe evalueert u de 'Top 100' aanpak overbelading, zoals door de ILT ingezet in 2014 en 2015?
2.3. Hoe evalueert u de samenwerking op het gebied van kennisdeling en handhaving van overbelading tussen wegbeheerders/handhavers in de Europese Unie?
2.4. Hoe evalueert u de samenwerking op het gebied van kennisdeling en handhaving van overbelading tussen wegbeheerders/handhavers op verschillende schaalniveaus binnen Nederland?
2.5. Op welk schaalniveau of welke schaalniveaus vindt u dat handhavingsbeleid gemaakt en uitgevoerd zou moeten worden?

DEEL B – REFLECTIE OP ONDERZOEKSRESULTATEN

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

Respondent krijgt Figure 9, de nalevingsschatting, voorgelegd

3.1. In hoeverre kunt u zich vinden in de nalevingsschatting van de huidige situatie?
3.2. Wat is voor u de betekenis en meerwaarde van de nalevingsschatting?

Respondent krijgt Figure 5, de maatregelcategorieën met groepen, voorgelegd

3.3. Gelet op de door u geschetste handhavingssituatie, op welk vlak of welke vlakken is in uw opinie beleid nodig en effectief?

Respondent krijgt Figure 8, de Tafel van Elf voor de huidige handhavingssituatie, voorgelegd

3.4. Bent u bekend met de Tafel van Elf en/of heeft u deze zelf toegepast of mee gewerkt?
3.5. Reactie op de analyse van de huidige handhavingssituatie in de Tafel van Elf?
3.6. Wat is voor u de betekenis en meerwaarde van de toepassing van de Tafel van Elf?

4. UITGANGSPUNTEN VOOR HANDHAVING

Respondent krijgt de uitgangspunten voor handhaving, zoals beschreven in hoofdstuk 5, voorgelegd

4.1. In hoeverre hecht u waarde aan elk van de volgende uitgangspunten voor handhaving?
4.2. Ontbreken er nog uitgangspunten?
4.3. Wat wordt binnen uw eigen organisatie gehanteerd als uitgangspunten voor handhaving?

5. DOEL VAN HANDHAVING

5.1. Wat zou voor u idealiter het effect moeten zijn van handhaving op overbelading?
5.2. Wat is een realistisch en aanvaardbaar eindbeeld in de nalevingsschatting?

6. INTEGRALE BENADERING VAN OVERBELADING

Respondent krijgt Figure 30, de vier uitgewerkte coherente handhavingsstrategieën, voorgelegd

6.1. Wat vindt u van de combinatie van gebruikte matregelen binnen de strategieën en voldoet de strategie aan het eerder door u benoemde aanvaardbare eindbeeld in de nalevingsschatting?
6.2. Hoe realistisch acht u de implementatie van de volgende handhavingsstrategieën?

7. EFFECTIVITEIT EN KOSTEN-EFFECTIVITEIT

Respondent krijgt Figure 32, de Tafel van Elf per strategie, voorgelegd

7.1. Hoe realistisch acht u de effectiviteit zoals geschetst in de getoonde analyse?
7.2. Wat is voor u de betekenis en meerwaarde van de toepassing van de indeling van handhavingsstrategieën volgens de Bruijn & ten Heuvelhof en de Tafel van Elf?

DEEL C – OVERIGE VRAGEN

8. IMPLEMENTATIE VAN STRATEGIEËN

8.1. Welke uitdagingen ziet u met betrekking tot de technische, juridische en organisatorische implementatie van de genoemde handhavingsstrategieën?

9. OMGANG MET ONZEKERHEID

9.1. Hoe zou uw inziens omgegaan moeten worden met de geschetste onzekerheid in de bepaling van de maatschappelijke schade als gevolg van overbelading?
9.2. Hoe zou uw inziens omgegaan moeten worden met de geschetste onzekerheid in de bepaling van de effecten van de handhavingsstrategieën op de mate van overbelading?

10. AFSLUITING

10.1. Is er nog iets dat u kwijt wil of wil toevoegen aan uw antwoorden?

APPENDIX XII – INTERVIEW REPORT RIJKSWATERSTAAT

1. INTRODUCTIE

- Rijkswaterstaat WVL Afdeling synchromodaal vervoer en scheepvaart
- Kennisgebieden truck platooning, overbelading, truck parking

2. EVALUATIE HUIDIGE SITUATIE

Voor RWS is overbelading belangrijk, enerzijds om onnodige slijtage van wegen, bruggen en tunnels te voorkomen en anderzijds om een 'level playing field' voor vervoerders te garanderen en overbelading strafbaar is. Daarnaast constateert RWS een toename in verkeersintensiteiten en toename van het aandeel zwaar vrachtverkeer hierin. RWS plaatst de discussie rond zwaar vrachtverkeer in een breder perspectief. Vanuit een duurzaamheidsperspectief kan het gewenst zijn langere en zwaardere voertuigen zoals LVZ's in te zetten, om ook het aantal transportbewegingen te verminderen. Het is voor RWS van belang om ook mee te bewegen richting duurzamer transport en te luisteren naar de wens vanuit de logistieke sector om duurzamer te vervoeren. Deze (creatieve) discussie wordt momenteel gevoerd en maakt dat inzet van zwaarder vrachtverkeer in een breder perspectief bekeken moet worden.

Het is complex om tot overeenstemming te komen over een harmonisatie van maximumgewichten in Europa. Het besef is er wel om toe te werken naar uniformiteit, maar welke kant dit op zal gaan is onbekend. Nederland staat hogere maximumgewichten toe. De Europese wetgeving op het gebied van handhaving op maximumvoertuiggewichten wordt door RWS gezien als een kans. Het WiM netwerk in Nederland is geografisch al goed verspreid, maar mist flexibele inzet (de meetlocaties liggen vast). De keuze tussen WiM en On-Board Weighing moet nog gemaakt worden, en hangt af van hoe On-Board Weighing wordt uitgewerkt en of op afstand inzicht kan worden verkregen in aslasten door de ILT. Ook hier maken landen in Europa eigen keuzes en wordt uniformiteit in gebruikte technieken wel nagestreefd, maar dit blijkt in de praktijk wel lastig te zijn.

RWS wijst op een pilot door de RDW, waarbij twee bedrijven in het exceptioneel transport real-time gps-data afstaan, in ruil voor snellere afhandeling en toewijzing van ontheffingen. Een situatie waarin vervoerders real-time informatie delen over waar en hoe zwaar zij rijden wordt door RWS als veelbelovend beschouwd. Dit mag echter niet leidt tot een forse toename van het aantal ontheffingen op exceptioneel transport (zeer belastend voor wegdek, tunnels en bruggen).

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

RWS vindt het moeilijk de nalevingsschatting te beoordelen, maar benadrukt dat de situatie complexer is dan het weergegeven diagram. Als voorbeeld worden deeltransporten aangehaald, waarin aslastoverschrijdingen voorkomen na tussentijdse lossingen. Het is volgens RWS de vraag of dit bewust dan wel onbewust gebeurt. RWS ziet aan de zijde van onbewuste overtreders een kans om hen bewust te maken van overbelading. Aan de zijde van bewuste overtreders is strikte handhaving nodig. RWS benadrukt dat handhaving niet alleen als kostenpost moet worden gezien, maar ook de positieve effecten in termen van bv. minder slijtage moet worden meegenomen.

RWS vindt het gelijke speelveld in de sector belangrijk. Hierin zou de overheid bij overbelading niet de andere kant op moeten kijken, maar de good guys juist moeten belonen door de bad guys aan te pakken. Doe je dat niet dan leidt dat terecht tot frustratie bij de overgrote groep van welwillenden. Overigens is het een probleem dat kentekens van buitenlandse vervoerders nog niet gekoppeld zijn aan het Nederlandse systeem: dit bemoeilijkt het gewenste gelijke speelveld in de sector.

Met betrekking tot de Tafel van Elf, wordt door RWS dimensie 'imago' gezien als een kans om overbelading te reduceren. Het aanstellen van een aantal ambassadeurs in de sector, die het goede voorbeeld geven en andere transporteurs meetrekken, wordt genoemd als mogelijkheid. Hierin spelen vooral de opdrachtgevers (verladers) een belangrijke rol: zij huren immers vervoerders in en kunnen bij hen het gewenste gedrag afdwingen. Imago en andere vormen van sociale controle zijn van belang en hierin zijn volgens RWS stappen te maken.

4. UITGANGSPUNTEN VOOR HANDHAVING

Gelijk speelveld moet worden gestimuleerd en slijtage op infrastructuur moet worden verminderd. Ook het stimuleren van bewustwording bij de sector van het beleidsdoel en de reden waarom er wordt gehandhaafd op overbelading is van belang: slijtage aan infrastructuur is voor hen niet altijd zichtbaar.

Met betrekking tot het eerste uitgangspunt wordt door RWS aangegeven dat de discussie over het al dan niet toestaan van langere, zwaardere voertuigen hierin ook een rol speelt, in het kader van duurzaamheid en de vermindering van het aantal transportbewegingen. RWS streeft naar een beperkt aantal zwaar-transportcorridors, waarin wegen zwaarder worden gedimensioneerd. Op die manier kan een overbelasting van regionale en lokale wegen worden voorkomen. De combinatie van consequent sanctioneren, maar ook informeren wordt als een belangrijke combinatie gezien. Het handhaven van zowel Nederlandse als buitenlandse chauffeurs is volgens RWS van belang om een gelijk speelveld te bevorderen, maar blijkt in de praktijk een ingewikkelde uitdaging.

5. DOEL VAN HANDHAVING

RWS zou het aandeel overbeladen transporten het liefst zien dalen naar 0 procent, maar benadrukt dat dit investeringen vergt en veel vraagt van overheid en sector. Dit zijn volgens RWS investeringen die zich zeker zullen terugverdienen door minder onderhoudskosten.

RWS geeft aan te streven naar een significante reductie in het aantal overbeladen transporten. Hierbij zou, naast fysieke meetpunten, ook moeten worden gezocht naar opties waarbij het voertuig zelf overbelading detecteert. Volgens RWS kan hierin enorme effectiviteit worden behaald en mogelijk kan dit de handhaving aanzienlijk goedkoper maken.

6. INTEGRALE BENADERING VAN OVERBELADING

De principes achter de samenstelling van de strategieën, waarbij zowel strategische als bureaucratische en sanctie-gerichte als informatie-gerichte handhavingsactiviteiten nodig zijn, worden door RWS gedeeld.

Door RWS wordt het ontbreken van het verrassingselement genoemd als beperking van WiM (chauffeurs weten doorgaans waar de meetpunten liggen), waar mobiele handhaving dit wel heeft. RWS ziet de komende jaren wel een rol weggelegd voor de WiM-systemen, maar ziet ook meerwaarde in aslastsensoren in voertuigen. Als aslastsensoren werken zullen ze de komende 20 tot 30 jaar mogelijk kunnen functioneren in combinatie met de WiM-systemen. Dit hangt af van hoe snel On-Board Weighing op de rails staat en bijvoorbeeld juridisch als bewijslast kan dienen. Een ultiem systeem zou volgens RWS On-Board Weighing voor directe handhaving zijn. Een vergelijking met het alcoholslot wordt gemaakt, waarbij niet kan worden gereden terwijl het voertuig overbeladen is. Of het zover komt is echter de vraag, maar het zou zeker consequent en effectief zijn.

7. EFFECTIVITEIT EN KOSTEN-EFFECTIVITEIT

RWS is voorstander van een principe waarbij de overtreder betaalt. De transporteur moet kunnen aantonen dat hij gebruik maakt van het wegennet zonder overbeladen te zijn. De kosten van de on-board aslastsensoren zouden hierom volgens RWS moeten liggen bij sector.

8. IMPLEMENTATIE VAN STRATEGIEËN

Het is RWS een doorn in het oog dat handhaving door technische problemen met de WiM systemen de mogelijkheden van handhaving beperkt. Ondanks dat overbelading niet de hoogste prioriteit heeft, gelooft RWS er niet in dat er daarom minder aan hoeft te gebeuren. In de implementatie van On-Board Weighing is het volgens RWS van belang alle partijen mee te krijgen in de denktrant in deze richting.

9. OMGANG MET ONZEKERHEID

RWS geeft aan dat deugdelijke berekeningen over slijtage door overbelading nodig zijn en bij kunnen dragen aan het draagvlak voor het tegengaan van overbelading.

10. AFSLUITING

RWS ziet, ondanks dat het al een langslepend en niet-sexy dossier is, veel kansen in de handhaving van overbelading met de beschikbaarheid van nieuwe technologie.

APPENDIX XIII – INTERVIEW REPORTS PROVINCE OF ZUID-HOLLAND

INTERVIEW STRATEGIC LEVEL

1. INTRODUCTIE

- Assetmanager Wegen Provincie Zuid-Holland
- Adviseur Verhardingen Provincie Zuid-Holland

2. EVALUATIE HUIDIGE SITUATIE

De huidige handhavingssituatie op het hoofdwegennet en regionaal wegennet wordt door respondenten zowel niet effectief als efficiënt beschouwd. Het effect van de Top 100 aanpak op het aantal overbeladen transportbewegingen op het regionaal wegennet wordt door respondenten als niet significant geschat. Lokaal zou de Top 100 aanpak wel effect gehad kunnen hebben, op bedrijven die zijn aangeschreven en aangesproken door ILT. Respondenten schatten in dat de soft governance zijde van de top 100 aanpak het meest heeft bijgedragen aan de effectiviteit van de aanpak, aangezien het aantal uitgeschreven bekeuringen slechts een fractie bedraagt van het ingeschatte aantal overbeladen transportbewegingen.

Respondenten denken dat de overheidssamenwerking op het gebied van overbelading niet intensief is, maar dat partijen wel hetzelfde belang hebben. Er wordt ingeschat dat de politie overbelading niet als prioriteit ziet, net als veel provincies. Provincie Overijssel wordt genoemd als provincie die wel prioriteit legt bij overbelading. De samenwerking tussen PZH en ILT wordt als niet bestaand ervaren: Handhaving door de ILT op het PZH-wegennet heeft de afgelopen jaren volgens respondenten niet plaatsgevonden. Respondenten vinden dat in handhaving op overbelading op het PZH-areaal zowel een rol voor PZH als ILT is weggelegd en dat dit een verantwoordelijkheid is van de twee partijen gezamenlijk. Het wordt als taak van ILT gezien om ook op het PZH-areaal te handhaven, maar hierin ligt ook een rol voor PZH zelf.

De verschillen in karakteristieken van lokale wegennetten worden door respondenten gezien als een van de oorzaken waardoor er door de ene provincie meer aandacht aan overbelading wordt gegeven als door de ander. PZH en Noord-Brabant worden genoemd als provincies met zware belasting, waar het eerder gewenst is iets te doen met overbelading. Tegelijkertijd wordt benoemd dat overbelading bij PZH geen hoge prioriteit heeft.

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

Het ingeschatte percentage bewuste overtreders wordt door respondenten als hoog ervaren. Ook het totaal percentage overbelading wordt gezien als hoog. Door respondenten wordt ingeschat dat de groei in de sector en met name het aantal nieuwe vervoerders er oorzaak van zijn dat het percentage overbelading al langere tijd gelijk blijft. Voor respondenten biedt de nalevingsschatting een mogelijkheid om richting bestuurders het probleem te communiceren en een richting te bepalen om met overbelading om te gaan.

De indeling in groepen en maatregelcategorieën wordt door respondenten gezien als een mogelijkheid om beleid mee te maken. Een inschatting van het verwachte gedrag van de sector wordt gezien als gewenst, maar in het geval van overbelading lastig in te schatten. In aanvulling op het weergegeven model zien respondenten ook mogelijkheid bewuste overtreders en handhavingsafgeschrikten tot inkeer te laten komen met behulp van soft governance. Het aanduiden van risico's zou hierbij kunnen helpen. Door toepassing van soft governance op bewuste overtreders en handhavingsafgeschrikten om ze zo af te buigen naar bewuste nalevers wordt geopperd als aanvulling op het getoonde model.

Respondenten kunnen zich vinden in de getoonde analyse in de Tafel van Elf. Binnen de Tafel van Elf zien respondenten vooral de lage controlekans als problematisch en een kans. De meerwaarde ervan wordt gezien in

het inzichtelijk maken van waar de toepassing van maatregelen het effectiefst zou zijn. Het zou kunnen helpen in beredeneren en afwegen van beleidskeuzes. Het geeft ook aan dat een benadering vanuit gedrag noodzakelijk is en niet alleen vanuit techniek moet worden gedacht.

4. UITGANGSPUNTEN VOOR HANDHAVING

Voldoen aan Europese en nationale wetgeving is een vereiste. Keuze tussen WiM en ON-BOARD WEIGHING is een voldongen feit. Voor PZH speelt vooral het belang van vermindering van slijtage en onderhoudskosten door overbelading een rol. Het verminderen van marktverstoring wordt gezien als mooie bijkomstigheid. Respondenten kunnen zich vinden in de gestelde uitgangspunten.

Volgens respondenten is maatschappelijke kosteneffectiviteit een randvoorwaarde bij de handhaving van overbelading. Interne kosteneffectiviteit, de vraag of de kosten van handhaving voor PZH opwegen tegen de baten van minder onderhoudskosten voor PZH, speelt geen rol en is geen uitgangspunt.

5. DOEL VAN HANDHAVING

Idealiter zouden respondenten het aantal bewuste overbeladers terugbrengen tot 0 procent. Zij gaan ervan uit dat altijd een groep onbewuste overbeladers aanwezig zal blijven. Realistisch gezien zouden zij tevreden zijn als het percentage bewuste overbeladers kan worden gereduceerd met 5 procentpunt. Het doel zou echter moeten zijn het aantal bewuste overbeladers terug te brengen tot 0.

6. INTEGRALE BENADERING VAN OVERBELADING

Automatische handhaving met behulp van On-Board Weighing wordt door respondenten gezien als meest gewenste strategie. De verwachting dat dit de provincie zelf de minste moeite zal kosten, afgezet tegen de ingeschatte hoge effectiviteit, worden hiervoor als argumenten genoemd.

De verdeling van maatregelen in meer sanctionerende of meer informerende en meer bureaucratische of meer strategische gezien als waardevol in het maken van keuzes en beleid.

7. EFFECTIVITEIT EN KOSTEN-EFFECTIVITEIT

De Tafel van Elf geeft respondenten inzicht om te beoordelen wat de verwachte effecten van maatregelen zijn. Bij de inschatting van kosten en baten wordt het verschil tussen een maatschappelijke kosten-batenanalyse en een analyse van de kosten en baten voor de provincie als wegbeheerder benadrukt. De getoonde analyse is een maatschappelijke kosten-batenanalyse, waarin ook kosten zijn opgenomen die niet op rekening van de provincie komen. Als voorbeeld wordt de investering in aslastsensoren genoemd, die respondenten zouden neerleggen bij de sector zelf.

8. IMPLEMENTATIE VAN STRATEGIEËN

Risico's bij de implementatie van strategieën die worden genoemd zijn het niet verkrijgen van toestemming van de Minister in een eventuele aanvraag zelf handhavingsactiviteiten te starten, investeringen in handhavingsactiviteiten op basis van foute aannames of investeringen in handhavingsactiviteiten terwijl een sturing door de provincie als opdrachtgever in onderhouds- en aanlegprojecten al veel effectiviteit oplevert. Respondenten zien ook een afwachtende houding van de provincie als risico.

9. AFSLUITING

Geen aanvullende opmerkingen.

INTERVIEW TACTICAL LEVEL

1. INTRODUCTIE

- Senior beleidsmedewerker kunstwerken
- Meegewerkt aan Praktijkbundel overbelading Wegbeheerders ontmoeten Wegbeheerders (WoW)
- Lid werkgroep Zwaartekracht (RWS, RDW, ILT en PZH namens de provincies)

2. EVALUATIE HUIDIGE SITUATIE

Respondent ervaart geen handhavingsactiviteiten op het hoofdwegennet en eigen areaal, maar beschouwt het wel als taak van de ILT om te handhaven op het areaal van PZH. Respondent vindt het van groot belang dat wetten en regels ook daadwerkelijk worden gehandhaafd en dat bedrijven momenteel te veel ruimte krijgen om wet- en regelgeving op het gebied van maximumgewichten te overtreden.

WiM wordt door respondent gezien als een goed begin van handhavingsactiviteiten, maar respondent vindt het onbegrijpelijk dat deze systemen al een tijd staan uitgeschakeld. Respondent ziet de risicoprofilering uit de Wim systemen als een startpunt voor eventuele handhaving door de provincie zelf. Hiermee zou gerichter kunnen worden gehandhaafd, door aan de hand van kentekens voertuigen langs de kant te zetten. Hiermee hoeven nalevers minder vaak lastiggevallen te worden door handhavingsactiviteiten. Respondent vindt dat de provincie ook inzicht zou moeten krijgen in WiM data vanuit het hoofdwegennet.

De verplichte keuze voor WiM dan wel On-Board Weighing wordt door respondent positief ervaren. Op provinciaal niveau vindt respondent dat de meningen en mate van aandacht voor overbelading ver uiteenlopen. Respondent vindt dat het technische verhaal beter vertaald zou moeten worden richting politiek snapbare verhalen. In marges zou moeten worden aangegeven wat overbelading kost en hoe effectief maatregelen zijn.

Respondent schat in dat de maatschappelijke kosten als gevolg van snellere slijtage van wegdek en kunstwerken op het provinciaal wegennet veel hoger zijn dan op het hoofdwegennet, omdat hoofdwegen zwaarder gedimensioneerd zijn. Volgens respondent ligt bij provincies een taak om aan te geven waar wegen op gedimensioneerd zijn.

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

Respondent acht de voorgelegde nalevingsschatting realistisch en ziet als provincie een kans onbewuste overtreders bewust te maken in de vorm van regels in bestekken. Hierbij kan worden laten zien dat bedrijven die zich aan de regels houden hier punten voor krijgen.

Respondent geeft aan dat er altijd een groep bewuste overtreders zal blijven en dat sanctionering daarom ook altijd nodig zal blijven. Informeren is volgens respondent lang genoeg geprobeerd en werkt niet, maar het bevoordelen van nalevende transporteurs in aanbestedingen wel.

Respondent ziet voor de provincie zelf een voorbeeldfunctie als opdrachtgever en speler op het gebied van bijvoorbeeld het verlenen van vestigingsvergunningen. Hierin zou de provincie bedrijven moeten stimuleren nalevend gedrag te vertonen. Respondent geeft aan dat de provincie het via twee kanten speelt, door zowel te kijken wat de mogelijkheden zijn om zelf te gaan handhaven, waarmee bewuste overtreders worden aangepakt, en te kijken hoe overbelading kan worden opgenomen in contracten, waarmee ook onbewuste overtreders worden gestimuleerd nalevend gedrag te vertonen.

Met betrekking tot de Tafel van Elf, waarin de huidige handhavingssituatie is weergegeven, geeft respondent aan dat de lage controlekans een overtredingsbevorderend karakter heeft. Regels die niet worden gehandhaafd zouden beter niet kunnen worden gemaakt. Binnen de Tafel van Elf is dit ook waar het meeste valt te winnen.

4. UITGANGSPUNTEN VOOR HANDHAVING

Een belangrijk uitgangpunt voor handhaving is dat het risico gestuurd vormgegeven dient te worden. Op wegvakken waar veel schade wordt geconstateerd, zou eerder moeten worden gehandhaafd. Hierbij is het van belang dat handhaving kosteneffectief is. Een investering in buitengewoon opsporingsambtenaren moet worden terugverdiend in besparingen in onderhoudskosten van het areaal. Hierbij is het ook van belang om te weten wat de wegen en kunstwerken aankunnen. Aannemers zouden ook moeten worden aangesproken op het gedrag van hun onderaannemers.

5. DOEL VAN HANDHAVING

Volgens respondent is het doel van handhaving bereikt als handhaving niet meer kosteneffectief is. Zolang de baten van minder onderhoudskosten opwegen tegen de kosten van handhaving moet worden gestreefd overbelading verder te beperken.

6. INTEGRALE BENADERING VAN OVERBELADING

Respondent kan zich vinden in de twee uitgangspunten die gebruikt zijn in de vorming van strategieën, namelijk de classificering in en toepassing van meer bureaucratisch gestandaardiseerde en meer strategische handhavingsactiviteiten en in meer sanctie-gerichte en meer informatie-gerichte handhavingsactiviteiten. Respondent zou graag zien dat de marges in wetgeving voor meetinstrumenten worden verruimd, om ook direct te kunnen bekeuren. De mogelijkheid om bijvoorbeeld doorlopende vergunningen voor exceptioneel transport alleen nog uit te geven als in ruil data wordt afgestaan over gewicht en route, wordt geopperd. Ook op het gebied van verzekeringen.

Respondent geeft aan dat WiM met glasvezeltechniek mogelijk wel toegepast kan worden op het provinciaal areaal, omdat de investeringskosten hiervan lager zijn. Bovendien zou het datakastje om de zoveel tijd verplaatst kunnen worden. Respondent gaat ervan uit dat de kosten hiermee een flink stuk lager zullen uitvallen, zeker als al gebruik wordt gemaakt van bestaande camera's aan wegkantsystemen.

7. EFFECTIVITEIT EN KOSTEN-EFFECTIVITEIT

Respondent verwacht dat ook met aslastsensoren gefraudeerd zou kunnen gaan worden. Inzet van WiM zou hierbij als onafhankelijk controlemiddel kunnen dienen, om fraude tegen te gaan

8. IMPLEMENTATIE VAN STRATEGIEËN

Respondent ziet het politieke klimaat als oorzaak van het nog steeds voorkomen van overbelading. Het belang van een begrijpbaar verhaal wordt onderstreept, waarin vooral wordt duidelijk gemaakt dat met investering in handhaving geld vrijkomt voor andere zaken. Het is volgens respondent een risico om in te veel cijfers achter de komma te willen denken, terwijl dit niet nodig is. Het is van belang het technische verhaal om te buigen naar een communiceerbaar en helder verhaal voor de politiek.

9. AFSLUITING

Geen aanvullende opmerkingen.

APPENDIX XIV – INTERVIEW REPORT HUMAN ENVIRONMENT AND TRANSPORT INSPECTORATE

1. INTRODUCTIE

- Projectleider Weigh-in-Motion en aanpak overbelading
- 10 jaar betrokken bij introductie WiM systemen en ontwikkeling toezicht en bestuursrechtelijke handhaving

2. EVALUATIE HUIDIGE SITUATIE

De huidige wetgeving voorziet in handhaving waarbij gebruik wordt gemaakt van meetmiddelen die voldoen aan de eisen gesteld in de Regeling Meetmiddelen. Het WiM systeem voldoet niet aan die eisen. Hierom is besloten een toezichtsmethodiek te ontwikkelen waarbij bedrijfsprofielen worden gemaakt. Op basis van het kentekenregister wordt achterhaald welk bedrijf eigenaar is van het voertuig, om zo een ranking te maken van meest overtredende transportbedrijven. Momenteel wordt gewerkt aan de vervanging van de wegkantsystemen, welke na 10 jaar aan het eind van hun levensduur zijn. Van de huidige 16 systemen zijn er 14 niet werkzaam, waardoor geen bedrijfsprofilering plaatsvindt. Op basis van een inmiddels afgeronde proof of concept voor twee nieuwe WiM technieken wordt door RWS gekozen voor ofwel een nieuw WiM systeem met 18 meetpunten, ofwel een ander systeem. De huidige situatie is niet naar wens, aldus de ILT. De ILT heeft slechts een handvol inspecteurs beschikbaar, waarmee alleen fysiek handhaven volgens respondent niet effectief is. Het is de intentie van de ILT om wel weer bestuursrechtelijk te gaan handhaven, gebruikmakend van de WiM systemen, als deze zijn vernieuwd.

Binnen de Top 100 aanpak werden vervoerders maandelijks geïnformeerd over het gewicht van hun voertuigen. Het directe contact met de ondernemer gaf de ILT het voordeel direct te kunnen uitleggen wat er aan de hand was. De aanpak bestond uit een stuk gedragsbeïnvloeding, waarbij bij de ondernemer awareness werd gekweekt. Volgens de ILT leidde de aanpak tot de inzet van andere voertuigen door ondernemers en het maken van afspraken tussen ondernemers en verladers. Volgens ILT moet de gehele keten worden meegenomen in de aanpak van overbelading. Elke schakel in de vervoersketen, bestaande uit opdrachtgevers, verladers en transporteurs, vormt een zeker risico.

De ILT geeft aan dat buitenlandse vrachtwagens op totaalgewicht bijna nooit overbeladen zijn, door de lagere maximumgewichten die worden gehanteerd in de andere Europese lidstaten. Als zij zijn overbeladen, zijn zij meestal overbeladen op de trekas van de trekker in een trekker-opleggercombinatie. Samenwerking in handhaving binnen Europa vindt niet plaats, wel wordt informatie uitgewisseld. Wel wordt binnen Europa gestreefd naar uniformiteit in handhaving, in samenwerkingsverband European Controle Route. In alle Europese lidstaten wordt WiM gebruikt voor preselectie. In Hongarije en Tsjechië wordt gekeken of gehandhaafd kan gaan worden op de zorgplicht in plaats van aslasten. Hierbij wordt de vervoerder verantwoordelijk gehouden voor het voldoen aan de maximumgewichten en wordt hierop ook gehandhaafd. Vanuit de ILT wordt dit gezien als positieve ontwikkeling. Wel schat de ILT het als lastig in om hierop te handhaven. Gebaseerd op de WiM data voert de ILT bedrijfsbezoeken uit, waarbij de gehele bedrijfsvoering wordt bekeken. Onder andere wordt gekeken of chauffeursbijeenkomsten worden georganiseerd en of chauffeurs worden aangesproken op eventueel foute gedragingen. Hierbij focust de ILT voornamelijk op grotere bedrijven, zodat veel potentiële overtreders worden bereikt. De ILT ervaart dit positief.

Samenwerking met RWS wordt positief ervaren. Volgens de ILT ervaren provinciale wegbeheerders met de introductie van WiM dat omgereden wordt via het provinciaal wegennet. De ILT is momenteel in gesprek met provincies om te kijken hoe dit, bijvoorbeeld in samenwerking met lokale politie, kan worden aangepakt. De ILT geeft wel aan dat een deel van de door mensen ervaren overlast ook komt door de positionering van bijvoorbeeld

bedrijventerreinen, waarbij soms ook dorpskernen moeten worden doorkruist om bij de snelweg te komen. Uit een proef bij de A12 bij Bodegraven bleek dat nauwelijks sprake is van overbelading. De ILT deelt de hypothese dat een toename van de handhavingsactiviteiten op het hoofdwegennet zou kunnen leiden tot een toename van strategisch ontwijkend gedrag door bewust overbeladen transporteurs. Over het algemeen wil een transporteur echter zo snel mogelijk van A naar B en leent het onderliggend wegennet zich hier in mindere mate voor, onder andere door rotondes, verkeersdrempels en stoplichten. De ILT is er wel van op de hoogte dat door sommige transporteurs bewust andere snelwegen worden gekozen.

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

De ILT vindt dat onderscheid gemaakt moet worden tussen overbelading op totaalgewicht en aslastoverschrijdingen. Met betrekking tot overbelading op totaalgewicht, is overbelading binnen de marges van het handhavingsbeleid (5 procent extra) altijd bewust. Aangezien tot 52,5 ton niet wordt beboet, laden veel transporteurs tot 52,5 ton, volgens de ILT. Een categorie vrachtwagens, bestaande uit een trekker-opleggercombinatie met 2 en 3 assen, heeft een kentekengewicht van 47 ton, maar belaadt bewust tot 52,5 ton. Dit is een forse en vaak voorkomende overschrijding. In het losgestort vervoer wordt nog vaak op het blote oog en ervaring beladen. Dit is bijvoorbeeld het geval bij zandtransporten, waarbij de vervoerder meestal ook de eigenaar van het zand is. De ILT classificeert dit als bewust niet naleven. Bij asfaltcentrales daarentegen is wel een weegbrug aanwezig en wordt het totaalgewicht minder overschreden.

Met betrekking tot aslasten en deelladingen, denkt de ILT dat ook hier een groep bewust niet naleeft, vanwege het kostenaspect. Een toenemende schoteldruk leidt tot aslastoverschrijdingen na een lossing van een deel van de lading. Om dit te voorkomen moet de lading na tussenlossing naar achteren worden verplaatst, wat een investering vergt in bijvoorbeeld een walking floor of zijlossers. Gezien de regelgeving bij de sector goed bekend is, wordt het gezien als bewuste keus om hierin niet te investeren. De ILT gaat ervanuit dat 80 procent van de gehele sector weet hoe de regelgeving in elkaar zit. Op basis van de WiM data worden niet-nalevende bedrijven ook specifiek geïnformeerd. De ILT gaat ervan uit dat er altijd een groep zal blijven die uit economisch belang wetgeving met betrekking tot maximumgewichten zal blijven overtreden.

De Tafel van Elf wordt door de ILT altijd gebruikt in thematische acties, om de doelgroep te verkennen. Echter, niet alles is te vatten in deze methodiek. Als voorbeeld wordt distributievervoer genoemd. Voor elke sector In het distributievervoer is de naleving hoog, tot het komt op deelladingen. Dit is het gevolg van het bestaan van filialen, die door dezelfde vrachtwagen na elkaar worden beleverd. De ILT geeft aan dat transport vaak het sluitstuk van de begroting is en dat hier met name in economisch zwaardere tijden verder op bezuinigd wordt. Anderzijds zijn transporteurs in economisch betere tijden goed in staat en bereid te investeren. De ILT maakt hier gebruik van door transporteurs hier actief op te wijzen: “Als de zon schijnt moet je het dak repareren”. De ILT geeft aan dat geen meldingen bij de ILT worden gedaan van overbelading door andere transporteurs.

Op dit moment wordt een studie gedaan naar de koppeling tussen kilometerheffing en andere digitale handhavingsmogelijkheden. De gedachte hierbij is dat de opbrengsten van de kilometerheffing terug moeten vloeien naar de sector, die heeft aangegeven dat meer handhaving gewenst is. Onder andere wordt onderzocht of de handhaving op overbelading kan worden gecombineerd met de wegkantsystemen die ingezet gaan worden in het kader van kilometerheffing.

De ILT kan zich vinden in de gemaakte analyse in het kader van de Tafel van Elf, maar draagt aan dat de perceptiekans (subjectieve controlekans) hierin ontbreekt. Als voorbeeld wordt genoemd de plaatsing van borden waarop meetpunten worden aangekondigd. Ook het verschil tussen verwachte controles en onverwachte controles draagt hieraan bij.

4. UITGANGSPUNTEN VOOR HANDHAVING

De ILT kan zich vinden in de gebruikte uitgangspunten voor handhaving op overbelading. Variatie in handhavingsstijl wordt gezien als een lastige opgave. Uitgaan van de maatschappelijke schade die overbeladen transporten veroorzaken wordt gezien als een erg belangrijk uitgangspunt.

5. DOEL VAN HANDHAVING

Het doel van de ILT was om het aandeel overbeladen transporten onder de 10 procent te krijgen. Gezien de complexiteit van het probleem, waarin onder andere economisch getijde, bewust en onbewust gedrag, calculerend gedrag en de hele vervoersketen van invloed zijn, zou de ILT blij zijn het percentage niet-nalevers op het gebied van aslastoverschrijdingen terug te krijgen tot 5 a 10 procent. Op totaalgewicht zou de ILT graag terug willen naar 0 tot 5 procent, gezien overbelading op totaalgewicht meer impact heeft. Overbelading op assen heeft voornamelijk impact op wegdek, overbelading op totaalgewicht ook op kunstwerken. Hier doen zich dan ook de grootste maatschappelijke gevolgen voor. De ILT geeft aan dat RWS zegt dat totaalgewichtoverschrijdingen nu meer toenemen dan vroeger. De ILT koppelt deze ontwikkeling aan het zware economische getijde van de afgelopen jaren.

6. INTEGRALE BENADERING VAN OVERBELADING

De ILT kan zich vinden in de twee uitgangspunten die gebruikt zijn in de vorming van strategieën, namelijk de classificering in en toepassing van meer bureaucratisch gestandaardiseerde en meer strategische handhavingsactiviteiten en in meer sanctie-gerichte en meer informatie-gerichte handhavingsactiviteiten. Voor de ILT staat hierbij informeren en communiceren bovenaan, omdat hiervandaan gedragsverandering kan plaatsvinden. Een sterke focus op sanctionering maakt transporteurs wellicht handhavingsafgeschrikt, maar nog geen bewuste nalever.

De ILT geeft aan dat een sterke analyse uit WiM data informatie kan geven over type voertuig (carrosseriebouwer), lading (opdrachtgevers), wagenparkgegevens per sector. Van daaruit kan met behulp van de Tafel van Elf een nalevingsperspectief voor een deel van de sector worden gevormd. De sterkte van handhaving zit in het bekijken en benaderen van deelsectoren vanuit een sterke analyse. Deelsectoren kunnen worden aangesproken op gedrag en na een afgesproken periode kan handhaving op specifieke deelsectoren worden ingezet.

De ILT gebruikt een piramide, waarin de top van de piramide bestaat uit grote bedrijven, welke vrijwel altijd naleven. De bodem van de piramide bestaat uit eenmanszaken en hobbyisten. Het middensegment van bedrijven die bij de top proberen te horen, worden op kostenniveau naar beneden getrokken. Voor de ILT is dit de groep die met informatie en communicatie geholpen moet worden, door te laten zien hoe bedrijven bovenin de piramide overbelading tegen gaan. De groep cowboys aan de onderzijde van de piramide moet gehandhaafd op worden.

Alhoewel de ILT er wel voorstander van is, is de sector (nog) niet bereid de data van de in de vrachtauto ingebouwde aslastsensoren voor handhaving ter beschikking te stellen.

Er is nog geen wetgeving die erin voorziet dat de inspectie inzicht kan krijgen in de data die aslastsensoren leveren en de ILT verwacht ook niet dat dit zal gebeuren.

Echter, de ILT vindt wel dat On-Board Weighing systemen kunnen bijdragen aan de awareness van de transporteur en informatiepositie van de transporteur. Hierop kan ook gehandhaafd worden. Indien de transporteur aangeeft de aslast niet vooraf te hebben afgelezen is dit al fout. Indien de transporteur overbeladen is, dan is dit dus altijd bewust en daarmee dubbel fout.

De ILT zou het mooi vinden als in de toekomst On-Board Weighing systems op bepaalde punten data uitzenden naar wegkantsystemen. In het geval van de digitale tachograaf is voor de ILT voldoende bewezen dat er

gefraudeerd is als het wegkantsysteem detecteert dat de digitale tachograaf uitstaat. Voor overbelading zou dat net zo kunnen gelden.

Met betrekking tot het opnemen van een contractparagraaf tegen overbelading in contracten vanuit de overheid, geeft de ILT aan dat contractbeheer en toezicht van belang zijn om dit te laten slagen. Het blijkt in de praktijk een lastig verhaal om een verbod op overbelading op te nemen in contracten en het beheer en toezicht vorm te geven.

7. IMPLEMENTATIE VAN STRATEGIEËN

Het ministerie van I&W heeft nog een jaar om te kiezen tussen WiM en ON-BOARD WEIGHING, volgens de Europese richtlijn. Een vergelijking met de introductie van de slimme tachograaf leert dat de introductie van nieuwe technologie onderhevig kan zijn aan sterke lobby. Gezien wordt verwacht dat de introductie van verplichte On-Board Weighing systemen nog op zich laat wachten, wordt in ieder geval de komende 5 jaar nog voortgebouwd op WiM met verbeterde technologie. Na die tijd wordt gekeken of de technische en organisatorische invoering van On-Board Weighing dichterbij komt.

8. AFSLUITING

Geen aanvullende opmerkingen.

APPENDIX XV – INTERVIEW REPORT DUTCH VEHICLE AUTHORITY

1. INTRODUCTIE

- Manager ontheffingen
- Betrokken bij overbelading in de ontheffingen voor exceptioneel transport en aslast- en gewichtsoverschrijdingen die daarbij plaats kunnen vinden.

2. EVALUATIE HUIDIGE SITUATIE

RDW vindt het jammer dat handhaving met WIM niet meer kan plaatsvinden. RDW heeft geen handhavende taak, maar geeft aan dat het aantal controles laag is. RDW benadrukt dat de handhavingssituatie een politieke keuze is. En deze er anders uit zou kunnen komen te zien bij andere sturing. RDW geeft aan dat zij handhaving nastreven en graag een bijdrage leveren door handhaving zo goed als mogelijk te ondersteunen. Zij geven een zo goed mogelijke ontheffing af, op basis van informatie aangeleverd door wegbeheerders en vervoerders.

Volgens de RDW zou, als je het beter wil doen, meer aandacht moeten worden gegeven aan overbelading en een koppeling moeten worden gemaakt met resultaten die voor wegbeheerders meetbaar zijn, reductie van onderhoudskosten. De samenwerking tussen RDW en andere partijen wordt, binnen het speelveld dat er nu is, geëvalueerd als prima. Er is meer bewustzijn bij wegbeheerders, maar het zou goed zijn als die krachten meer gebundeld worden. Wat de RDW graag zou zien, is dat transporteurs die naleven ervan op aan kunnen dat collega's die overtreden hierop ook worden aangesproken, om zo een gelijk speelveld te bevorderen. De RDW benadrukt dat de kwaliteit van de ontheffing steeds beter wordt, onder andere door digitale kaarten en meer expertise bij wegbeheerders in hun areaalbeoordelingen. De gebruiker kan op basis van goede informatie een verstandige keuze maken om het op een juiste manier te doen. Volgens de RDW is dit wellicht zelfs effectiever dan handhaving; de combinatie van beide is wenselijk.

Het zou wenselijk zijn als de pakkans groter wordt, maar daarbij moet volgens RDW ook gekeken worden naar de effectiviteit van te nemen maatregelen. Het liefst zou RDW zien dat de overbeladers er nog uit worden gepakt, maar volgens RDW lukt dit onvoldoende met de huidige middelen. Tegelijkertijd moet de wegbeheerder de faciliteiten aanbieden zodat de transporteur binnen de kaders kan blijven. De wegbeheerder moet weten wat hij de transporteur aan kan bieden, om aan de voorkant een stimulatie te bieden voor nalevend gedrag. De RDW gelooft dat het effectief is om de transportbranche mogelijkheden te bieden ergens te rijden zonder dat ze daar schade toe brengen. Volgens RDW kan een wegbeheerder die keuze aanbieden door het areaal inzichtelijk te maken en duidelijk aan te geven waar transporten wel en niet mogen komen. Hierin hebben provincies volgens RDW een grote slag gemaakt, maar valt ook nog veel verder te verbeteren. Op het moment dat je dit goed op orde hebt, sorteer je al veel effect en heb je en duidelijke basis voor handhaving.

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

RDW schat het gebruik van een ontheffing hoog in. Op het gebied van belading hebben veel transporteurs in het exceptioneel transport de keuze hun transport goed uit te voeren. De RDW denkt dat zowel informeren als sanctioneren gedaan moet worden. Aangezien het informeren al goed gebeurd, zou de RDW meer druk willen zetten op de handhaving zelf. De RDW verwacht dat onder toenemende druk van handhaving, transporteurs ook zelf meer informatie zullen gaan ophalen bij de RDW. Het een versterkt hierin het ander, waarin een balans wordt gevormd. Wat meer aandacht voor handhaving in combinatie met slimmere technieken zorgt voor een verandering in het krachtenspel. De RDW heeft het gevoel alsof zij de sector al goed bereiken.

De RDW kan zich aardig goed vinden in de analyseresultaten verkregen in de Tafel van Elf. De RDW herkent de resultaten en bevindingen en ziet hier geen verrassingen in.

4. UITGANGSPUNTEN VOOR HANDHAVING

De RDW mist de brancheorganisaties in het uitgangspunt “de handhavingsstrategie dient de horizontale en verticale samenwerking tussen wegbeheerders en handhavingsinstanties op het gebied van handhaving meer te structureren”, benadrukt dat je hen niet tegen je wil hebben en juist wil meekrijgen zodat zij ook aangesloten transporteurs kunnen informeren. De RDW geeft aan dat door de verschillen tussen (deel)sectoren onderling, een aanpak die op de ene sector wel werkt op een andere sector ook niet kan werken. De RDW mist geen uitgangspunten in de getoonde analyse.

5. DOEL VAN HANDHAVING

Het doel van de RDW in handhaving op overbelading zou zijn om 0 procent overbelading te realiseren, rekening houdend met een meetonnauwkeurigheid.

6. INTEGRALE BENADERING VAN OVERBELADING

De RDW kan zich vinden in de twee uitgangspunten die gebruikt zijn in de vorming van strategieën, namelijk de classificering in en toepassing van meer bureaucratisch gestandaardiseerde en meer strategische handhavingsactiviteiten en in meer sanctie-gerichte en meer informatie-gerichte handhavingsactiviteiten. RDW geeft de voorkeur aan een systeem waarin overbelading niet meer voor zou kunnen komen. Hierbij zou bijvoorbeeld een koppeling gemaakt kunnen worden van aslastsensoren aan het systeem wat ontheffingen afgeeft. Op basis van een real-time vergelijking tussen die twee kan de vervoerder zich aanmelden en het transport uitvoeren. Dit heeft voordelen voor zowel RDW, wegbeheerder als transporteur. Laatstgenoemde kan veel sneller een ontheffing krijgen, omdat vanuit genoemde vergelijking altijd zeker is dat hij het goed doet.

7. EFFECTIVITEIT EN KOSTEN-EFFECTIVITEIT

Een goede onderbouwing van alle kosten wordt noodzakelijk geacht. De kosten voor aslastsensoren kunnen wat RDW betreft worden neergelegd bij de markt, waarbij de verwachting is dat deze worden doorberekend aan opdrachtgevers. Kosteneffectiviteit is voor de RDW wel een uitgangspunt. De kosten voor een dergelijk systeem mogen niet hoger uitvallen dan de huidige maatschappelijke kosten van overbelading. De RDW zou goed kijken naar of je dit voor de hele sector doet (alle transporten boven de 12 ton), of alleen voor transporten boven de 50 ton. Laatste optie wordt door RDW als realistisch geacht. Politieke prioriteit is hierbij wel een vereiste, alsmede een vertaling naar het effect op beheer en onderhoudskosten.

8. OMGANG MET ONZEKERHEID

In de werkgroep Zwaartekracht is een tool ontwikkeld om meer inzicht te krijgen in het verband tussen aslasten, totaalgewichten en extra kosten door wegslijtage. De tool is ontwikkeld om het bewustzijn bij wegbeheerders te vergroten en inzicht te geven in de omvang van schade door overbelading. Zwaartekracht is een samenwerking tussen RWS, ILT de Provincies en de RDW.

9. AFSLUITING

Geen aanvullende opmerkingen.

APPENDIX XVI – INTERVIEW REPORT DUTCH ASSOCIATION FOR TRANSPORT AND LOGISTICS

Due to the absence of a response from the interviewee, the content of this interview report is not approved by the interviewee.

1. INTRODUCTIE

- Secretaris Techniek
- Secretaris Deelmarkt exceptioneel vervoer
- Secretaris Deelmarkt autotransporteurs

2. EVALUATIE HUIDIGE SITUATIE

Er is door de sector geïnvesteerd in voorlichting, nieuw materieel, andere werkwijzen. Handhaving kan oneerlijke concurrentie tegengaan. Bedrijven die nog steeds overbeladen hebben een concurrentievoordeel. Het grootste deel van de partijen zorgt dat ze de zaken goed voor elkaar hebben, maar onder druk van concurrentie en invloed van opdrachtgevers komt overbelading nog wel voor. Handhaving is nodig als signaal naar de markt en stok achter de deur, dat als je de regels overtreedt, je de kans loopt gepakt te worden.

TLN stond achter het geschepte verwachtingspatroon van de uitrol van het landelijke netwerk aan weeglussen, omdat dit een level playing field bevordert. De werking van het systeem bleef achter bij de verwachtingen. De gedachtegang achter de hieraan gekoppelde Top 100 aanpak was volgens TLN goed, maar het is helaas misgegaan op de betrouwbaarheid van de techniek.

TLN vindt het positief dat in veel andere Europese landen overbelading ook wordt gezien als aandachtspunt. In de aanpak van overbelading worden wel grote verschillen gezien tussen landen. Als voorbeeld wordt België genoemd, waar de boetebedragen voor aslastoverschrijdingen door TLN als bijzonder hoog worden gezien. Het is volgens TLN pijnlijk als hoge boetes worden uitgedeeld voor onbewuste en kleine overschrijdingen op aslast. De door Europa voor lidstaten verplichte implementatie van WiM of On-Board Weighing wordt toegejuicht door TLN.

TLN constateerde een terugloop in controle-activiteiten met de invoer van de Nationale Politie, en na het eindigen van het gebruik van WiM. Volgens TLN moet, nu de WiM systemen zijn uitgeschakeld, worden teruggevallen op handmatige selectie op basis van uiterlijke voertuigkenmerken. Het nadeel hiervan is dat ook good guys aan de kant worden gezet bij willekeurige selectie. TLN merkt op dat overbelading van bestelwagens niet kan worden gedetecteerd met WiM, maar ook voorkomt en resulteert in oneerlijke concurrentie.

3. EVALUATIE ONDERZOEKSRESULTATEN HUIDIGE SITUATIE

TLN geeft aan het frappant te vinden dat het aandeel overbeladen vrachtwagens al 15 jaar op 15 procent ligt, terwijl er in die jaren wel veel aandacht is besteed aan overbelading. TLN geeft aan dat er een onderscheid gemaakt moet worden tussen voertuigen die op totaalgewicht zijn overbeladen en voertuigen die op asgewicht zijn overbeladen. De tweede groep, die op 80 procent van de totale groep wordt geschat, heeft geen concurrentievoordeel. In de 15 procent zit ook een groep die nog wel valt binnen de marges van 10 procent op aslast en 5 procent op totaalgewicht. Veel vervoerders nemen het risico om de marge als eigen speelruimte te beschouwen, waarmee zij voor de wet wel zijn overbeladen maar nog wel binnen de marges vallen waarbinnen niet wordt gesanctioneerd. Als vervoerder die dagelijks te maken heeft met deelladingen, waardoor aslastoverschrijdingen kunnen voorkomen, moet je volgens TLN investeren in een trekkend voertuig dat voldoet, of een extra hulpas.

De nadruk in handhaving zou volgens TLN moeten liggen op de bewuste overtreders. Voor good guys, die proberen zich aan de regels te houden, is het lastig te zien dat bad guys zich niet aan de regels houden. Een categorie good guys zal als de nood hoog is melding maken bij het meldpunt van de ILT. Het is echter de indruk van TLN dat dit voor het grootste deel van de vervoerders een stap te ver gaat.

Met betrekking tot exceptioneel transport is bijna altijd een ontheffing nodig. Onder invloed van opdrachtgevers en concurrentie worden vervoerders beinvloed om te rijden zonder ontheffing: Als de ene vervoerder het transport niet wil uitvoeren zonder ontheffing, gaat de opdrachtgever op zoek naar een ander die dat wel wil doen. Volgens TLN zit het met de helderheid van regelgeving wel goed, maar is de pakkans met name voor de echte bad guys, die willens en wetens overbeladen, te laag. Het is de taak van bedrijven om de kennis over te brengen op chauffeurs.

4. UITGANGSPUNTEN VOOR HANDHAVING

TLN benadrukt dat een van de uitgangspunten in de omgang met overbelading een adequate handhaving moet zijn. Voorlichting en wijzen op risico's, regelgeving en sancties draagt zeker ook bij, en hierin ziet TLN ook een taak voor zichzelf weggelegd, maar zonder handhaving worden deze activiteiten door TLN gezien als een wassen neus.

Een startblokkering bij overbelading wordt door TLN geopperd als mogelijke oplossing. Een groot deel van de nieuwe vrachtwagens heeft al aslastsensoren en in deel daarvan ook een display in de cabine waarop de aslasten en het totaalgewicht worden weergegeven. Als voorbeeld wordt door TLN losgestort genoemd, waarbij vrachtwagens vaak op weegschalen staan tijdens het storten. In bijvoorbeeld het containervervoer is het lastig voor chauffeurs om aan te geven dat zij niet willen rijden met een verkeerd of overbeladen container. Dit is een situatie waarbij een chauffeur wel kan zien dat er sprake is van overbelading, maar niet de middelen heeft daarmee om te gaan.

Volgens TLN zou ook op het gebied van verzekeringen winst te behalen zijn, door bij bewuste overbelading niet meer uit te keren. TLN geeft aan dat bij ongevallen vaker moet worden gekeken of overbelading de oorzaak is.

De door Europa gestelde keuze tussen WiM en On-Board Weighing juicht TLN toe. Hierbij zouden volgens TLN vanaf een gegeven moment aslastsensoren moeten worden verplicht, maar alleen bij nieuwe voertuigen. Veel nieuwe voertuigen hebben de techniek al.

5. DOEL VAN HANDHAVING

TLN benadrukt dat het doel van handhaving moet zijn dat een eerlijk speelveld wordt gecreëerd in de transportmarkt. Het is voor TLN van groot belang dat nalevende bedrijven niet lijden onder overtredende.

6. INTEGRALE BENADERING VAN OVERBELADING

TLN krijgt de indruk dat overbelading geen hoge prioriteit heeft bij het ministerie van I&W en betreurt het dat de WiM systemen op het hoofdwegennet er al zo lang uit liggen.

Volgens TLN is de toepassing van On-Board Weighing uitsluitend voor de weergave van aslasten en totaalgewicht aan de chauffeur niet afdoende, maar is het nodig dat het uitleesbaar is. De pakkans moet volgens TLN namelijk omhoog. Een vergelijking met de tachograaf wordt gemaakt, waarbij data 30 dagen wordt opgeslagen in het voertuig.

Probleem met WiM nu is dat het niet automatisch kan bekeuren. Techniek in Nederland is niet goed genoeg. Dynamisch wegen lastig. TLN gelooft niet in WiM voor automatisch beboeten. TLN denkt dat andere landen

zullen kiezen voor On-Board Weighing, nieuwe voertuigen met On-Board Weighing verplichten is TLN voor. Verwachting dat kosten mee zullen vallen.

7. IMPLEMENTATIE VAN STRATEGIEËN

TLN benadrukt dat zij vindt dat een snelle keuze moet worden gemaakt tussen On-Board Weighing en Weigh-in-Motion. In de overgangsperiode naar ON-BOARD WEIGHING moet worden voorkomen dat de controlekans voor transporteurs met aslastsensoren groter wordt dan die voor transporteurs zonder.

8. AFSLUITING

Volgens TLN zijn we het stadium voorbij waarin we kunnen zeggen dat we een goed werkend WiM systeem hebben, omdat de techniek ons in de steek heeft gelaten. De pakkans moet omhoog.