TØI report 1312/2014

Alena Høye

Institute of Transport Economics
Norwegian Centre for Transport Research

Road safety program for Stockholm 2010-2020: Review and evaluation of goals, indicators and measures

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Summary:

The goal of a 40% reduction of the annual numbers of killed or severely injured road users in Stockholms stad until 2020 may be attained only if the goals for all chosen road safety indicators are attained, and otherwise only if there are considerable external effects. For most indicators however, goal attainment seems not very likely unless considerable additional efforts are made, especially to reduce vehicle speeds and to improve the road infrastructure for pedestrians and cyclists. It is not recommended to adjust the overall goal, the indicators or the goals for the indicators. However, adjustments to the definitions of some indicators may be recommendable in order to improve the coverage of effective safety measures that are under the responsibility of the municipality.

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Sammendrag:

Målet om å redusere det årlige antall drepte eller hardt skadde i trafikken i Stockholms stad med 40% til 2020 kan bli nådd kun hvis målene for alle valgte trafikksikkerhetsindikatorene blir nådd, eller hvis det er store effekter av andre faktorer. For de fleste indikatorene er det imidlertid usannsynlig at målene vil bli nådd uten en betydelig innsats, især for å redusere farten og for å forbedre infrastrukturen for fotgjengere og syklister. Det er ikke gjort anbefalinger om å endre det overordnede målet, men det er gjort forslag om å endre noen av indikatorene for å fange opp virkninger av flere effektive tiltak.

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Preface

In this report we have on behalf of Trafikkontoret of the City of Stockholm investigated the progress towards the goal of reducing the annual numbers of killed or severely injured road users in Stockholms stad by 40% until 2020. It is a follow-up of TØI-report 1044/2009 that was written by Michael W. J. Sørensen, Astrid H. Amundsen and Rune Elvik, with a detailed investigation of the goal, sub-goals and indicators in the present road safety program.

At TØI, Alena Høye has made the data analyses and evaluations and written the report. Rune Elvik and Michael W. J. Sørensen have contributed with their experience from the previous report. Rune Elvik has been project manager. Michael W. J. Sørensen has been quality manager of the report and Trude Rømming has edited and prepared the report for printing.

Contact persons at Trafikkontoret were Anna-Sofia Welander, Daniel Firth and Ulrika Bladh. The report would not have been possible without the contributions from Leena Tippana, Johan Bergkwist and Per Karlsson from Trafikverket, and Jan Östlund from Trafikanalys.

Oslo, April 2014
Institute of Transport Economics

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Director

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Research director

Contents

Summary:

Road safety program for Stockholm 2010-2020: Review and evaluation of goals, indicators and measures

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The goal of a 40% reduction of the annual numbers of killed or severely injured (KSI) road users in Stockholms stad until 2020 may be attained only if the goals for all chosen road safety indicators are attained, and otherwise only if there are considerable effects of factors that are not covered by the indicators. For most indicators however, goal attainment seems not very likely at present, unless considerable additional efforts are made, especially to reduce vehicle speeds and to improve the road infrastructure for pedestrians and cyclists. Improvements for pedestrians and cyclists should be in accordance with the indicators safe main roads, safe local roads and management and maintenance and additionally with the bicycle strategy and mobility plan. It is not recommended to adjust the overall goal, the indicators or the goals for the indicators. However, adjustments to the definitions of some indicators may be recommendable, especially to the speed and safe main roads indicators, in order to improve the coverage of effective safety measures that are under the responsibility of the municipality.

The main goal in the road safety program for Stockholm stad 2010-2020 is a reduction of the number of killed or severely injured (KSI) by 40% from an average of 278 in 2006-2009. Stockholms stad refers to the municipality of Stockholm. A number of sub-goals were identified, based on several road safety indicators: Speed, Safe main roads, Increased knowledge about road safety, Management and maintenance, Heavy vehicles, Safe local roads, Seat belt use, Bicycle helmet use, and Driving under the influence of alcohol (DUI). For each indicator a specific sub-goal is identified, which is meant to facilitate the identification of specific measures and continuous monitoring.

The present report is a follow-up of the report from 2009 (Sørensen et al., 2009) that has been the basis for the development of the goals, indicators and recommended measures. A detailed investigation has been made of the goal, sub-goals and indicators in the present road safety program.

For each indicator a target group has been identified, i.e. a group of KSI that are assumed to be affected by the indicator, and it has been investigated

- How the indicator has developed from 2006-2009 to 2012, how it is likely to develop until 2020 and what measures (planned and others) may contribute to improving the indicator

- How the number of KSI in the target group for the indicator is likely to develop until 2020 if everything except exposure remains unchanged, if the goal for the indicator is attained and if goal is partly attained (if the present development of the indicator continues until 2020); for some indicators it has also been investigated how additional measures that are not covered by the definition of the indicator may contribute to the number of KSI in the target group

Finally, aggregated calculations were made for the development of the number of KSI until 2020 in different scenarios: When the goals for all indicators are unattained, partly attained, or completely attained, including a scenario with the most likely changes for each indicator. Other factors that may affect the development of the number of KSI are discussed and taken into account as well. Based on these investigations and calculations, answers can be provided to a number of questions about the road safety program.

Present development: Are crash statistics and road safety indicators developing in accordance with the goals?

The present development of the numbers of KSI in Stockholms stad does not seem to be in the right direction. The total number of KSI has increased each year after 2009, especially among pedestrians and cyclists. However, it has been concluded that the observed increase probably is due to random variation rather than to a reversion of the long-term downward trend and no predictions are made for 2020 based on the development of the numbers of KSI during the past few years.

Table S.1 summarizes the present development of the indicators, including the status in 2006-2009 and 2012, the expected status in 2020 if the current trend continues and planned measures are implemented, and the goal for 2020. For the indicators speed, safe main roads, safe local roads, and management and maintenance (M&M) the current development is not sufficient. At present, the attainment of the goals for these indicators does not seem likely, but there are a number of effective measures that are under the responsibility of the municipality of Stockholm that may improve the development. For the indicators seat belt use, bicycle helmet use and driving under the influence of alcohol (DUI), the goals will most likely be attained or almost attained, but the effects on the numbers of KSI are limited and there is little the municipality can do to improve the development. For the indicators heavy vehicles and increased knowledge, there is at present no precise definition of the indicators and effects on the number of KSI in 2020 could not be estimated.

Table S.1: Status of the road safety indicators in 2006-2009, expected status in 2020 and status at goal attainment, incl. expected effects on KSI in 2020 at expected status and goal attainment.

	Status 2006-2009	Status in 2012	Expected in 2020[1]	Goal[2]
Speed				
▪ ***Proportion of all vehicles driving at or below the speed limit*** ***Target group:*** KSI in crashes involving a motor vehicle	**50%**	**74%**	**83%** (-14% KSI)	**98%** (-28% KSI)
▪ ***Comments:*** The development is probably in the right direction, but the goal is not likely to be achieved without considerable additional efforts. Available information is however insufficient. Planned speed limit reductions will affect the indicator unfavorably, even if they will contribute to reducing the number of KSI in the target group for the indicator. A revision of the indicator is therefore recommended.				
Safe main roads				
▪ ***Proportion of safe GCM-passages[4]*** ***Target group:*** Pedestrians and cyclists in motor vehicle crashes at GCM-passages	**18%**	**19%**	**22%** (-10% KSI)	**80%** (-17% KSI)
▪ ***Proportion of safe junctions*** ***Target group:*** KSI in crashes at junctions	**51%**	**52%**	**62%** (-0.8% KSI)	**80%** (-1.3% KSI)
▪ ***Comments:*** The present development is in the right direction, but far from sufficient to attain the goal. The empirical basis for estimating effects on the number of KSI in 2020 is insufficient. Possible effects of measures at schools are included in the effects of safe main roads.				
Increased knowledge about road safety				
▪ ***Measurement and analysis plan*** ***Target group:*** All KSI	**None**	**None**	**?**	**Existence of a plan**
▪ ***Comments:*** The goal is imprecisely defined and no information is available about the development of a measurement and analysis plan. Effects on the number of KSI in 2020 could not be estimated.				
Management & Maintenance (M&M)				
▪ ***Standard of M&M on bicycle tracks*** ***Target group:*** KSI cyclists in single crashes	**?**	**?**	**Optimal on main network** (-8.7% KSI)	**Optimal on whole network** (-29% KSI)
▪ ***Standard of M&M on pedestrian facilities*** ***Target group:*** KSI pedestrians in falls	**?**	**?**	**Optimal for 50% of pedestrians** (-14.5% KSI[3])	**Optimal for all pedestrians** (-29% KSI[3])
▪ ***Standard of M&M on roads*** ***Target group:*** KSI motor vehicle occupants in single crashes	**?**	**?**	(KSI unchanged)	(KSI unchanged)
▪ ***Comments:*** The likely development and effects on KSI are difficult to estimate because the status of the indicator in the present situation is not known. The empirical basis for estimating development until 2020 and effects on KSI is consequently insufficient.				

Table S.1: Present development of the road safety indicators (continued).

	Status 2006-2009	Status in 2012	Expected in 2020[1]	Goal
Heavy vehicles				
▪ ***Heavy vehicle strategy*** ***Target group:*** KSI in crashes with a heavy vehicle	**None**	**None**	**?**	**Existence of a strategy**
▪ ***Comments:*** The goal is only imprecisely defined and no information is available about the development of a heavy vehicles strategy. No effects on the number of KSI in 2020 could be estimated.				
Safe local roads				
▪ ***Proportion of safe pedestrian / bicycle crossings*** ***Target group:*** KSI pedestrians and cyclists in crashes involving a motor vehicle at GCM-passages on local roads	**16.7%**	**17.1%**	**19%** (-11% KSI)	**75%** (-32% KSI)
▪ ***Comments:*** The present development is in the right direction, but far from sufficient to attain the goal. The empirical basis for estimating effects on the number of KSI in 2020 is insufficient.				
Seat belt use				
▪ ***Proportion of front seat occupants in passenger cars using the seat belt*** ***Target group:*** Adult KSI front seat occ. in cars	**90.1%**	**97.1%**	**98-99%** (-6 - -11% KSI)	**98%** (-6 - -10% KSI)
▪ ***Comments:*** The goal is likely to be attained if the present development continues. The expected effect on the number of KSI in the target group is however not large and uncertain.				
Bicycle helmet use				
▪ ***Proportion of all cyclists wearing a helmet*** ***Target group:*** KSI cyclists	**56%**	**71%**	**92%** (-1.3% KSI)	**80%** (-1.0% KSI)
▪ ***Comments:*** The goal will be more than attained if the present development continues. The expected effect on the number of KSI in the target group is however only small.				
Driving under the influence of alcohol (DUI)				
▪ ***Proportion of sober drivers (BAC < .20)*** ***Target group:*** KSI in crashes with a motor vehicle involved	**99.56% or 99.75%**	**99.59% or 99.78%**	**99.63% or 99.82%** (-9%/-15%)	**99.90%** (-36/-46% KSI)
▪ ***Comments:*** The current trend is in the right direction but not quite sufficient to attain the goal. The expected effect on the number of KSI in the target group is highly uncertain because of contradicting information about the status in 2006-2009 and because of the general inclination of drunk drivers to high-risk behavior and involvement in serious crashes.				

[1] Expected status of the indicator in 2020 if present trend continues / if planned measures are implemented (bold) and expected change of the number of KSI in 2020 in the target group for the indicator if the indicator is as expected (in parentheses).

[2] Status of the indicator in 2020 at goal attainment (bold) and expected change of the number of KSI in 2020 in the target group of the indicator if the goal for the indicator is attained (in parentheses).

[3] Refers to hospital reported KSI pedestrians (pedestrian falls are not included in official crash statistics).

[4] Crosswalks: GCM = “gående, cycler, mopeder” (pedestrians, cyclists, mopeds)

The goal: Is the overall goal likely to be attained?

Aggregated calculations were made for all indicators in order to estimate changes of the number of KSI until 2020 in different scenarios for the development of traffic volumes, the indicators, additional measures, and external effects (other factors that affect road safety). In the aggregated scenarios

- *Traffic volumes* are either unchanged (which is unrealistic), increasing moderately for all road users, increasing more for motorized and moderately for unmotorized road users or increasing moderately for motorized and more for unmotorized road users
- *The indicators* are either unchanged on the level from 2006-2009 (which is unlikely), the goals for all indicators are attained (which is unlikely as well), the goals for all indicators are partly attained (which is more likely), or the most likely development for each indicator is assumed, including effects of additional measures that are not directly under the definition of the indicator but that affect the same type of KSI
- *External effects*, i.e. effects of factors that affect the numbers of KSI but that are not covered by any of the indicators, are absent, small (-10%), medium (-20%) or large (-30%); the assumed effects refer to the percentage reduction of the number of KSI in 2020 that can be attributed to external factors

The results show that the goal of a 40% reduction of the annual numbers of KSI in Stockholms stad until 2020 will not be attained unless the goals for all indicators are attained, and otherwise only if there are considerable effects of factors that are not covered by the indicators. More specifically, the goal may be attained

- When the goals for all indicators are achieved and when there are external effects of at least -10% (at least -20% in the traffic volumes scenario that predicts a larger increase of pedestrian and bicycle volumes); achieving the goals requires considerable additional efforts, especially for speed and safe main roads
- When the goals for all indicators are partly achieved and when there are external effects of at least -30% and / or effects of additional measures
- In the indicator-scenario “Likely changes” only when there are considerable external effects of at least 30%, except in the traffic volumes scenario that assumes larger increases of pedestrian and bicycle volumes; in this scenario the goal is not likely to be attained if all indicators develop according to the currently most likely scenario.

The results are similar for motorized and non-motorized road users. However, for pedestrians / cyclists a 40% reduction of the number of KSI seems somewhat more unlikely than for motor vehicle occupants and there are more scenarios that predict increases of the number of KSI. The main reason for the less favorable predicted development for pedestrians and cyclists is the likely increase of these road user groups.

The goal: Should the goal be revised in order to take into account hospital-reported injury statistics?

Current official crash statistics contain only police reported crashes and are most likely not affected by the increased reporting of hospital data. Hospital reported injury data do not need to be taken into account in interpreting results from official crash statistics and it is concluded that the goal should not be revised. Otherwise, the base of comparison (hospital reported crashes in 2006-2009) would not be adequate because of the increase of the number of hospitals reporting injuries in this period.

Road safety indicators and sub-goals: Are the present indicators and sub-goals sufficient?

If all goals for all indicators are attained, the overall goal may be (almost) attained if traffic volumes increase only moderately. The level of the goals seems therefore, overall, sufficiently ambitious. Some of the indicators might however benefit from revised (extended) definitions, especially the speed and safe main and local roads indicators. These have the greatest impact on the total number of KSI in Stockholm and they might benefit most from the suggested revisions. Suggested changes to the indicators are:

- *Speed:* It is recommended to supplement the speed indicator with a goal for reduced speed limits. Reduced speed limits will contribute to reducing average speeds, but they would affect the speed indicator as it is defined now negatively. The revised goal might be ***"The proportion of all vehicles driving at or below the speed limit should not be below 98% and all roads should have reasonable speed limits".*** A precise definition for reasonable speed limits would have to be elaborated in "Rätt fart i staden", according to the criterion that vehicles driving at or below the speed limit will not inflict disabling injury to any road users they may come into conflict with.
- *Safe main and local roads:* It is suggested to supplement the indicator with a goal for dedicated pedestrian and bicycle facilities. The definitions of safe main and local roads are quite narrow. A number of measures that affect the safety of bicycles and pedestrians are at present not covered by any of the indicators, even if they would favorably affect the number of KSI in the target groups for these two indicators. The revised goal might be: ***"The proportion of safe junctions and GCM-passages should be at least 80% (75% on local roads), the proportion of the commuting and main bicycle networks with dedicated bicycle facilities and sufficient capacity should be at least 90% and walkability audits should reveal safety deficits on no more than 5% of the pedestrian infrastructure."***
- *Increased knowledge about road safety:* A suggestion for a more precise definition of the increased knowledge indicator is: ***"A systematic review of the development of road safety in Stockholm should be conducted (with a more specific description of how and how often), all those responsible for measures that (directly or indirectly) affect road safety should be involved in the reviews and there should be economic or other incentives to improve road safety."***

- ***Management & maintenance:*** It is suggested to develop a precise definition of an "optimal standard" of management and maintenance which includes spring cleaning in addition to winter maintenance.
- ***Heavy vehicles:*** A suggestion for a more precise definition of the heavy vehicles indicator and corresponding goal for 2020 is: ***"The most important safety problems with heavy vehicles are identified and measures have been taken that address the most important crash contributing factors (factors contributing to at least 50% of all heavy vehicle crashes with KSI)."***
- ***Seat belt use:*** No suggestions are made for changes to the seat belt indicator.
- ***Bicycle helmet wearing:*** Helmet use in general is likely to continue to increase, but the effect on the number of KSI is limited. However, among children, bicycle helmets are likely to have a greater effect than among adults and the municipality may have greater influence on helmet wearing rates. A possible redefined goal that also takes into account that increased cycling is an important goal as well is: ***"The proportion of cyclists under 18 years who are wearing a bicycle helmet should be at least 90%, and no school children shall refrain from cycling because they do not have or do not want to wear a bicycle helmet.".***
- ***DUI:*** No suggestions are made for changes to the seat belt indicator.

Goal level and priorities: Should the present goal levels and priorities be changed?

The goal of a 40% reduction of the number of KSI in 2020 may be attained, unless there are no external effects or a traffic growth that is more than moderate. Goal attainment does at present not seem likely but becomes more likely if

- The goals for all indicators, and especially for the speed and safe main roads indicators, are attained, which requires considerable additional efforts
- The speed, safe main roads and safe local roads indicators are supplemented as described in the previous section
- A heavy vehicles indicator and goal is developed (and set into action)
- An increased knowledge indicator and goal is developed (and set into action)
- Increasing bicycle and pedestrian volumes are met by an infrastructure with a high safety level and sufficient capacity (or if pedestrian and bicycle volumes do not increase, this is however not desirable)

Since the goal is not impossible to be attained, but requires considerable efforts, it can still be regarded as both ambitious and realistic. It is therefore not suggested to change the goal or priorities (other than those changes that are suggested in the previous section).

Management and maintenance: Should a new indicator be defined for pedestrians and cyclists?

The M&M indicator affects a considerable number of KSI pedestrians (those injured or killed in falls) that are not represented in official police reported crash statistics. It is therefore suggested to extend the overall goal to include KSI pedestrians in falls. The goal would remain the same, only the number of KSI in the present and goal situation would be adjusted from 278 to 278 + 66 = 344 in 2006-2009 and from 167 to 206 for the situation in which the goal is attained. 66 is the number of KSI pedestrians in falls in 2010 to 2012 (in 2006-2009 far fewer hospitals were reporting injuries).

Road safety plans and measures: Are the measures described in the annual road safety plans sufficient and implemented satisfactorily?

A number of measures are planned according to the road safety plans and according to the bicycle plan and mobility strategy. However, those measures that are currently planned to be implemented are not sufficient for attaining the goals for all indicators as has been discussed in the preceding sections, especially for the speed, safe main roads and safe local roads indicators. Specific plans that refer to the increased knowledge and heavy vehicles indicators are still more or less absent. It is suggested that such plans could improve the monitoring of the progress towards goal attainment if each measure that is described in the road safety plans were directly related to one of the indicators (except measures that are not relevant to any of the indicators), and if an overview were provided for each indicator about the current status, the goal and the degree to which the planned measures will contribute to goal attainment.

1 Introduction

The road safety program for Stockholm city 2010-2020 (Trafikkontoret, 2010) has been agreed upon November 8th 2010. The program describes road safety efforts and goals to be achieved by 2020. The main goal is a reduction of the number of killed or severely injured (KSI) by 40% from an average of 278 in 2006-2009. In other words, the goal is to reduce the number of KSI by at least 111 to a maximum of 167 in 2020. This goal is more ambitious than the national goal to reduce the number of fatalities by 50% and the number of severely injured by 25%. Not only is the combined reduction of KSI for the whole country less than 40%, but the population and the numbers of vulnerable road users are growing far faster in Stockholm than in the rest of the country.

A number of sub-goals were identified, based on several road safety indicators. Those indicators facilitate the identification of specific measures and continuous monitoring. Each year since 2011 Trafikkontoret presents road safety plans for measures that are to be implemented during the following year.

As a contribution to the road safety program, TØI has in 2009 prepared a report that describes the basis for the development of the goals, indicators and recommended measures (Sørensen et al., 2009). The present report is a follow-up of the report from 2009, with a detailed investigation of the goal, sub-goals and indicators in the present road safety program. It is a part of the revision of the goals and indicators that is planned in 2013 and 2016 in order to ensure that indicators and sub-goals are appropriate in order to achieve the main goal of a 40% reduction of the annual numbers of KSI by 2020.

Questions to be answered in this report are the following:

- ***Present development:*** Are road safety indicators and crash statistics developing in accordance with the goals? What level of goals and indicators will be achieved if actual trends are continuing?
- ***The goal:*** Should the goal be revised in order to take into account hospital-reported injury statistics?
- ***Road safety indicators and sub-goals:*** Are the present indicators and sub-goals sufficient in order to achieve the main goal of a reduction of the annual number of KSI by 40%, or should some of them be dropped, revised or supplemented by other indicators and sub-goals? The goals should be both ambitious and realistic. The indicators should be relevant in planning concrete road safety measures and they should contribute significantly to a reduction of the number of KSI in road crashes.
- ***Goal level and priorities:*** Should the present goal levels and priorities be changed on the background of the actual development of road safety indicators and crash statistics?
- ***Management and maintenance:*** Should a new indicator for management and maintenance be defined for pedestrians and cyclists?

- ***Road safety plans and measures***: Are the measures described in the annual road safety plans sufficient and are they implemented satisfactorily? What more has to be done in order to achieve the goals? What are the challenges?

In order to answer these questions the report describes the observed and expected developments of the indicators and the numbers of KSI in different scenarios – with different developments of exposure and different levels of goal attainment for the indicator. It is structures as follows:

Chapter 2 describes ***the goal, the indicators and the target groups*** for each indicator; the target groups are those KSI that are assumed to be affected by the indicators.

Chapter 3 gives an overview of the ***development of exposure*** (the amount of travel with different types of transport) ***and safety*** (numbers of KSI among different road user groups. Chapter 3 also discusses possible explanations for the observed increase of the numbers of KSI after 2009 and whether increased reporting from hospitals may have contributed.

Chapter 4 describes ***baseline scenarios***, i.e. possible developments of the number of KSI until 2020 than can be expected if everything except exposure remains unchanged. These will be the basis for the scenarios that are calculated in chapter 5.

Chapter 5 describes for each of the indicators:

- The indicator, target group and goal for the indicator, and the relationship between the indicator and safety
- The state of the indicator 2006-2009 and changes from then to 2012
- Measures for improving the indicator, including expected effects on safety, including both planned and other possible measures
- The development of the number of KSI in the target group for the indicator: The observed development from 2006-2009 and the predicted development until 2020 in the baseline scenarios (if everything except exposure remains unchanged) and in different scenarios for possible developments of the indicator

Chapter 6 summarizes the results from chapter 5 in aggregated calculations for different scenarios in which the goals for all indicators are either unattained, partly attained, or completely attained, including a scenario with the most likely changes for each indicator. Other factors that may affect the development of the number of KSI are discussed and taken into account in the aggregated scenario calculation as well. Finally, based on the scenario calculations and other assessments, answers are provided to the questions that are stated above.

2 The goal, indicators and target groups

The ***goal*** that was defined in 2009 is a reduction of the number of KSI in Stockholms stad by 40% in 2020, compared to the average number of KSI in 2006-2009. The goal is partly based on estimates made by Sørensen et al. (2009) about how large reductions of the number of KSI are realistic to achieve if a certain set of measures is implemented.

Nine ***indicators*** are defined in Trafikkontoret (2010) for a number of factors that affect the number of KSI in Stockholms stad. The indicators are classified according to the priority that is given to them, based on the relationship between the indicator and the number of KSI and the degree to which the municipality can influence the indicator. Three priority levels are defined:

- *Level 1:* A large amount of efforts and resources is required: Indicators with a strong relationship with the number of KSI and that can be influenced by the municipality
- *Level 2:* A limited amount of efforts and resources is required: Indicators with a weak relationship with the number of KSI *or* that can only to a very limited degree be influenced by the municipality
- *Level 3:* A small amount of efforts and resources is required: Indicators with a weak relationship with the number of KSI *and* limited possibilities for the municipality to influence the indicator

For each indicator a ***target group*** is defined. The target groups comprise all those KSI that are assumed (or intended) to be affected by the indicator. For each indicator table 2.2.1 summarizes the definition of the indicator, including the goal and the status in 2006-2009, and the target group.

Table 2.2.1: Target groups for all indicators.

	Description	Target group
Level 1 indicators		
1. Speed	Proportion of all vehicles driving at or below the speed limit. ***Goal:*** 98% ***Status:*** 50%	▪ All KSI involved in crashes with at least one motor vehicle
2. Safe main roads	Proportions of safe junctions and pedestrian / bicycle crossings ***Goal:*** 80% ***Status:*** 18% (GCM-passages; 51% (junctions)	▪ KSI Pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on main roads ▪ KSI motor vehicle occupants in all type of crashes at at-grade junctions on main roads
3. Increased knowledge	No indicator defined	▪ All KSI
Level 2 indicators		
4. Management & maintenance (M&M)	Standard of M&M on roads, and winter maintenance on pedestrian and bicycle tracks ***Goal:*** Optimal standard ***Status:*** Not available	▪ KSI pedestrians and cyclists in single accidents (falls) ▪ KSI motor vehicle occupants in single crashes
5. Heavy vehicles	***Goal:*** Existence of a heavy vehicle strategy ***Status:*** No heavy vehicle strategy exists	▪ KSI involved in collisions with heavy vehicles
6. Safe local roads	Proportions of safe pedestrian / bicycle crossings ***Goal:*** 75% ***Status:*** 17%	▪ KSI pedestrians and cyclists at junctions or crosswalks on local roads
Level 3 indicators		
7. Seat belt use	Proportion of front seat occupants in passenger cars that are using the seat belt ***Goal:*** 98% ***Status:*** 92%	▪ KSI adult front seat passengers in passenger cars
8. Bicycle helmet use	Proportion of all cyclists wearing a helmet ***Goal:*** 80% ***Status:*** 56%	▪ All KSI cyclists
9. Driving under the influence of alcohol (DUI)	Proportion of sober drivers (BAC < .20) ***Goal:*** 99.90 % ***Status:*** 99.76% or 99.56%	▪ All KSI involved in crashes with a drunk driver

3 Development from 2006-2009 to 2012

This chapter summarizes information that has been collected about the amount of road travel with different modes of transport (exposure) and about the number of KSI in different road user groups and from different sources (safety) from 2006 to 2012. Additionally, predictions are made about possible changes of exposure and safety until 2020 if current trends continue.

3.1 Exposure

Information about the amount of travel with different modes of road transport in 2006 to 2012 is available from a number of different sources. Information has been gathered for different modes of transport and for each mode of transport it is estimated how the amount of travel will develop until 2020 if current trends continue. These estimates will be used in the development of the baseline scenarios that are described in section 4. The baseline scenarios will be the starting point for the estimated possible changes of the numbers of KSI for each of the indicators until 2020.

Swedish national travel survey

Based on results from the Swedish national travel survey (Trafikanalys, 2013) the changes of the numbers of person kilometers travelled in road transport in the whole country from 2006-2009 (average) to 2012 are as follows for different modes of transport:

- Passenger car +1.2%
- MC -0.4%
- Buss +0.2%
- Pedestrians, cyclists, moped +4.8%
- Total: +1.3%

In Stockholm county, the modal split in terms of number of trips and person kilometers travelled in 2011 was as shown in figure 3.1.1.

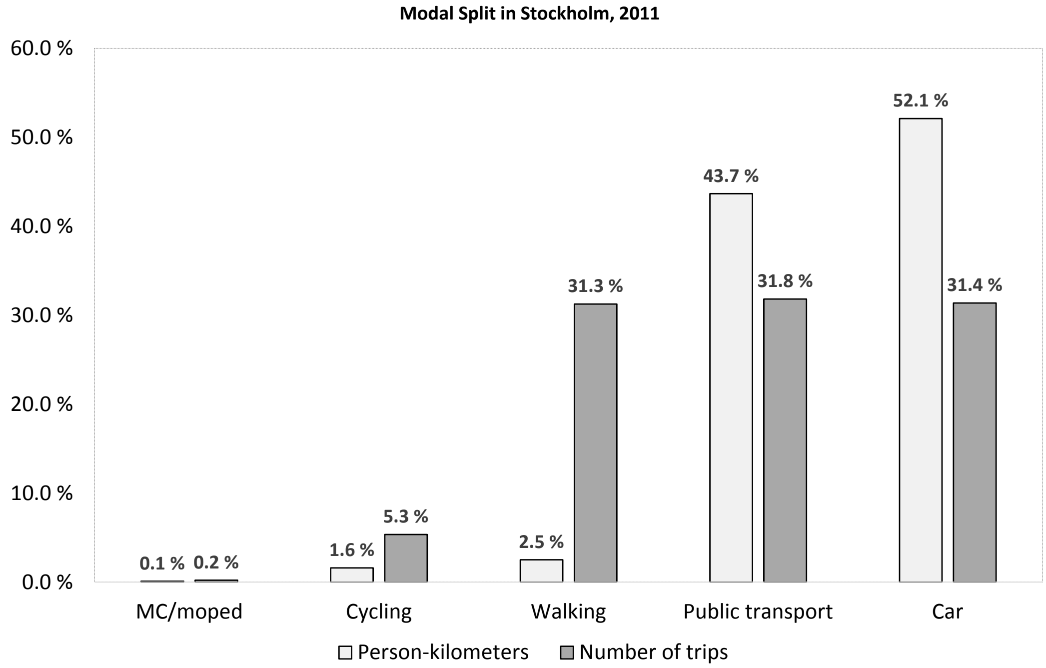

Figure 3.1.1: Modal split in terms of number of trips and person kilometers travelled in Stockholm county in 2011 (Trafikanalys, 2013).

These results show that an average trip by bicycle is about four times as long as an average walking trip, and trips with public transport and by car are 17 and 20 times as long as an average walking trip, respectively. The results do not say anything about the changes of the modal split over time. They indicate however that there may be a considerable potential of replacing car trips by trips with public transport, and probably also of increasing the amount of walking and cycling.

Compared to other European countries, the proportion of walking trips in Sweden is somewhat higher than average, while the proportion of cycling trips is smaller than in most other countries (Figure 3.1.2; Buehler & Pucher, 2012). According to Quester (2012) between 40 and 94% of all trips by car in Stockholms stad could theoretically be replaced by walking or cycling trips or public transport. The minimum estimate is based on the assumption that all trips by car that are made alone and not related to holiday, shopping or transport of people or goods could be replaced. The maximum estimate is based on the assumption that all car travel that is not related to professional passenger or goods transport can be replaced, except among people who cannot use other transport modes because of disabilities or allergies.

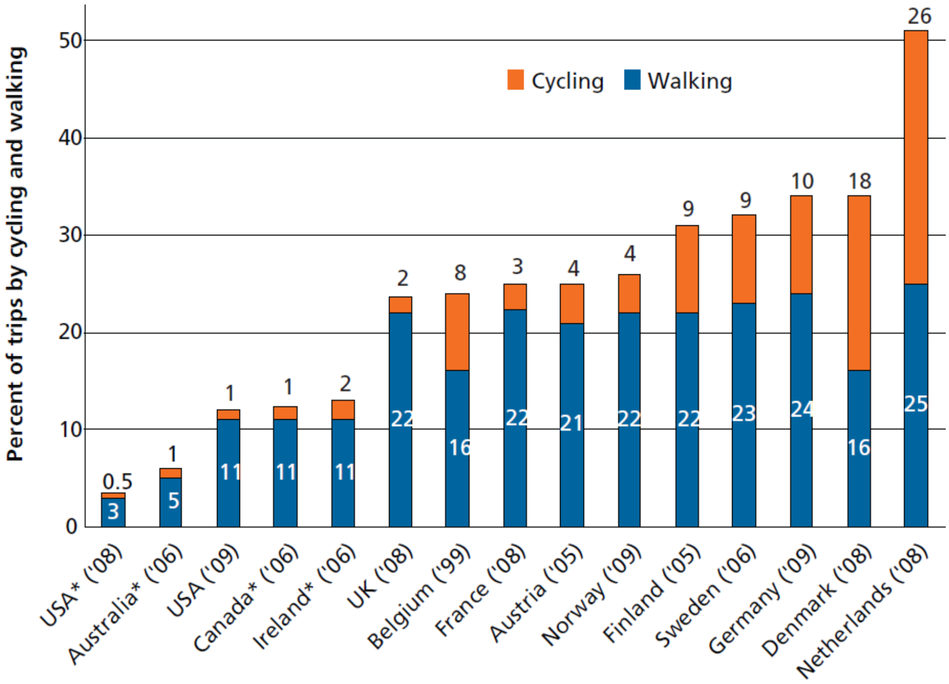

FIGURE 1 Cycling and walking share of daily trips in Europe, North America, and Australia, 1999–2009.

Figure 3.1.2: Proportions of walking and cycling trips in other countries (Buehler & Pucher, 2012).

Population

Figure 3.1.3 shows the population of Stockholm city in 2005-2012 (Stockholms stad, 2013, Statistisk årbok). In 2012 the number of inhabitants was 9.6% higher than it was on average in the years 2006-2009. In 2020 it is expected to be 21.5% higher than it was on average in 2006-2009. The estimated trend is based on expected values in Stockholms stad (2013). The estimated population growth is somewhat smaller than it would be according to a polynomial trend function, which is the one that has the best fit to the data from 2005-2012.

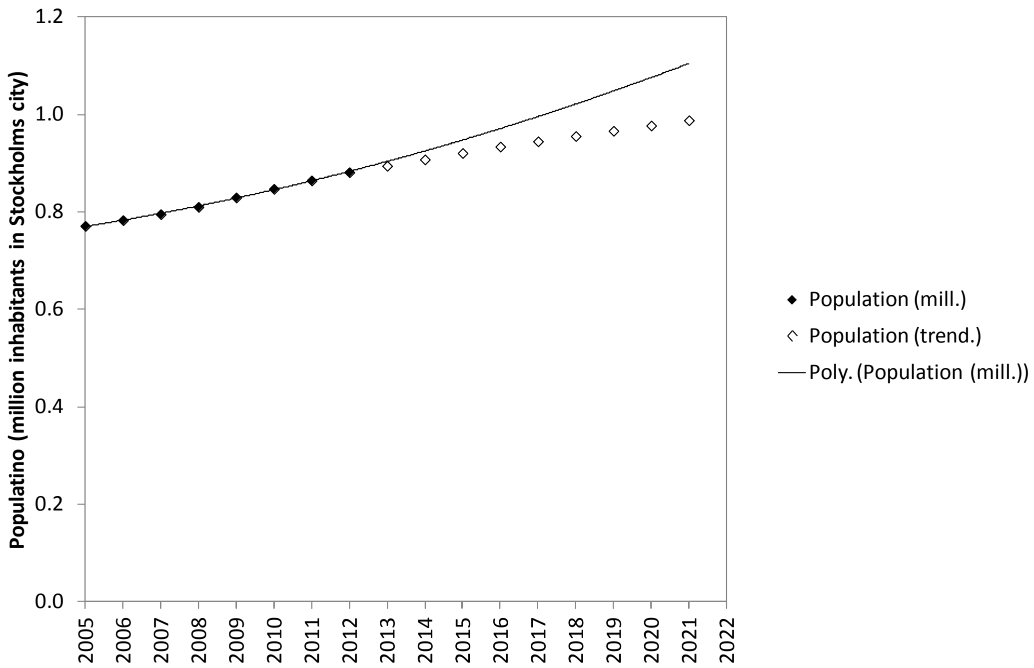

Figure 3.1.3: Population in Stockholm city in million inhabitants in 2005-2012 and estimated in 2016 and 2021 (Stockholms stad, 2013).

Motorized traffic

Information about traffic volumes in the whole Stockholms stad is not available. Available information is summarized in the following sections. In summary, motorized traffic in the inner city has decreased in recent years and may continue to decrease. In the outer city motorized traffic may not decrease as much or even increase in line with motor vehicle travel in the whole country. Information about the proportion of all travel in the inner city is not available, but one may assume that the proportion is smaller than in the outer city because the largest part of the road network in Stockholm is in the outer city.

- *Increased motorized traffic in Sweden*

Based on data from trafikanalys (1950-2012) figure 3.1.4 shows the total amount of travel in Sweden with different means of road transport in 1950-2020 and the estimated trend functions (polynomic trend functions are those with the best fit, however, for years after 2020 they would predict decreases of traffic volumes). The predicted values for 2020 are almost the same when logarithmic trend functions are estimated based on data from 2000-2012. The trend functions based on 1950-2012 predict slightly more traffic in 2020. According to these functions the total amount of travel was 1.6% greater in 2012 than in 2006-2009 and will be 2.3% greater in 2020 than in 2006-2009. Motorized traffic was 2.5% greater in 2012 than in 2006-2009 and will be 4.4% greater in 2020 than in 2006-2009.

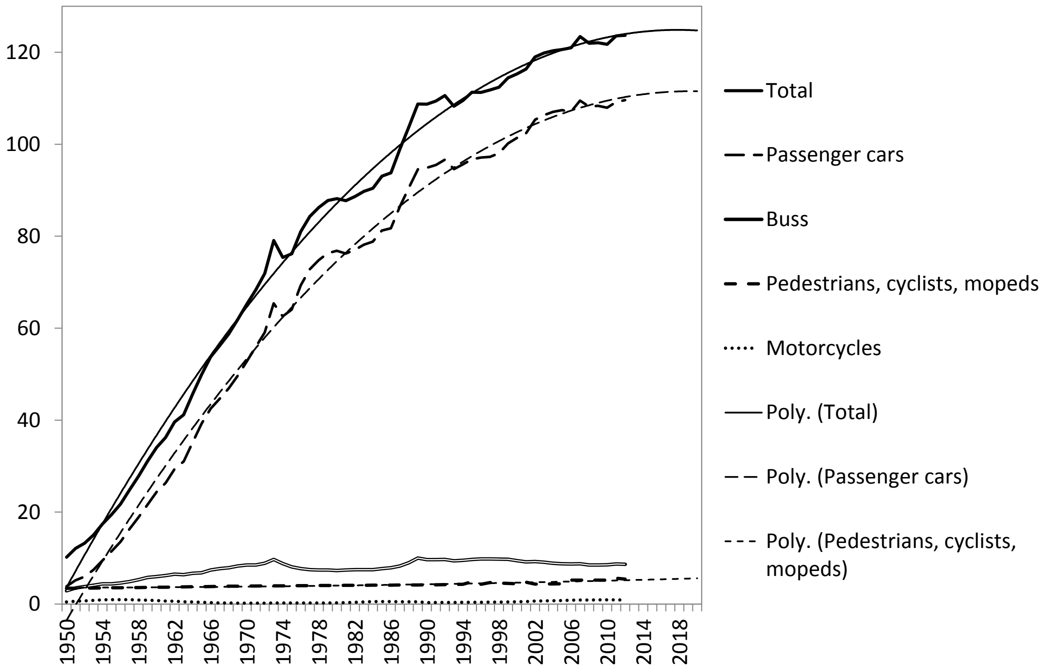

Figure 3.1.4: Total amount of travel in Sweden with different means of road transport in 1950-2020 and estimated polynomic trend functions (trafikanalys).

In the inner city of Stockholm however, the development has been different. In August 2007 road pricing (congestion charging) has been introduced permanently after a test period from January 2006 to July 2007 (Sørensen et al., 2009).

- ***Reduced motorized traffic in Stockholms stad (inner city)***

According to information in Stockholms stad (2013; chapter 8.16) the numbers of cars and buses in the inner city has decreased by about 1.7% per year in the years 2008-2011 (figure 3.1.5). According to the information provided in the chapter 8.13 of Stockholms stad (2013), the total number of vehicles has even decreased by 3.6% annually in 2005-2011. If the trend continues, in 2012 there would have been 7.2% fewer cars and buses in the inner city than in 2006-2009, and in 2020 there can be expected to be about 20.0% fewer cars and buses in the inner city than there were in 2006-2009 and 13.8% fewer cars than in 2012.

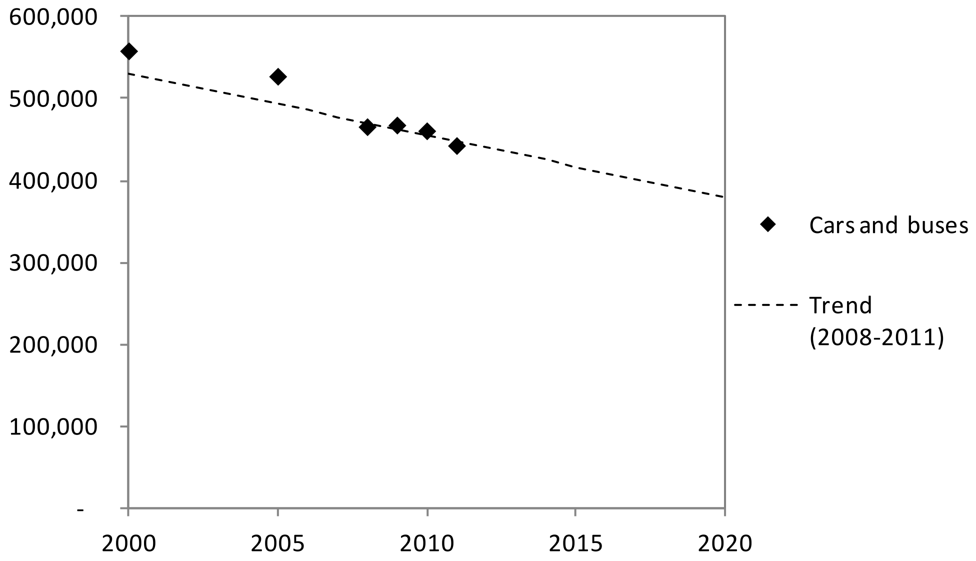

Figure 3.1.5: Development of the numbers of cars and buses in the inner city (2000-2011; trend estimated based on data from 2008-2011; Stockholms stad, 2013).

If the estimated trend for the inner city gives a realistic prediction is doubtful. Public transport should be expected to increase. Car traffic in Sweden is not generally decreasing but rather strongly increasing. However, the increase might be counteracted by road pricing and by measures giving more space to pedestrians, cyclists and public transport and complicating access for private cars. Several of the infrastructure projects that are planned in Stockholm for the period 2011-2012 as part of trafiksatsning Stockholm (http://trafiksatsningstockholm.se/) have the aim to relieve the inner city from car traffic. Therefore, the best estimate for the expected development is still as show in figure 3.1.5.

- *Effects of congestion charging in the inner city*

The road pricing scheme in Stockholm has reduced the number of journeys by car by 15% (Jensen-Bulter et al., 2008). The road pricing scheme affects only the inner city. Outside the toll ring (the outer city), traffic has increased. Reduced traffic has, as intended, increased average speeds in the inner city. The effect on the numbers of crashes has most likely still been favorable. Jensen-Bulter et al. (2008) have estimated that the road pricing scheme has reduced the total number of crashes with 5-10% in the inner city. Once implemented, the road pricing scheme is not expected to have any further influence on traffic volumes or crashes.

Bicycle travel

According to information in Stockholms stad (2013) bicycle traffic in the inner city has increased by about 65% in the years 2002-2008 (only 5-year average estimates are available). That corresponds to an average annual increase by 8.8%. Three different trend lines were fitted: exponential, linear and logarithmic. Table 3.1.1 and figure 3.1.6 show the expected relative number of bicycles in the inner city in 2012 and 2020 according to each of the estimated trend functions (the number of bicycles in the inner city in 2006-2009 is set equal to one). The expected increase according to the logarithmic trend function (+22.6%) is almost the same as the expected increase of the population (+21.5%).

Table 3.1.1: Relative numbers of bicycles in the inner city of Stockholm in 2012 and 2020 (rel. number in 2006-2009 = 1).

	Exponential trend	Linear trend	Logarithmic trend
2012 vs. 2006-2009	1.45	1.31	1.11
2020 vs. 2006-2009	2.85	1.85	1.23
2020 vs. 2012	1.96	1.42	1.10

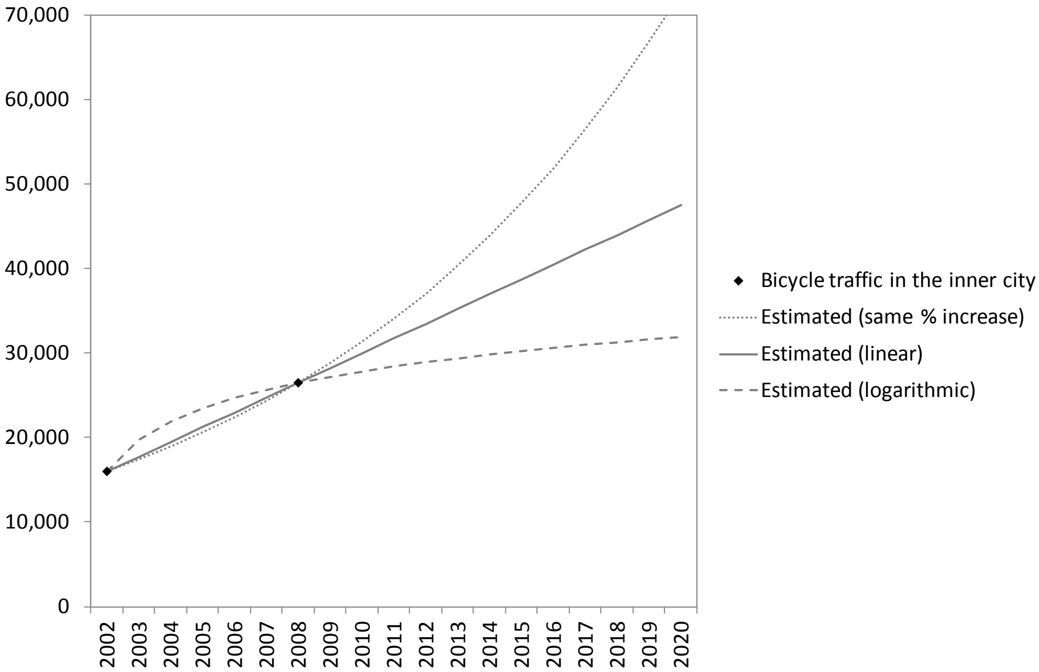

Figure 3.1.6: Number of bicycles in the inner city, 5-year averages 2002 and 2008 (Stockholms stad, 2013), and estimated trend functions.

If measures that aim at making the city more attractive for cyclists are successful, the increase of the number of bicycles may even be stronger. However, as long as one does not know the explanation for the present increasing trend, one might as well assume that the measures that are planned as a part of the bicycle strategy are necessary if one wants to prevent a stagnation of the trend.

On the other hand, there is already too little space for bicycles in many places, especially in the inner city. It is therefore not easy to predict the development of bicycle travel. In order to achieve a further increase of bicycle travel additional measures are probably necessary to make bicycle travel more attractive in general (including safety measures, since "safe" is an important part of "attractive"). Increasing the capacity for bicycles will probably be necessary as well.

In the following analyses a ***logarithmic*** trend that predicts a 23% increase of the amount of bicycle travel in 2020, compared to 2006-2009, will be taken as the best estimate. It is assumed that the development is the same in whole Stockholms stad as in the inner city. This is the most conservative estimation. The trend with the smallest increase was chosen firstly, because bicycle travel may increase less in the outer city than in the inner city, and secondly because of the present capacity limitations for bicycles in the inner city.

- *Bicycle travel in winter*

In summer (May-September) there are according to Stockholms stad (2008) between two and four times as many cyclists in Stockholm as in winter (November-March). The months October and April are in between. In the analyses for winter maintenance it will be assumed that 20% of all bicycle kilometers in Stockholm are travelled in winter. The proportion may increase as winter maintenance for cyclists improves, but the extent of the increase is at present not possible to estimate.

- *Bicycle travel on bicycle main routes (commuter network)*

It is estimated that about 30% of all bicycle kilometers in summer are traveled on the commuter network (the estimate is a rough guess by Trafikkontoret, 2013A). The proportion is assumed to remain unchanged until 2020. In winter the proportion is probably higher because commuters probably cycle more in winter than other cyclists. It is assumed that the proportion in winter is 40%.

Pedestrians

In the absence of any information about pedestrian travel in Stockholm, either the population or bicycle travel can be used as the basis for estimating changes in pedestrian travel. Compared to the average in 2006-2009, the population is expected to have increased by 21.5% in 2020, while bicycle travel is expected to have increased by 22.5% (according to a logarithmic trend function) or by 85.4% (according to a linear trend function). There is no big difference between these two estimates 21.5% and 22.5% and for the sake of simplicity it will therefore be assumed that the amount of pedestrian travel increases as much as the amount of bicycle travel, i.e. by 23% in 2020, compared to 2006-2009.

3.2 Safety

Information about the development of the number of KSI in Stockholms stad from 2006 to 2012 is manly based on police reported crash statistics (Strada). It is also discussed whether hospital reported injuries may have affected results from Strada and what other factors may have contributed to the observed increase of the numbers of KSI after 2009.

3.2.1 Total number of KSI in Stockholms stad (Strada)

The number of killed and severely injured road users in Stockholm city in the years 2001 to 2012 is shown in figure 3.2.1, based on police reported crash data (Strada). Two trend lines are shown, the one estimated by Sørensen et al. (2009) based on data from 2001 to 2008, and a new one estimated based on data from 2001 to 2012. The figure shows the following:

- The numbers of KSI in 2010 to 2012 were not only higher than estimated with the trend function for 2001-2008, but also increasing continuously after 2009.

- According to the trend line that was estimated in 2009 (Sørensen et al., 2009; based on the numbers of KSI in 2001-2008), the goal would be achieved if the trend continues.
- According to the trend function that is based on data from 2001 to 2012 the goal for 2020 will *__not__* be achieved if the trend continues.

The proportion of all KSI road used that were killed was about 3.5% in 2003-2012 with a considerable variation from year to year and no clear increasing or decreasing trend.

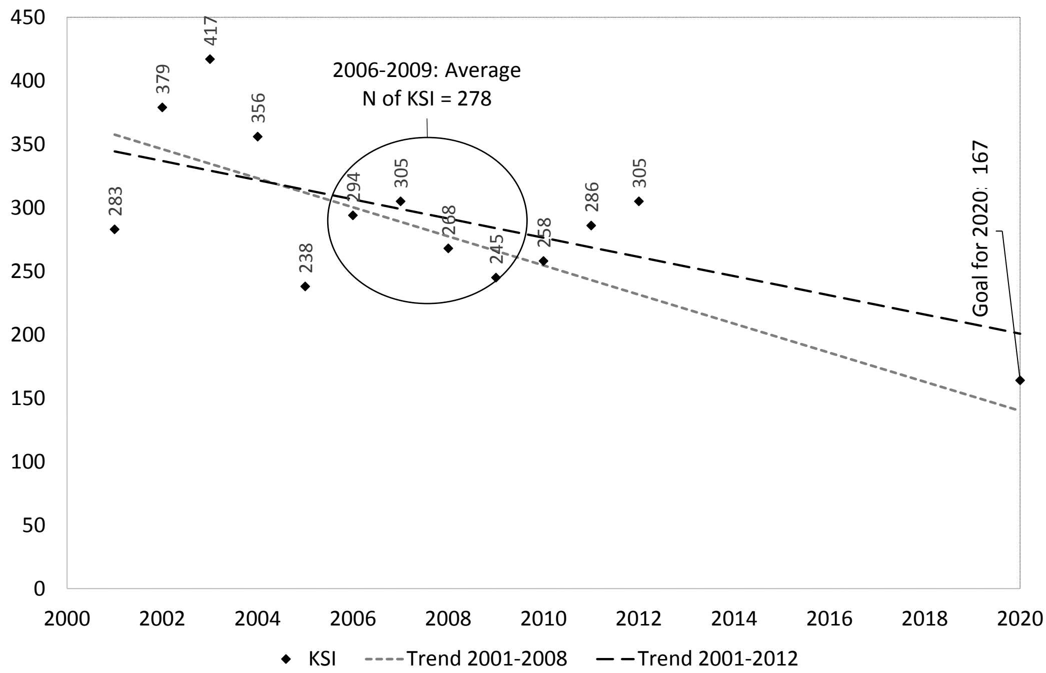

Figure 3.2.1: Total number of KSI road users (police reported) in Stockholms stad (2000-2012), estimated trend (based on data 2001-2008 and 2001-2012).

The findings about the development of the number of KSI in Stockholms stad in recent years raise some questions that will be discussed in the following sections.

Why did the numbers of KSI increase from 2009 to 2012?

There are several possible explanations for the increase of the number of KSI in 2010-2012:

(1) ***Random variation:*** The number of KSI may increases in three consecutive years even if the underlying (decreasing) trend remains unchanged.

(2) ***Increased awareness for pedestrian and bicycle crashes and especially of collisions between pedestrians and cyclists:*** These types of crashes may to a larger degree be represented in police data than previously (Trafikkontoret, Leena Tippana). The number of KSI pedestrians and cyclists in 2012 was 59% higher than in 2006-2009 for crashes only involving pedestrians and cyclists, and "only" 35% higher than in 2006-2009 for other crashes (figure 3.2.2). This finding seems to support the hypothesis that pedestrian-bicycle crashes are increasingly being reported by the police. However, the linear trend of the number of KSI pedestrians and cyclists increases more for other crashes than for crashes involving only pedestrians and cyclists. Thus, no conclusions can be drawn and the observed increase of the number of KSI pedestrians and cyclists may as well only reflect random variation and the increased numbers of pedestrians and cyclists.

(3) ***Hard winters:*** There were some hard winters with long periods with much snow and ice, that may have contributed to the increasing crash numbers, if one assumes that much snow and ice increase numbers of serious crashes. The development of the number of motor vehicle single crashes seems to support this hypothesis. From 2006-2009 (average) to 2012 this crash type has increased by 13% in winter, while it has decreased 32% during the rest of the year (figure 3.2.3). However, most empirical evidence suggests that there are fewer serious crashes on roads covered by snow and ice, mainly because of reduced speed (Bjørnskau, 2011). For cyclists the numbers of single crashes are too small to allow any conclusions.

(4) ***Increased pedestrian and bicycle volumes:*** The numbers of bicycles and pedestrians has increased considerably and in many places there is at present quite little space for cyclists. The arising capacity problems may increase all types of conflicts: between cyclists on bicycle facilities, between cyclists and pedestrians, and between cyclists and motor vehicles where cyclists do not use (overcrowded) bicycle facilities.

(5) ***Increasing population:*** The total number of KSI per inhabitant is estimated based on police reported crash data and about the population in Stockholms stad (million inhabitants; Stockholms stad, 2013). The results are shown in figure 3.2.4. Compared to the average numbers in 2006-2009, the numbers of KSI has increased by 9.7% in 2012 and the population has increased by 9.6%. The number of KSI per 100,000 population has remained unchanged from 2006-2009 to 2012. Consequently, increasing population (and thereby increased travel) may be at least a part of the explanation for the increasing numbers of KSI.

(6) ***Increased reporting (not likely):*** As a consequence of the hospitals in Stockholm City starting to report crashes in 2010, more KSI may have been reported to the police according to Wärnhjelm (2013). However, according to information from Trafikkontoret (2013A) the police has not changed reporting routines and police reported statistics do not include crashes reported from hospitals that were not reported to the police previously.

(7) ***Negative developments of the indicators (not likely):*** If any of the indicators for road safety in Stockholms stad had developed unfavorably, this might be an explanation for the observed increase of the numbers of KSI. As will be seen in chapters 5.1 through 5.9, there have not been any such unfavorable developments.

In summary, it is most likely that random variation, some hard winters, and increased population are the most important factors that have contributed to the increasing numbers of KSI during recent years.

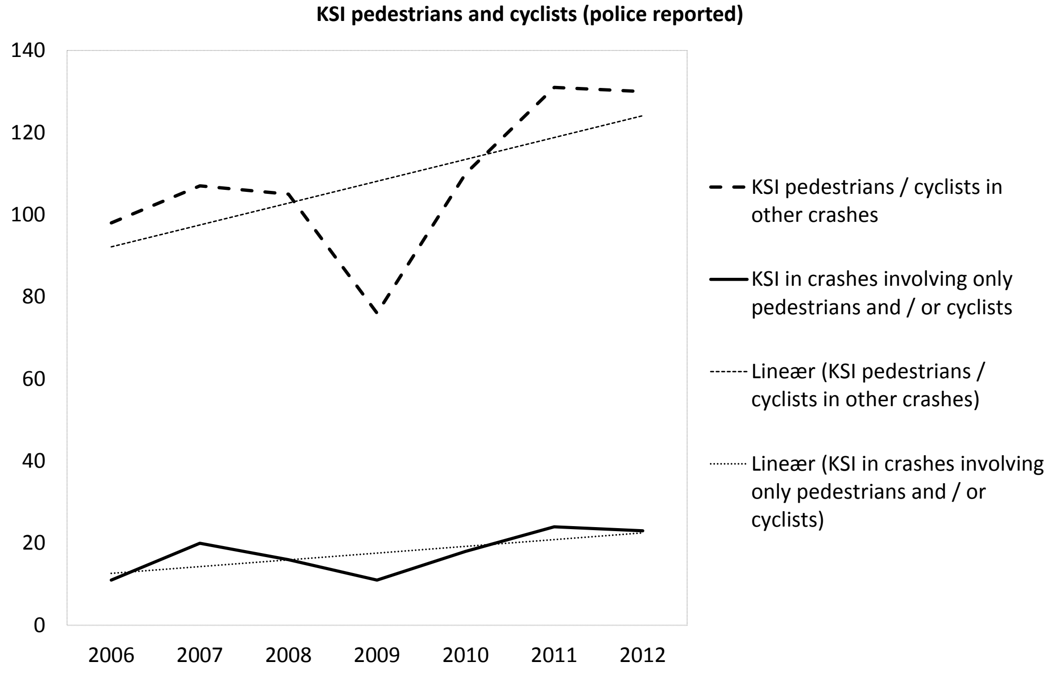

Figure 3.2.2: KSI in crashes only involving pedestrians and / or cyclists (bicycle-pedestrian collisions and bicycle single crashes) vs. KSI pedestrians and cyclists in other types of crashes (Stockholms stad, police reported).

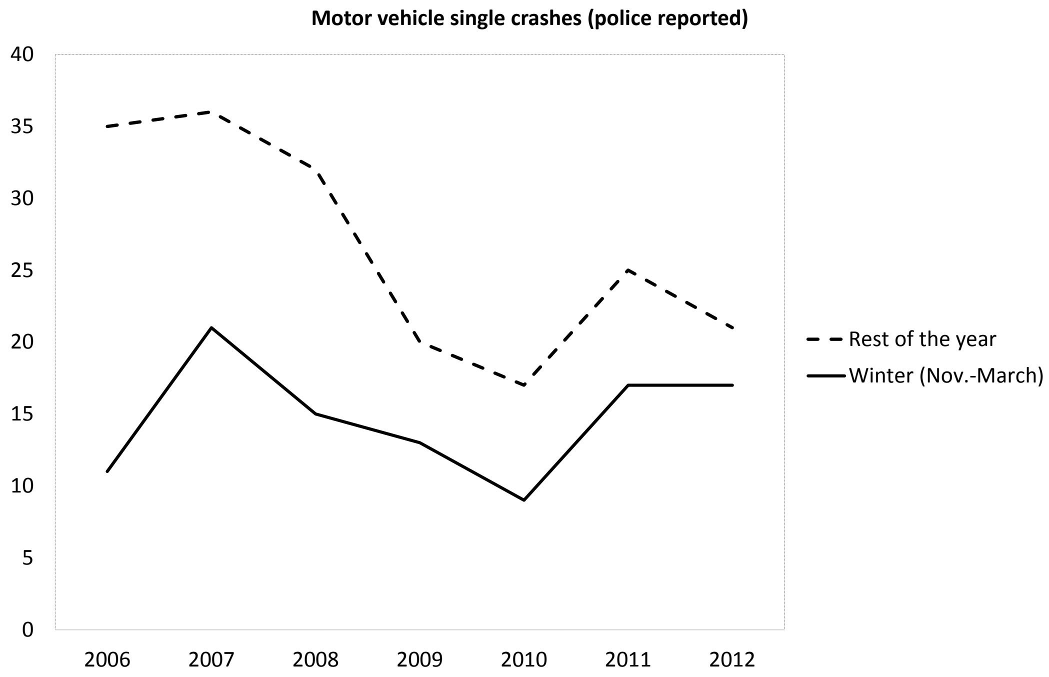

Figure 3.2.3: KSI in motor vehicle single crashes during winter (November-March) vs. KSI in motor vehicle single crashes during the rest of the year (Stockholms stad, police reported).

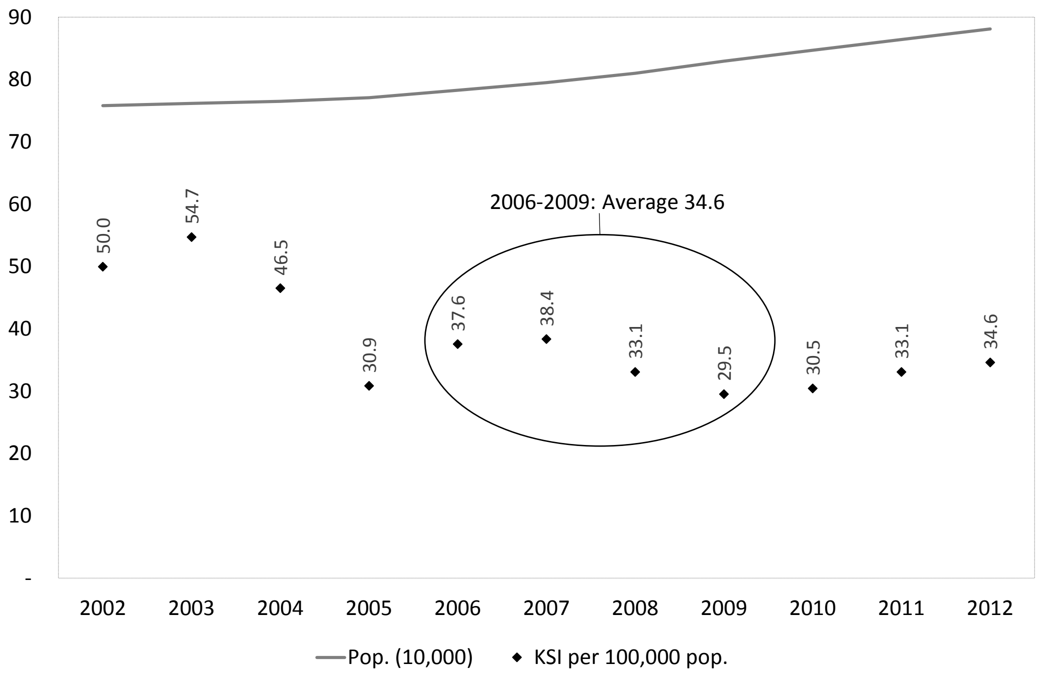

Figure 3.2.4: Estimates of the total number of KSI per million inhabitants (STRADA; Stockholms stad, 2013).

How did the numbers of KSI change for different road user groups?

The development of the numbers of KSI for different road user groups is shown in figure 3.2.5. A decrease of the number of KSI was observed for car drivers and passengers and MC/moped. For cyclists and pedestrians on the other hand, the number of KSI seems to have increased. There is however quite large variation in the numbers of KSI from year to year. E.g. the number of KSI car passengers has more than doubled from 2011 to 2012, although the overall trend seems to be decreasing.

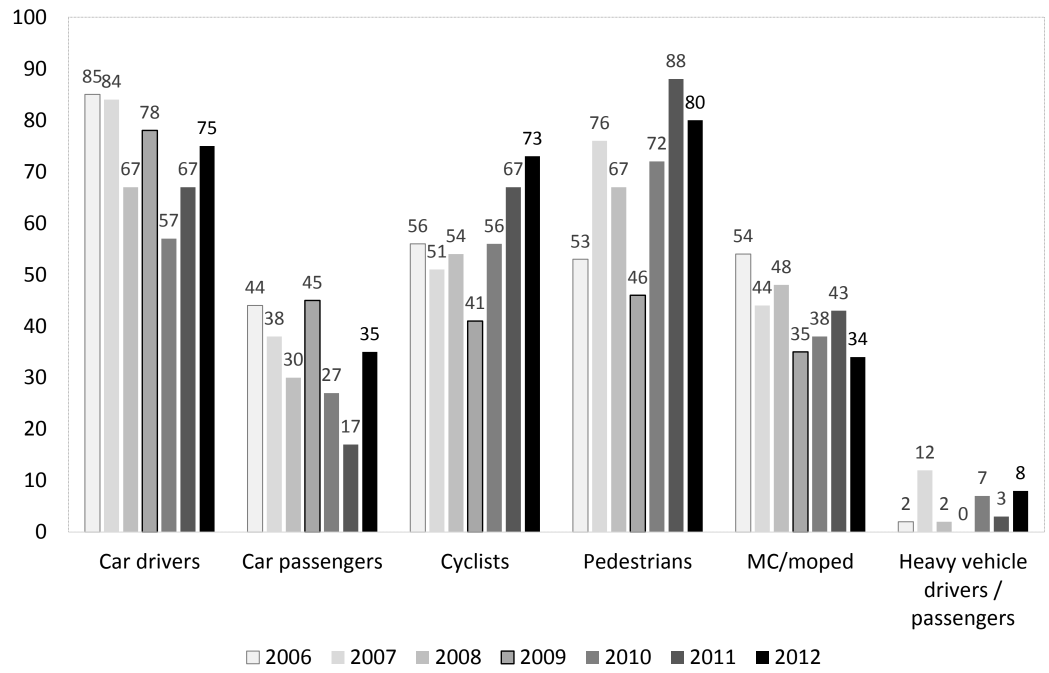

Figure 3.2.5: Development of the numbers of KSI for different road user groups in 2006-2009 (Stockholms stad, police reported).

3.2.2 Police reported vs. hospital reported crash and injury data

The goal for 2020 refers explicitly to police reported data. Hospital reported data are only sparsely available for the period of interest (2006-2012). All analyses in the present report are therefore based on police reported data (Strada), except an analysis for pedestrian fall that has been made for the indicator Management and Maintenance. Hospital reported data were also used to estimate the proportion of KSI cyclists not wearing a helmet.

The only crash type that is available from hospital statistics, but not from Strada, is pedestrian falls. Other crash types, especially pedestrian and bicycle crashes, may be underreported in police reported data and less so in hospital reported data. If hospital data are included in Strada before 2020, adjustments will have to be made to the observed numbers of KSI or to the goal for the number of KSI in 2020, in order to take into account the increased reporting of such crash types.

Figure 3.2.6 shows the numbers of police and hospital reported KSI in Stockholm county in the years 2001-2012. Police reported data show a similar trend in recent years as has been seen for Stockholms stad. Numbers of police reported KSI in Stockholm country increased from 2010 to 2012. No such trend can be seen in the hospital reported data. However, in other years there is no perfect relationship between the police and hospital reported data. It is therefore not possible to draw any conclusions from the observed changes in recent years.

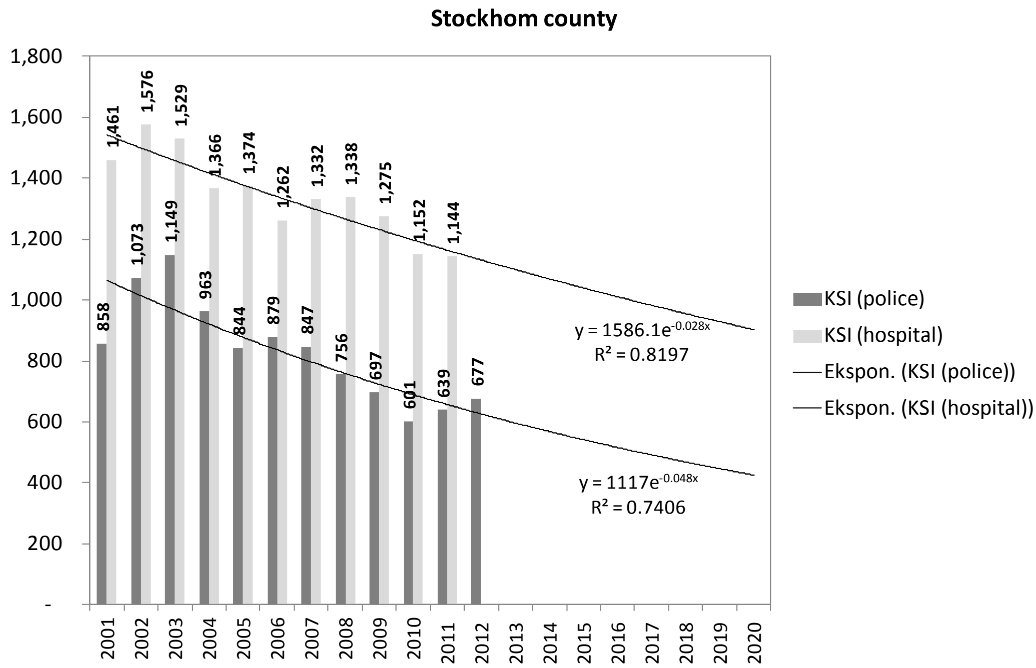

Figure 3.2.6: Police and hospital reported annual numbers of KSI in Stockholm county (2001-2012) and estimated trend.

4 Baseline scenarios: Development of the number of KSI from 2006-2009 to 2020

Based on the observed changes of exposure for different road user groups in recent years, three baseline scenarios were developed that describe possible changes of the amount of road travel for motorized and non-motorized road users from 2006-2009 until 2020. The three scenarios are defined as follows:

A. Status quo: Moderate changes of the amount of travel with all means of transport, no great change in the distribution of motorized and non-motorized traffic. These are conservative estimates that are based on the recent development of exposure.

B. Motorized: The amount of motorized traffic increases more than in scenario A. For non-motorized traffic the expected changes are as in scenario A

C. Non-motorized: The amount of non-motorized traffic increases more than in scenario A. For motorized traffic the expected changes are as in scenario A

Table 4.1 summarizes the expected changes for different means of transport in the three scenarios.

Table 4.1: Baseline scenarios for changes of traffic volumes in different road user groups until 2020; A: Status quo, B: Motorized, C: Non-motorized.

	Estimated change in 2012 (vs. 2006-2009)	Expected change in 2020 (vs. 2006-2009)			
	A	**A**	**B**	**C**	**Source**
Population	**9.55 %**	**21.5 %**	**21.5 %**	**21.5 %**	Statistisk årbok, expected development
Motorized traffic, inner city	-7.22 %	-20.0 %	0.0 %	-20.0 %	A, C: Statistisk årbok, trend based on data from 2008-2011 (cars and buses) B: - (zero)
Motorized traffic, outer city	2.46 %	4.4 %	6.0 %	4.4 %	A, C: Trafikanalys; trend based on 2000-2012 data (special assumptions for buss and MC)[1] B: - (somewhat more than in A and C)
Motorized traffic (total)	**1.09 %**	**1.0 %**	**5.1 %**	**1.0 %**	If 14% of all travel in the inner city in 2006-2009
Passenger cars, inner city	-7.22 %	-20.0 %	0.0 %	-20.0 %	A, C: Statistisk årbok, trend based on data from 2008-2011 (cars and buses) B: - (zero)
Passenger cars, outer city	1.92 %	3.1 %	5.0 %	3.1 %	A, C: Trafikanalys, trend based on 2000-2012 data B: - (somewhat more than in A and C)
Passenger cars	**0.62 %**	**-0.02 %**	**4.3 %**	**-0.02 %**	Weighted results from inner and outer city, assuming 14% in the inner city[2]
Heavy vehicles, inner city	0.00 %	0.0 %	0.0 %	0.0 %	No information available
Heavy vehicles, total	**0.00 %**	**0.0 %**	**0.0 %**	**0.0 %**	No information available
Bicycles, inner city	11.23 %	23.0 %	23.0 %	85.0 %	Statistisk årbok, trend based on data from 2002 and 2008 (5-year averages) A, B: Logarithmic trend C: Linear trend
Bicycles, outer city	9.55 %	21.5 %	21.5 %	43.0 %	A, B: Same as population growth C: Half the increase in the inner city
Bicycles, total	**10.39 %**	**22.3 %**	**22.3 %**	**64.0 %**	A-C: Weighted results from inner and outer city, assuming that half of all bicycle kilometers are cycled in the inner city
Pedestrians	**10.39 %**	**22.3 %**	**22.3 %**	**64.0 %**	A-C: Same as for bicycles

[1] Special assumption for bus: same increase as population, special assumption for MC: unchanged

[2] Assuming that 14% of all car travel is in the inner city, the change of the total amount of travel is zero; we have no empirical basis for estimating the amount of travel in the inner and outer city

For each scenario A, B, and C it is estimated how the number of KSI in Stockholms stad will have changed in 2020, compared to 2006-2009, if everything except the amount of travel remains unchanged. The results are summarized in table 4.2. The expected changes of the number of KSI are estimated as follows:

- *Exposure:* For each target group the expected change of the amount of travel is taken from table 4.1.

- ***Exposure of conflict partners:*** For non-motorized road users in collisions with motor vehicles, the product of the expected change for motorized and non-motorized road users is taken.
- ***Safety in numbers:*** It is taken into account that the number of crashes usually does not increase as a linear function of the amount of travel (Elvik, 2013). It is assumed that one percentage change of travel on averages leads to an increase of the number of KSI by 0.85% for motor vehicles and by 0.55% for non-motorized road users.

The safety in numbers effect leads to quite moderate expected increases of the numbers of KSI pedestrians and cyclists. The assumed increase of the number of KSI pedestrians and cyclists may in reality be larger in Stockholms stad because the number of pedestrians and cyclists in many places already exceeds the capacity of the existing infrastructure. Thus, more conflicts, especially among pedestrians and cyclists may result and more pedestrians and cyclists may use infrastructure not meant for them in order to avoid overcrowded pedestrian and bicycle tracks.

Table 4.2: Expected changes of the number of KSI in Stockholms stad in baseline scenarios A, B, and C if everything except the amount of travel remains unchanged.

			2012	2020		
Indicator	**Target group**	**Road users**	**A**	**A**	**B**	**C**
Speed	Involved in crashes with at least one motor vehicle	Motorized	1 %	1 %	4 %	1 %
		Non-mot.	6 %	12 %	15 %	32 %
		All	3 %	6 %	9 %	14 %
Safe main roads	Pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on main roads		6 %	12 %	15 %	32 %
	Motor vehicles in all type of crashes at at-grade junctions on main roads		1 %	1 %	4 %	1 %
Increased knowledge	All					
M&M	Pedestrians and cyclists in single accidents (falls), all		6 %	12 %	12 %	31 %
	Pedestrians and cyclists in single accidents (falls) on snow/ice covered roads (or in winter)		6 %	12 %	12 %	31 %
	Motor vehicle single crashes		1 %	1 %	4 %	1 %
Heavy vehicles	Involved in collisions with heavy vehicles, except target groups for safe main / local roads	Motorized	1 %	1 %	4 %	1 %
		Non-mot.	6 %	12 %	15 %	32 %
		All	3 %	6 %	9 %	14 %
Safe local roads	Pedestrians and cyclists at junctions or crosswalks on local roads		6 %	12 %	15 %	32 %
Seat belt use	Adult passenger car occupants		1 %	0 %	4 %	0 %
Bicycle helmet use	All cyclists		6 %	12 %	12 %	31 %
DUI	Involved in crash with a drunk driver	Motorized	1 %	1 %	4 %	1 %
		Non-mot.	6 %	12 %	15 %	32 %
		All	3 %	6 %	9 %	14 %

5 Development of the road safety indicators from 2006-2009 to 2020

This chapter summarizes for each of the nine road safety indicators

- How the indicator, the target group and goal for the indicator are defined, and the relationship between the indicator and the number of KSI
- The state of the indicator 2006-2009 and changes from then to 2012
- Measures for improving the indicator, including expected effects on safety, including both planned and other possible measures
- The development of the number of KSI in the target group for the indicator:
    - The observed development from 2006-2009 to 2012
    - The predicted development until 2020 in the baseline scenarios (if everything except exposure remains unchanged) and in different scenarios for possible developments of the indicator

The possible developments from 2006-2009 to 2020 are based on

- The baseline scenarios that describe possible developments of exposure
- The likely development of the indicator if the current trend for the indicator continues, or if all planned measures are implemented
- The optimal development of the indicator, i.e. goal attainment
- For some indicators, measures that do not directly contribute to the indicator but that still affect the same type of KSI are taken into account as well
- The development of the number of KSI in the target groups for the indicators are ***not*** taken into account (the starting point for all scenarios is the average number of KSI in 2006-2009); it is not possible to reliably estimate trends based on relatively small numbers from only a few years, moreover, for most target groups the development from 2006-2009 to 2012 suggest an increasing trend which is more likely to be a consequence of random variation rather than a reversion of the general downward trend

5.1 Speed

The current status and development of the speed indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportion of all vehicles driving at or below the speed limit
Target group:	All KSI in crashes with at least one motor vehicle
Status 2006-2009:	**50%** at or below the speed limit
Status and development 2012:	Compliance with speed limits is likely to increase, but most likely not sufficiently to attain the goal without additional efforts; data is however insufficient Police enforcement and physical speed reducing measures are likely to improve compliance with speed limits; speed limit reductions are planned and likely to reduce speed, but will not improve compliance with speed limits
Goal 2020:	**98%** at or below the speed limit

5.1.1 Description of the indicator and goal

The indicator for speed is the proportion of all vehicles driving at or below the speed limit. The same indicator is used in the national road safety strategy (Vägverket, 2008). The goal for 2020 is that 98% are driving at or below the speed limit on roads with all speed limits. Trafikverket (2012A) states however a proportion of 80% at or below the speed limit on national roads in Stockholm as the goal for 2020.

For the whole country the aim is to increase the proportion driving at or below the speed limit to 80% (Vägverket, 2008). The goal for Stockholm is more ambitious, which is regarded as realistic because in urban areas the willingness to comply with speed limits is usually greater and there are more speed reducing measures than in rural areas (Sørensen et al., 2009). A goal of 100% compliance with speed limits is not regarded as realistic.

In 2009 it was estimated that speed is the indicator with the greatest influence on the numbers of KSI, and that a reduction of the annual numbers of KSI by more than 26% is unlikely without a general decrease of the overall level of speed, even if all other sub-goals are met (Trafikkontoret, 2010; Sørensen et al., 2009).

Target group: The target group for the speed indicator are all KSI involved in crashes with at least one motor vehicle.

Potential and priority: Speed was classified as the most important of the three "top priority" indicators by Trafikkontoret (2010). Speed is one of the indicators with the strongest relationship to the number of KSI, and it is one of the indicators that can directly be influenced by measures that can be implemented by the city of Stockholm. It is therefore concluded that a considerable amount of resources and efforts should be directed towards speed reductions.

Speed and safety: Speed is known to have a strong relationship with the number and severity of motor vehicle crashes (Elvik, 2009). Motor vehicle speed has also a strong relationship with the severity of collisions with vulnerable road users. Therefore, there is a high potential to achieve considerable reductions of the number of KSI

- In general on roads with a high speed limit and / or high percentage driving above the speed limit
- Specifically in areas in which there are many pedestrians and cyclists, where driving speed is high and where motorized and other traffic is not physically separated (Sørensen et al., 2009).

Speed has a large and well-documented relationship to safety. Especially serious crashes tend to increase as speed increases, and the percentage increase of crashes and injuries is larger than the increase of mean speed. The most relevant indicator for speed, as regards the relationship to safety, is mean speed. The percentage driving at or below the speed limit can be assumed to be related to mean speed. All calculations that are made in this report for speed, are based on the ***power model*** by Elvik (2009). The power model states that a relative change of mean speed is associated with a relative change of the number of crashes and injuries. The change of the numbers of injuries is calculated as follows:

$$\frac{N\ of\ injuries\ after}{N\ of\ injuries\ before} = \left(\frac{Speed\ after}{Speed\ before}\right)^{Exponent}$$

Exponents were estimated by Elvik (2009) for different degrees of severity and for different types of road. E.g. for the number of fatalities on urban roads, the exponent is 3.0 and for the number of severely injured on urban roads the exponent is 2.0.

Estimating changes of the number of KSI as a function of mean speed is only an approximation to changes that may result from increasing proportions driving at or below the speed limit. It is assumed that speed is normally distributed and that mean speed can be estimated as a function of the proportion driving above the speed limit and the standard deviation of speed. This is not entirely correct, e.g. mean speed does not necessarily change as the proportion driving at or below the speed limit increases. It is however at present the best way to estimate safety effects of the speed indicator.

5.1.2 Status of the speed indicator

Information about speed and speed changes in ***Stockholms stad*** in recent years is scarce. Speed and speed changes where therefore estimated based on a number of sources that give some indication of likely developments. There may have been a development in the right direction, even if the goal does not seem likely to be met. The data are however far from adequate to make reliable estimates.

In the ***whole country***, the proportion driving at or below the speed limit on national roads was 43% initially and 46% in 2012. On municipal roads the respective proportions were 63% and 63% (unchanged). The national goal for 2020 is 80% driving at or below the speed limit. The present development in the whole country is regarded as insufficient (www.trafikverket.se).

For the practical application of the speed indicator, a clearly defined ***procedure*** would be necessary that describes where, when and how to conduct speed measurements and how to process the data. This procedure would have to be followed during the whole period 2010 to 2020 (Sørensen et al., 2009). Sørensen et al. (2009) summarize the requirements for such a procedure as follows:

- Measurements should be conducted on different types of roads with different speed limits (30, 50 and 70 km/h) in different parts of the city.
- Measurements should be made annually or at least every second year.
- Measurements should, ideally, be made for light and heavy vehicles separately.
- In order to be representative, the measurements should be made at a minimum number of times and places; the minimum numbers have to be considered. How low speed in rush hours, weekends and holidays are to be treated has to be considered as well.
- The Danish "Hastighedsbarometer" (Vejdirektoratet, 2009) might be used as an inspiration.

Information from different sources about speed changes in Stockholm and Sweden

In the following sections information from different sources is described that may be used to estimate changes of the proportions driving at or below the speed limit in Stockholms stad over time. Table 5.1.1 summarizes the results that are available from different sources.

Table 5.1.1: Proportions driving at or below the speed limit in Stockholm (all speed limits), summary of results from different sources.

Year	Proportion below speed limit (%)	Source	Geographical distribution	Comment
2013	**75.4**	Speed measurements in Stockholms stad (2013)	Stockholms stad	
2012	**62.7**	Vadeby & Anund (2013)	Municipal roads in urban areas in the whole country	Not specific for Stockholm, no results for 30 km/h speed limit
2004-2011	**2.3% decrease of mean speed**	Trafikverket (2012A)	Eastern Sweden	Proportion below speed limit not available
2009	**50**	Sørensen et al. (2009)	Stockholm	Few and not representative results, no results for 70 km/h speed limit
2004	**40**	Trafikverket (2012A)	Stockholm	National roads
2020 (goal)	**98**			

- ***Speed in Stockholms stad 2013***

In 2013 speed measurements were conducted at 200 locations in Stockholm. From 40 of these information is available about speed and the number of vehicles for each hour on all days on which measurements were conducted (per location, measurements were conducted on between one and five days, not on weekends).

Table 5.1.2. summarizes the results from the speed measurements in Stockholm in 2013 and shows the estimated mean speeds at goal attainment as well as the reductions of mean speed that are required in order to achieve the goal. Estimated percentages below the speed limit in 2013 are based on measured mean speeds and V85, assuming that speed is normally distributed. The estimated mean speeds at goal attainment are based on the assumption that speed is normally distributed and that the standard deviation is reduced to two third of the estimated standard deviation in 2013.

The overall mean speeds, V85 and proportions driving at or below the speed limit are calculated based on the available results for roads with speed limits 30, 50 and 70 km/h, and weighted with the amount of travel on each of the road categories. The amount of travel is estimated based on the numbers of kilometers of road with different speed limits (Sørensen et al., 2009, based on information from Vectura) and estimated traffic volumes from the speed measurements.

Table 5.1.2: Results from speed measurements in Stockholm, October 2013.

	In 2013			At goal attainment		
Speed limit	**Mean speed**	**V85**	**Below speed limit**	**Mean speed**	**Reduction of mean speed**	**Below speed limit**
30 km/h	27.4	33.4	67 %	22.1	-19 %	98 %
50 km/h	42.4	50.0	85 %	39.9	-76 %	98 %
70 km/h	64.2	75.3	71 %	55.4	-14 %	98 %
All	**45.2**	**53.4**	**75.4 %**	**39.8**	**-12 %**	**98 %**

The estimated percentages driving at or below the speed limit are far higher than those estimated by Sørensen et al. (2009). It is unlikely that the whole decrease is due to a reduction of actual speeds.

- ***National speed evaluation in 2012***

In 2012 a speed evaluation has been conducted on municipal roads in 23 urban areas in Sweden (Vadeby & Anund, 2013). Stockholm is one of the cities included in the evaluation, but results for individual cities or measurement points (there were three measurement points in Stockholm) are not available. The measurements were conducted in autumn 2012. The average speeds and proportions of drivers above the speed limit are shown in table 5.1.3. Since no corresponding data from earlier years is available, no conclusions can be drawn about changes over time.

Table 5.1.3: Average speeds and proportions of drivers above the speed limit on municipal roads in urban areas in 2012 (Vadeby & Anund, 2013).

			Proportion above speed limit (%)	
Speed limit	**Average speed (km/t)**	**Proportion below the speed limit (%)**	**5 km/h above speed limit**	**30 km/h above speed limit**
40 km/h[1]	39.0	53.0	23	0.3
50 km/h	47.0	59.0	19	0.3
60 km/h[1]	55.7	63.0	19	0.4
70 km/h	61.0	79.0	9	0.3
Total[2]	**49.6**	**62.7**	**17.1**	**0.3**

[1] Speed limits 40 km/h and 60 km/t do not exist in Stockholm city.

[2] Weighted average of results for 50 and 70 km/h speed limits, weighted with kilometers of road with the respective speed limits in Stockholm (Sørensen et al., 2009).

- ### *2004-2011: Sped index for eastern Sweden*

A speed index was developed for eastern Sweden (including Stockholm; Trafikverket, 2012A). The index is based on the development of the average speed measured at several locations. The index in 2004 is 1. The development of the index indicates changes in average speed. Figure 5.1.1 shows the speed index in 2004-2011, and a linear trend line that has been fitted based on data from 2006 to 2011, and extended until 2020.

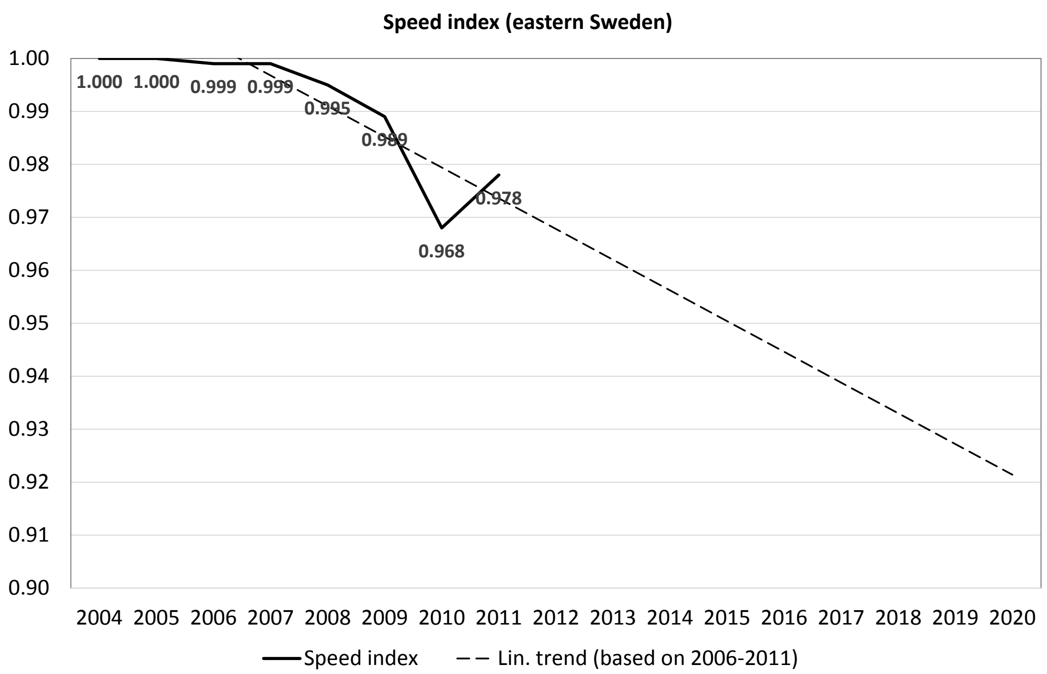

Figure 5.1.1: Speed index in eastern Sweden, 2004-2011.

The drop of the speed index in 2010 is probably due to the installation of speed cameras (speed cameras were installed in Stockholm county, but none of them in Stockholms stad) and a lot of snow in the winter 2009/2010. In 2010-2011 the index was 2.3% below the average index in 2006-2009.

- ***Estimated speed in 2009 (Sørensen et al., 2009)***

Sørensen et al. (2009) estimated the proportions driving at or below the speed limit as summarized in table 5.1.4. However, only few and not representative results are available for speed limits 30 and 50 km/t and none are available for speed limit 70 km/h.

Table 5.1.4: Estimated proportions driving below the speed limit in Stockholm in 2009 (Sørensen et al., 2009).

Speed limit	Below the speed limit
30 km/h	20 %
50 km/h	50 %
70 km/h	30 %
Total	**50 %**

- ***Speed on national roads in Stockholm 2004 (Trafikverket, 2012A)***

In 2004 representative speed measurements on national roads were conducted. It is estimated that 43% drove at or below the speed limit (Trafikverket, 2012A). The result refers most likely to Stockholm, but it is not specified whether it refers to Stockholms stad or Stockholm county. More recent results from representative speed measurements are not available. Instead, a speed index has been developed.

- ***Speed changes following the introduction of congestion charging***

The implementation of congestion charging in the inner city in 2008 has reduced motorized traffic and congestion. Consequently, average speed has increased (se section 3.1). Congestion charging is not assumed to affect changes of traffic volumes or speed over time after 2008.

- ***Speed at camera locations in Stockholm county***

An evaluation by Trafikverket och Polisen (2012) showed that the proportion of vehicles driving at speeds above the reporting limit for speed cameras was 6.9% on roads with a 70 km/h speed limit. On roads with other speed limits in Stockholm county the proportion was below 2%. No information is available about changes over time. The results do not say anything about the (development of the) proportion driving at or below the speed limit at other than camera sites.

- ***Rätt fart i staden***

A revision of speed limits in Stockholm is planned. In 2007 the range of possible speed limits was extended. Speed limits can now be set in intervals of 10 km/h (e.g. 30, 40, 50, …. km/h). A guide for how to set speed limits in urban areas has been developed as well ("Rätt fart i staden"). In 2012 (Trafikkontoret, 2012) it was planned to adjust "Rätt fart i staden" to Stockholm and to conduct a pilot project in Bromma, Kungsholmen and Hägersten. Results from the pilot studies and recommendations for speed limit changes were expected in 2013.

Summary: Estimated speed changes from 2006-2009 to 2020

Based on the results from speed measurements in Stockholms stad 2013 and the speed index for eastern Sweden (previous section), the estimated proportions driving at or below the speed limit and mean speeds for the years 2008-2009, 2012 and 2020 are shown in figure 5.1.2 and 5.1.3. The estimated mean speeds and percentages driving at or below the speed limit shown in figures 5.1.2 and 5.1.3 were developed as follows:

- For 2013 the results from speed measurements in Stockholms stad 2013 were used.
- For 2006-2020 the results from 2013 are annualized according to the development of the speed index for eastern Sweden (linear trend).
- The percentage at or below the speed limit are estimated based on the results for mean speed and V85, assuming a normal distribution of speed. At goal attainment it is assumed that the standard deviation of speed is reduced to 2/3 of the value in 2012.

The speed index for eastern Sweden is the only data source from which a change over time can be estimated. The results that were used in Sørensen et al. (2009) are not directly comparable to those available from 2013 and are therefore not used as a basis for estimated changes over time.

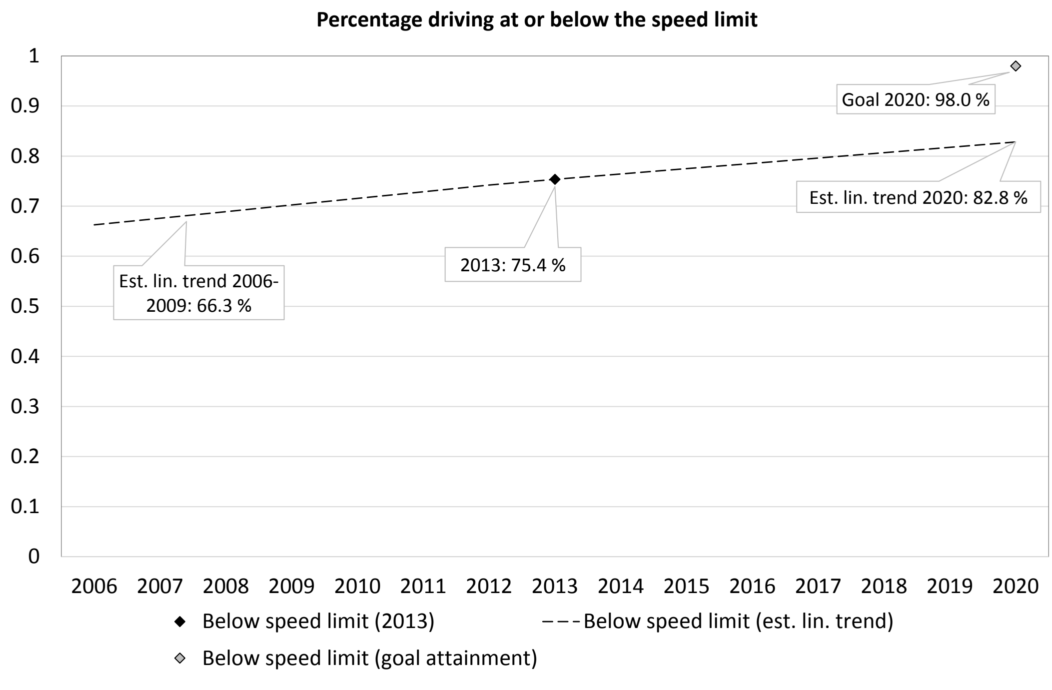

Figure 5.1.2: Percentages driving at or below the speed limit (measurements in Stockholms stad), estimated linear trend 2008-2020 and mean speed at goal attainment in 2020.

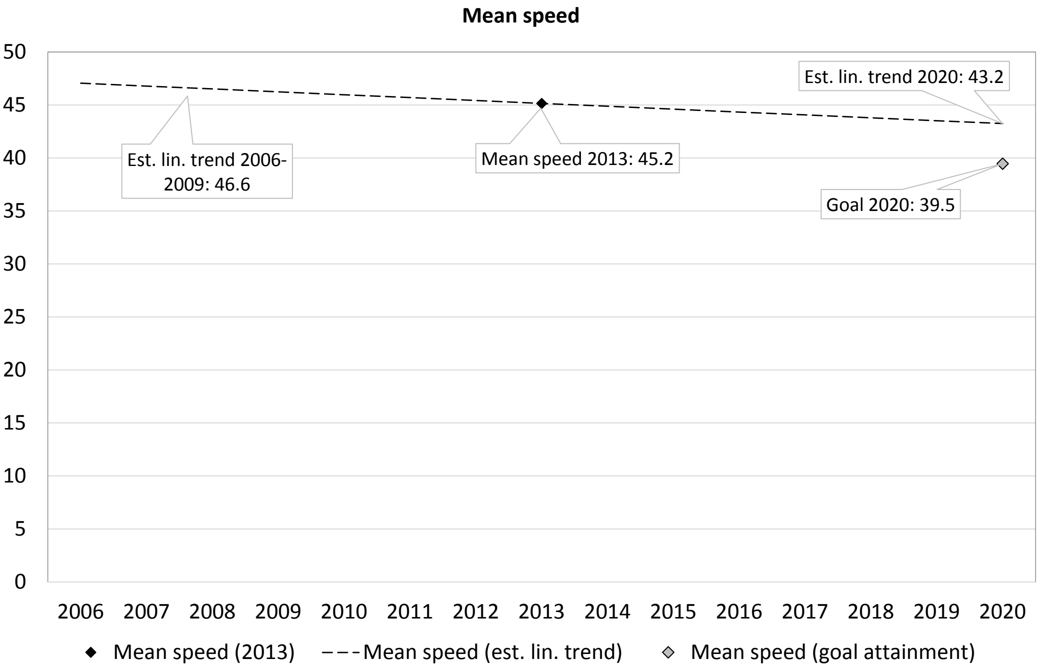

Figure 5.1.3: Mean speed in 2013 (measurements in Stockholms stad), estimated linear trend 2008-2020 and estimated mean speed at goal attainment in 2020.

Estimated percentages driving at or below the speed limit and mean speeds are also summarized in table 5.1.5 for different speed limits. The results indicate that in 2012 speeds on roads with a speed limit of 30 or 70 km/h were farthest away from the goal. Based on the linear trend, speed on these roads will still be far higher than at goal attainment. However, all predicted changes are based on the speed index for eastern Sweden, which does not include roads with a 30 km/h speed limit, and not for Stockholm or roads with specific speed limits. The predictions, especially for specific speed limits must therefore be regarded with great caution.

Table 5.1.5: Estimated changes of the proportion driving at or below the speed limit and mean speed based on an estimated linear trend and at goal achievement.

	Percentage at or below speed limit				Mean speed (km/h)			
	2006 -2009	2012	2020 (lin. trend)	2020 (goal)	2006 -2009	2012	2020 (lin. trend)	2020 (goal)
30 km/h	61 %	66 %	75 %	98 %	28.3	27.6	26.2	22.1
50 km/h	79 %	84 %	91 %	98 %	43.8	42.6	40.6	39.8
70 km/h	63 %	69 %	80 %	98 %	66.3	64.6	61.5	55.3
All	**68.9 %**	**74.2 %**	**82.8 %**	**98 %**	**46.6**	**45.4**	**43.2**	**39.8**

According to the results in table 5.1.5 mean speed has decreased by 2.6% from 2006-09 to 2012 (from 46.6 to 45.5 km/h). In order to achieve the goal, mean speed would have to be reduced by 14.8% (from 46.6 to 39.8 km/h). However, according to the estimated linear trend, it will only be reduced by 7.8% (from 46.6 to 43.2 km/h).

Factors that may have contributed to a reduction of average speed from 2009 to 2012 are according to Trafikverket (2012A) changes on the national road network, installation of speed cameras and much snow in winter 2009-2010. Speed cameras are however no likely explanation for reduced speed in Stockholm because no new cameras were installed after 2006.

5.1.3 Measures for improving the speed indicator

Several measures can be used to affect speed levels or the compliance with speed limits. Some such measures are not very popular, such as increased surveillance, or may have adverse side effects, such as speed humps that increase noise and emissions. Speed limit reductions are the only measure that is likely to contribute to reductions of the number of KSI in Stockholms stad until 2020. The speed indicator is however not likely to be affected favorably.

Several other measures are likely to reduce the number of KSI, but we have no information about plans for implementing any of these measures. These measures are: Increased police enforcement, speed cameras, physical speed reducing measures, and environmental streets.

- ***Reduced speed limits***

The length of roads with different speed limits in Stockholms stad in 2009 is shown in table 5.1.6 (Sørensen et al., 2009, based on information from Vectura). Almost to third of all roads (62%) have a 30 km/h speed limit, and one fourth (25%) have a 50 km/h speed limit.

Table 5.1.6: Road lengths with different speed limits.

	Private roads		Municipal roads		National roads		In total	
	km	%	km	%	km	%	km	%
Unknown	2	0 %	40	2 %	1	1 %	**43**	**2 %**
5 or 10 km/h	2	0 %	12	1 %	0	0 %	**14**	**1 %**
20 km/h	8	2 %	6	0 %	0	0 %	**13**	**1 %**
30 km/h	346	75 %	1,182	64 %	7	4 %	**1,534**	**62 %**
50 km/h	105	23 %	483	26 %	31	18 %	**618**	**25 %**
70 km/h	0	0 %	111	6 %	100	58 %	**211**	**9 %**
90 km/h	0	0 %	0	0 %	34	20 %	**34**	**1 %**
I alt	**462**		**1,833**		**172**		**2,467**	

Sørensen et al. (2009) suggest that speed limits may be reduced from 50 to 30 km/h in parts of the road network with large traffic volumes and many vulnerable road users and possibly also in other parts of the road network with higher speed. In Stockholm, reductions of the speed limit from 50 to 30 km/h were found to reduce average speed and 85th percentile speed by on average 3 km/h. Speed reductions may even be found on roads outside a speed reduced area (SKL, 2009). Speed reductions were however not always large or statistically significant.

Since 2008 speed limits can be set at 10 km/h intervals between 30 and 110 km/h. Thereby, a better adjustment between local conditions and speed limit is possible. The general speed limit in urban areas is still 50 km/t. However, local roads (which are about 75% of all roads in cities) have already a 30 km/h speed limit. According to Stockholms stad there are currently no plans of changing the general speed limits[1]. However, from approximately the end of 2014, new speed limits may be implemented according to the new system (Trafikkontoret, 2013A).

Reduced speed limits affect crashes mainly by reducing speed. A general relationship between changes of speed limit and changes of average speed has been described by Elvik (2009). According to the model by Elvik (2009) the expected change of average speed (y) can be calculated as a function of the change of the speed limit (x) as follows:

$$y = -0.0058x^2 + 0.2781x - 0.2343.$$

Where x is the changes of the speed limit in km/h (speed limit before minus speed limit after the change) and y is the expected change of average speed in km/h.

A reduction of average speed by 10% can on average be expected to reduce fatal crashes by 38% and injury crashes by 19% (Elvik, 2009). Speed limit reductions are most effective when implemented on roads with high speed and many (serious) crashes. Trials with new speed limits of 40 and 60 km/h in urban areas were evaluated by Hydén et al. (2008). Results showed that speed decreased on average by 1.6 km/h. Stockholm was ***not*** one of the trial areas.

According to Uppdragsbeskrivningen, Stockholms stad has started a review of existing speed limits with the aim of introducing new speed limits. Results from speed reviews in general, and from reviews of "Rätt fart i staden" specifically, are described in Edman et al. (2012), based on literature review, analyses of speed plans and expert interviews. The results show that speed reviews for the most part lead to reductions of speed limits. Trafikkontoret (2013B) has planned to reduce the speed limit form 50 to 30 km/h on roads in the inner city of Stockholm that have no separate cycle lane and on roads that do not fulfill environmental standards.

In Stockholm county, speed limits were changed on a number of roads with a speed limit of 70 km/h or higher in 2008 and 2009 (Trafikverket, 2012B). Information about speed limit changes in Stockholms stad is not available. As the changes for the most part are made on roads with speed limits at or above 70 km/t, the majority of roads with changed speed limits is likely to be outside the city of Stockholms stad. Changes on national roads in Sweden that have been made as a consequence of hastighetsöversyn in 2008 are likely to have contributed to a general reduction of mean speeds (Trafikverket, 2012A).

Expected effects: Speed limits are likely to be reduced on parts of the road network in Stockholms stad until 2020. Reduced speed limits can be expected to reduce speed and the number of KSI - but not the proportion driving above the speed limit.

[1] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Hastighetsdampande-atgarder/

- ***Speed plan***

Trafikkontoret (2010) states that a "speed plan" and a multi-year action plan will be developed (*"Staden behöver ta fram strategier och åtgärder för säkra hastigheter och en bättre efterlevnad av hastigheterna. Ett led i detta är att ta fram en hastighetsplan och en flerårig åtgärdsplan för hur staden på sikt ska nå fram till intentionerna i hastighetsplanen"*). A speed plan is not explicitly mentioned in Trafikkontorets road safety plans. These focus mainly on speed limits and police enforcement / speed cameras which are described below.

- ***Speed cameras***

Speed cameras reduce crashes by reducing speed. At most speed cameras, no more than about 2% of all vehicles are driving at speeds above the reporting limit (Trafikverket och Polisen, 2012). On average, speed cameras have been found to reduce the number of crashes by 67% (Høye et al., 2014a). A Swedish evaluation study in an urban area has been conducted in Umeå showed that speed cameras at crosswalks have a greater effect on speed than speed dumps. Speed and speed variation were reduced and the effect did not diminish over time (SKL, 2009).

According to Trafikverket (2012A) speed cameras may have contributed to a general reduction of average speeds in Stockholm county. In 2006 there were four speed cameras on roads in Stockholm (Trafikkontoret, 2012). In 2012 new speed cameras were installed in Stockholm county[2], but no more speed cameras were installed in Stockholms stad after 2006 (Trafikkontoret, 2013A). Trafikverket (2012C) presents crash analyses on national roads in Stockholm county and proposed possible new camera locations. None of the installed or proposed speed cameras are however in Stockholms stad.

Stockholm municipality has no direct responsibility for police enforcement, but may in cooperation with the Police be able to influence the installation of speed cameras. Trafikkontoret (2013B) suggests to wait for results from a revision of the criteria for installing speed cameras by Trafikverket and the development of guidelines for speed cameras that is under development by SKL. According to the current criteria for speed camera locations, speed cameras may be set up on roads with higher speed limits and only on two-lane roads. Since most roads in Stockholm have speed limits of 50 km/h or below and most roads with higher speed limits have more than two lanes, there is most likely no great potential for increasing the number of speed cameras in Stockholm

Expected effects: The total number of KSI in Stockholms stad is unlikely to be affected to a large degree by speed cameras until 2020.

- ***Police enforcement***

Mobile speed cameras were found to significantly reduce crashes. Injury crashes were on average reduced by 17% and fatal crashes were reduced by 35%. Visible cameras have the greatest effects at the camera locations while hidden cameras reduce crashes on longer stretches of road (Høye, 2014a).

[2] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Fartkameror/

Stockholm municipality has no direct responsibility for Police enforcement, but may in cooperation with the Police be able to influence the amount of police enforcement and when and where police enforcement is conducted. Trafikkontoret (2010) states in the Road safety program 2010-2020 that the municipality will increase its cooperation with the Police and support the establishment of an increased number of locations that can be used by the Police for speed enforcement. This ambition is followed up by Trafikkontoret (2012) in which it is stated that the municipality in cooperation with the Police have proposed several locations that can be used for speed enforcement (and for DUI, seat belt and other enforcement). The proposed locations were chosen based on traffic volumes and safety. Even if some new locations for Police enforcement were installed the total amount of police enforcement has most likely not increased (no information about the amount of police enforcement or its development over time is available). The police is at present working on a road safety strategy that will focus, amongst other things, on speed enforcement.

Expected effects: An increase of the amount of police enforcement may reduce crashes.

- ***Physical measures: Speed humps, transverse rumple strips, lane narrowing, lane displacement***

The purpose with physical measures is to design roads in a way that "automatically" makes the road users adjust their speed to a desired level, e.g. the speed limit (Trafikkontoret, 2010). Specific recommendations for the design of such measures are given in Trafikverket (2012D, 2012E). Physical speed reducing measures are most appropriate in areas with many vulnerable road users. Junctions and crossing locations can also be made safer (e.g. raised crosswalks, see safe local roads). Adverse effects are often increased noise and emissions which arise from breaking and accelerating. Transverse rumple strips produce additional noise due to the rumble effect. Lane narrowings can additionally create problems for motor vehicles in opposing directions and conflicts between motor vehicles and bicycles (SKL, 2009).

Physical speed reducing measures have been found to reduce injury crashes by about 15% (Elvik et al., 2009). The effect on injuries and fatalities are mainly depending on the effect on speed - the higher the speed reduction the greater the reduction of the number of injuries, and especially of the most severe injuries. Such measures can also affect the amount of traffic. Physical measures, such as speed humps or environmental streets are often more effective than speed limit reductions in reducing average speed and safety for pedestrians and cyclists (Jonsson et al., 2011).

An overview provided by Stockholms stad from 2010 shows that the number of physical speed reducing measures per kilometer road was 0.62 in the whole city (inner and outer city of Stockholms stad), 0.83 on roads with a speed limit of 30 km/h, 0.36 on roads with a speed limit of 50 km/h and 0.1 on roads with a speed limit of 70 km/h. In the inner city on roads with a 30 km/h speed limit there are 1.24 physical speed reducing measures per kilometer road. There is in other words already a high density of speed reducing measures. It is planned to install new speed reducing measures at several crosswalks and schools (see chapter 5.2).

Expected effects: Physical speed reducing measures may reduce speed and thereby the number of KSI, but no information is available about plans for installing speed reducing measures until 2020.

- *Environmental streets*

As an alternative to building bypasses, main roads may be made safer and more attractive by implementing speed reducing measures for motor vehicles and safety measures for pedestrians and bicycles. Examples of possible measures are reduced space for motor vehicles (and more space for pedestrians and bicycles), roundabouts, lane narrowings and displacement, medians, safe bus stops, road lighting and plants (SKL, 2009). Such measures often increased travel times for motor vehicles and thereby also reduce traffic volumes.

Safety effects of environmental streets depends on the speed reducing effect. Several studies found injury crash reductions of 24 to 45%. The largest speed reductions that were found were from 50-60 km/t to 35-40 km/t (SKL, 2009).

Expected effects: No information is available about plans to implement environmental streets until 2020.

- *Public education and campaigns*

Several anti-speeding campaigns have been conducted in Europe in the last 10 years. However, only few of these have been formally evaluated with regard to the effect on speed or crashes. Speed reductions are most likely when campaigns are accompanied by targeted police enforcement (Phillips & Torquado, 2009). Elvik et al. (2009) have estimated that speed campaigns reduce the number of crashes by 4% on average. The result is not statistically significant and may be affected by methodological weaknesses and publication bias.

Expected effects: Campaigns are not likely to influence the number of KSI in Stockholm, unless combined with Police enforcement.

5.1.4 Development of the number of KSI in the target group for the speed indicator from 2006-2009 to 2020

The target group for the speed indicator are all KSI in Stockholms stad in crashes that involve at least one motor vehicle. Only motor vehicle speeds are covered by the indicator, but cyclists and pedestrians in collisions with motor vehicles will also be affected by speed changes. The target group includes the target groups for most other indicators (except management and maintenance and bicycle helmet use). The indicator will also be affected by measures under safe main roads and safe local roads.

Development from 2006-2009 to 2012

The annual numbers of KSI in crashes involving at least one motor vehicle (the target group for the speed indicator) in 2006 to 2012 are shown in figure 5.1.4. In 2012 the number of KSI was 6% higher than in 2006-2009. When KSI pedestrians and cyclists at crosswalks or junctions are excluded, the number of KSI was 5% lower in 2012 than in 2006-2009. This may indicate that the observed increase mainly is due to the general increase of the number of KSI pedestrians and cyclists, which may be a consequence of increased exposure. However, the observed changes may just be a result of random variation form year to year and no predictions for future years can be made based on the results in figure 5.1.4. Numbers of KSI for individual speed limits are not available.

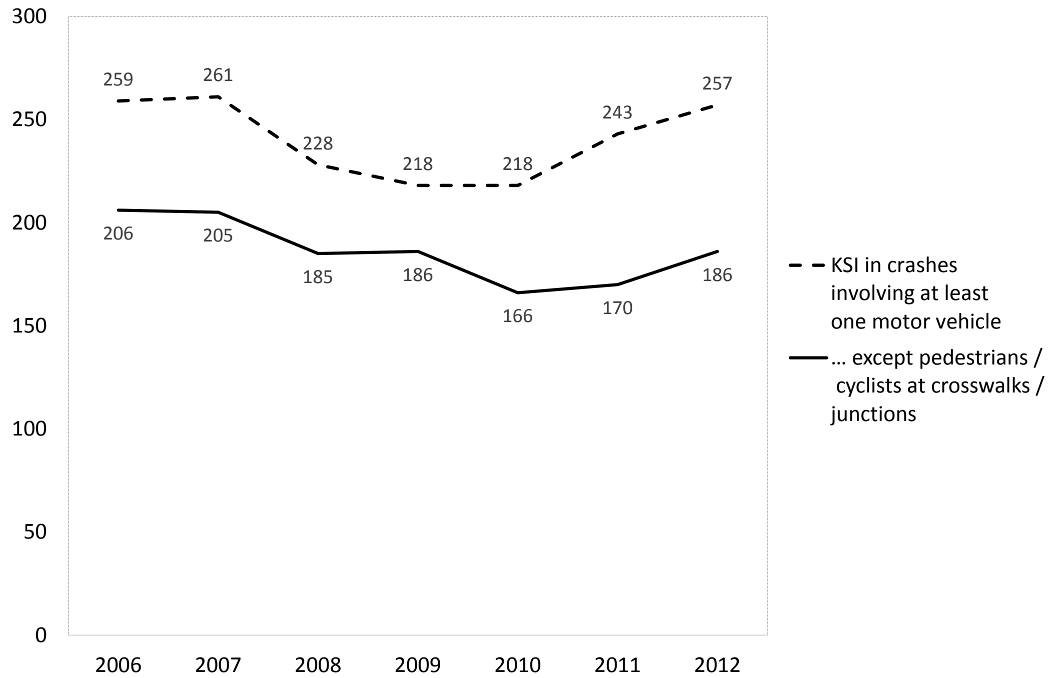

Figure 5.1.4: KSI in crashes involving at least one motor vehicle 2006-2012 (Stockholms stad, police reported).

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The actual numbers of KSI in motor vehicle crashes in 2006-2009 to 2012, together with the estimated trends until 2020 in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.1.5. The estimated trend lines show the expected numbers of KSI in the target group for the speed indicator if everything except exposure remains unchanged on the level from 2006-2009.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the speed indicator would have to be reduced to 145.

All three baseline scenarios predict increases of the number of KSI in the target group for the speed indicator. The greatest increase is predicted in scenario C in which the numbers of vulnerable road users increase most. The most favorable scenario is A (status quo).

In 2012 the number of KSI in the target group for the speed indicator was just above the trend line from 2006-2009 to 2020. The results from 2006-2009 to 2012 do not allow any conclusion about the development of the numbers of KSI until 2020, but goal attainment does not seem to have come any closer.

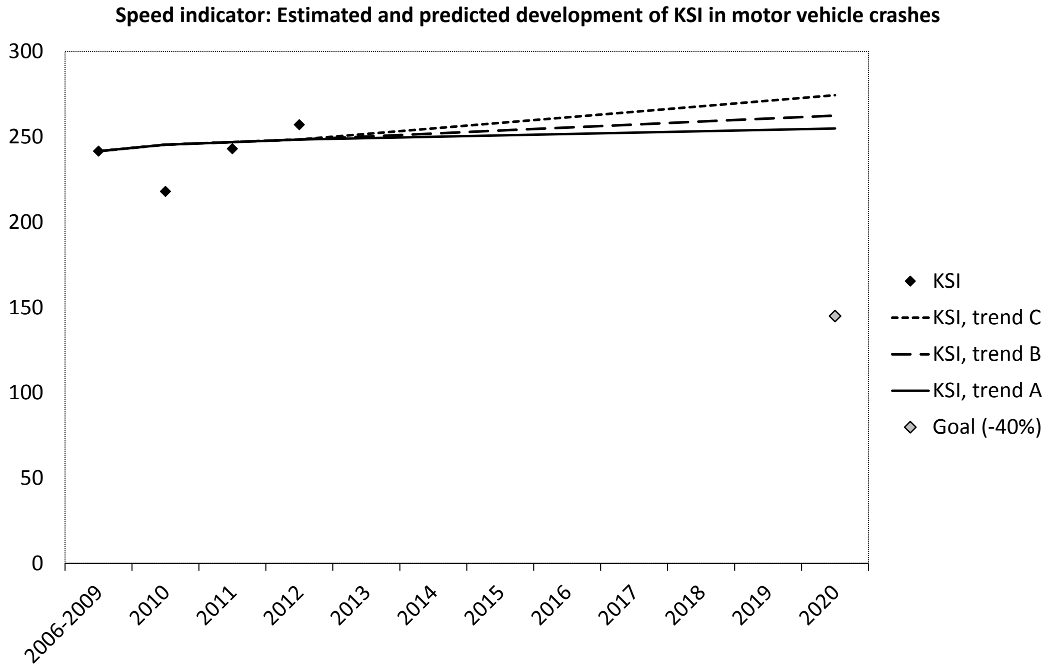

Figure 5.1.5: KSI in crashes involving at least one motor vehicle: Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the speed indicator and speed limits***

In order to estimate changes of the number of KSI in the target group for the speed indicator, several scenarios were defined for changes of the speed indicator and speed limit changes:

Indicator: For the speed indicator three different scenarios are assumed.

- ***Unchanged:*** Mean speeds and the proportions driving at or below the speed limit remain unchanged on the average level from 2006-2009.
- ***Goal attainment:*** 98% of all motor vehicles are driving at or below the speed limit.
- ***Linear trend:*** The estimated linear trend (see section 5.1.2) continues, speed in 2020 is in between "unchanged" and goal attainment.

Speed limit reductions: Additional scenarios are calculated for speed limit changes. Speed limits are not part of the speed indicator, but are still likely to affect average speed. Two scenarios are defined for speed limit changes:

- ***None:*** Speed limits remain unchanged
- ***Some:*** Speed limits are reduced by 10 km/h on half of all roads that today have a speed limit of 50 or 70 km/h (as a part of Rätt fart i staden) and additionally from 50 to 30 km/h on half of all roads with a 50 km/h speed limit in the inner city (according to Trafikkontoret, 2014).

The estimated effects on the number of KSI of speed limit reductions are calculated with the power model (Elvik, 2009). The percentages of all travel on roads with different speed limits are estimated based on road length according to Sørensen et al. (2009) and average traffic volumes according to the speed measurements in Stockholms stad in 2013. The proportions driving at or below the speed limit are not assumed to be affected by speed limit changes. The effects of speed limit changes and increasing proportions driving at or below the speed limit are assumed to complement each other. When speed limits are lowered, more may actually be driving above the speed limit. However, the number of KSI is not directly affected by the proportion driving at or below the speed limit, but rather by the absolute speed level (represented by mean speed in our calculations).

Table 5.1.7 summarizes the estimated changes of the number of KSI in the target group for the speed indicator until 2020. In 2006-2009, the average number of KSI in this group was 242.

Table 5.1.7: Estimated changes of the number of KSI in the target group for the speed indicator in 2020 (all KSI in motor vehicle crashes).

		Indicator		**Speed limit**		**Total change**	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**reductions**	**Effect**	**%**	**N**
A Status quo	5.5 %	**Unchanged**	0 %	**None**	0 %	**12 %**	**29.6**
	5.5 %		0 %	**Some[2]**	-7 %	**4 %**	**10.7**
	5.5 %	**Goal attainment**	-28 %	**None**	0 %	**-19 %**	**-45.0**
	5.5 %		-28 %	**Some[2]**	-7 %	**-24 %**	**-58.7**
	5.5 %	**Linear trend**	-14 %	**None**	0 %	**-4 %**	**-9.1**
	5.5 %		-14 %	**Some[2]**	-7 %	**-10 %**	**-25.3**
B Mot.	8.6 %	**Unchanged**	0 %	**None**	0 %	**15 %**	**35.8**
	8.6 %		0 %	**Some[2]**	-7 %	**7 %**	**16.4**
	8.6 %	**Goal attainment**	-28 %	**None**	0 %	**-17 %**	**-40.5**
	8.6 %		-28 %	**Some[2]**	-7 %	**-23 %**	**-54.6**
	8.6 %	**Linear trend**	-14 %	**None**	0 %	**-2 %**	**-3.8**
	8.6 %		-14 %	**Some[2]**	-7 %	**-8 %**	**-20.4**
C Non-motorized	13.6 %	**Unchanged**	0 %	**None**	0 %	**32 %**	**77.2**
	13.6 %		0 %	**Some[2]**	-7 %	**23 %**	**54.9**
	13.6 %	**Goal attainment**	-28 %	**None**	0 %	**-4 %**	**-10.5**
	13.6 %		-28 %	**Some[2]**	-7 %	**-11 %**	**-26.6**
	13.6 %	**Linear trend**	-14 %	**None**	0 %	**13 %**	**31.7**
	13.6 %		-14 %	**Some[2]**	-7 %	**5 %**	**12.6**

[1] Estimated change of the number of KSI in the target group if everything except exposure remains unchanged on the level of 2006-2009.

[2] Speed limits are reduced by 10 km/h on half of all roads with a speed limit of 50 or 70 km/h.

Predicted changes of the numbers of KSI: The greatest and most favorable changes of the numbers of KSI are according to table 5.1.7 predicted for goal attainment. However, even at goal attainment and with speed limit reductions the greatest estimated reduction is still well below the overall goal of -40%. The predicted reductions at goal attainment are between 11 and 24% when speed limit reductions are assumed, and between 4 and 19% when no speed limit reductions are assumed. When the estimated linear trend of the speed indicator continues, the change of the number of KSI in 2020 may be between a 10% reduction and a 13% increase. When speed remains unchanged the number of KSI is most likely to increase, in the worst case by 32%.

The estimates of expected changes of the number of KSI until 2020 have several weaknesses. The most serious weakness is probably that the estimated speed distributions at goal attainment and when speed continues to follow the present trend could not be empirically tested. Mean speeds are already well below the speed limit. Increasing proportions driving at or below the speed limit were assumed to be accompanied by further reductions of mean speed. It is however possible to increase compliance with speed limits without decreasing mean speeds. Consequently, the estimated effects of increased compliance with speed limits are most likely overestimated, which makes the goal of reducing the number of KSI still more unlikely to be achieved.

Another weakness is the lack of data that allow an estimation of the most likely development of speed without speed reducing measures. The speed index for eastern Sweden is not necessarily representative of speed in Stockholms stad. It was developed for roads with a speed limit of 50 km/h or above, not for roads with a speed limit of 30 km/h.

In summary, the results indicate that the overall goal of a reduction of the number of KSI by 40% is unlikely to be attained. Even if speed limits are reduced on over half of the road network and if the amount of travel does not increase more than in the most conservative scenario, the estimated reduction of the number of KSI in the target group for the speed indicator in 2020 is only 24%. This may even be an overestimate.

5.2 Safe main roads: Safe junctions and GCM-passages

The current status and development of the safe main roads indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportions of safe junctions and GCM-passages on main roads (GCM-passages are mainly crosswalks; GCM = "gående, cycler, mopeder" - pedestrians, cyclists, mopeds)
Target group:	All KSI in crashes involving at least one motor vehicle at GCM-passages or junctions on main roads
Status 2006-2009:	**18%** of all GCM-passages on main roads and about **51%** of all junctions on main roads are safe according to the definition of the indicator
Status and development 2012:	There are plans to increase the number of safe GCM-passages; if the increase continues at the current pace for both GCM-passages and junctions, about 22% of all GCM-passages and about 62% of all junctions on main roads will be safe in 2020, which is far from goal attainment Additional measures that are planned as a part of the bicycle plan and walkability strategy are likely to improve the safety at GCM-passages on local roads as well
Goal 2020:	**80%** of all junctions and GCM-passages on main roads are safe

5.2.1 Description of the indicator and goal

The indicator for safe main roads is the proportion of safe junctions and pedestrian / bicycle crossings, including signalized junctions and crossings, on main roads (main roads are those with a speed limit above 30 km/h).

The indicator overlaps (theoretically) with the speed-indicator. However, safe main roads refers to junctions and crosswalks, while speed measurements that can be applied in the evaluation of the speed-indicator most likely are not made at junctions.

The goal for 2020 is that 80% of all junctions and pedestrian / bicycle crossings on main roads are safe:

- A ***pedestrian / bicycle crossing*** (hereafter referred to as GCM-passage according to the terminology of Trafikkontoret) is regarded as safe if vehicle speeds (actual speeds, not the speed limit) are below 30 km/h or if it is grade separated. According to trafikverket.se, 85% of all motorized traffic should travel at 30 km/h or below
- A ***junction*** is regarded as safe if all approaches to the junction have a speed limit of 50 km/h or below. The indicator refers to all types of at-grade junctions (unsignalized and signalized).

No corresponding goal is defined for road safety in the whole country.

Target group: The target group for the indicator safe main roads are

- Pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on main roads

- Motor vehicles in all type of crashes at at-grade junctions on main roads

According to Trafikkontoret (2010) there are several safety problems on main streets that should be addressed in addition to unsafe pedestrian and bicycle crossings:

- High speed
- Complicated road environments
- Unsafe roadsides

While "high speed" is addressed by the speed indicator, complicated environments and unsafe roadsides are not addressed by any of the indicators.

There are several other goals related to bicycle traffic in Stockholm that do not directly affect the indicator safe main roads, but that still can affect KSI in its target group, mainly by increasing exposure, i.e. the number of cyclists (Stockholms stad, 2012A):

- Increased proportion of journeys in rush hours by bicycle to 12% in 2018 and 15% in 2030 (information about the present proportion of bicycle journeys in rush hours is not available)
- Increased numbers of bicycles passing one of the seven automatic measuring points where passing bicycles are counted continuously, or at one of the 57 locations the city where cyclists are counted manually once a year by 50% in 2018 and by 100% in 2030. The number of automatic measuring points is being increased. The automatic measuring points are at the same locations where public transport vehicles and other motor vehicles are counted
- Improved maintenance in the bicycle track network, such that an inspection results in zero comments; inspections are being conducted several times a year, additionally random checks are conducted in winter
- Increase of the proportion of safe bicycle crossings and junctions to 80% in 2020 and 100% in 2030; in 2012 20% are safe
- Reduction of the risk of being killed or severely injured in a police reported bicycle crash by 50% in 2020, compared to the average risk in 2006-2009
- Reduced travel times and smoother speed on the bicycle commuting network (at present 55% of all those working in the city also live in the city and 22% live in one of the 10 neighboring communes, Stockholms stad, 2012B)
- Increased number of bicycle parking areas by 500 per year
- The impression that Stockholm is a good cycling city.

A general problem for bicycle traffic in Stockholm is that most roads have been built for motor vehicles, leaving little space for pedestrians and bicycles. As a consequence, many pedestrian and bicycle tracks are narrow and crowded and there are many conflicts between cyclists and pedestrians.

Potential and priority: Safe main roads were classified as the second of the three "top priority" indicators by Trafikkontoret (2010; the first top priority is speed). The majority of crashes occur on main roads, safe main roads are therefore expected to have a strong relationship to the number of KSI. The safety on main roads can also to a large extent be influenced by the municipality. It is therefore concluded that a considerable amount of resources and efforts should be directed towards making main roads safer.

Safe main roads and safety: Sørensen et al. (2009) assume that safe junctions and crosswalks have half the risk of fatal or severe injuries than other junctions and crosswalks. This is a rough guess and not based on empirical results. In the present report we will assume that

- The number of KSI pedestrians and cyclists at safe GCM-passages is 50% lower than at other GCM-passages, while the number of KSI in motor vehicles is unchanged
- The number of KSI among all road users at safe junctions is 9% lower than at other junctions

The background for these assumptions is described below. We will further assume that 50% of all KSI pedestrians and cyclists at GCM-passages and junctions were involved in crashes at GCM-passages, and that 90% of all KSI motor vehicle occupants at GCM-passages and junctions were involved in crashes at junctions.

- ***Safe vs. unsafe GCM-passages***

Raised crosswalks were found to reduce the total number of injury crashes by 42% and lighting of crosswalks (which is not a speed reducing measure) was found to reduce the total number of crashes by 63% (Høye et al., 2014a). These results may be somewhat overestimated because of methodological weaknesses of the studies, but they still indicate that considerable crash reductions are possible. Effects on fatal and severe injuries are usually greater that effects on minor injuries.

Studies that have investigated the effects of measures at GCM-passages for pedestrians and motor vehicles separately, have for the most part found crash reductions for pedestrians. For motor vehicle crashes, both reductions, increases and no changes were found. We will in the calculations of scenarios of the development of the number of KSI until 2020 therefore assume that measures at GCM-passages only affect non-motorized road users.

Grade separated pedestrian crossings may according to Elvik et al. (2009) reduce the number of pedestrian crashes by up to 80%. The safety effects depend on the degree to which the grade separated crossing actually is used by pedestrians and cyclists. Those who still cross the road at grade are at increased risk of crashes. Moreover, grade separated pedestrian crossings cause detours and inconvenience to pedestrians and cyclists and increase conflicts between pedestrians and cyclists. In general, at-grade crossings with adequate motor vehicles speeds are therefore preferable in urban areas (SKL, 2009).

- *Safe vs. unsafe junctions*

The assumed 50% reduction of the risk of being killed or severely injured at safe junctions (Sørensen et al., 2009) requires a considerable reduction of speed (if one assumes that the effect is mainly due to reduced speed). According to the power model, mean speed would have to be reduced from 70 to 50 km/h on urban roads in order to achieve a reduction of the number of KSI by 50%. Taking into account that speed usually is not reduced as much as the speed limit, the number of KSI can only be assumed to be reduced by 9% at those junctions where speed limits are reduced. If one assumes that the percentage increase of the number of safe junctions will be the same as the percentage increase of the number of safe GCM-passages (+20%), 62% of all junctions will be safe in 2020.

5.2.2 Status of the safe main roads indicator

Information about the safe main roads indicator is only available from 2010 for safe GCM-passages. Information about the number of safe junctions is not available. Information about changes of the safe main roads indicator in the past years is not available either and it is not possible to make a trend estimate about how it will develop if all else remains unchanged. According to the available information it is assumed that the proportion of safe GCM-passages in 2010 was 18% and that the proportion of safe junctions was 51%.

- *Safe GCM-passages*

An inventory of all GCM-passages in Stockholms stad was made by Trafikkontoret in 2010 (Bergkwist, 2013). The inventory was based on a definition of "safe" that is somewhat different from the definition of the indicator. The criteria and the numbers of GCM-passages are shown in table 5.2.1. Some GCM-passages meet several of the criteria. The total number of GCM-passages is 9520 (8936 were included in the inventory) and 1662 of these (17.4%) are regarded as safe. 2687 of all GCM-passages are on main roads and 493 of these (18.3%) are regarded as safe. There is in other words a large potential for increasing the number of safe GCM-passages.

Table 5.2.1: Criteria for safe GCM-passages and numbers of safe GCM-passages (Bergkwist, 2013).

	All roads			Main roads		
	N	% of safe	% of all	N	% of safe	% of all
Grade separated	584	34 %	6.1 %	323	66 %	12.0 %
85-percentile speed below 30 km/h	21	1 %	0.2 %	5	1 %	0.2 %
Unsignalized crosswalk within 10 m from a stop- or yield-sign	292	17 %	3.1 %	45	9 %	1.7 %
Within 25 m from a speed hump in the same street	652	37 %	6.8 %	101	20 %	3.8 %
Within 25 m from other type of speed reducing measure on a road with a 30 km/h speed limit	191	11 %	2.0 %	19	4 %	0.7 %
Sum meeting one or more of the criteria	1662		17.4 %	493		**18.3 %**

In 2009 it was estimated that only between 10 and 30% of all pedestrian / bicycle crossings and junctions were safe (Sørensen et al., 2009). The number of pedestrian bridges and tunnels on main roads (speed limit above 30 km/h) in 2009 was 262 (Hermansson, 2009). According to Stockholms stad (2012A) the proportion of safe bicycle crossings and junctions was 20% in 2012. These figures are too imprecise to allow conclusions about changes of the number of safe GCM-passages.

A recent study by Trafikverket at 19 GCM-passages in Stockholms stad found that only 65% of all motor vehicles yielded for pedestrians. Yielding behavior is however not part of the definition of the indicator.

- *Safe junctions*

No information is available about the number of safe junctions. The proportion of roads with a speed limit of 50 km/h or lower is 71.6% in Stockholms stad (see section 5.1.3 under Reduced speed limits). If roads were intersecting each other randomly (independent of the speed limit) 51% of all junctions on main roads would have a speed limit of 50 km/h or lower on all approaches.

5.2.3 Measures for improving the safe main roads indicator

Measures that aim at improving the safe main roads indicator are described in the following. Some of the measures are planned to be implemented during the next years. Effects on the number of KSI that can be expected of the planned measures by 2020 are summarized in table 5.2.2.

Table 5.2.2: Summary of expected effects on the number of KSI of planned measures in 2020.

Measures	Target group for measures	Effect[1]
Measures directly relevant to the indicator		
▪ Trafikkontorets road safety plan: Increasing the proportion of safe GCM-passages from 18.3% to 22.1%	Pedestrians and cyclists at GCM passages (22% of the target group for safe main roads indicator)	-5% to -10%
▪ Reduced speed limits: Increasing the number of safe junctions from 51% to 62%	All KSI at junctions (62% of the target group for safe main roads indicator)	-0.9%
▪ Measures at schools and trafiksatsning Stockholm: Speed reducing measures at a limited number of GCM-passages and junctions	Whole target group for the safe main roads indicator	-1%
Measures not directly relevant to the indicator		
▪ Stockholms stads bicycle plan and walkability audits	Pedestrians and cyclists at GCM passages and junctions (37% of the target group for safe main roads indicator)	-5% to -10%

[1] Possible effect on KSI in the target group for the measures.

Several of those measures that are described in the following are likely to affect safety at GCM-passages and junctions favorably, especially for pedestrians and cyclists, but without directly contributing to the safe main roads indicator. Such measures are

- Measures for cyclists at junctions: bicycle boxes, red bicycle lanes and raised bicycle (and pedestrian) tracks through junctions
- Signalized pedestrian and bicycle crossings
- Road lighting
- Reduced parking places

Planned measures

A number of measures are planned to be implemented during the next years. All measures that are described in the following are likely to affect the number of KSI in crashes involving at least one motor vehicles at GCM-passages or junctions. However, only Trafikkontorets road safety plan, reduced speed limits, and measures at schools can be expected to directly influence the indicator.

- *Trafikkontorets road safety plan*

Trafikkontoret (2012) has planned to increase the number of safe GCM passages. Locations will be selected based on speed measurements and other observations. According to Trafikkontoret (2013B) there are concrete plans for improving safety at GCM-passages at five locations in 2014 and to implement measures at two crosswalks on multilane roads per year from 2014.

Instructions for an inventory of pedestrian and bicycle crossings are given by Sandberg (2013). Results can be reported directly to NVDB. Recommendations and examples are given in Wallberg et al. (2010) for measures for pedestrians and cyclists in general, in Eriksson et al. (2009) for the design of bicycle facilities, and in Kronborg et al. (2004) for the bicycle-friendly design of signalized junctions. More information about safety effects of measures for pedestrians and cyclists can be found in Høye et al. (2014a) and in Jonsson et al. (2011).

Expected effects: Assuming that the number of safe GCM-passages increase by 10 per year until 2020 and halve the risk for fatal or severe injuries at safe GCM-passages, the number of KSI at GCM passages will be reduced by 2.5% in 2020 if all else is equal. The proportion of safe GCM-passages will then be 22.1%. However, the effects of increasing the number of safe GCM-passages will be far greater when those with the highest pedestrian and bicycle volumes are improved first. We assume therefore that a reduction of KSI pedestrians and cyclists at GCM passages by between 5 and 10% may be achieved in 2020.

In order to achieve the overall goal of a 40% reduction of the number of KSI in the target group for the safe main roads indicator and when taking into account increasing exposure, the number of safe GCM-passages would theoretically have to be increased by 100 per year. In 2020 56% of all GCM-passages would then be safe.

- ***Reduced speed limits***

As a part of Rätt fart i staden speed limits are likely to be reduced on a number of roads in Stockholms stad. Junctions on main roads are considered as safe if the speed limit on all approaches is 50 km/h or below. About 9% of all roads have a speed limit above 50 km/h. Reducing the speed limit on these roads in the vicinity of at-grade junctions would contribute to the safe main roads indicator. It is however not known how many at-grade junctions there are on roads with a speed limit above 50 km/h or if speed limits will be reduced to 50 km/h or below on such roads.

Expected effects: According to the general relationships between speed limits, mean speed, and crashes it is estimated that a reduction of the speed limit form 70 to 50 km/h will be accompanied by a reduction of the number of KSI by 9% (section 5.2.1 under Safe main roads and safety). If the number of safe junctions increases from 51% to 62% and the risk of being killed or severely injured is 9% lower at safe junctions than at other junctions, the total number of KSI at junctions will be reduced by 0.9% (if speed were reduced to 50 km/h the number of KSI in crashes involving motor vehicles at junctions would be reduced by 6.9%).

- ***Stockholms stads bicycle plan***

Stockholms stad (2012A) has prepared a bicycle plan that describes goals for bicycle traffic in Stockholm and a number of measures that contribute to achieving the goals. The goals are mainly increasing the number of cyclists and making cycling safer and more attractive. In order to establish a bicycle track network in Stockholm an inventory of existing bicycle routes has been made, the bicycle network has been divided into three types of routes (commuting routes, main routes and local routes), standards have been defined for each of the three types of routes, and suggestions have been made for measures in order to attain the standards on all routes. Most measures aim mainly at making cycling more attractive (like building new bicycle tracks and lanes). Such measures are however not directly related to the safe main roads indicator[3].

The municipality[4] has planned to build one mile new bicycle tracks in the city in 2013. In total, new bicycle track are built on 11 roads. Additionally, a new bicycle lane is installed on one road. Resurfacing is planned on three routes, and on two roads the existing bicycle track is widened. New bicycle facilities (unspecified) are installed at three locations. After 2013 bicycle facilities may be built or improved at seven locations.

The following measures are or are planned to be implemented in order to make Stockholm more bicycle friendly:

- more bicycle tracks
- signposting bicycle routes
- bicycle parking
- public air compressor bicycle pumps
- increased number of bicycles for hire (no separate crash records for these bicycles are available)

Expected effects: Most of the measures proposed in the bicycle plan do not directly affect the safe main roads indicator, but they may still have favorable effects on the number of KSI in the target group for the indicator.

- ***Stockholms stads mobility strategy: Walkability audits***

Stockholms stad (2012B) has developed a mobility strategy that includes proposals for several measures that also will improve safety. A walking plan should be / will be developed in which the most important walking routes in Stockholm are identified and which proposes locations that may be improved for pedestrians. Attention is given especially to locations where there are many conflicts between pedestrians and cyclists. In autumn 2011 "walkability audits" have been conducted. The aim was to develop methods for making the city more attractive for pedestrians. It is also suggested that strategies and measures for management and maintenance should be developed and coordinated. Several measures in the mobility strategy are also referred to in the bicycle plan (see above).

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[3] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Cykla-och-ga/Cykelplan-/

[4] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Cykla-och-ga/Cykelsatsning-Stockholm/Pagaende-projekt/

Expected effects: Effects on the safe main roads indicator and on the number of KSI pedestrians at crosswalks and junctions depend on the implemented measures. The safety effects are most likely positive and walkability audits may help to identify those locations where safety improvements will have the greatest effect.

- *Measures at schools*

Examples of measures at schools are traffic reducing measures, speed reducing measures, improved pedestrian crossings, and measures that prevent motor vehicles from stopping, parking and passing at schools, generally improved pedestrian facilities around schools, safe delivering places in some distance from the school and improved winter maintenance[5, 6]. The speed limit on road past schools is in general 30 km/h (permanently), also on main roads[7].

Trafikkontoret (2010) has made a survey of the city's 260 primary schools and has identified schools with a particular need of road safety measures. In total, 20 schools that are in need of measures were identified[8]. Measures at schools are planned in all available road safety action plans.

Expected effects: Several of the measures at schools are likely to contribute to the safe main roads indicator (or to the speed indicator). Measures will be limited to a small number of GCM-passages and junctions but safety effects are likely to be positive.

- *Trafiksatsning Stockholm*

Several of the projects that are described in Trafiksatsning Stockholm will benefit pedestrians and cyclists. However, most of the projects are not in Stockholm city. The only projects in Stockholm city are

- Slussen: A new busterminal will be built, including a number of new pedestrian and bicycle facilities[9]
- Norra Länken: Building of 4 to 13 km tunnel that connects parts of the main road network in Stockholm; no measures for pedestrians or cyclists are mentioned
- E4 Tomteboda – Haga Södra: extension of E4 for increased capacity; no measures for pedestrians or cyclists are mentioned

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[5] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Barn-i-trafiken_ny/Trafikkontorets-arbete-med-skolorna/

[6] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Barn-i-trafiken_ny/Trafiksakerhetsatgarder-vid-skolor-2011-2012/

[7] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Hastighetsdampande-atgarder/

[8] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Barn-i-trafiken_ny/Trafiksakerhetsatgarder-vid-skolor-2011-2012/

[9] http://bygg.stockholm.se/slussen or http://trafiksatsningstockholm.se/

Expected effects: All three measures affect pedestrian and bicycle traffic. However, improvements will be relevant to the safe main roads indicator only at Slussen. At the other two locations safety for pedestrians and cyclists may be improved by separating motorized and non-motorized traffic.

Other measures

The following sections describe several measures that may favorably affect the safe main roads indicator or KSI in the target group for the safe main roads indicator. Some of them may be used along with the safety plans and measures described above, others may additionally improve safety, especially for vulnerable road users, at GCM-passages and junctions but without directly contributing to the safe main roads indicator.

- *Measures for cyclists at junctions*

The greatest safety problems at junctions are for the most part conflicts between pedestrians or cyclists and right turning vehicles. Most conflicts between motor vehicles and cyclists occur when there is a bicycle track (instead of a bicycle lane) and when a bicycle track is withdrawn from the road such as is often the case with two-lane bicycle tracks; cyclists most at risk are however those turning left (SKL, 2009).

Speed reducing measures are described above in chapter 5.1.

Examples of measures at junctions that are frequently used in Stockholm are bicycle boxes, red bicycle lanes and raised bicycle (and pedestrian) tracks at signalized junctions (Stockholms stad, 2012A; Gustafsson, 2011):

- *Bicycle boxes* are installed at most junctions (at 300 signalized junctions[10]) and an inventory has been made of junctions / crossings that need safety improvements. In 2009 there were 360 bicycle boxes according to SKL (2009). Bicycle boxes in Stockholm were found to reduce the total number of bicycle crashes at junctions by 40%, and the number of crashes between cyclists and right turning vehicles by 100% (SKL, 2009). In general, the effects of measures at junctions are highly dependent on how the measures are designed and in what type of junctions they are installed. E.g. greater and more favorable effects were found at X-junctions than at T-junctions.
- *Colored bicycle lanes* were found to reduce crashes due to improved yielding behavior among motor vehicles, but increased bicycle speeds may counteract this effect (SKL, 2009).
- *Raised pedestrian and bicycle tracks through junctions* have been found to reduce pedestrian and bicycle crashes by about 50% and motor vehicle crashes by about 35%. The crash reductions are due to improved yielding behavior and reduced speed among motor vehicles (SKL, 2009). The track is raised, painted red and additionally the pavement between the through lane and the bicycle track is designed as a rumble strip. This type of crossing is mostly used at junctions between main roads with large pedestrian and bicycle volumes and side roads.

[10] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Cykla-och-ga/Cykelbox/

Other measures that may reduce conflicts and collisions between cyclists and motor vehicles at junctions are according to Gustafsson (2011) early green light at signalized junctions, and a black-spot mirror that may be combined with a variable message sign with a bicycle warning. Information about the effects of these measures on crash numbers is not available.

Expected effects: These measures are not contributing to the indicator as it is defined now. Maybe the definition of the indicator should be revised (extended) to include several of these measures.

- *Measures at GCM-passages*

Crosswalks for pedestrians and cyclists are primarily a mobility measure, not a safety measure. Without additional measures, crossing at a crosswalks may even be more risky than crossing where there is no crosswalk. After introduction of the "zebra law" in 2000 the proportion of motor vehicles yielding for pedestrians increased form an average of 20% to 40-50% (SKL, 2009). A recent study by Trafikverket at 19 crosswalks in Stockholm found that only 65% of all drivers yielded for pedestrians. At the same time, many pedestrians are feeling safe and therefore fail to pay attention[11]. Examples for measures at crosswalks are:

- ***Raised crosswalks:*** Raised crosswalks reduce speed and improve yielding behavior among motor vehicle drivers. Raised crosswalks have according to Elvik et al. (2009) about 40% fewer injured pedestrians than crosswalks that are not raised, and 65% fewer injury crashes than locations without pedestrian crossings.
- ***Speed reducing measures for bicycles (such as rumble strips, raised crosswalk, signs):*** At pedestrian crosswalks over a bicycle track, speed reducing measures for bicycles were found to yield only temporary speed reducing effects among cyclists, but for the most part long-term increased attention and improved yielding behavior among cyclists (SKL, 2009).
- ***Median (refuge):*** The purpose of medians at crosswalks is to facilitate crossing for pedestrians, making it possible to cross one driving lane at a time. Medians (refuges) at crosswalks may also reduce the number of pedestrian crashes. Additionally, medians that reduce lane width are likely to reduce motor vehicle speeds. A possible adverse effect when medians are installed along longer stretches of road is that more pedestrians are crossing outside pedestrian crossings and at increased risk of crashes. Additionally, medians may prevent turning movements, which may have favorable safety effects (at those locations in question, but possibly not at other locations where the number of turning movements increases), but adverse mobility effects.

Expected effects: The described measures at crosswalks have positive safety effects.

[11] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Overgangsstallen-/

- ***Signalized pedestrian and bicycle crossings***

On roads with high traffic volumes signalization of crosswalks may be an option. Disadvantages are however relatively high costs and on average longer waiting times for both pedestrians / cyclists and for motor vehicles.

Safety effects of signalized crosswalks depend on the proportion of red-light running. On average the number of injury crashes with pedestrians or cyclists is reduced by about 5-10%. At the crosswalk, the crash reduction is far greater (about 27%), but within 50 m of the crosswalk, injury risk is increased. Favorable safety effects can according to SKL (2009) only be expected on roads with a traffic volume above 13,000 per day and a road width of at least 15 m.

Expected effects: Signalization has positive safety effects, but does not contribute to the indicator as it is defined now.

- ***Road lighting***

Road lighting improves visibility in the dark and may also make it more secure and pleasant to be outside. In urban areas it is often difficult to increase road lighting because there already is much light and because of environmental considerations (Sørensen et al., 2009). It may still be possible to improve road lighting at specific locations such as junctions and pedestrian and bicycle crossings. In Stockholm city trials have been made with LED-lighting on pedestrian and bicycle tracks[12]. LED-lighting saves energy and may also provide better lighting.

Crash risk for motor vehicles is on average 1.5 to 2 times as high in darkness as in daylight, cyclists have 5 times as high crash risk and for pedestrians is 10 times the risk in daylight (SKL, 2009). Road lighting leads often to increase speed, but has all the same been found to reduce injury crashes by 13% (Elvik et al., 2009). Road lighting on previously unlit roads can reduce fatal crashes by up to 70% and injury crashes by 25% (SKL, 2009). For pedestrians and bicycles a crash reduction of about 50% was found for new or improved lighting (SKL, 2009). The effect depends on the lighting conditions before road lighting is installed and on the level of lighting (the more lighting conditions are improved, the greater the crash reduction). LED-lighting may improve safety if it provides more light than conventional lighting, or if more lighting is installed for the same amount of money.

Expected effects: Road lighting improves safety at crosswalks and junctions, but does not contribute to the indicator as it is defined now.

- ***Parking places***

Parking may impair not only mobility but also safety in many ways (sight obstructions, opening doors towards a bicycle lane, reduced space for safe bicycle and pedestrian facilities). Moreover, available parking space limits the amount of private car traffic in the city. The mobility plan (Stockholms stad, 2012B) has therefore a special focus on reducing parking places for private cars in the city.

Effects of reducing parking places are difficult to quantify because they depend on local conditions. Safety may be improved by reduced parking places in the city by

[12] http://www.stockholm.se/TrafikStadsplanering/Gator-och-torg/Belysning/Belysningsprojekt/

- Reducing conflicts between cyclists and parking cars and conflicts that arise because of parking cars
- Providing more space for safe pedestrian and bicycle facilities
- Reducing travel with private cars
- Reducing travel times for public transport (which may make public transport more attractive).

Expected effects: Reduced numbers of parking places have most likely positive safety effects, not only at junctions and crossroads. These are however not directly relevant to the indicator safe main roads.

- *General improvements for bicycles in the inner city in 1998-2006*

Stockholms stad (2007) has analyzed the effects of a number of general improvements for bicycles in the inner city of Stockholm in 1998-2006. Among the improvements were 13.4 km two-way bicycle lanes and tracks, 14.4 km new one-way bicycle tracks and 18.7 km new bicycle lanes. Additionally, roads and sidewalks were upgraded and new lighting was installed. In the same period the number of bicycles in the inner city increased by 55%. The total number of bicycle crashes in the inner city was unchanged, while it decreased by 20% on those roads were improvements were made.

Expected effects: No effects in 2009-2020 can be expected (the measures were implemented and evaluated before 2009), but the results suggest that general infrastructure improvements improve safety.

- *Proposed measures at three junctions (Wärnhjelm, 2013)*

Wärnhjelm (2013) has analyzed bicycle crash data from Stockholm, and proposed measures for three junctions that are among those with most bicycle-motor vehicle crashes. The three junctions had 19 police reported collisions between a bicycle and a motor vehicle during the past five years. Most cyclists were only slightly injured, two were severely injured (one in a collisions with a right turning vehicle, one in the middle of the junction) and one killed (in a collision with a right turning heavy vehicle). Based on observation and conflict studies, a number of measures was proposed for each junction and it was estimated that the number of injured cyclists could be halved by these measures. Among the measures were bicycle boxes, red bicycle lanes through the junctions, and advanced bicycle stop line.

Expected effects: Reducing the number of KSI cyclists in collisions with motor vehicles at the three junctions covered by the study by 50% corresponds to a reduction of 0.3 KSI cyclists per year which is 1.9% of all KSI cyclists in Stockholm. The measures are however merely proposed by Wärnhjelm (2013) and it is not known whether or not they will be implemented, and if so if they will be implemented in addition to or as a part of measures implemented as a part of Trafikkontorets road safety plan.

- *Other measures*

A number of other measures are proposed by Sørensen et al. (2009) and Trafikkontoret (2010) to improve the safety of main roads that are not directly related to the indicator in its present definition:

- Bypasses
- Median barriers
- Improvement of sight distances at junctions
- Separation of different road user groups (e.g. pedestrian and bicycle tracks)

Bypasses and median barriers are quite costly measures and none of these four measures is mentioned by Trafikkontoret (2010).

None of the proposed measures addresses non-yielding of motor vehicles. An example of a measure that may improve yielding behavior is Variable Message Signs (*VMS*) that display a ***pedestrian/bicycle warning*** when a pedestrian or cyclist is crossing a crosswalk.

- *Tram stops*

The tram network in Stockholm is expanding. Since crashes between trams and other road users often are more serious than other crashes, the design of the tram system, especially tram stops, is likely to affect the number of KSI (Trafikkontoret, 2010). However, the expansion is at present not proceeding at the expected pace and the number of tram stops is regarded as too small for including safe tram stops in the indicator safe main roads.

5.2.4 Development of the number of KSI in the target group for safe main roads from 2006-2009 to 2020

The target group for safe main roads are:

- KSI Pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on main roads
- KSI motor vehicle occupants in all type of crashes at at-grade junctions on main roads

Development from 2006-2009 to 2012

The annual numbers of KSI pedestrians and cyclists in crashes involving at least one motor vehicle at crosswalks or junctions on roads with a speed limit above 30 km/h (the target group for the main roads indicator) in 2006 to 2012 are shown in figure 5.2.1. For pedestrians and cyclists no clear trend can be seen, although the numbers of KSI in 2011 and 2012 are higher than in 2006-2009. In 2012 there were 24% more KSI pedestrians and cyclists than in 2006-2009. For motor vehicle occupants, there may be a decreasing trend. Assuming that risk has decreased for all road users, the developments are consistent with the changes of exposure (about unchanged for motor vehicles and increasing for pedestrians and cyclists).

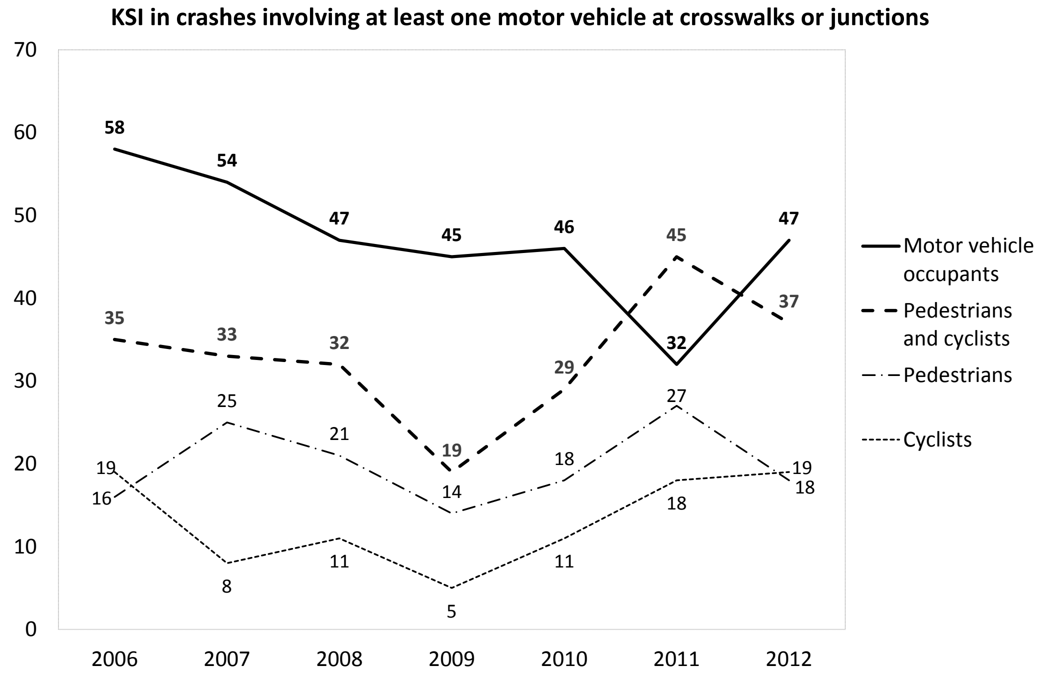

Figure 5.2.1: KSI in crashes involving at least one motor vehicle 2006-2012 (Stockholms stad, police reported).

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The numbers of KSI in crashes involving at least one motor vehicle at crosswalks and junctions on main roads, together with the estimated trends in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.2.2. for pedestrians and cyclists and in figure 5.2.3 for motor vehicle occupants. The estimated trend lines show the expected numbers of KSI in the target group for the safe main roads indicator if everything except exposure remains unchanged.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the main roads indicator has to be reduced to 17.9 KSI pedestrians and cyclists and 30.6 motor vehicle occupants in crashes involving at least one motor vehicle at crosswalks and junctions.

For motor vehicle occupants, there seems to be a development in the right direction, but the numbers of KSI pedestrians and cyclists in the target group for safe main roads seems quite far away from goal attainment and the numbers of KSI in 2011 and 2012 were even higher than those in 2006-2009. Factors that may have contributed to the high numbers of KSI pedestrians and cyclists in 2011 and 2012 are:

- ***Random variation:*** There is a large amount of random variation from year to year. As could be seen in figure 5.2.1 there is no clear trend in the numbers of KSI cyclists and pedestrians when the whole period from 2006 to 2012 is regarded.

- *Increasing exposure:* Increasing numbers of pedestrians and cyclists are likely to contribute to increasing numbers of KSI. Additionally, the assumed safety in numbers effect may be too large as explained in section 4. If the number of pedestrians and cyclists in reality follows scenario C (greatest increase for non-motorized road users) and if there is no safety in numbers effect, the number of KSI pedestrians and cyclists would be expected to increase considerably more, and the numbers of KSI pedestrians and cyclists in 2011 and 2012 would be more in line with the expected numbers. In this case however, the expected numbers of KSI pedestrians and cyclists in 2020 would be far higher as well.

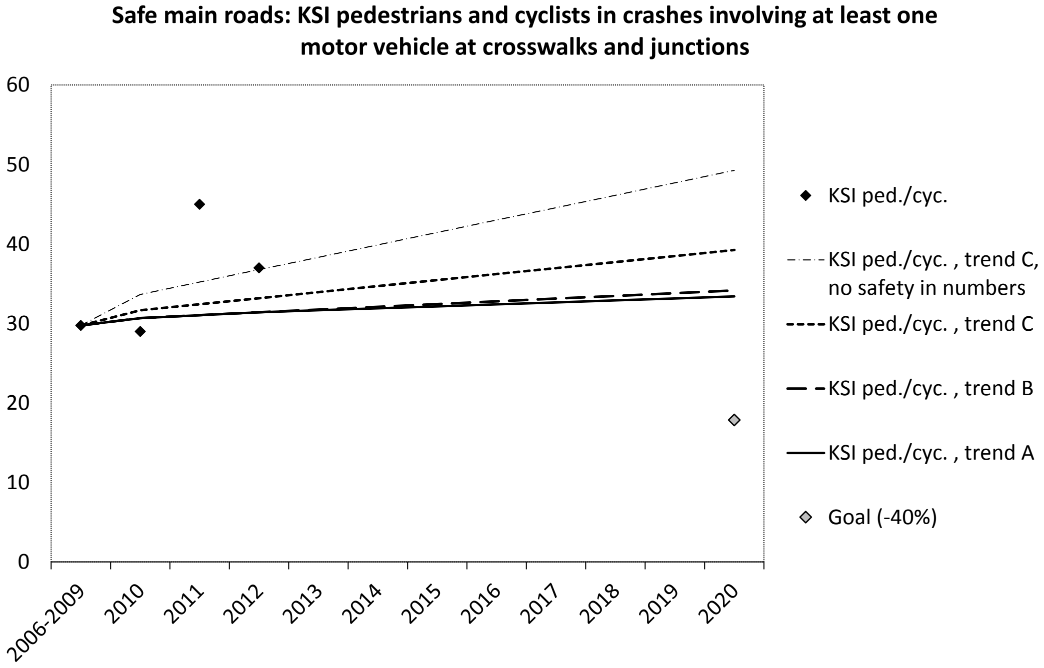

Figure 5.2.2: KSI pedestrians and cyclists in crashes involving at least one motor vehicle at crosswalks and junctions: Actual numbers and estimated trends.

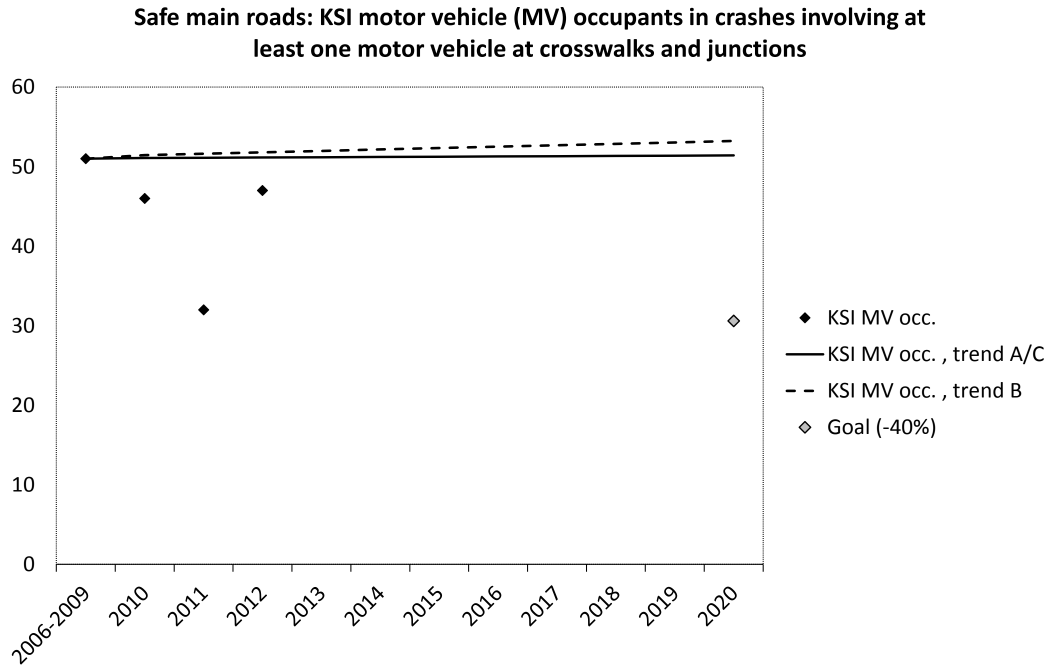

Figure 5.2.3: KSI motor vehicle occupant in crashes at crosswalks and junctions: Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the safe main roads indicator***

In order to estimate changes of the number of KSI in the target group for the safe main roads indicator, several scenarios were defined for changes of the indicator and for additional measures.

Indicator: For the safe main roads indicator three different scenarios are defined.

- ***Unchanged:*** The proportion of safe GCM-passages and junctions on main roads remains unchanged on the level from 2010 which is 18.3%. The proportion of safe junctions remains unchanged as well (51%). In this scenario the only factor that affects the number of KSI is exposure (and possibly additional measures).
- ***Partial goal attainment:*** The proportion of safe GCM-passages increases in line with the development that is expected if the planned measures that directly affect the safe main roads indicator are implemented. The proportion of safe GCM-passages on main roads in this scenario increases from 18.3% in 2006-2009 to 22.1% in 2020 (a 20% increase). The number of safe junctions is assumed to increase from 51% to 62%, which is the same percentage increase as assumed for GCM-passages.
- ***Goal attainment:*** 80% of all GCM-passages and junctions on main roads are safe.

Additional measures: In addition to the scenarios for the safe main roads indicator, there are two scenarios for measures that aim at reducing the number of KSI in the target group for the safe main roads indicator, but without affecting the indicator. The two scenarios are:

- ***None:*** No additional measures

- ***Some:*** Several additional measures for pedestrians and cyclists are implemented in accordance with Stockholms bicycle plan and mobility strategy.

How the effects on the numbers of KSI are calculated for goal attainment, partial goal attainment, and additional measures is summarized in table 5.2.3. The figures highlighted with a grey background are those that are used in the calculation for tables 5.2.5, 5.2.6 and 5.2.7. The assumed distribution of KSI pedestrians / cyclists and motor vehicle occupants on GCM-passages and junctions is shown in table 5.2.4 (see also section 5.2.1 under Safe main roads and safety). E.g. for "Road safety plan: GCM-passages" a 10% reduction of the number of KSI pedestrians and cyclists at GCM-passages is assumed. This translates into a 5% reduction of the number of KSI at all GCM-passages and junctions (based on the assumption that KSI at GCM-passages are 50% of all KSI at GCM-passages and junctions).

5.2.3: Calculation of the effects on the numbers of KSI for partial goal attainment, goal attainment and additional measures.

				All locations		
	Road users	Locations	Effect loc. / road user group[1]	Effect ped./cyc.	Effect motor veh. occ.	Effect all
Partial goal attainment[2]						
▪ **Red. speed limits at junctions**	**All**	**Junctions**	-0.9 %	-0.5 %	-0.8 %	-0.7 %
▪ **Road safety plan: GCM-passages**	**Ped./ cyc**	**GCM-passages**	-10.0 %	-5.0 %	0.0 %	-1.8 %
▪ **Schools, trafiksatsning**	**All**	**All**	-1.0 %	-1.0 %	-1.0 %	-1.0 %
▪ **All measures**	**All**	**All**		**-6.5 %**	**-1.8 %**	**-3.5 %**
Additional measures						
▪ **Bicycle plan, mobility plan**	**Ped./ cyc.**	**All**	-10.0 %	**-10.0 %**	**0.0 %**	**-3.7 %**
Goal attainment						
▪ **80% safe junctions**	**All**	**Junctions**	-2.6 %	-1.3 %	-2.3 %	-1.9 %
▪ **80% safe GCM-passages**	**All**	**GCM-passages**	-34.3 %	-17.1 %	0.0 %	-6.3 %
▪ **All**	**All**	**All**		**-18.4 %**	**-2.3 %**	**-8.3 %**

[1] Effect in the respective road user groups and at the respective locations; e.g. for "Road safety plan: GCM-passages" the effect for pedestrians and cyclists at GCM-passages is given
[2] Effects of those measures that are planned to be implemented until 2020 and where sufficient information is available for calculating possible effects on the number of KSI

Table 5.2.4: Assumed distribution of the numbers of KSI pedestrians / cyclists and motor vehicle occupants on GCM-passages and junctions (90% of all motor vehicle occupants at junctions, 50% of all pedestrians and cyclists at GCM-passages, 37% of all KSI pedestrians and cyclists).

	Junctions	GCM-passages	Total
Pedestrians / cyclists	0.18	0.18	**0.37**
Motor vehicle occupants	0.57	0.06	**0.63**
	0.67	**0.33**	1.00

Tables 5.2.5, 5.2.6 and 5.2.7 summarizes the estimated changes of the number of KSI in the target group for the safe main roads indicator until 2020 for pedestrians and cyclists, for motor vehicle occupants and for all road users, respectively. In 2006-2009, the average number of KSI in this group was 29.8 among pedestrians and cyclists, 51.0 among motor vehicle occupants and 80.8 in total.

Table 5.2.5: Estimated changes of the number of KSI among pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages and junctions on main roads.

		Indicator		Add. measures		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**reductions**	**Effect**	**%**	**N**
A Status quo	12.3 %	**Unchanged**	0.0 %	**None**	0 %	**12 %**	**3.6**
	12.3 %		0.0 %	**Some[2]**	-10 %	**1 %**	**0.3**
	12.3 %	**Partial goal att.**	-6.5 %	**None**	0 %	**5 %**	**1.5**
	12.3 %		-6.5 %	**Some[2]**	-10 %	**-5 %**	**-1.6**
	12.3 %	**Goal attainment**	-18.4 %	**None**	0 %	**-8 %**	**-2.5**
	12.3 %		-18.4 %	**Some[2]**	-10 %	**-18 %**	**-5.2**
B Mot.	14.8 %	**Unchanged**	0.0 %	**None**	0 %	**15 %**	**4.4**
	14.8 %		0.0 %	**Some[2]**	-10 %	**3 %**	**1.0**
	14.8 %	**Partial goal att.**	-6.5 %	**None**	0 %	**7 %**	**2.2**
	14.8 %		-6.5 %	**Some[2]**	-10 %	**-3 %**	**-1.0**
	14.8 %	**Goal attainment**	-18.4 %	**None**	0 %	**-6 %**	**-1.9**
	14.8 %		-18.4 %	**Some[2]**	-10 %	**-16 %**	**-4.7**
C Non-motorized	32.0 %	**Unchanged**	0.0 %	**None**	0 %	**32 %**	**9.5**
	32.0 %		0.0 %	**Some[2]**	-10 %	**19 %**	**5.6**
	32.0 %	**Partial goal att.**	-6.5 %	**None**	0 %	**23 %**	**7.0**
	32.0 %		-6.5 %	**Some[2]**	-10 %	**11 %**	**3.3**
	32.0 %	**Goal attainment**	-18.4 %	**None**	0 %	**8 %**	**2.3**
	32.0 %		-18.4 %	**Some[2]**	-10 %	**-3 %**	**-0.9**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.
[2] Measures in accordance with Stockholms bicycle plan and mobility strategy.

Table 5.2.6: Estimated changes of the number of KSI among motor vehicle occupants in crashes involving at least one motor vehicle at GCM-passages and junctions on main roads.

		Indicator		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**%**	**N**
A Status quo / C Non-mot.	0.8 %	**Unchanged**	0.0 %	**0.8 %**	**0.4**
	0.8 %	**Partial goal attainment**	-1.8 %	**-1.0 %**	**-0.5**
	0.8 %	**Goal attainment**	-2.3 %	**-1.5 %**	**-0.8**
B Mot.	4.4 %	**Unchanged**	0.0 %	**4.4 %**	**2.2**
	4.4 %	**Partial goal attainment**	-1.8 %	**2.4 %**	**1.2**
	4.4 %	**Goal attainment**	-2.3 %	**1.9 %**	**1.0**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.

Table 5.2.7: Estimated changes of the total number of KSI in crashes involving at least one motor vehicle at GCM-passages and junctions on main roads.

		Indicator		Add. measures		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**reductions**	**Effect**	**%**	**N**
A Status quo	5.0 %	**Unchanged**	0.0 %	**None**	0.0 %	**5.0 %**	**4.1**
	5.0 %		0.0 %	**Some[2]**	-3.7 %	**0.9 %**	**0.7**
	5.0 %	**Partial goal att.**	-3.5 %	**None**	0.0 %	**1.2 %**	**1.0**
	5.0 %		-3.5 %	**Some[2]**	-3.7 %	**-2.7 %**	**-2.2**
	5.0 %	**Goal attainment**	-8.3 %	**None**	0.0 %	**-4.1 %**	**-3.3**
	5.0 %		-8.3 %	**Some[2]**	-3.7 %	**-7.4 %**	**-6.0**
B Mot.	8.2 %	**Unchanged**	0.0 %	**None**	0.0 %	**8.2 %**	**6.6**
	8.2 %		0.0 %	**Some[2]**	-3.7 %	**4.0 %**	**3.2**
	8.2 %	**Partial goal att.**	-3.5 %	**None**	0.0 %	**4.3 %**	**3.4**
	8.2 %		-3.5 %	**Some[2]**	-3.7 %	**0.3 %**	**0.2**
	8.2 %	**Goal attainment**	-8.3 %	**None**	0.0 %	**-1.1 %**	**-0.9**
	8.2 %		-8.3 %	**Some[2]**	-3.7 %	**-4.6 %**	**-3.7**
C Non-motorized	12.3 %	**Unchanged**	0.0 %	**None**	0.0 %	**12.3 %**	**9.9**
	12.3 %		0.0 %	**Some[2]**	-3.7 %	**7.4 %**	**6.0**
	12.3 %	**Partial goal att.**	-3.5 %	**None**	0.0 %	**8.0 %**	**6.4**
	12.3 %		-3.5 %	**Some[2]**	-3.7 %	**3.4 %**	**2.8**
	12.3 %	**Goal attainment**	-8.3 %	**None**	0.0 %	**1.8 %**	**1.5**
	12.3 %		-8.3 %	**Some[2]**	-3.7 %	**-2.1 %**	**-1.7**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.
[2] Measures in accordance with Stockholms bicycle plan and mobility strategy.

The results in tables 5.2.5, 5.2.6 and 5.2.7 show that considerable reductions of the numbers of KSI in the target group for the safe main roads indicator are not likely in any of the scenarios. The greatest possible reduction of -7.4% is achieved when the goal for safe main roads is attained, additional measures are implemented and when traffic volumes increase only moderately in all road user groups. Among pedestrians and cyclists, a reduction of up to 18% may be achieved. In most other scenarios the number of KSI is expected to increase, in the worst case by up to 12.3%.

Even among pedestrians and cyclists at GCM-passages the goal of a 40% reduction of the number of KSI is not likely to be achieved. At goal attainment, a reduction by 34.4% is predicted, which is less than 40% and which partly will be counteracted by the expected increase of traffic volumes.

The most serious weaknesses of the scenario calculations are the assumed effects of safe GCM-passages and junctions and of additional measures. The assumed effects of safe GCM-passages and junctions are based on empirical studies of measures that may be comparable to making GCM-passages and junctions "safe", but not of actually making GCM-passages and junctions "safe". The assumed effects of additional measures are still more uncertain because it is not very well known what additional measures may or will be implemented or what effects such measures may have. It is however unlikely that the assumed effects on the numbers of KSI are seriously underestimated.

In summary, the results indicate that the overall goal of a reduction of the number of KSI by 40% is highly unlikely to be attained, even when the amount of travel only increases moderately, when the goal for the safe main roads indicator is achieved, and when additional measures are implemented. The effects are uncertain, but not likely to be seriously underestimated.

5.3 Increased knowledge about road safety

The current status and development of the increased knowledge indicator that is described in the following sections can be summarized as follows:

Indicator:	The indicator is at present not precisely defined
Target group:	All KSI in all types of crashes; a specific target group are KSI involving school children in crashes near schools, these addressed as a part of the target group for the safe main roads indicator
Status 2006-2009:	-
Status and development 2012:	Plans that may be relevant to the increased knowledge indicator are at present not under development
Goal 2020:	The existence of ▪ A measurement and analysis plan in order to ensure a systematic review of the development of road safety in Stockholm ▪ A communication plan that ensures continuous dissemination of relevant information about road safety

5.3.1 Description of the indicator and goal

The indicator for increased knowledge about road safety among all those living or working in the city is not based on analyses by Sørensen et al. (2009). It aims at improving knowledge among all who are concerned with road safety: Decision makers, including employees of the municipality, and road users. The indicator is based on the assumptions that

- Road safety measures are more effective when roads users are informed about the aim of the measures
- Road users behave better when they have knowledge about road safety (e.g. about the safety effects of speed, seat belts, and bicycle helmets)
- More effective measures can be implemented when there is knowledge about the current safety situation and about the effects of measures

The indicator is according to Trafikverket (2012A) one of the top priority factors, i.e. one that is both influenceable by the municipality and that has a great influence on the number of KSI, and on which a considerable amount of efforts and resources should be spent. However, a precise definition of the indicator is still lacking. The goal for 2020 is that there is a measurement and analysis plan in order to ensure a systematic review of the development of road safety in Stockholm, and a communication plan that ensures continuous dissemination of relevant information about road safety (Trafikverket, 2012A).

Amongst other things, the indicator implies the increased use of road safety audits, i.e. the systematic consideration of road safety effects in the planning processes of infrastructure measures (Trafikkontoret, 2010).

Other factors that contribute to the indicator are knowledge about road safety and road safety measures, increased awareness about road safety issues among decision makers, and increased cooperation between relevant authorities (Trafikkontoret, 2010). The same applies to all other actors that may contribute to road safety, such as companies and employers.

A general problem with the indicator is that it is difficult to measure. Despite the attempt to define a specific goal, the existence of a measurement and analysis plan and a communication plan, there are many ways to interpret the goal. Moreover, the existence of a plan is in practice quite far from actual road safety improvements. Even if the developed plans are "good" (e.g. comprehensive and containing specific actions and responsibilities), considerable resources and action are required before any specific safety measures are implemented.

Target group: The target group for the indicator increased knowledge are all KSI in all types of crashes.

Increased knowledge and safety: No estimate is available for how goal attainment may affect the number of KSI and there is no straightforward way to estimate possible effects. One might assume that more effective safety measures will be implemented when the goal is attained. For example, at goal attainment one might expect that the most effective measures will be used to increase the safety of crosswalks, and that those crosswalks with the greatest need for improvements will be selected, while measures and selection might be less effective in the absence of goal attainment.

5.3.2 Measures for improving the increased knowledge indicator

There are a number of measures that may be relevant to the increased knowledge indicator, which are described in the following.

- *Road safety audits and inspections*

One of the goals of the municipality (Trafikkontoret, 2012) is to conduct safety audits (trafiksäkerhetsanalyser eller revisioner) in some of the bigger infrastructure projects. E.g. an audit has been conducted for spårväg city and an inspection on Bergsagsvägen (Trafikkontoret, 2013A). Road safety inspections were planned for 2012 on some arterials (infartsleder) and roads with a 70 km/h speed limit and many rear end collisions (it should be noted that rear end collisions are not one of the crash types that contributes most to the number of KSI). Inspections will also be used in preparation of the installation of new speed cameras.

- *Safe communities*

A measure that is comparable to the plans that are described in the goal for the increased knowledge indicator is "Safe communities". Safe community programs are accident prevention programs that have the following characteristics (Elvik et al., 2009):

- The systematic recording of accidents in a local community over a given period of time. Normally, hospitals or other health institutions are responsible for the records.
- On the basis of accident records, the dominant accident problems in the local community are identified and published.
- A steering group for accident prevention is set up, with participation from all parties which are presumably able to contribute to preventing accidents, usually including the municipality (administration and politicians), schools, the health service, the police, the fire service, representatives of trade and industry and voluntary organizations.
- A quantified target for accident reduction during a given period is set and a set of measures designed to achieve this target is developed.
- Changes in the number of accidents and injuries are monitored and information on new developments is given to all those participating in the program.
- The effects of the program on the number of accidents are studied, the results are published and changes may be made in the targets or in the safety program.

Programs containing these elements have been introduced in a number of local communities, both in Norway and in other countries. The programs have been directed both towards traffic accidents and towards other types of accidents.

Safety effects of "Safe communities" are summarized by Høye et al. (2014a). Several empirical studies were found, the results are however inconsistent. Among the studies that have investigated programs directed at different types of safety problems (not only road safety) the results are inconsistent; some studies found reduced crash numbers while others found increased crash numbers. Among the studies that have investigated effects of "Safe communities" specifically aiming at improving road safety, reductions of hospital recorded injuries by 20-25% were found. Police recorded injuries were not always found to decrease, most likely because the safety programs involved improved crash reporting procedures (the same problem that is encountered in the present project!). Results from those studies that found injury reductions can not necessarily be generalized because communities with safety plans and programs often had extraordinarily high injury numbers before implementation of the plans or programs.

Even if the road safety plan in Stockholm can be regarded as a part of this indicator, its effects on the numbers of KSI cannot be counted as an independent contribution, otherwise all reductions of the number of KSI that are achieved by the program would be counted twice.

- *Resource allocation / incentive systems*

A number of different resource allocation and incentive systems are described by Elvik et al. (2009). It is assumed that incentives for road safety improvements improve safety by supporting the increased use of effective road safety measures. Incentives may be specific monetary rewards for injury reductions, or more generally a system in which those who bear the costs for safety measures also benefit from safety improvements (which is not usually the case, e.g. those who build roads do not have to bear the costs for hospital treatments and other health effects). Making decisions that are relevant for road safety on the basis of cost-benefit analysis is also assumed to support the implementation of the most (cost-)effective road safety measures. Consequently more safety can be achieved for the same amount of money. Unfortunately, none of the measures or approaches has been evaluated empirically with respect to the effect on road safety. Quantifying the effects would be difficult.

The current indicator "Increased knowledge" does not explicitly contain an aim of making it more profitable to invest in road safety or to make decisions on the basis of cost-benefit considerations. The goal might however become more effective if this were the case.

- *Measures at schools*

Trafikkontoret (2010) has made a survey of the city's 260 primary schools and has identified schools with a particular need of road safety measures. These are described under the indicator safe main roads.

Additionally, the municipality has in the past years supported schools in increasing the numbers of pupils that walk or cycle to school and in general to increase awareness of and knowledge about safe walking and cycling. The support is aimed at teachers, parents and pupils and includes inspiration and education for teachers and information and different activities for parents and pupils. At present, about 25% of all pupils are delivered and collected at / from school by car[13].

Many schools in Sweden have a "school police" which are pupils that have the task of supervising other pupils on their way to and from school. School police is not mentioned as one the possible measures that may contribute to achieving any of the goals in the road safety program. According to an evaluation by Ingelstam et al. (2010) and other previous evaluations, school police has no effect on the number of crashes occurring on the way to or from school.

Increasing numbers of pupils walking or cycling to school may have contradictory effects on road safety. In general, increased walking and cycling can be expected to increase the number of KSI pedestrians and cyclists. However, many pupils who are injured on their way to school are injured in collisions with cars driven by parents delivering or collecting their children to / from school. A reduction of the number of parents driving their children to and from school can therefore be expected to have positive safety effects. Another positive effect may be that children walking or cycling to school get more used to being a pedestrian or cyclist and thereby become "safer" road users in general (in addition to becoming more healthy and improving performance at school). Measures such as walking or cycling school buses may contribute additionally to making the way to school safer. In summary, there may be safety effects of increasing the number of pupils walking or cycling to school, but it is at present not possible to quantify the effect.

Information and education measures are being conducted at many schools, but road safety education for school children has not consistently been found to improve safety (Ingelstam et al., 2010; Elvik et al., 2009).

[13] http://www.stockholm.se/TrafikStadsplanering/Trafik-och-resor-/Trafiksakerhet-/Barn-i-trafiken_ny/

5.4 Management and maintenance (M&M)

The current status and development of the M&M indicator that is described in the following sections can be summarized as follows:

Indicator:	Standard of M&M on roads in general, and winter maintenance on pedestrian and bicycle tracks specifically
Target group:	▪ KSI cyclists in single accidents (falls) on bare roads and on roads covered by snow / ice ▪ Motor vehicle single crashes on bare roads and on roads covered by snow / ice: These are however not assumed to be affected by the standard of M&M ▪ KSI pedestrians in falls: These are only included in hospital reported injury data and not part of official crash statistics
Status 2006-2009:	The status in 2006-2009 is unknown. It is assumed that **20% of all bicycle kilometers** are cycled on roads / bicycle tracks with an optimal standard of M&M and that **20% of all pedestrian kilometers** are walked on pedestrian facilities with an optimal standard of M&M
Status and development 2012:	The status in 2012 is unknown as well There are considerable efforts to improve the standard of M&M and it is therefore assumed that the standard may become **optimal on the whole bicycle network** and **optimal for half of all pedestrian kilometers** walked in 2020
Goal 2020:	The standard of M&M is **optimal on all** roads and pedestrian and bicycle tracks; a precise definition of “optimal standard” is lacking

5.4.1 Description of the indicator and goal

The indicator for M&M is the standard of M&M on roads and pedestrian and bicycle tracks, including winter maintenance.

The goal for 2020 is that an optimal standard is attained on all roads and pedestrian and bicycle tracks by 2020. It is not defined what is meant by an "optimal standard". Sørensen et al. (2009) propose to define an "optimal" standard as one that contributes to fewest possible injuries among pedestrians and cyclists (Sørensen et al., 2009).

Trafikverket is working on (more specific) indicators for M&M on pedestrian and bicycle tracks. Sørensen et al. (2009) had proposed an indicator that only encompasses M&M on the pedestrian and bicycle network (not on roads). The Norwegian Public Roads Authority (Statens vegvesen) proposes an indicator for M&M that refers to the societal costs and benefits of M&M, with a goal of increasing the standard to a level that is economically beneficial to society (Elvik, 2007). In general, it is difficult to define an indicator, because there are many different factors that indicate the general standard of M&M, e.g. rutting, friction and snow depth.

Target group: The target group for the indicator M&M are

- KSI cyclists in single accidents (falls) on bare roads and on roads covered by snow / ice (alternatively during winter months and during the rest of the year)
- Motor vehicle single crashes on bare roads and on roads covered by snow / ice (alternatively during winter months and during the rest of the year)

Theoretically, pedestrians in single crashes (falls) should also be included in the target group. These are however not represented in official (police reported) crash statistics.

Potential and priority: The municipality of Stockholm can influence the standard of M&M in Stockholm. M&M is classified as a level 2 priority by Trafikkontoret (2010), which means that a limited amount of efforts should be directed towards improvement of M&M.

Efforts should according to Trafikkontoret (2010) at present mainly be directed towards increasing knowledge about the present situation (especially hospital recorded injuries among pedestrians / cyclists that are related to inadequate winter maintenance) and about the effects of winter maintenance on injuries among pedestrians and cyclists. Trafikkontoret acknowledges the importance of M&M for injuries among pedestrians and bicyclists and wishes to increase the priority that is given to measures on this area.

M&M and safety: Sørensen et al. (2009) assume that optimal M&M reduces the number of KSI pedestrians and cyclists in falls by 50% in winter (December to February) and by 25% during the rest of the year. The total annual number of police reported KSI is assumed to be reduced by 3 (1%) when the level of M&M is increased to "optimal". If hospital reported crashes were included in crash statistics the reduction would most likely be considerably greater.

These estimates refer to crash risk and not necessarily to the absolute number of crashes. As M&M improves, vehicle speeds and the number of pedestrians and cyclists are likely to increase (which, in the case of pedestrians and cyclists, is the main aim of improved M&M). Consequently, the absolute number of crashes and KSI may increase, even if risk decreases. Another example is described by SKL (2009): For cyclists, the risk of single crashes was found to be halved in winter, while pedestrians have 5 to 15 times as high risk in winter, compared to summer. The explanation is most likely that only a specific type of persons is cycling in winter and that these generally have lower risk than other cyclists.

More recent findings about the effects of M&M and conclusions for the assumed effects of the indicator are summarized in the following.

- ***M&M in winter***

A more recent review of the literature on winter maintenance (Bjørnskau, 2011; Høye et al., 2014a) showed that the effects on motor vehicle crashes are highly dependent on the effect of winter maintenance on friction and vehicle speeds, and that the effect on serious crashes may be adverse. On snow- and ice-covered roads minor crashes are usually increasing, while removing snow and ice leads to increased speed, which may increase serious crashes. Therefore, on roads with low speed limits the effects can be expected to be more favorable than on roads with high speed limits (Bjørnskau, 2011). Based on these findings it is assumed that ***KSI in motor vehicle crashes*** will be unaffected by improved M&M.

Pedestrian and cyclist falls are reduced by about 50% on snow- and ice-free roads compared to snow- and/or ice-covered roads (Elvik et al., 2009). However, pedestrian and bicycle crashes may increase if the actual friction does not correspond to the expected friction. It is often practically difficult or impossible to maintain completely snow- and ice-free roads in winter. Therefore, it will be assumed that the number of ***KSI in pedestrian and bicycle single crashes (falls) are reduced by 40%*** in winter (December to February).

The majority of pedestrian falls occur on slippery roads, and in about 10% of all pedestrian falls uneven, dirty or damaged road surfaces were contributing factors (SKL, 2009). Among bicycle crashes, the road surface (not including slippery roads) has contributed to about 25% of crashes (SKL, 2009).

The numbers of cyclists injured in single crashes and the proportion of permanently disabled cyclists on dry vs. snow- or ice-covered roads in nine Swedish cities is available from Folksam (2012; table 5.4.1). The results indicate that the risk of being permanently disabled is 2.6 times as high for cyclists on roads covered by snow or ice than on dry roads. However, only in 10% of all cases the road condition is known, and not data are available only from Stockholm or from earlier years.

Table 5.4.1: Injured cyclists and proportion of permanently disabled cyclists (Folksam, 2012).

	Dry road	Snow / ice
Crashes	1678	686
Permanently disabled	145	156
Relative risk of permanent disability	0.086	0.227

The numbers of cyclists injured in single crashes with disabling injuries by type of road is shown in table 5.4.2. The results are based on crashes in nine Swedish cities (N = 3577; Folksam, 2012). No results are available only from Stockholm or from earlier years.

Table 5.4.2: Cyclists injured in single crashes with disabling injuries by type of road (Folksam, 2012).

	Disabling injuries
Crossroads	8 %
Road section	39 %
Pedestrian / bicycle track (road)	38 %
Pedestrian track (separate)	5 %
Roundabout	1 %
Unknown	5 %
Parking lot	1 %
Other	2 %

- *M&M in summer*

No studies were found that have empirically investigated the effects of improved M&M on crashes on roads that are free from snow and ice. It will therefore, in accordance with Sørensen et al., (2009) be assumed that the effect is half the effect in winter, i.e. that the number of ***KSI in pedestrian and bicycle single crashes (falls) are reduced by 20%*** during the months (March to November).

5.4.2 Status of the M&M indicator

Information about the M&M indicator in 2006-2009 is not available.

5.4.3 Measures for improving M&M

According to Trafikkontoret (2010) priority should at present be given to

- development of an indicator for M&M (Trafikverket is working on a proposal for such an indicator)
- knowledge about the present situation (hospital recorded injuries among pedestrians / cyclists that are related to inadequate winter maintenance)
- knowledge about the effects of winter maintenance on injuries among pedestrians and cyclists (it is referred to VTI reports).

Specific measures that can be taken in order to improve M&M are described below.

- *Resurfacing*

Newly resurfaced roads have in general better friction and less unevenness and rutting than older surfaces. Water drainage and the risk of icy roads is also affected. Average speeds on newly resurfaced roads are normally increased. Improved friction can reduce motor vehicle crashes. However, resurfacing may have none or an adverse effect on safety because improved driving conditions usually increased speed.

For pedestrians and cyclists, improved road surfaces are likely to reduce the risk of sliding or stumbling and falling. At junctions, improved friction before and at bicycle crossings has been found to reduce crash risk by as much as 15-25% (SKL, 2009). Resurfacing of pedestrian and bicycle tracks may reduce the number of KSI pedestrians and cyclists as well. The extent of the reduction depends on the road condition and crash risk before resurfacing.

Expected effects: Resurfacing affects mainly falls and single crashes with bicycles, i.e. crashes that are either not included or severely underreported in police reported crash statistics. For such crashes, a new goal might / should be defined.

- *Continuous maintenance of road markings, signs and other road equipment*

Improvements of road markings, signs and other road equipment are seen as a part of the M&M indicator. Effects on crashes may be positive, but are not possible to quantify. Information about actual improvements that are made or planned to be made is not available.

- *Cleaning road surfaces*

Leaves, gravel, sand and other dirt on road surfaces not only reduces friction for motor vehicles, but increases the risk of sliding and falling for pedestrians and cyclists. In spring, sand has to be removed by 1st May in the inner city of Stockholm and by 15th May in the outer city. However, in years with early snow melting there are often long periods where sand remains on the roads (Stockholms stad, 2012A). Leaves are removed by 15th November[14].

Cleaning road surfaces may reduce pedestrian and bicycle crashes by removing leaves, gravel, sand and other dirt that may increase the risk of stumbling or sliding. Sørensen et al. (2009) assume that optimal M&M reduces KSI pedestrians and bicyclists in falls by 25% in the months March to November.

- *Winter maintenance (snow clearing, salting, sanding)*

Winter maintenance has primarily the aim of improving mobility, i.e. to keep the road network and pedestrian and bicycle facilities accessible. However, since snow or ice covered roads are common crash contributing factors especially for pedestrians and cyclist, winter maintenance also can be expected to affect safety (SKL, 2009; see section 5.4.1 under M&M and safety).

There are many different ways to improve winter maintenance, e.g. snow clearing, salting and sanding, as well as warming up of sidewalks (SKL, 2009; Høye et al., 2014a). In Stockholm, different types of plowing, salt and sand are used. On pedestrian and bicycle tracks and lanes plowing is normally supplemented by sanding. Maintenance of pedestrian and bicycle facilities requires different equipment than maintenance of roads and is therefore not usually conducted simultaneously[15].

Winter maintenance on pedestrian and bicycle facilities is according to the municipality continuously evaluated and improved[16]. In winter 2011-2012 a pilot project was initiated with increased winter maintenance standards on selected commuting routes for bicycles (Stockholms stad, 2012A). It is planned to extend the raised standards to the whole commuting network for bicycles. Improved winter maintenance on pedestrian and bicycle facilities is also a part of the mobility Strategy in Stockholm (Stockholms stad, 2012B). Additionally those responsible for snow and sand clearing are educated with a special focus on the safety effects (Trafikkontoret, 2013A).

14 http://www.stockholm.se/TrafikStadsplanering/Gator-och-torg/Stadning/Lovstadning/

15 http://www.stockholm.se/TrafikStadsplanering/Gator-och-torg/Sno-och-halka/

16 http://www.stockholm.se/TrafikStadsplanering/Gator-och-torg/Sno-och-halka/

Expected effects: Assuming that 30% of all bicycle kilometers are cycled on the main bicycle routes and that improved winter maintenance reduces the number of KSI pedestrian and bicycle single crashes (falls) by 40% in winter, the number of KSI pedestrians and cyclists in this type of crashes will be reduced by 18%.

- *Improved reporting of problems per app*

According to Stockholms stad (2012A) apps for mobile phones are being developed for reporting of sand or gravel on roads or pedestrian / bicycle tracks or other safety problems. Thereby, M&M may be improved, but effects on M&M or on the number of KSI cannot be quantified.

- *Bicycle plan*

Among the goals related to bicycle traffic in Stockholm (Stockholms stad, 2012A) one is directly related to the M&M indicator: "improved maintenance in the bicycle track network, such that an inspection results in zero comments; inspections are being conducted several times a year, additionally random checks are conducted in winter".

- *Maintenance of roadsides (lawn mowing, cutting of trees and bushes, filling holes etc.)*

Maintenance of road sides may have positive safety effects, e.g. by removing sight obstructions, but effects on the number of KSI are not known.

5.4.4 Development of the number of KSI in the target group for the M&M indicator from 2006-2009 to 2020

Development from 2006-2009 to 2012

The annual numbers of KSI in single crashes (the target group for the M&M indicator) in 2006 to 2012 are shown in figures 5.4.1 and 5.4.2. The number of KSI cyclists in summer was 65% higher in 2012 than in 2006-2009. The numbers of KSI cyclists in winter are too small to allow any conclusions about general changes over time. The large increase of the number of KSI pedestrians is due to the increased reporting from hospitals. Thus, nothing can be said about the development of this crash type over time. Among motor vehicle occupants (figure 5.4.2), the number of KSI in single crashes was 32% smaller in summer and 13% higher in winter, compared to 2006-2009.

Changes of the numbers of KSI cyclists and motor vehicle occupants in single crashes in summer may, at least partly, reflect changes of the amount of travel (increased for cyclists, reduced for motor vehicles).

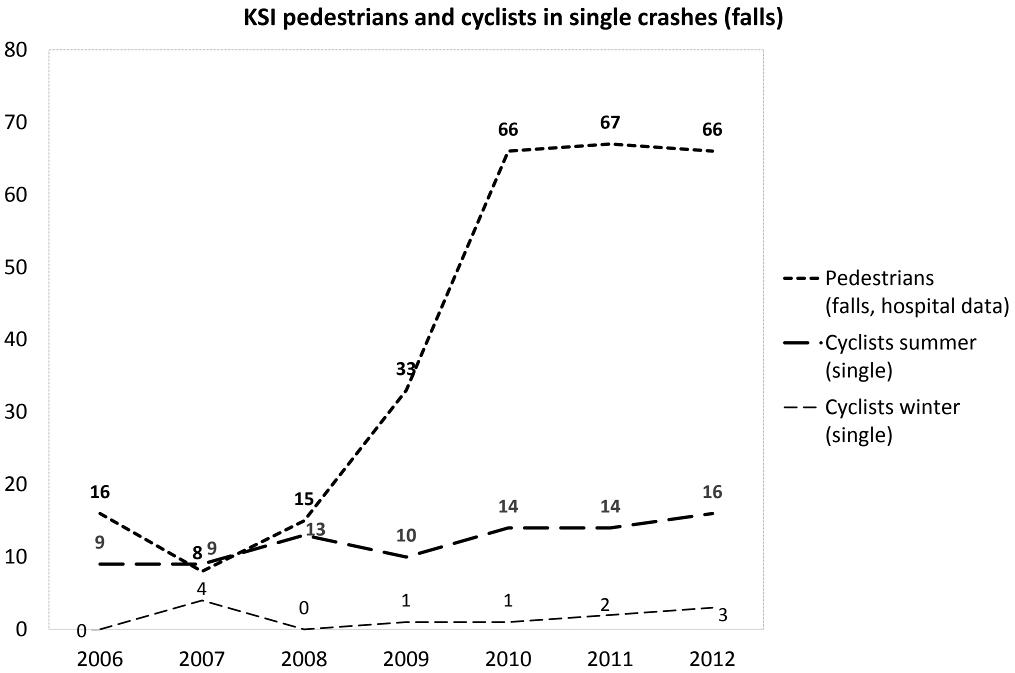

Figure 5.4.1: KSI pedestrians and cyclists in single crashes 2006-2012, winter and summer (Stockholms stad, police reported; hospital reported for pedestrians).

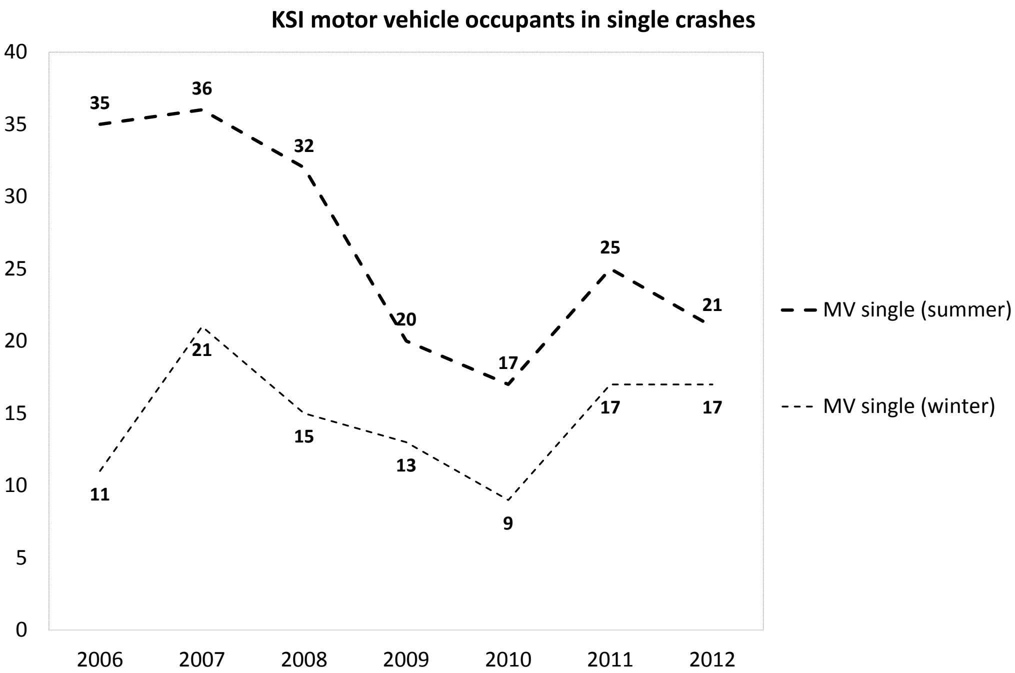

Figure 5.4.2: KSI motor vehicle occupants in single crashes 2006-2012, winter and summer (Stockholms stad, police reported).

A general trend that is described by Trafikverket (2012A) is a reduction of the number of fatalities in winter. From 2006 to 2011 the proportion of fatalities in winter (October - March) has decreased almost continuously from about 35% in 2006 and about 53% in 2007 to about 20% in 2011. The proportion of travelled kilometers in winter is about 45%. These results refer to Stockholm county. Road user groups or vehicle types are not specified.

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The actual numbers of KSI cyclists in single crashes in 2006-2009 to 2012, together with the estimated trends until 2020 in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.4.3. The estimated trend lines show the expected numbers of KSI cyclists in single crashes if everything except exposure remains unchanged. In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI among cyclists in single crashes has to be reduced to 6.9.

In 2010 to 2012 the number of KSI cyclists in single crashes was far higher than the estimated trend lines. Increasing exposure is not likely to be the only explanation for the increasing numbers of KSI.

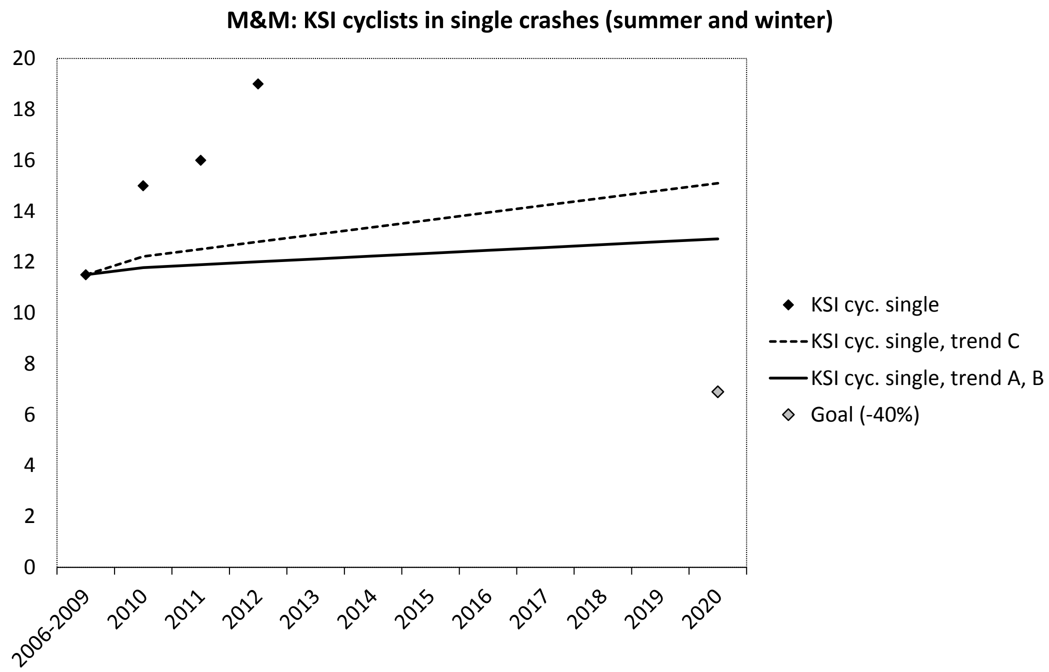

Figure 5.4.3: KSI cyclists in single crashes: Actual numbers and estimated trends.

The numbers of KSI pedestrians in falls in 2006-2009 to 2012, together with the estimated trends until 2020 in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.4.4. Because of the change of the numbers of hospitals reporting injured pedestrians, the average number of pedestrians in falls in 2006-2009 is set equal to the average in 2010-2012, adjusted for the change of the amount of travel in scenario C. The estimated trend lines show the expected numbers of KSI pedestrians in falls if everything except exposure remains unchanged. Because of the adjustment of the estimated number of KSI pedestrians in falls in 2006-2009, the observed numbers in 2010 to 2012 are close to the trend line for scenario C. In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI among pedestrians in falls has to be reduced to 36.6.

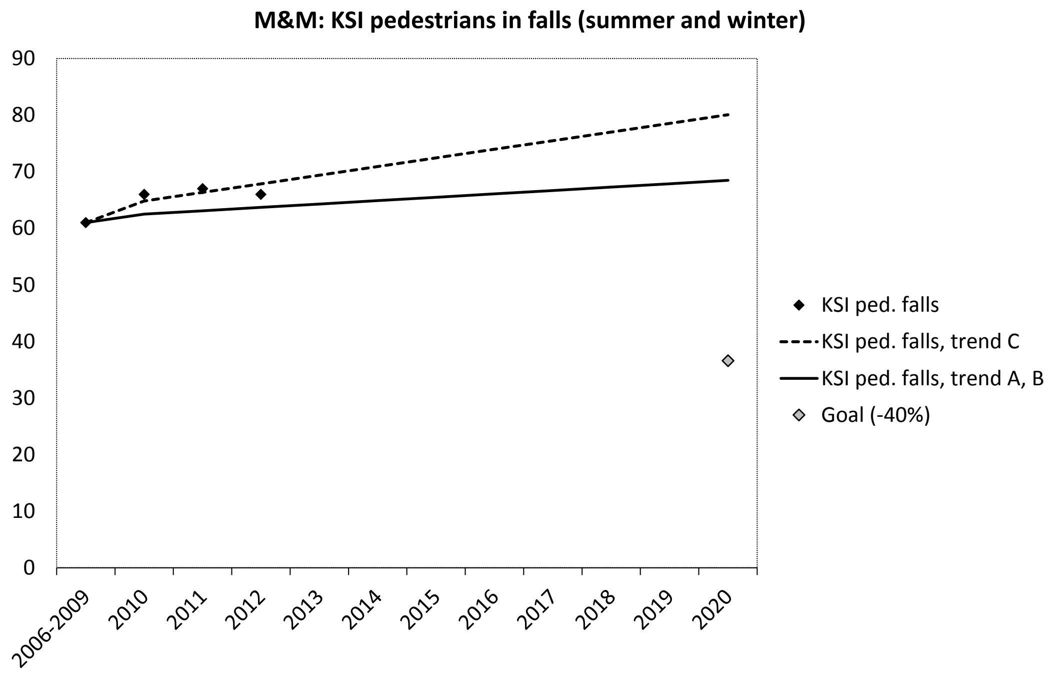

Figure 5.4.4: KSI pedestrians in falls: Actual numbers (2006-2009 estimated as the average number in 20010-2012) and estimated trends (hospital reported).

- ***Baseline scenarios and changes of the M&M indicator***

In order to estimate changes of the number of KSI in the target group for the M&M indicator, four different scenarios were defined for changes of the M&M indicator.

- ***Unchanged:*** The status of M&M remains unchanged on the level from 2006-2009
- ***Partial goal attainment for cyclists:*** M&M is optimal on the main bicycle network
- ***Partial goal attainment for pedestrians:*** Half of all pedestrians kilometers are walked on optimally managed and maintained surfaces
- ***Goal attainment:*** Optimal standard on all roads and pedestrian and bicycle tracks

A problem for the calculation of the effect of goal attainment (or partial goal attainment) is that the status in 2006-2009 is unknown. It is assumed that 20% of all pedestrian and bicycle kilometers in 2006-2009 were travelled on infrastructure that fulfills the criteria for "optimal" M&M. This assumption has unfortunately no empirical basis. It has only been made because without any assumption it would not have been possible to calculate any of the scenarios. The same applies to the assumed status of the indicator in 2020 at partial goal attainment.

Other assumptions for the calculation of the scenarios are as follows.

- Proportion of all bicycle travel that is cycled on the main bicycle network: 30% (16.5% in summer, 13.5% in winter)
- Proportion of all pedestrian travel in winter: 45%

Table 5.4.3 summarizes the estimated changes of the number of KSI among cyclists in single crashes until 2020. In 2006-2009, the average number of KSI in this group was 19.

Table 5.4.3: Estimated changes of the number of KSI cyclists and pedestrians in single crashes / falls.

		Indicator		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**%**	**N**
Cyclists (police reported)					
A Status quo or B Motorized	11.7 %	**Unchanged**	0.0 %	**12 %**	**1.3**
	11.7 %	**Partial goal attainment**	-8.7 %	**2 %**	**0.2**
	11.7 %	**Goal attainment**	-29.0 %	**-21 %**	**-2.4**
C Non-motorized	31.3 %	**Unchanged**	0.0 %	**31 %**	**3.6**
	31.3 %	**Partial goal attainment**	-8.7 %	**20 %**	**2.3**
	31.3 %	**Goal attainment**	-29.0 %	**-7 %**	**-0.8**
Pedestrians (hospital reported)					
A Status quo or B Motorized	11.7 %	**Unchanged**	0.0 %	**12 %**	**7.1**
	11.7 %	**Partial goal attainment**	-14.5 %	**-5 %**	**-2.8**
	11.7 %	**Goal attainment**	-29.0 %	**-21 %**	**-12.6**
C Non-motorized	31.3 %	**Unchanged**	0.0 %	**31 %**	**19.1**
	31.3 %	**Partial goal attainment**	-14.5 %	**12 %**	**7.5**
	31.3 %	**Goal attainment**	-29.0 %	**-7 %**	**-4.1**
Pedestrians and cyclists					
A Status quo or B Motorized	11.7 %	**Unchanged**	0.0 %	**12 %**	**8.5**
	11.7 %	**Partial goal attainment**	-13.6 %	**-3 %**	**-2.5**
	11.7 %	**Goal attainment**	-29.0 %	**-21 %**	**-15.0**
C Non-motorized	31.3 %	**Unchanged**	0.0 %	**31 %**	**22.7**
	31.3 %	**Partial goal attainment**	-13.6 %	**13 %**	**9.7**
	31.3 %	**Goal attainment**	-29.0 %	**-7 %**	**-4.9**

[1] Estimated change of the number of KSI cyclists / pedestrians in single crashes / falls if everything except exposure remains unchanged on the level of 2006-2009

Predicted changes of the numbers of KSI: At goal attainment the number of KSI pedestrians and cyclists in single crashes / falls may be reduced by 21% if the increase in pedestrian and bicycle traffic is only moderate. The reduction will be smaller if pedestrian and bicycle traffic increases more. For pedestrians, the reduction will not affect the overall goal because pedestrian falls are not included in police reported crash statistics.

A serious weakness with the results for the M&M indicator is that the calculations mainly are based on several assumptions that lack any kind of empirical basis. The status in 2006-2009 is unknown, and the possible effect on the number of KSI on any change of the indicator is therefore highly uncertain. The effects in table 5.4.3 may equally well be overestimated as they may be underestimated.

In summary, the results do not indicate that the overall goal of a reduction of the number of KSI by 40% is likely to be attained. The results are however highly uncertain because the most important assumptions are lacking an empirical basis.

5.5 Heavy vehicles

The current status and development of the heavy vehicles indicator that is described in the following sections can be summarized as follows:

Indicator:	The indicator is at present not defined
Target group:	All KSI in crashes involving a heavy vehicle
Status 2006-2009:	No heavy vehicle strategy exists
Status and development 2012:	A heavy vehicle strategy is not under development
Goal 2020:	A strategy for heavy vehicles exists

5.5.1 Description of the indicator and goal

No indicator is defined for heavy vehicles in Stockholm. The greatest safety problems of heavy vehicles are crashes with pedestrians or cyclists, most of which are related to reversing or right-turning heavy vehicles or to centered bus lanes. About half of all KSI pedestrians and cyclists are killed or injured in crashes with heavy vehicles.

It is difficult or impossible to define an indicator that is directly related to these safety problems. The indicator that Vägverket (2009) has defined for the whole country, the proportion of heavy vehicles with automatic emergency brakes, is not related to the safety problems in Stockholm, and not under the influence of the municipality (Sørensen et al., 2009).

Crashes resulting from conflicts between pedestrians or cyclists and right turning heavy vehicles are partly addressed by the indicators safe main roads and safe local roads. Such conflicts and crashes should therefore not be included in the indicator for heavy vehicles (or otherwise excluded from the indicators safe main / local roads).

The ***goal*** for 2020 is that there is a strategy for heavy vehicles.

It was estimated by Sørensen et al. (2009) that goal attainment will reduce the annual number of KSI by 4 (2%). This estimate is based on the assumption that a heavy vehicle strategy is fully implemented and that the measures included in the strategy reduce the number of KSI in heavy vehicle crashes by 33%.

Target group: The target group for the indicator heavy vehicles are all KSI involved in collisions with heavy vehicles. In order to avoid an overlap with the indicator safe main / local roads, the target groups for these two indicators should be excluded from the heavy-vehicles target group.

Potential and priority: The development of a strategy for heavy vehicles and several effective measure are under the influence of the municipality. However, existing safety problems are for the most part related to specific situations or locations and to a small degree relevant for the city as a whole. Therefore Trafikkontoret (2010) has classified heavy vehicles as a level 3 goal which means that there is little need for resources and efforts.

5.5.2 Status of the heavy vehicles indicator

So far, a strategy for heavy vehicles has not been developed and heavy vehicles are not mentioned in available road safety plans.

5.5.3 Measures that aim at reducing heavy vehicle crashes

A heavy vehicle safety strategy may according to Sørensen et al. (2009) include the following measures:

- Recommended routes for heavy vehicles
- Heavy vehicle fleet management (ITS)
- Speed plan for roads that are not part of a heavy vehicle route
- Green goods supply
- Campaigns for heavy vehicle drivers, pedestrians and cyclists
- Black spot analysis of junctions
- Increased safety standard on main and local roads (see indicators for main roads and local roads)

Stockholms stads (2012B) mobility strategy proposes increased efforts for improving goods transport in Stockholm city and for improving safety for pedestrians and cyclists[17]. No specific measures are however suggested. A reduction of goods transport in the city is not regarded as realistic.

Measures at junctions or crossroads should be treated as part of the indicator safe main roads (or safe local roads). Remaining measures are mainly measures that aim at reducing the number of heavy vehicles in locations with many pedestrians or cyclists.

The greatest effects on the numbers of KSI can probably be expected of measures that separate heavy vehicles and vulnerable road users, and of speed reducing measures.

[17] "Trafikkontoret ska fördjupa arbetet med godstrafik genom att ta fram en handlingsplan för hur målet om åkeribranschens nöjdhet kan uppnås. Arbetet kommer bl.a. att drivas tillsammans med ett citylogistikråd där godsbranschen, övriga näringslivet och myndigheter kan samverka för att förbättra möjligheterna för en mer effektiv godsdistribution. Handlingsplanen kan även ha stor betydelse för de oskyddade trafikanternas trafiksäkerhet samt för den tunga trafikens miljöpåverkan. Reglerna för godstrafikens rörlighet i staden kan behöva ses över med syfte att bättre svara upp mot det moderna näringslivets behov samt minimera godsdistributionens påverkan på andra trafikanters tillgänglighet och med hänsyn till de boendes behov." (Stockholms stad, 2012, Handlingsplan p. v - framkomlighetsstrategin).

5.5.4 Development of the number of KSI in the target group for the heavy vehicles indicator from 2006-2009 to 2020

Development from 2006-2009 to 2012

The annual numbers of KSI in crashes involving at least one heavy vehicle (the target group for the heavy vehicles indicator) in 2006 to 2012 are shown in figure 5.5.1. The total number of KSI in heavy vehicle crashes has increased by 23% from 2006-2009 to 2012. Among pedestrians and cyclists the number of KSI in heavy vehicle crashes has decreased by 33%, among motor vehicle occupants is has increase by 24%.

There is a large variation in the annual numbers of KSI in heavy vehicle crashes and no clear trend can be seen.

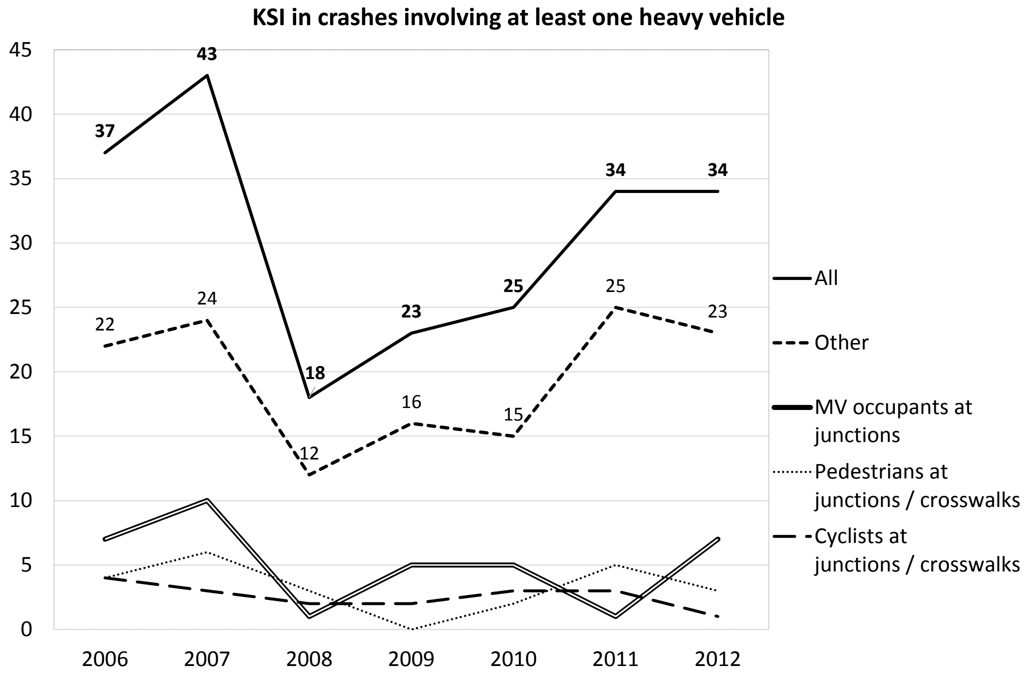

Figure 5.5.1: KSI in crashes involving a heavy vehicle.

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The actual numbers of KSI in heavy vehicle crashes in 2006-2009 to 2012, together with the estimated trends until 2020 in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figures 5.5.2 for all KSI in heavy vehicle crashes, in figure 5.5.3 for pedestrians and cyclists in heavy vehicle crashes at crosswalks or junctions and in figure 5.5.4 for motor vehicle occupants at junctions. The estimated trend lines show the expected numbers of KSI in heavy vehicle crashes if everything except exposure remains unchanged.

For the total number of KSI in heavy vehicle crashes the goal seems already to be achieved. There is however large variation in the annual numbers of KSI and a prediction of how the numbers of KSI in heavy vehicle crashes will develop is therefore not possible to make. If one takes the number of KSI in heavy vehicle crashes in 2010 as the starting point and follows the trend lines, the goal will almost be achieved in 2020, even if nothing is done.

For motor vehicle occupants in heavy vehicle crashes at junctions and for pedestrians and cyclists in heavy vehicle crashes at crosswalks or junctions, there is so much variation the numbers of KSI from year to year, that it seems impossible to make any predictions for the development until 2020.

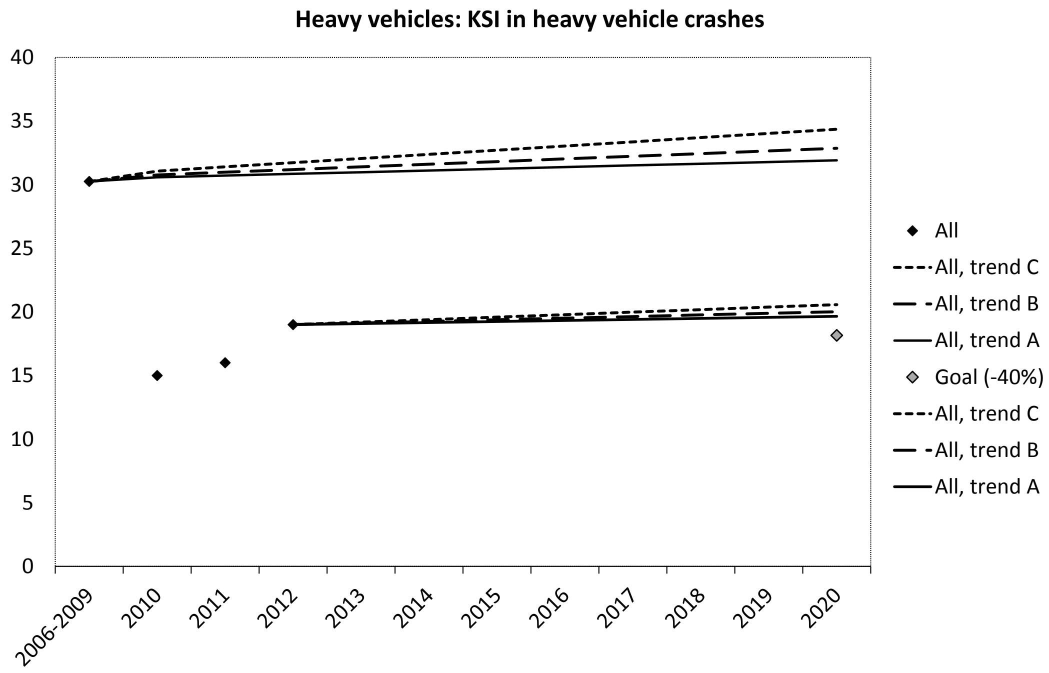

Figure 5.5.2: KSI in crashes involving at least one heavy vehicle: Actual numbers and estimated trends.

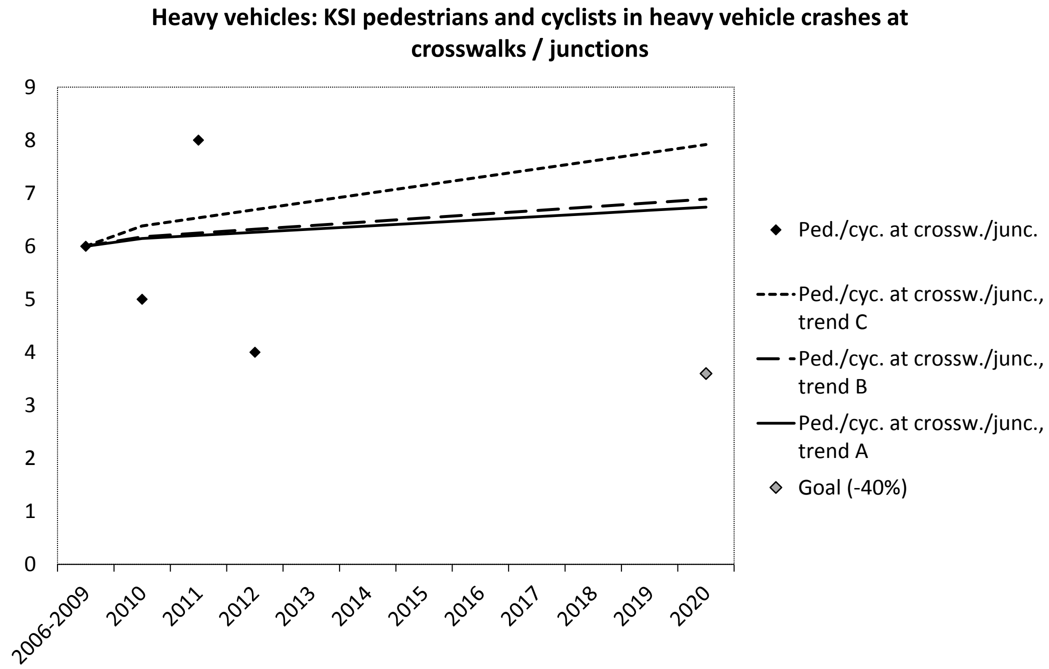

Figure 5.5.3: KSI pedestrians and cyclists in crashes involving at least one heavy vehicle at crosswalks or junctions: Actual numbers and estimated trends.

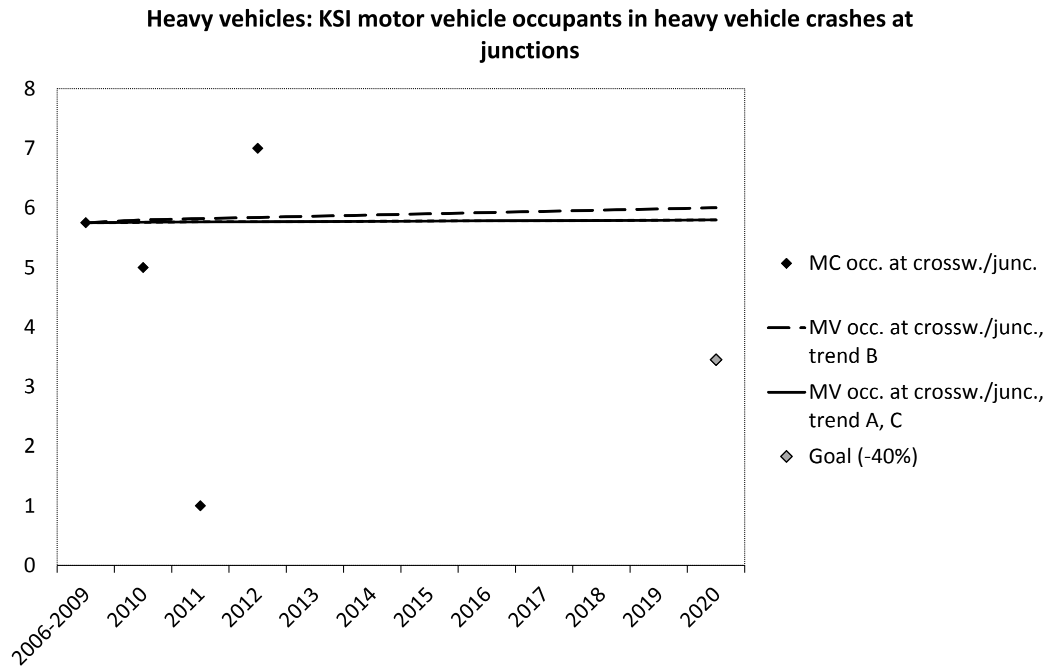

Figure 5.5.4: KSI motor vehicle occupants in crashes involving at least one heavy vehicle at junctions: Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the heavy vehicles indicator***

It is not possible to make any predictions for how the heavy vehicles indicator will affect changes of the number of KSI in heavy vehicle crashes until 2020. A heavy vehicles strategy (the existence of which is defined as goal attainment for the heavy vehicles indicator) does not exist and is not under development. It is therefore not possible to estimate how such a strategy might affect the number of KSI in heavy vehicle crashes. Moreover, the large annual variation in the numbers of KSI in heavy vehicle crashes makes it difficult or impossible to predict the numbers of KSI in such crashes without any heavy vehicles strategy.

5.6 Safe local roads: Safe pedestrian and bicycle crossings

The current status and development of the safe local roads indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportion of safe GCM-passages on local roads
Target group:	All KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages on local roads
Status 2006-2009:	**17%** of all GCM-passages on local roads are safe
Status and development 2012:	There are plans to increase the number of safe GCM-passages, if the increase continues at the current pace, about 19% of all GCM-passages on local roads will be safe in 2020, which is far from goal attainment Additional measures that are planned as a part of the bicycle plan and walkability strategy are likely to improve the safety at GCM-passages on local roads as well
Goal 2020:	**75%** of all GCM-passages on local roads are safe

5.6.1 Description of the indicator and goal

The indicator for safe local roads is the proportion of safe pedestrian / bicycle crossings on local roads. Local roads are defined as roads with a 30 km/h speed limit (Sørensen et al., 2009). Most of these are residential roads.

The goal for 2020 is that 75% of all junctions and pedestrian / bicycle crossings on local roads are safe. Safe means basically that any collision will not result in fatal or other serious injuries if traffic rules are obeyed. This is the same as the national goal (Vägverket, 2009), even if Trafikverket.se does not include any such goal in the overview of national goals.

A pedestrian / bicycle crossing is regarded as safe if vehicle speeds are below 30 km/h (85% of all motor vehicles according to trafikverket.se) or, theoretically, if it is grade separated (junctions on 30 km/h roads are usually not grade separated).

Target group: The target group for the safe local roads indicator are all KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages on local roads.

Potential and priority: The safety on local roads can to a large extent be influenced by the municipality. However, there are for the most part no great safety problems on local roads (feelings of insecurity should not be treated as safety problems). Existing safety problems are mostly related to local characteristics of specific locations, and not to the road network as a whole. Safe local roads are therefore classified by Trafikkontoret (2010) as a level 2 problem, that requires limited efforts and resources. Safety problems on local roads that should be addressed are according to Trafikkontoret (2010) related to the following specific local safety problems:

- Pedestrian / bicycle crossings
- High vehicle speeds
- Roads in the vicinity of schools (measures at schools are addressed by the indicator increased knowledge)

Safe local roads and safety: Sørensen et al. (2009) assumed that safe pedestrian crossings have half the risk of fatal or severe injuries than other pedestrian crossings. For the present analysis, the same effect of safe GCM-passages is assumed on local roads as on main roads (section 5.2). It is assumed that the number of KSI pedestrians and cyclists at safe GCM-passages is 50% lower than at other GCM-passages, while the number of KSI in motor vehicles is unchanged.

5.6.2 Status of the safe local roads indicator

An inventory of all GCM-passages in Stockholms stad was made by Trafikkontoret in 2010 (Bergkwist, 2013; see section 5.2.2). The criteria for safe GCM-passages and the numbers of GCM-passages on local roads are shown in table 5.6.1. Some GCM-passages meet several of the criteria. The total number of GCM-passages on local roads is 6842 and 1169 of these (17.1%) are regarded as safe. There is in other words a large potential for increasing the number of safe GCM-passages on local roads. It is however not known how pedestrian and bicycle traffic is distributed on safe and not-safe GCM-passages on local roads.

Table 5.6.1: Criteria for safe GCM-passages and numbers of safe GCM-passages on local roads.

	All roads			Local roads		
	N	% of safe	% of all	N	% of safe	% of all
Grade separated	584	34 %	6.1 %	261	21 %	3.8 %
85-percentile speed below 30 km/h	21	1 %	0.2 %	16	1 %	0.2 %
Unsignalized crosswalk within 10 m from a stop- or yield-sign	292	17 %	3.1 %	247	20 %	3.6 %
Within 25 m from a speed hump in the same street	652	37 %	6.8 %	551	44 %	8.1 %
Within 25 m from other type of speed reducing measure on a road with a 30 km/h speed limit	191	11 %	2.0 %	172	14 %	2.5 %
Sum meeting one or more of the criteria	1662		17.4 %	1169		17.1 %

In 2009 it was estimated that only about 25% of all pedestrian / bicycle crossings on local roads were safe (the corresponding figure for all roads in the whole country is 25%; Vägverket, 2009). This is somewhat more than according to the inventory that was made in 2010.

5.6.3 Measures for improving safe local roads

There are several specific measures that can contribute to making junctions and crossings safer according to the present definition of the indicator for safe main roads. These are described in the following. Trafikverket (2010) intends to apply guidelines for when, where and how to implement speed reducing measures at junctions and crossings, including measures in work zones. Nothing is however known about what measures actually are planned to be implemented and how many GCM-passages on local roads are planned to be made "safe".

- *Safer crosswalks (e.g. raised crosswalks)*

Raised crosswalks have according to Elvik et al. (2009) about 40% fewer injured pedestrians than raised crosswalks, and 65% fewer injury crashes than locations without pedestrian crossings.

- *Grade separated pedestrian and bicycle junctions*

Grade separated pedestrian and bicycle crossings are quite expensive measures and seldom used on roads with low volumes. In 2009 there were 184 pedestrian bridges and tunnels on local roads (Hermansson, 2009). Grade separated pedestrian crossings reduce the number of pedestrian crashes by about 80% and the number of motor vehicle crashes by about 14 % (not statistically significant).

- ***Raised junctions***

At raised junctions the motor vehicles lanes are raised to the level of the sidewalk. The aim is to reduce motor vehicles speeds. The effect on crashes depends mainly on the speed reducing effect. Many junctions that are converted to raised junctions have according to SKL (2009) low speeds already before conversion and the safety effects are therefore limited. When vehicle speeds were high however, both speeds and crashes are likely to be reduced. The results from different studies are quite heterogeneous (SKL, 2009).

- ***Traffic calming***

Traffic calming combines several measures in a larger area with the aim of reducing motor vehicles speeds and making the area safer and more attractive for pedestrians and cyclists. Measures are for the most part physical measures such as speed humps, lane narrowings and displacements, small curve radii, roundabouts etc. On local roads, a possible disadvantage is that the area also will become less attractive for motor vehicles, which often leads to increased motor vehicles volumes (and increased crashes) on parallel roads (SKL, 2009).

Traffic calming measures on local roads reduce often crashes, on average by 24% on local roads and by 8% on main roads (SKL, 2009). However, the crash reduction effects are for the most part achieved by reduced motor vehicle volumes. As a consequence, motor vehicles volumes and crashes are likely to increase on other (parallel) roads if counter measures are not introduced (SKL, 2009).

- ***Gångfartsområde and shared space***

Gångfartsområde and shared space are areas without any separation between different types of road users. In gångfartsområde the maximum speed for motor vehicles is at walking pace and there are usually several physical speed reducing measures. Shared space has not necessarily a reduced speed limit, but the area is deregulated in the sense that everyone has to adjust their behavior to the needs of the weakest road users (SKL, 2009).

Effects on crashes depend to a large degree on the speed reducing effect and yielding behavior. For gångfartsområden injury crash reductions of about 25% were found (SKL, 2009). Adverse effects cam however arise on other / parallel roads where motor vehicles volumes increase. Speeds on other / parallel roads may increase because drivers want to compensate for the time loss caused by the detour. For shared space, large crash reductions were found, but these may to a large degree be caused by methodological weaknesses of the studies.

- ***Other measures***

A number of other measures are proposed by Sørensen et al. (2009) and Trafikkontoret (2010) to improve the safety of local roads that are not directly related to the indicator in its present definition:

  - Improvement of sight distances at junctions
  - Separation of different road user groups

- Pedestrian and bicycle tracks (may increase the number of pedestrian / bicycle crashes, partly due to increased number of pedestrians and bicyclists, partly due to increased vehicle speeds)
- Center bicycle lanes
- Speed limits (the speed limit is per definition 30 km/h on local roads)
- Signalized pedestrian crossings (may reduce the number of pedestrian crashes by 5 to 10%; seldom used on roads with low volumes)

None of the proposed measures addresses non-yielding of motor vehicles (see above, safe main roads).

5.6.4 Development of the number of KSI in the target group for safe local roads from 2006-2009 to 2020

The target group for safe local roads are all KSI pedestrians and cyclists in crashes involving motor vehicles at junctions or crosswalks on local roads.

Development from 2006-2009 to 2012

The annual numbers of KSI pedestrians and cyclists in crashes involving at least one motor vehicle at crosswalks or junctions on roads with a speed limit of 30 km/h (the target group for the safe local roads indicator) in 2006 to 2012 are shown in figure 5.6.1. In 2012 the number of KSI pedestrians and cyclists in this type of crashes was 2.09 times as high as in 2006-2009.

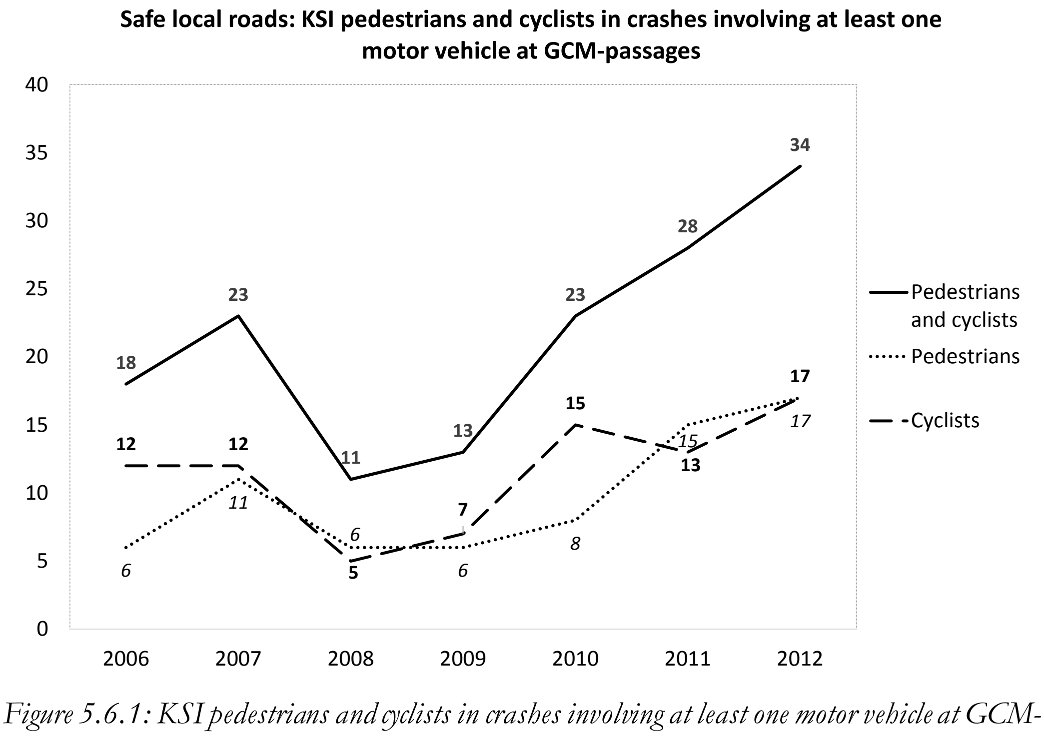

Figure 5.6.1: KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages.

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The numbers of KSI pedestrians and cyclists in crashes involving at least one motor vehicle at crosswalks on local roads, together with the estimated trends in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.6.2. The estimated trend lines show the expected numbers of KSI in this type of crashes if everything except exposure remains unchanged.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the local roads indicator has to be reduced from 16.3 to 9.8. The development in the recent years does not seem to indicate that goal attainment has come any closer. The increase is greater than what would be expected based on the increase of the numbers of pedestrians and cyclists alone. Even the trend line for scenario C (with the greatest increase of pedestrian and bicycle volumes) and without safety in numbers effect is considerably lower than the observed numbers of KSI in 2010-2012. Other factors that may have contributed to the high numbers of KSI in 2010-2012 are random variation (there may have been exceptionally few KSI pedestrians and cyclists in this type of crashes in 2006-2009, or exceptionally many in 2010-2012) and winter weather (section 3.2.1).

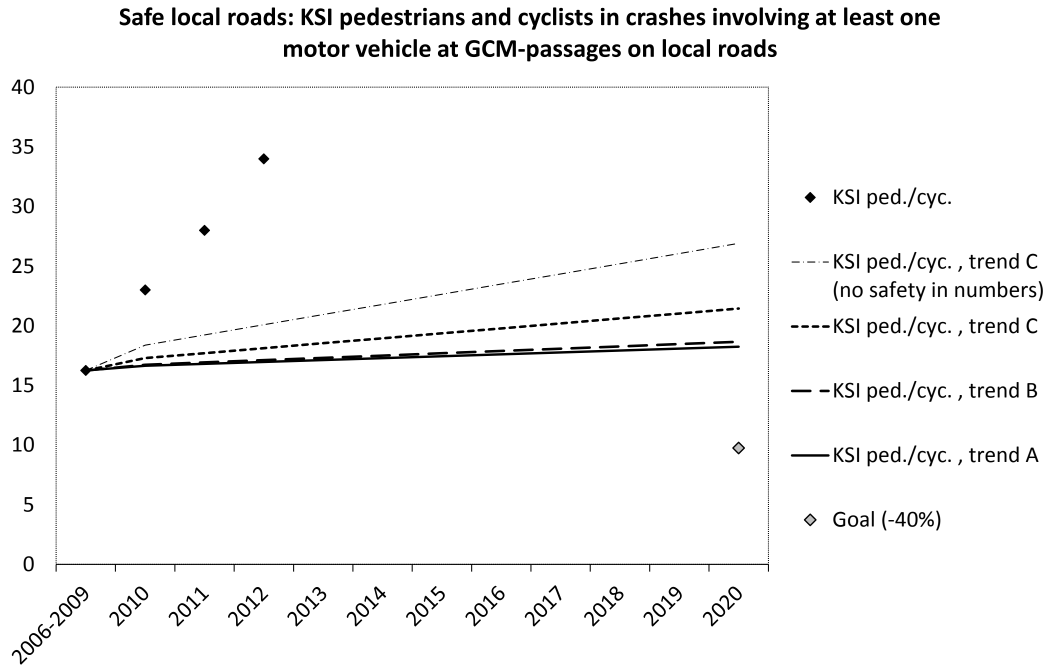

Figure 5.6.2: KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages on local roads: Actual numbers and estimated trends.

- *Baseline scenarios and changes of the safe local roads indicator*

In order to estimate changes of the number of KSI in the target group for the safe local roads indicator, several scenarios were defined for changes of the indicator and for additional measures.

Indicator: For the safe local roads indicator three different scenarios are defined.

- *Unchanged:* The proportion of safe GCM-passages and junctions on local roads remains unchanged on the level from 2010 which is 17.1%. In this scenario the only factor that affects the number of KSI is exposure (and possibly additional measures).
- *Partial goal attainment:* The proportion of safe GCM-passages on local roads increases in line with the development of the proportion of safe GCM-passages on main roads at partial goal attainment (by 10 improved GCM-passages per year; section 5.2.4). The effect on the number of KSI pedestrians and cyclists is assumed to be a reduction by 11%.
- *Goal attainment:* 75% of all GCM-passages on local roads are safe. The number of KSI pedestrians and cyclists at GCM-passages in crashes involving at least one motor vehicle will be reduced by 31.8% when 75% of all GCM passages on local roads are safe and assuming that safe GCM-passages have half the risk of non-safe GCM-passages.

Additional measures: In addition to the scenarios for the safe local roads indicator, there are two scenarios for measures that aim at reducing the number of KSI in the target group for the safe local roads indicator, but without affecting the indicator. The two scenarios are:

- *None:* No additional measures
- *Some:* Several additional measures for pedestrians and cyclists are implemented in accordance with Stockholms bicycle plan and mobility strategy. The assumed effect is as for safe main roads, a reduction of the number of KSI in the target group for the indicator by 10%.

Table 5.6.2 summarizes the estimated changes of the number of KSI in the target group for the safe local roads indicator until 2020. In 2006-2009, the average number of KSI in this group was 16.3.

Table 5.6.2: Estimated changes of the number of KSI in the target group for the safe local roads indicator in 2020 (KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages on local roads).

		Indicator		Add. measures		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**reductions**	**Effect**	**%**	**N**
A Status quo	12.3 %	**Unchanged**	0.0 %	**None**	0 %	12 %	2.0
	12.3 %		0.0 %	**Some[2]**	-10 %	1 %	0.2
	12.3 %	**Partial goal att.**	-11.0 %	**None**	0 %	0 %	0.0
	12.3 %		-11.0 %	**Some[2]**	-10 %	-10 %	-1.6
	12.3 %	**Goal attainment**	-31.8 %	**None**	0 %	-23 %	-3.8
	12.3 %		-31.8 %	**Some[2]**	-10 %	-31 %	-5.1
B Mot.	14.8 %	**Unchanged**	0.0 %	**None**	0 %	15 %	2.4
	14.8 %		0.0 %	**Some[2]**	-10 %	3 %	0.5
	14.8 %	**Partial goal att.**	-11.0 %	**None**	0 %	2 %	0.4
	14.8 %		-11.0 %	**Some[2]**	-10 %	-8 %	-1.3
	14.8 %	**Goal attainment**	-31.8 %	**None**	0 %	-22 %	-3.5
	14.8 %		-31.8 %	**Some[2]**	-10 %	-30 %	-4.8
C Non-motorized	32.0 %	**Unchanged**	0.0 %	**None**	0 %	32 %	5.2
	32.0 %		0.0 %	**Some[2]**	-10 %	19 %	3.0
	32.0 %	**Partial goal att.**	-11.0 %	**None**	0 %	17 %	2.8
	32.0 %		-11.0 %	**Some[2]**	-10 %	6 %	0.9
	32.0 %	**Goal attainment**	-31.8 %	**None**	0 %	-10 %	-1.6
	32.0 %		-31.8 %	**Some[2]**	-10 %	-19 %	-3.1

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.

[2] Measures in accordance with Stockholms bicycle plan and mobility strategy.

The results in table 5.6.2 show that the number of KSI in the target group for the safe local roads indicator may be reduced in 2020, but only when the goal for safe local roads is attained, or when the goal is partly attained and additional measures implemented. When the indicator remains unchanged, the number of KSI in the target group will most likely increase, in the worst case by up to 32%.

The most serious weaknesses of the scenario calculations are the same as for the safe main roads indicator: The assumed effects of safe GCM-passages are highly uncertain, and the assumed effects of additional measures are still more uncertain. It is unlikely that the assumed effects on the numbers of KSI are seriously underestimated.

In summary, the results do not indicate that the overall goal of a reduction of the number of KSI by 40% is likely to be attained within the target group for the safe local roads indicator, even when the amount of travel only increases moderately, when the goal for the safe local roads indicator is achieved, and when additional measures are implemented. The estimated effects are uncertain, but most likely not overestimated.

5.7 Seat belt use

The current status and development of the seat belt use indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportion of front seat occupants above 10 years in passenger cars that are using the seat belt
Target group:	All KSI front seat occupants above 10 years in passenger cars
Status 2006-2009:	**92%** of all front seat occupants above 10 years in passenger cars were using the seat belt
Status and development 2012:	Seat belt usage rates are increasing, mainly because of increasing proportions of cars with a seat belt reminder, usage rates are increasing in cars without seat belt reminders as well There are currently no measures under the responsibility of the municipality that are likely to increase seat belt usage rates
Goal 2020:	**98%** of all front seat occupants above 10 years in passenger cars were using the seat belt

5.7.1 Description of the indicator and goal

The indicator for seat belt use is the proportion of front seat occupants in passenger cars that are using the seat belt. The same indicator is used in the national road safety program (Vägverket, 2009). Seat belt use in the back seat is more difficult to register and has smaller effect on the number of KSI (Sørensen et al., 2009). The goal for 2020 is that 98% of all front seat occupants in passenger cars are using the seat belt. In 2009, 92% were using the seat belt according to observations by Vectura (2009). Among drivers the proportion was 93%.

As a comparison, in the whole country seat belt use was 95% in 2007 (Cedersund & Henriksson, 2008): 96% among car drivers, 80% among back seat passengers in cars, 88% in the age group 18-25 years, 92% among taxi drivers, 76% among drivers of light trucks, 38% among drivers of heavy single trucks and 42% among drivers of tractor-trailers. In 2010 and 2011 seat belt use in the whole country was 96% and 97% respectively (Trafikverket, 2012A). Sørensen et al. (2009) estimated that goal attainment will reduce the annual number of KSI by 14 (7%).

Target group: The target group for the indicator seat belt use are all KSI that are adult front seat occupants in passenger cars, more specifically those not using the seat belt.

Potential and priority: Seat belt use was classified as a level 3 indicator by Trafikkontoret (2010) which means that there is little need for resources and efforts. Even if seat belt use has a large impact on safety, Stockholm municipality has little influence on measures that can effectively increase seat belt use.

Seat belt use and safety: The average effect of seat belt use on KSI is a 36% reduction among car drivers and a 29% reduction among front seat passengers (Høye, 2014b). The proportion of car drivers among all drivers and front seat passengers is 69% (in Norway). When estimating the effect of increased seat belt use, Høye (2014b) assumes that those who are not using the seat belt today have 1.5 times the crash risk as those wearing the seat belt today, while those who still will be driving unbelted when the goal is achieved have twice the crash risk of those wearing the seat belt today.

In fatal crashes with passenger cars in Stockholm in 2005-2009 42.2% of the killed passenger car occupants had not been wearing the seat belt. 63% of these would most likely have survived if they had used the seat belt (Trafikverket, 2010). Most of these crashes occurred in the outer parts of the city where the speed limit is 70 km/h. The number of unbelted killed drivers in Stockholm was four in 2009 and 2010 and three in 2011. These numbers are too small for interpreting them as a trend.

5.7.2 Status of the seat belt indicator

Information that is available on seat belt use in Stockholm is summarized in table 5.7.1.

Table 5.7.1: Seat belt use in Stockholm.

	Seat belt use (%) in passenger cars				City / county	Source
	Drivers	**Front seat passengers**	**Back seat passengers**	**All front seat occupants**		
2002	82.0	82.0	68.0	**82.0**	city	Cronvall (2002)
…						
2009	93.0	90.0	83.0	**92.0**	city	Vectura (2009)
2010				**95.4**	county	NTF
2011				**96.7**	city	NTF
2012				**96.4**	city	NTF

Seat belt use has increased from 2002 to 2011. From 2011 to 2012 no increase was observed according to NTF.

- ***Why has seat belt use increased after 2002?***

The information that is available from Stockholms stad is summarized in figure 5.7.1, together with a linear trend line. According to the linear trend, seat belt use has increased by 7.7% in 2012, compared to the average seat belt use in 2006-2009. Seat belt use in cars without seat belt use is also shown in figure 5.7.1. The latter is estimated based on estimated proportions of all vehicle kilometers travelled with passenger cars that have a seat belt reminder and the assumption that 99% of all occupants of passenger cars with seat belt reminder use the seat belt (Folksam). The estimated proportions of all vehicle kilometers travelled with passenger cars that have a seat belt reminder is based on a Norwegian study (Høye et al., 2014B). The proportion of cars with seat belt reminder may be somewhat larger in Sweden than in Norway. However, even if one assumes that the proportion of new cars with seat belt reminder in all years has been the same in Sweden as in Norway, but that the car park turns over more quickly (15 years as the maximum life time per car instead of 18 as in Norway), the estimated seat belt use in cars without seat belt reminders is only slightly lower.

Figure 5.7.1 shows that seat belt use has increased considerably since 2002 in all cars and even more in cars without seat belt reminder. The increase in seat belt use cannot solely be due to the increase in the number of cars with seat belt reminder, but other factors are likely to have contributed as well.

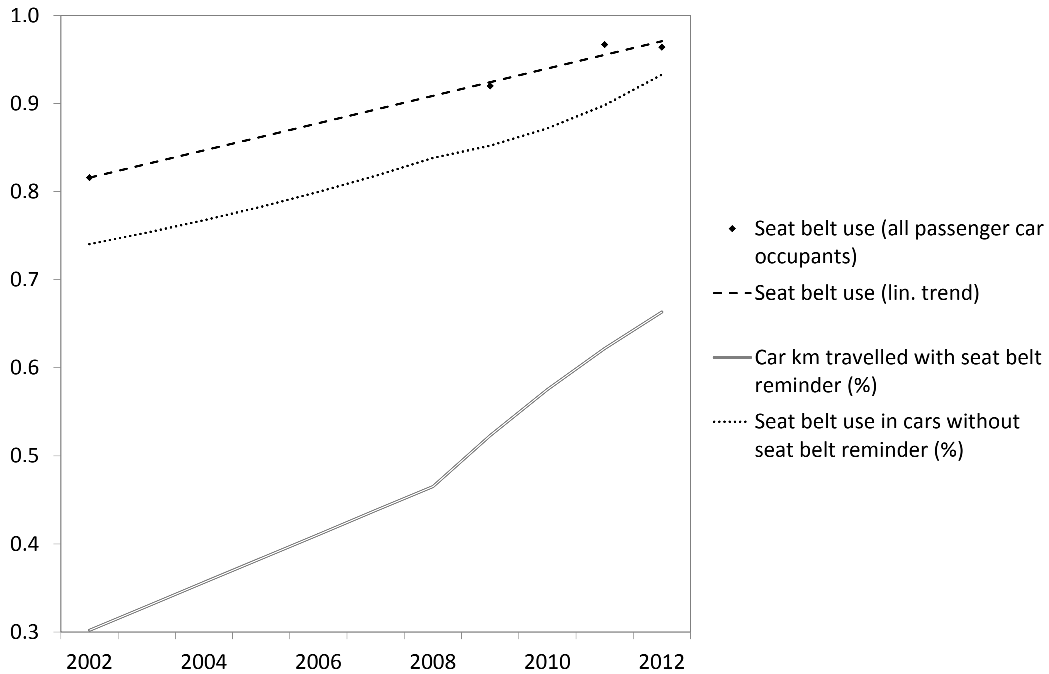

Figure 5.7.1: Seat belt use in Stockholms stad 2002-2012 in passenger cars, linear trend, estimated proportion of all car kilometers travelled with seat belt reminder, and estimated seat belt use in cars without seat belt reminder.

- ***Will seat belt use continue to increase?***

Seat belt use is likely to increase because of the increase of the proportion of cars with seat belt reminder. In cars with seat belt reminder seat belt use is estimated to be 99% according to Folksam. Figure 5.7.2 shows the estimated increase of the proportion of car kilometers travelled with seat belt reminder (based on Norwegian estimates) and the estimated increase of seat belt use that is expected assuming that only the increased proportion of cars with seat belt reminder contributes to the increase (constant seat belt use in cars without seat belt reminder on the level from 2012), and assuming that both seat belt reminders and increasing seat belt use in cars without seat belt reminder contribute to the increase. In the latter case, seat belt use in cars without seat belt reminders is assumed to increase linearly with the same trend as in 2002-2012 until it has reached 99% in 2016. In 2016 and later years it is assumed to remain at 99% (same as in cars with seat belt reminders).

The expected seat belt use in 2020 is under these assumptions

- 98.4% if only the increase of the proportion of cars with seat belt reminders contributes to increasing seat belt use
- 99% if seat belt reminders and increasing seat belt use in cars without seat belt reminders contribute to the increase

In both scenarios the goal of 98% seat belt use will be met. Even if seat belt use in cars without seat belt reminder remains unchanged on the estimated level from 2012, the increase of the proportion of cars with seat belt reminder will be sufficient to achieve the goal for seat belt use.

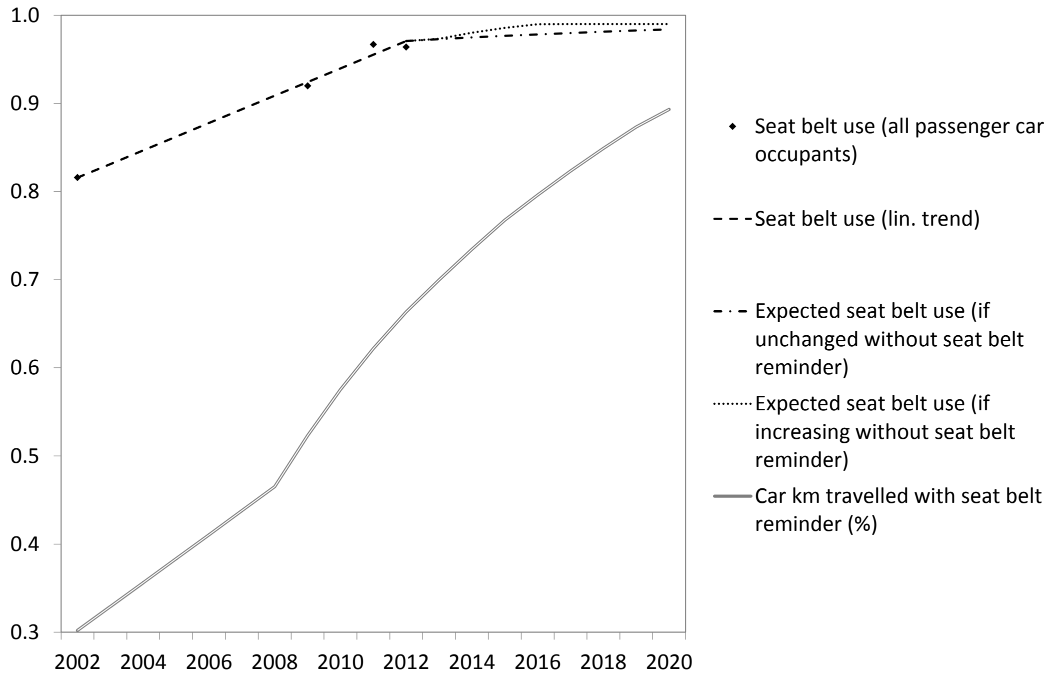

Figure 5.7.2: Seat belt use in Stockholms stad 2002-2012 in passenger cars, linear trend, estimated proportion of all car kilometers travelled with seat belt reminder, and estimated seat belt use in 2013-2020 with unchanged and increasing seat belt use in cars without seat belt reminders.

- ***Seat belt use in Sweden increasing and higher than in Stockholm***

Seat belt use in Sweden has been investigated by Larsson et al. (2012). In general, seat belt use is higher in the rest of the country than in Stockholms stad. The results are shown in table 5.7.2. The goal for the whole country is that 99% of all drivers and front seat passenger are wearing the seat belt in 2020.

Table 5.7.2: Seat belt use in Sweden (Larsson et al., 2012; Cedersund & Henriksson, 2010)

	2008	2009	2010	2011	2012
Drivers	95.2	96.0	96.5	96.9	97.7
Front seat passengers	94.8	96.2	95.7	96.4	97.6
Rear seat passengers (adults)	74.3	79.7	81.3	83.7	87.1
Rear seat passengers (children)	94.8	94.7	95.2	96.1	96.7

5.7.3 Measures for increasing seat belt use

Measures that are known to effectively increase seat belt use are enforcement and seat belt reminders. These measures are however not or only to a small degree influenceable by the municipality of Stockholm. When considering the effectiveness of measures it should be taken into account that it gets more difficult to increase seat belt use the higher the usage rates are. The "last" unbelted car occupants are not only more difficult to influence, they have also a higher crash risk than those who are using the seat belt.

- ***Campaigns***

Campaigns may affect seat belt use, but have proven to be most effective when combined with enforcement. Seat belt campaigns have not been conducted in recent years and none are planned.

- ***Requirements to transport on behalf of the municipality and support for other actors***

The municipality may theoretically require the use of vehicles with a seat belt reminder for all road transport on behalf of the municipality and it may support other actors in making the same demand (they might also require the seat belt to be used but this is most likely not very effective since seat belt use already is required by law).

- ***Enforcement***

Seat belt enforcement is mostly carried out on roads with a speed limit of 30 or 50 km/h. Targeted enforcement can increase the use of seat belts. However the "last" remaining non-users of seat belts are unlikely to respond to increased enforcement. The police would be responsible for conducting seat belt enforcement. However, in Stockholms stad no targeted seat belt enforcement is conducted according to Trafikkontoret (2013A).

- *Seat belt reminders*

Seat belt reminders in cars have been found to increase seat belt use considerably. Seat belt use in cars with seat belt reminds is about 99% according to Folksam.

5.7.4 Development of the number of KSI in the target group for the seat belt indicator

Development from 2006-2009 to 2012

The annual numbers of KSI front seat occupants of passenger cars above 10 year of age (the target group for the safe local roads indicator) in 2006 to 2012 are shown in figure 5.7.3. The figures are based on the numbers of KSI car drivers and car passengers from Strada. Since no information about age or seating position is available from Strada, the numbers of KSI car occupants is weighted with the proportion of car occupants that are front seat occupants older than 10 years in Norway (65%). In 2012 the number of KSI pedestrians and cyclists in this type of crashes was 6% higher than in 2006-2009.

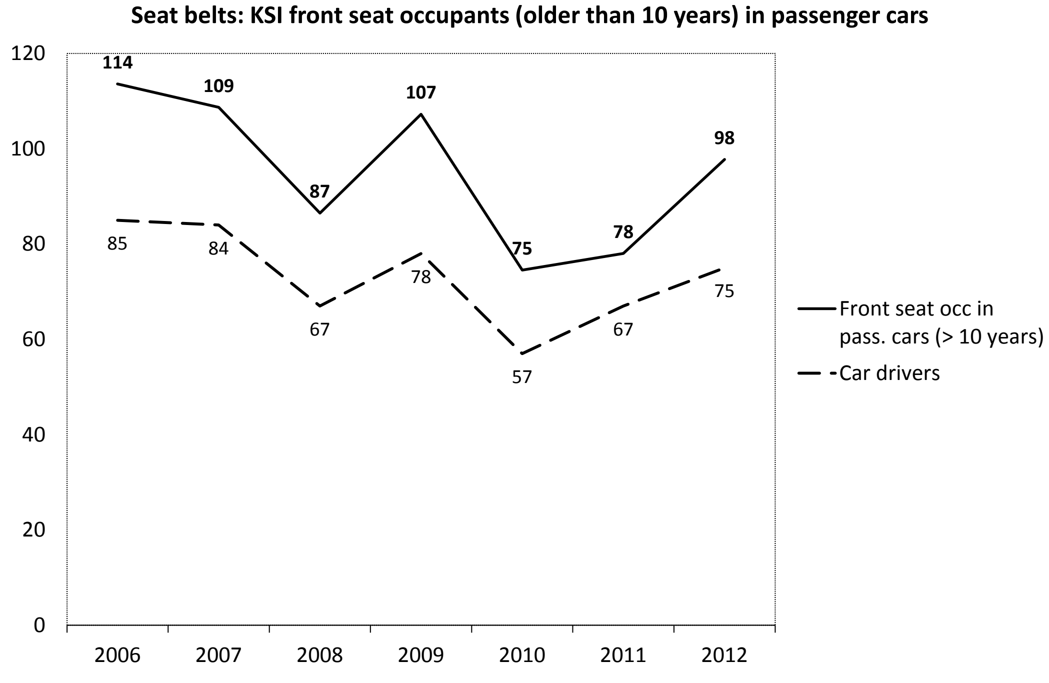

Figure 5.7.3: KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages.

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The numbers of KSI front seat passenger car occupants (older than 10 years), together with the estimated trends in the baseline scenarios A/C (status quo / non-motorized) and B (motorized), are shown in figure 5.7.4. The estimated trend lines show the expected numbers of KSI if everything except exposure remains unchanged.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the local roads indicator has to be reduced from 104 to 62. The development in the recent years may have been in the right direction, even if no clear trend can be seen.

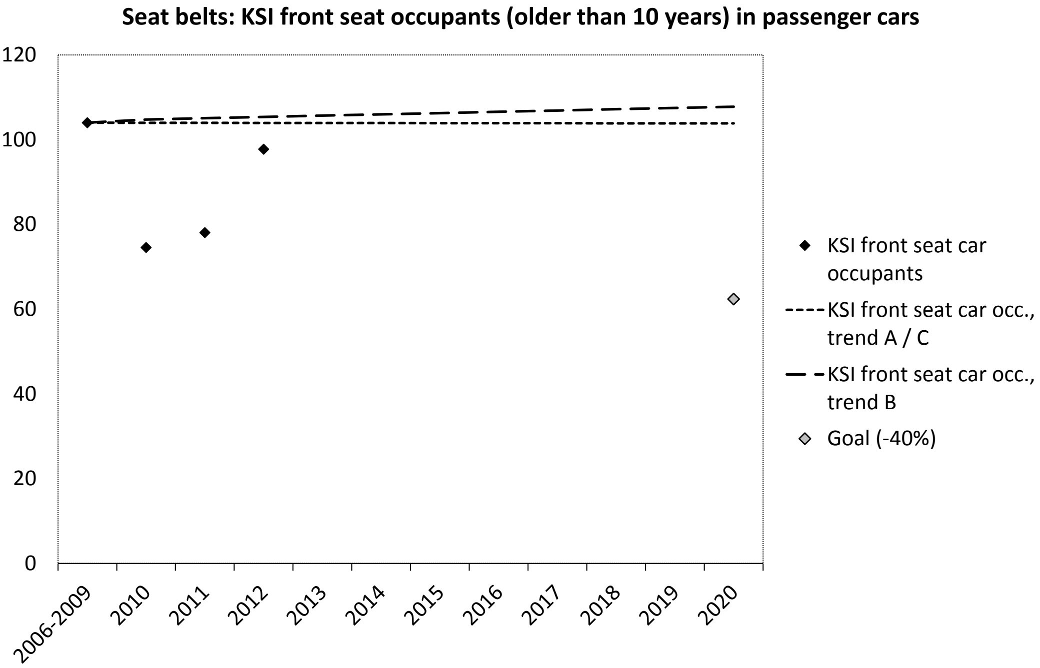

Figure 5.7.4: KSI front seat passenger car occupants (older than 10 years): Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the seat belt indicator***

Seat belt use has been increasing in recent years and is likely to continue increasing. In 2020 the goal for the seat belt indicator is likely to be achieved, even if no targeted measures are taken to increase seat belt use (section 5.7.2).

In order to estimate changes of the number of KSI in the target group for the seat belt indicator, the following scenarios were defined for changes of the indicator and for the expected effect of increased seat belt use.

Indicator: Two scenarios are defined for the seat belt indicator:

- ***Goal attainment A:*** Seat belt use in 2020 is 98.4%. This is the expected proportion of car occupants using the seat belt in 2020 if increasing seat belt use after 2012 is solely due to an increasing proportion of cars with a seat belt reminder (seat belt use in cars without seat belt reminders is assumed to remain unchanged).
- ***Goal attainment B:*** Seat belt use in 2020 is 99.0%. This is the expected proportion of car occupants using the seat belt in 2020 if an increasing proportion of cars with a seat belt reminder and increasing seat belt use in cars without seat belt reminders contribute to increasing seat belt use.

Seat belt effect: The effect of increasing seat belt use on the number of KSI can be estimated in two different ways. In both cases the expected numbers of KSI in the years 2010 to 2020 are estimated as a function of the average number of KSI in 2006-2009 and the observed / expected seat belt use in each year from 2006-2009 to 2020. Additional assumptions are as follows.

- ***Conservative estimate:*** The only additional assumption is that those car occupants that did not use a seat belt in 2006-2009 have twice the risk of being involved in a serious crash. The relative number of KSI for each year in 2010 to 2020 is estimated as

$$Rel.N\ of\ KSI = \frac{a*0.7+2*[(b-a)*0.7+(1-b)]}{a*0.7+2*(1-a)*0.7}$$

  where a is the proportion using a seat belt in 2006-2009 and b is the proportion using a seat belt in the respective year. The relative number of KSI in 2020 will then be ***0.94***.

- ***Optimistic estimate:*** The expected percentage decrease of the number of KSI is estimated based on the assumptions that 40% of all KSI in 2006-2009 had not been using the seat belt and that the number of KSI will be reduced by 30% among those who were not wearing the seat belt in 2006-2009. The total number of KSI will then be reduced by 12% when all front seat car occupants are wearing the seat belt (when 40% are reduced by 30%, the total number is reduced by 12%). The relative number of KSI in 2020 will then be ***0.90***.

Table 5.7.3 summarizes the estimated changes of the number of KSI in the target group for the seat belt indicator until 2020. In 2006-2009, the average number of KSI in this group was 104.

Table 5.7.3: Estimated changes of the number of KSI in the target group for the seat belt indicator in 2020 (KSI front seat occupants in passenger cars, older than 10 years).

		Indicator	Seat belt effect		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Scenario**	**Effect**	**%**	**N**
A Status quo / C Non-motorized	-0.2 %	**Goal attainment A**	**Conservative**	-5.9 %	**-6 %**	**-6.3**
	-0.2 %		**Optimistic**	-9.9 %	**-10 %**	**-10.5**
	-0.2 %	**Goal attainment B**	**Conservative**	-6.4 %	**-7 %**	**-6.9**
	-0.2 %		**Optimistic**	-10.8 %	**-11 %**	**-11.4**
B Motorized	3.6 %	**Goal attainment A**	**Conservative**	-5.9 %	**-2 %**	**-2.6**
	3.6 %		**Optimistic**	-9.9 %	**-7 %**	**-6.9**
	3.6 %	**Goal attainment B**	**Conservative**	-6.4 %	**-3 %**	**-3.2**
	3.6 %		**Optimistic**	-10.8 %	**-8 %**	**-7.8**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.

The results in table 5.7.3 show that the number of KSI in the target group for the seat belts indicator is likely to be reduced in 2020. Even in the most optimistic scenarios however, the reductions are far smaller than 40%.

In summary, even if the goal for the seat belt indicator most likely will be achieved, the most optimistic effect on the number of KSI in the target group is a reduction by about 10%.

5.8 Bicycle helmet use

The current status and development of the bicycle helmet use indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportion of all cyclists wearing a helmet
Target group:	All KSI cyclists
Status 2006-2009:	**55.6%** of all cyclists were wearing a helmet
Status and development 2012:	Bicycle helmet wearing rates are increasing and the goal is likely to be more than attained if the current trend continues There are currently no measures under the responsibility of the municipality that are likely to increase helmet wearing rates
Goal 2020:	**80%** of all cyclists were wearing a helmet

5.8.1 Description of the indicator and goal

The indicator for bicycle helmet use is the proportion of all cyclists wearing a helmet. Bicycle helmet wearing is obligatory for children under 15 years, but the definition of the indicator is independent of age. The same indicator is used in the national road safety program (Vägverket, 2009). The goal for 2020 is that 80% of all cyclists are wearing a helmet. In 2009, 65% were using a helmet.

In the whole country, the average proportion of cyclists wearing a helmet was estimated to be 64.2% in 2004, 67.1% in 2010, and 67.4% in 2011. The goal for the whole country is a proportion of 70% wearing a bicycle helmet. Sørensen et al. (2009) estimated that goal attainment will reduce the annual number of KSI by 4 (2%).

Target group: The target group for the indicator bicycle helmet use are all KSI cyclists in all types of crashes.

Potential and priority: Bicycle helmet use was classified as level 3 indicator by Trafikkontoret (2010) which means that there is little need for resources and efforts. Even if bicycle helmet use affects the number of KSI, Stockholm municipality has little influence on measures that can effectively increase the use of bicycle helmets.

Bicycle helmet use and safety: A meta-analysis by Elvik (2013) shows that bicycle helmet reduce head and neck injuries by about 12%. This estimate is far smaller than the effect assumed by Sørensen et al. (2009) which was a 60% reduction of head injuries. Elvik (2013) showed that results from many studies are most likely affected by methodological flaws and that publication bias is likely to be present. Publication bias is the bias in results from meta-analysis that arises when results from studies that do not confirm the researchers expectations remain unpublished. The overall effect has therefore been adjusted for publication bias and is based only on the most recent studies. The proportion of all KSI cyclists that have head or neck injuries in Norway is about 25% (with and without helmet; Bjørnskau, 2005). Since no such information is available from Sweden, the Norwegian result is used to calculate the overall effect of bicycle helmet use on the number of KSI. When bicycle helmets reduce the number of KSI by 12% among those 25% that have neck or head injuries, the overall effect on the number of KSI is a reduction by 3%.

5.8.2 Status of the bicycle helmet use indicator

Estimated proportions of cyclists using a bicycle helmet vary between different sources more than between years. The results from Gustafsson (2013) indicate that there has been an increase in bicycle helmet use from 2009 to 2012. These results refer however only to adult cyclists on bicycle lanes. Larsson (2013) fount almost the same proportion of adult cyclists on bicycle lanes wearing a helmet, but a smaller proportion among all cyclists.

Based on the results from Larsson (2013) and Gustafsson (2013) bicycle helmet wearing rates for all cyclists are estimated for 2009-2012 in the last four rows of table 5.8.1.

Table 5.8.1: Bicycle helmet use among adult cyclists in Stockholm.

	Bicycle helmet use (%)	City / county	Source
2008	65	?	Sørensen et al. (2009), basert på resultater fra Thulin (2008): all cyclists
2009	58	?	Sørensen et al. (2009), basert på resultater fra Vectura
2009	71.2	city(?)	Gustafsson (2013): adults (16+) on bicycle lanes
2010	74.3	city(?)	Gustafsson (2013): adults (16+) on bicycle lanes
2011	74.3	city(?)	Gustafsson (2013): adults (16+) on bicycle lanes
2012	79.6	city(?)	Gustafsson (2013): adults (16+) on bicycle lanes
2012	79.9	city(?)	Larsson (2013): adults (16+) on bicycle lanes
2012	71.4	city(?)	Larsson (2013): all cyclists
2009	**55.6**	city(?)	estimated based on Larsson (2013) and Gustafsson (2013)
2010	**62.2**	city(?)	estimated based on Larsson (2013) and Gustafsson (2013)
2011	**66.6**	city(?)	estimated based on Larsson (2013) and Gustafsson (2013)
2012	**71.4**	city(?)	estimated based on Larsson (2013) and Gustafsson (2013)

The proportion of cyclists using a helmet is far higher in Stockholm than in other parts of the country (Gustafsson, 2013). In the whole country, the proportion wearing a bicycle helmet was 66% among cyclists under 10 years and 22% among commuters (Thulin, 2008). In Stockholm 73% of all children in primary school use a helmet and 62% of all commuting cyclists used a bicycle helmet in 2007 (Sørensen et al., 2009). Thulin (2008) found differences in helmet wearing rates between different groups of cyclists in Stockholm:

- 62% among commuters
- 69% on bicycle tracks
- 78.5% among children under 10 years

Larsson (2013) found the following proportions of cyclists wearing a bicycle helmet in Stockholm:

- 76.7% among children (10 years or younger) in residential areas
- 77.0% among primary school children
- 61.1% among commuting adults
- 79.9% among all cyclists on bicycle tracks (cykelstråk)

Vectura (2009) found the following proportions wearing a bicycle helmet on roads with different speed limits:

- 55% on roads with a 30 km/h speed limit
- 59% on roads with a 50 km/h speed limit
- 74% on roads with a 70 km/h speed limit

In general, far more ***children*** are wearing a bicycle helmet than adults. However, the proportion of children wearing a bicycle helmet does not seem to have increased in recent years. The estimated proportion was 78.5% in 2008 and 76.7% in 2012.

- *How will bicycle helmet use develop until 2020?*

In order to estimate bicycle helmet use in the years until 2020, a logarithmic trend function has been fitted to the estimated wearing rate for bicycle helmets in 2009-2012 (based on Larsson, 2013 and Gustafsson, 2013) in figure 5.8.1. The linear trend line shows the possible wearing rates in earlier years. Based on the linear trend the average wearing rate in ***2006-2009*** was ***48.4%***. The logarithmic trend line shows the expected wearing rate until 2020. If the wearing rate follows the logarithmic trend it will be at ***92.5%*** in ***2020***. The goal of 80% wearing a bicycle helmet will then be more than achieved. It is not reasonable to assume that the bicycle helmet wearing rates continues to increase linearly (it would reach above 100% in 2018).

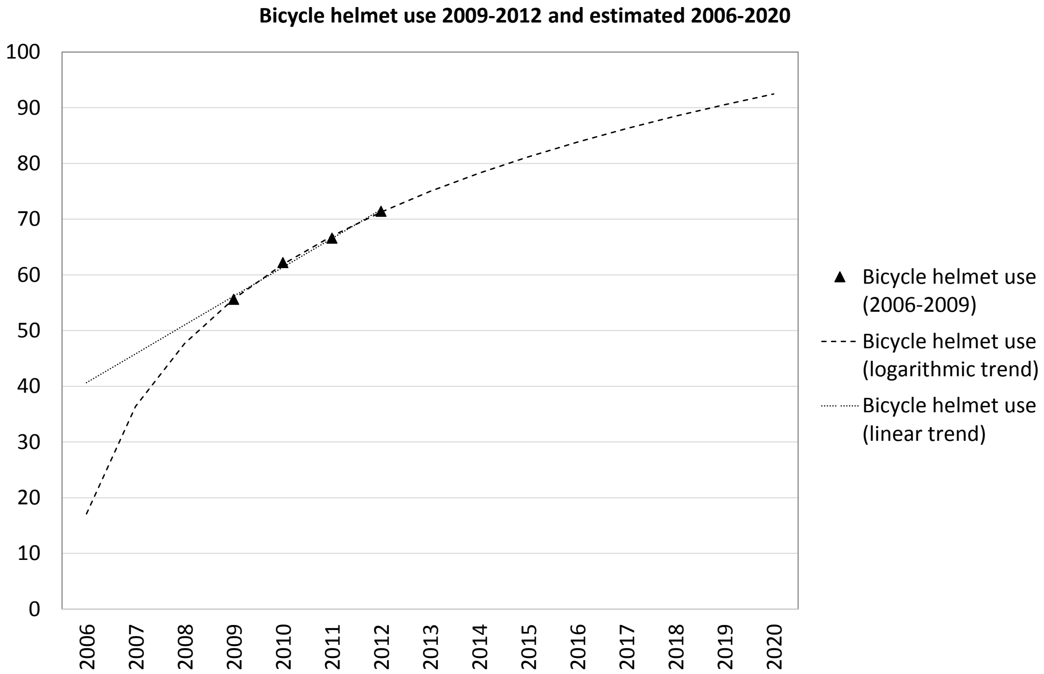

Figure 5.8.1: Bicycle helmet use in 2009-2012 and estimated bicycle helmet use in 2006-2008 and 2013-2020.

5.8.3 Measures for increasing bicycle helmet use

Trafikverket has in cooperation with Transportstyrelsen in 2011 developed a strategy and an action plan for increased and safer cycling. The strategy involves, amongst other things, increased cooperation between the state government and the 50 largest municipalities and in increased focus on cycling in society planning. The strategy also involves increased efforts to analyze the effects of bicycle safety measures. There are some measures that may increase bicycle helmet use, information about possible effects is however sparse.

- *Bicycle helmet law*

A measure that is known to effectively increase bicycle helmet use is a bicycle helmet law. Such a law can however not be implemented by Stockholm municipality, and is not even regarded as realistic for the whole country. A negative side effect would be that the number of cyclists most likely would decrease considerably.

- *Campaigns*

User information and campaigns may increase the use of bicycle helmets. According to Sørensen et al. (2009) campaigns (and e.g. competitions) might be conducted in cooperation with schools, working places and bicycle organizations.

- *Requirements to transport on behalf of the municipality and support for other actors*

Helmet use might be made obligatory for all cycling on behalf of the municipality. However, such a requirement would be difficult to implement in practice and it would not affect a significant proportion of all bicycle kilometers travelled.

5.8.4 Development of the number of KSI in the target group for the bicycle helmet use indicator

Development from 2006-2009 to 2012

The annual numbers of KSI cyclists in 2006 to 2012 are shown in figure 5.8.2. The figures are based on the numbers of KSI cyclists from Strada. Information about bicycle helmet use is not available from Strada. The numbers of KSI cyclists wearing / not wearing a helmet were therefore estimated by weighting the total numbers of KSI cyclists with the average number of KSI cyclists in hospital reported data that wore / did not wear a helmet. The total numbers of KSI cyclists is far smaller in hospital reported data than in Strada. In 2012 the number of KSI cyclists was 44% higher than in 2006-2009.

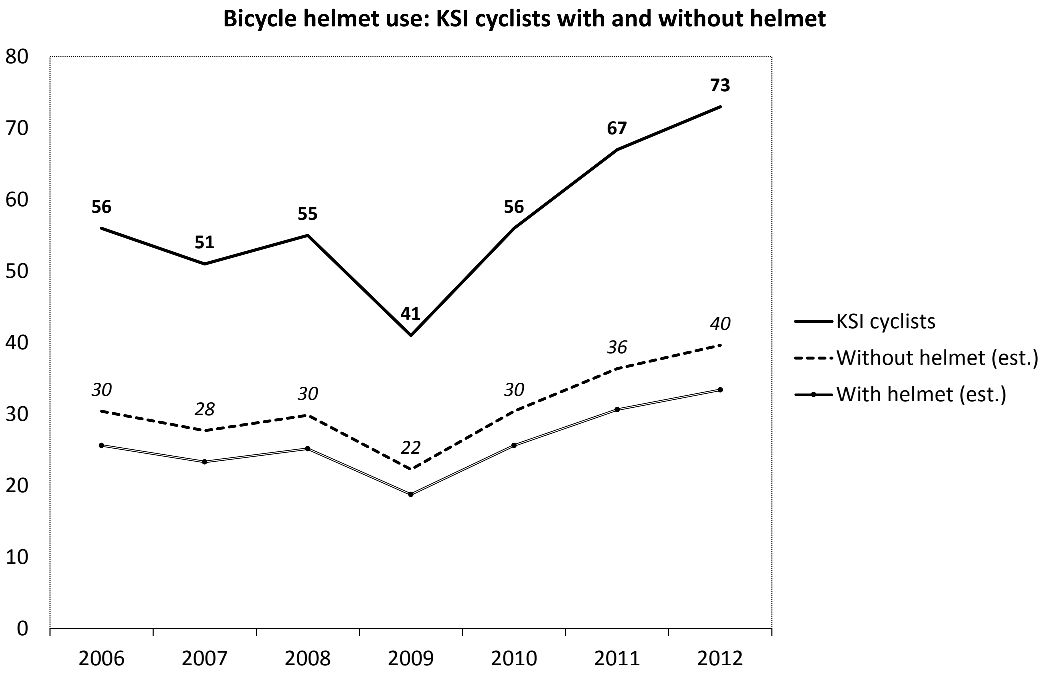

Figure 5.8.2: KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages.

Predicted development from 2006-2009 to 2020

- ***Baseline scenarios***

The numbers of KSI cyclists, together with the estimated trends in the baseline scenarios A/B (status quo / motorized) and C (non-motorized), are shown in figure 5.8.3. The estimated trend lines show the expected numbers of KSI if everything except exposure remains unchanged.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the bicycle helmet wearing indicator would have to be reduced from 50.8 to 30.5. The development in recent years does not seem to have been in the right direction, even when increasing bicycle volumes are taken into account. The seemingly increasing numbers of KSI may however be a result of random variation.

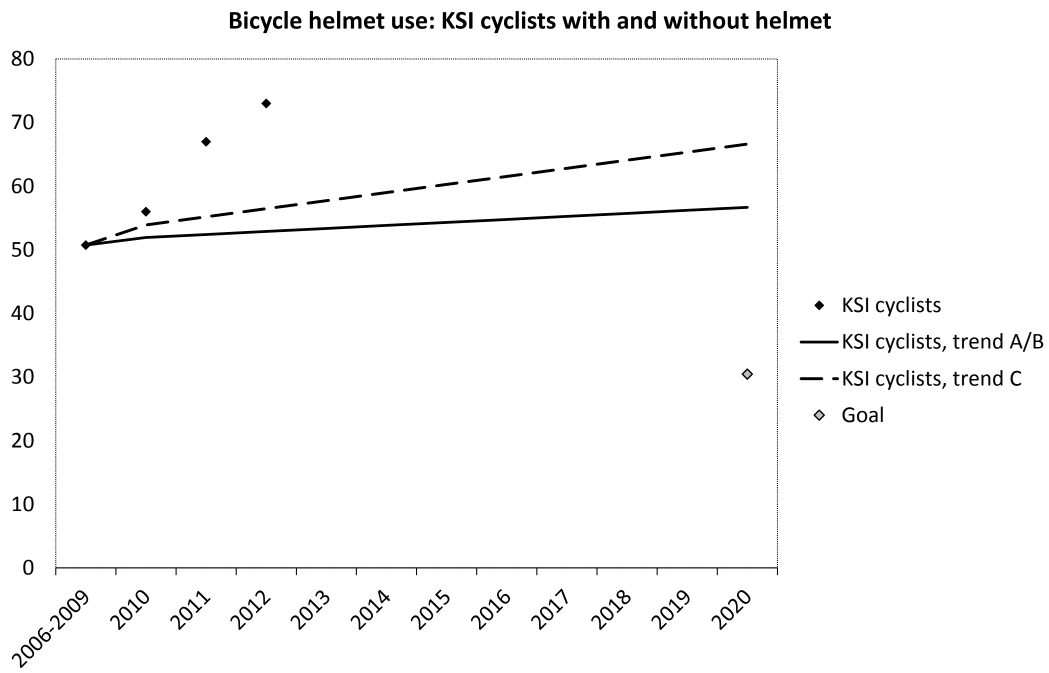

Figure 5.8.3: KSI cyclists: Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the seat belt roads indicator***

Bicycle helmet wearing rates have been increasing in recent years and are likely to continue increasing. In 2020 the goal for the bicycle helmet wearing indicator is likely to be achieved, even if no targeted measures are taken to increase seat belt use (section 5.8.2).

In order to estimate changes of the number of KSI in the target group for the bicycle helmet wearing indicator, the following scenarios were defined for changes of the indicator.

Indicator: Two scenarios are defined for the bicycle helmet wearing indicator:

- ***Goal attainment A:*** The goal for bicycle helmet use is achieved, 80% of all cyclists are wearing a helmet.

- *Goal attainment B:* Bicycles helmet wearing rates continue to increase as estimated with a logarithmic function that is based on the wearing rates in 2009-2012 (section 5.8.2). The proportion of cyclists wearing a helmet will then be 91.5% in 2020.

The effect of increasing bicycle helmet wearing rates are estimated in the same way as for seat belts (conservative estimate, section 5.7.4), based on the assumption that bicycle helmets reduce the risk of being KSI in a crash by about 3%. Estimating the effect of increasing bicycle helmet wearing rates as in the optimistic scenario for seat belt wearing yields about the same results as the "conservative" estimates (which therefore cannot be regarded as conservative for bicycle helmet wearing). The most likely explanation is that there are no or only small general difference in the risk for being involved in serious crashes between cyclists wearing and not wearing a helmet. Among car occupants on the other side, those not wearing a seat belt have far higher risk of being involved in a serious crash than those wearing a seat belt.

Table 5.8.2 summarizes the estimated changes of the number of KSI in the target group for the bicycle helmet wearing indicator until 2020. In 2006-2009, the average number of KSI in this group was 50.8.

Table 5.8.2: Estimated changes of the number of KSI in the target group for the bicycle helmet wearing indicator in 2020 (KSI pedestrians and cyclists in crashes involving at least one motor vehicle at GCM-passages on local roads).

		Indicator		Total change	
Scenario	**Trend[1]**	**Status 2020**	**Effect**	**%**	**N**
A Status quo / B Motorized	11.7 %	**Goal attainment A**	-1.0 %	**10.6 %**	**5.4**
	11.7 %	**Goal attainment B**	-1.3 %	**10.2 %**	**5.2**
C Non-motorized	31.3 %	**Goal attainment A**	-1.0 %	**30.0 %**	**15.2**
	31.3 %	**Goal attainment B**	-1.3 %	**29.5 %**	**15.0**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.

The results in table 5.8.2 show that the effect of increasing bicycle helmet use most likely is not sufficient for outweighing the effect of increasing bicycle traffic, even in the scenario with moderate traffic growth and a helmet wearing rate well above goal attainment.

In summary, even if the goal for the bicycle helmet wearing indicator most likely will be achieved or more than achieved, the number of KSI cyclists is likely to continue increasing as a function of increasing bicycle volumes.

5.9 Driving under the influence of alcohol (DUI)

The current status and development of the DUI indicator that is described in the following sections can be summarized as follows:

Indicator:	Proportion of sober drivers (BAC < .20)
Target group:	All KSI involved in crashes with a drunken driver
Status 2006-2009:	Two estimates are available: ▪ **99.56%** ▪ **99.76%**
Status and development 2012:	The proportion of sober drivers is slightly increasing, but if the current trend continues this will not be sufficient to attain the goal There are currently no measures under the responsibility of the municipality that are likely to reduce drunk driving
Goal 2020:	**99.90%** of all drivers are sober

5.9.1 Description of the indicator and goal

The indicator for DUI is the proportion of sober drivers. A sober driver is one with a BAC-level (blood alcohol concentration) below 0.20. The same indicator is used in the national road safety program (Vägverket, 2009). It requires regular (e.g. every second year) road side studies which have to be conducted in cooperation with the police (Sørensen et al., 2009).

The goal for 2020 is that 99.90% of all drivers are sober. Sørensen et al. (2009) estimated that goal attainment will reduce the annual number of KSI by 12 (6%).

Target group: The target group for the indicator DUI are all KSI motor vehicle occupants that were involved in a crash with a drunk driver, including drunk drivers and other KSI.

Potential and priority: Even if DUI has a large impact on safety, Stockholm municipality has little influence on measures that can effectively reduce the number of drunk drivers. DUI was therefore classified as a level 3 indicator by Trafikkontoret (2010) which means that there is little need for resources and efforts.

DUI and safety: DUI is one of the factors with the greatest effect on crash risk. The relative risk of being involved in an injury crash (when the relative risk of a sober driver is set equal to one) is 2.1 for drivers with 0.2 to 0.5 BAC, 8.3 for drivers with 0.8 to 1.3 BAC and 87.2 for drivers with more than 1.3 BAC (Assum et al., 2005). Crash risk among young drivers increases even more with increasing BAC level (Elvik et al., 2009). Taking into account the distribution of the different BAC levels among drunk drivers, it is estimated that the risk of being involved in a serious crash for an average drunk driver is about five times the risk of a sober driver. Theoretically, that means that driving sober reduces the risk of being involved in a serious crash by about 80%.

The proportion of drivers with an illegal BAC was about 8% in injury crashes in 2003-2006 in Stockholm (Sørensen et al., 2009). In Sweden it was between 18 and 33% among fatally injured drivers in 2004-2011 (Trafikverket, 2012A). Translated into relative risks, this would correspond to a relative risk of being involved in an injury crash of 17 and a relative risk of being fatally injured in a crash of 68 (this is not entirely correct because the proportions are from different years and different geographical regions but they still give an indication of the approximate size of the effect of alcohol on crash and fatality risk).

5.9.2 Status of the DUI indicator

Information about the proportion of sober drivers in Stockholm is available from different sources. The results are summarized in table 5.9.1 and in figure 5.9.1. The results are not quite consistent and two estimates are available for the status in 2006-2009:

- According to Trafikverket (2012a) the proportion of sober drivers has been between ***99.56%*** in 2006 and 99.59% in 2006-2011 in Stockholms stad.
- According to Trafikkontoret (2010) the proportion of sober drivers was ***99.76%*** in 2009.

The second estimate is based on Sørensen et al. (2009). Sørensen et al. (2009) had no results available for Stockholm and therefore used a result for the whole country as the estimate for Stockholm. The difference between the results for the whole country and Stockholms stad may be due to differences in the selection of control points, rather than to real difference in the amount of drunk driving.

The results from Trafikverket (2012A) indicate a slightly increasing trend of the proportion of sober drivers, which is shown as a linear trend line and extrapolated until 2020 in figure 5.9.1. A trend line with the same slope has been drawn through the data point from 2009 that is based on Trafikkontoret (2010) in figure 5.9.1. The end points of the two trend lines will be taken as two possible scenarios for the development of the DUI indicator until 2020.

Table 5.9.1: Development of the proportion of sober drivers in 2007 to 2011 in Stockholm county (Forsman, 2011; Trafikverket, 2012A).

	Proportion of sober drivers	**Source**
"Starting point"	99.56 %	Trafikverket (2012A): Stockholms stad
2008	99.53 %	Forsman (2011): Stockholm county
2009	99.52 %	Forsman (2011): Stockholm county
2009	99.76 %	Trafikkontoret (2010, TS-program): Sweden
2010	99.57 %	Trafikverket (2012a): Stockholms stad
2011	99.59 %	Trafikverket (2012a): Stockholms stad

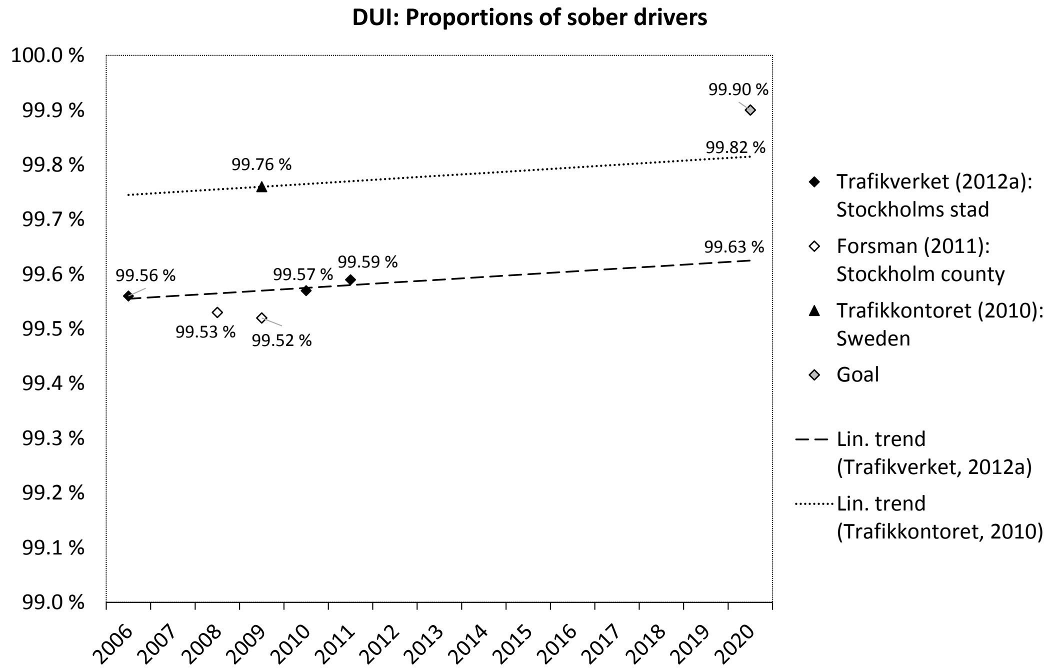

Figure 5.9.1: Estimated proportions of sober drivers in Stockholm from different sources and estimated linear trends until 2020.

No information is available for driving while intoxicated. About 43% of all drivers charged for DUI in 2011 were also under the influence of other substances (Trafikverket, 2012A).

5.9.3 Measures for reducing drunk driving

Measures that are known to effectively reduce DUI are enforcement, sanctions (especially vehicle impoundment), and alcolock. Measures that are under the responsibility of Stockholm municipality according to Trafikverket (2012A) are the following:

- Campaign Don't Drink and Drive (DDD)
- Joint action against alcohol and drugs in road traffic (SMADIT)
- Alcolock

These and other measures are described in the following sections. None of them is expected to contribute considerably to reducing the proportion of drunk drivers until 2020.

A general challenge for measures against DUI is that most drunk drivers are quite resistant against any attempt to modify their drinking behavior, and that many of them also are high risk drivers in other respects. E.g. a large proportion of drunk drivers are young men, non-users of seat belts, speeding or engaging in other illegal or criminal activities (Elvik et al., 2009).

- ***DDD (Don't drink and drive)***

DDD is a preventive measure that is aimed at young people 15-24 years and conducted under the responsibility of the municipality of Stockholm. Hallgren & Andréasson (2013) found little or no effect on attitudes and drinking behavior in an evaluation of the Swedish six-community alcohol and drug prevention trial (2003–2007) in which DDD was one of several programs among youths aged 15-19 years.

A meta-analysis by Elvik et al. (2009) found that campaigns against drunk-driving reduce crashes by 18% on average. The result is mainly based on studies from Australia, and most of the campaigns were accompanied by high-level police enforcement. The effect of drunk driving campaigns as a single measure is not known. On the background of the results from numerous studies that indicate that drinking drivers are quite resistant to any attempt to modify their drinking behavior, and considering that the proportion of sober drivers already is very high in Stockholm, it is most likely that campaigns as a single measure (without accompanying enforcement) have little or no effect on drunk driving and crashes.

- ***SMADIT (Samverkan mot alkohol och droger i trafiken - joint action against alcohol and drugs in road traffic)***

SMADIT is a program that offers contact to rehab for DUI drivers. It is conducted under the responsibility of the municipality of Stockholm and permanently implemented since 2012.

No evaluation is available of the effects of SMADIT on recidivism or crashes. Forsman et al. (2011) found that only 8% of all who received an offer from the police actually attended a consultation. In general, rehabilitation measures may reduce recidivism and crashes by up to 8% in the short term. In the long term however, such measures have most likely only little or no effect according to Elvik et al. (2009). Several studies have found reductions of both recidivism and crashes. These results may however be affected by methodological weaknesses and there is most likely publication bias, i.e. studies with less favorable results are less likely to be published that studies with favorable results. Based on these results it cannot be assumed that SMADIT will have any considerable effect on the amount of drink-driving.

- ***Alcolock***

Alcolock has been tested among several groups of professional drivers in Sweden. Since January 2012 DUI convicted drivers may keep their driver's license if they install alcolock in their car. The use of alcolock for convicted drivers is not under the responsibility of the municipality.

Alcolock has in several studies been found to reduce drink-driving in the period during which alcolock is installed in the cars of DUI-convicted drivers. No effect was found after alcolock was removed from the cars (Elvik et al., 2009). Installing alcolock was voluntary in most studies (in exchange against reduced sanctions), and it is not known how alcolock would affect drivers when mandated by court. An evaluation of a trial in Sweden found a 60% reduction of recidivism among those who had completed a 2-year program (Nordbakke et al., 2007).

If alcolock were installed in all vehicles owned by the municipality, other public authorities or by companies, the proportion of sober drivers would be likely to increase.

- *Enforcement*

An increase in the amount of enforcement has been found to reduce the number of crashes in those areas / on those roads where the enforcement is conducted by between 10 and 15% on average. Crashes involving alcohol are reduced by about 17% (Erke et al., 2009). The greatest effect was found for DUI-checkpoints in Australia. These checkpoints are highly visible "booze buses" where drivers are tested randomly. Additionally, the proportion of drunk drivers was higher than in many other countries. In general, enforcement is more effective in reducing crashes when all drivers are tested (or when drivers are tested randomly), than when only drivers suspected for rink driving are tested. Paid publicity has not been found to increase the effectiveness of DUI-checkpoints (Erke et al., 2009). How the amount of DUI enforcement will develop until 2020 is not known.

- *Vehicle impoundment or immobilization*

Vehicle impoundment or immobilization is not among those mentioned by Sørensen et al. (2009) or Trafikkontoret, but it has been proven to be one of the most effective sanctions for DUI-convicted drivers in a number of American studies. The vehicle can be impounded (or immobilized) if the driver has been drunk-driving, even if the driver is not the owner. Several studies found reductions of both drunk driving and crashes of up to 60%, even after the vehicle had been released.

5.9.4 Development of the number of KSI in the target group for the DUI indicator

Development from 2006-2009 to 2012

The annual numbers of drunk drivers and other KSI in crashes with drunk drivers in 2006 to 2012 are shown in figure 5.9.1. There is a clear relationship between the numbers of KSI drunk drivers and the number of other KSI in crashes with drunk drivers. In 2012 the total number of KSI in crashes with drunk drivers was 22 which is 22% above the average in 2006-2009 which was 18. There is large variation from year to year and no clear trend over time can be seen.

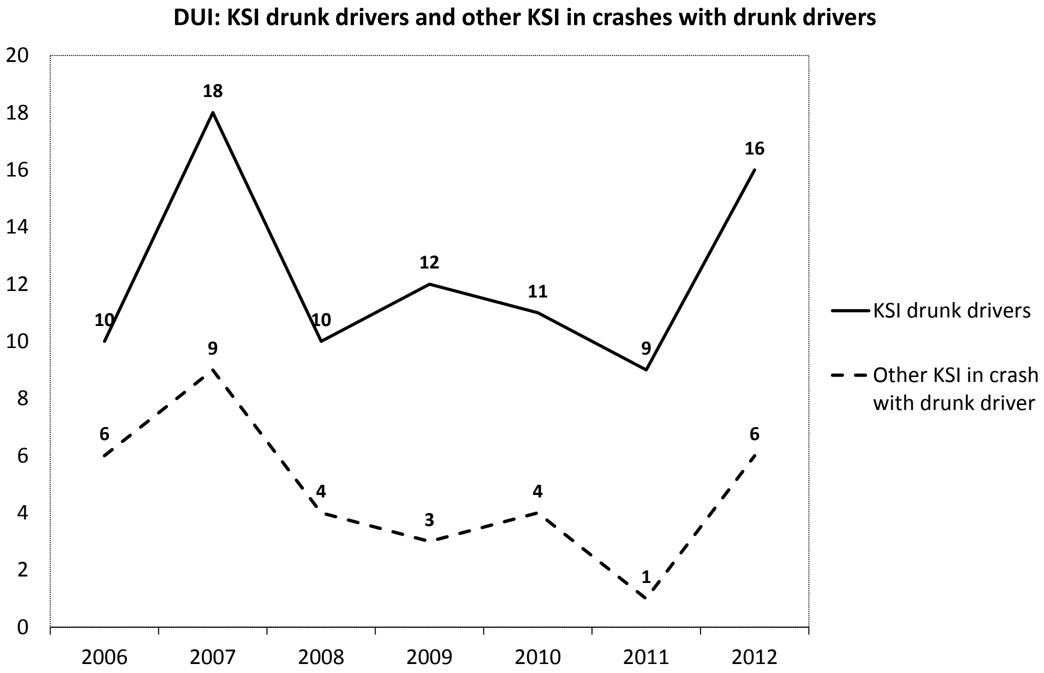

Figure 5.9.1: KSI drunk drivers and other KSI in crashes with a drunk driver.

Predicted development from 2006-2009 to 2020

- *Baseline scenarios*

The numbers of KSI in crashes in which a drunk driver was involved, together with the estimated trends in the baseline scenarios A (status quo), B (motorized) and C (non-motorized), are shown in figure 5.9.2. The estimated trend lines show the expected numbers of KSI if everything except exposure remains unchanged.

In order to attain the overall goal of a 40% reduction of the number of KSI in 2020, the number of KSI in the target group for the DUI indicator would have to be reduced from 18 to 10.8. In 2011 the number of KSI in crashes involving a drunk driver was 10. There is however large variation from year to year.

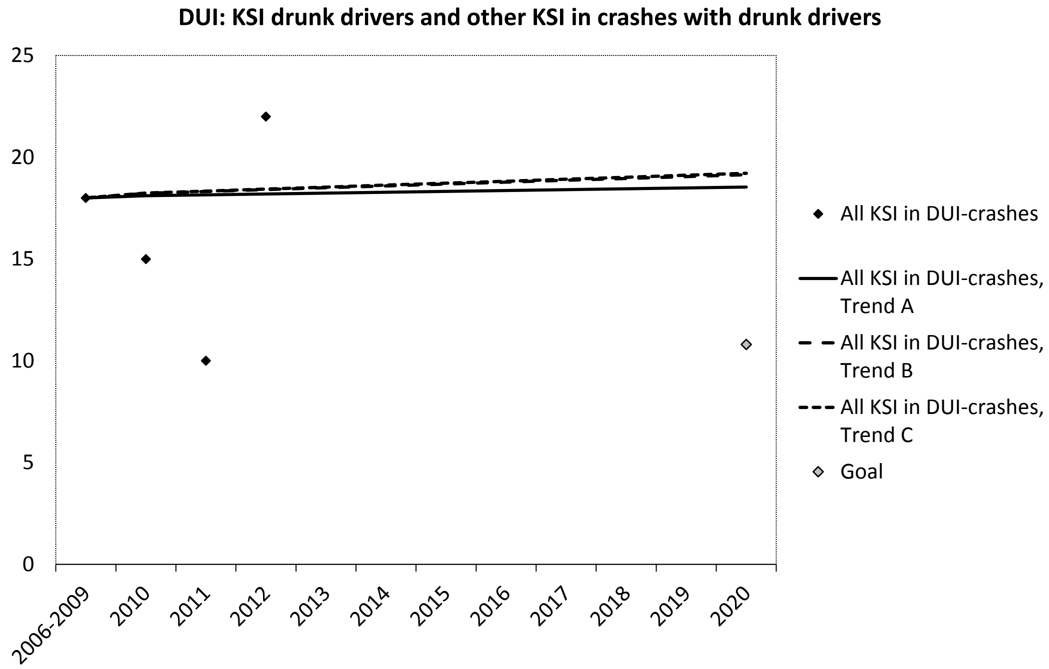

Figure 5.9.2: KSI cyclists: Actual numbers and estimated trends.

- ***Baseline scenarios and changes of the DUI indicator***

In order to estimate changes of the number of KSI in the target group for the DUI indicator, the following scenarios were defined for changes of the indicator:

- ***Min-linear trend:*** The proportion of drunk drivers in 2006-2009 was as estimated by Trafikverket (2012A), i.e. 99.65% and follows the estimated linear trend until 2020 as described in section 5.9.2
- ***Max-linear trend:*** The proportion of drunk drivers in 2006-2009 was as estimated by Trafikkontoret (2010), i.e. 99.75% and follows the estimated linear trend until 2020 as described in section 5.9.2
- ***Min-goal attainment:*** The proportion of drunk drivers in 2006-2009 was as estimated by Trafikverket (2012A), i.e. 99.65%, and will be 99.90% in 2020 (goal attainment)
- ***Max-goal attainment:*** The proportion of drunk drivers in 2006-2009 was as estimated by Trafikkontoret (2010), i.e. 99.75%, and will be 99.90% in 2020 (goal attainment)

The effect of increasing proportions of sober drivers are calculated based on the assumption that the number of KSI in crashes involving drunk drivers would be reduced by 80% if all drivers were sober. This is based on the assumption that drunk drivers have five times the risk a sober driver of being involved in a serious crash. Thus, not all crashes involving drunk drivers will be avoided (even if the crashes no longer will be crashes involving drunk drivers).

Table 5.9.2 summarizes the estimated changes of the number of KSI in the target group for the DUI indicator until 2020. In 2006-2009, the average number of KSI in this group was 18.

Table 5.9.2: Estimated changes of the number of KSI in the target group for the DUI indicator in 2020 (KSI in crashes involving a drunk driver).

Scenario	Trend[1]	Indicator Status 2020	Effect	Total change %	N
A Status quo	3.0 %	**Min - linear trend**	-8.6 %	**-6 %**	**-1.1**
	3.0 %	**Max - linear trend**	-15.2 %	**-13 %**	**-2.3**
	3.0 %	**Min - goal attainment**	-46.3 %	**-45 %**	**-8.0**
	3.0 %	**Max - goal attainment**	-35.8 %	**-34 %**	**-6.1**
B Motorized	6.3 %	**Min - linear trend**	-8.6 %	**-3 %**	**-0.5**
	6.3 %	**Max - linear trend**	-15.2 %	**-10 %**	**-1.8**
	6.3 %	**Min - goal attainment**	-46.3 %	**-43 %**	**-7.7**
	6.3 %	**Max - goal attainment**	-35.8 %	**-32 %**	**-5.7**
C Non-motorized	6.7 %	**Min - linear trend**	-8.6 %	**-2 %**	**-0.4**
	6.7 %	**Max - linear trend**	-15.2 %	**-9 %**	**-1.7**
	6.7 %	**Min - goal attainment**	-46.3 %	**-43 %**	**-7.7**
	6.7 %	**Max - goal attainment**	-35.8 %	**-31 %**	**-5.7**

[1] Estimated change of the number of KSI in target group if everything except exposure remains unchanged on the level of 2006-2009.

The results in table 5.9.2 indicate that the goal of reducing the number of KSI by 40% is likely to be achieved in the target group for the DUI indicator if the goal for the DUI indicator is achieved, independent of the assumed scenario for changes of traffic volumes. If the current trend continues, the goal is not likely to be achieved, even if the number of KSI probably will decrease.

The results are to a large degree depending on the assumed difference of the risk of being involved in a serious crash between drunk and sober drivers. It is assumed that an average drunk driver has five times the risk of a sober driver. If they have only twice the risk or less, the expected reductions of the numbers of KSI at goal attainment will no longer be above 40%.

However, in order to achieve the goal for the DUI indicator, effective measures against drunk driving would have to be implemented. Current measures and plans are most likely not sufficient to achieve considerable reductions of the amount of drunk driving.

In summary, if the goal for the DUI indicator is achieved, the goal of a 40% reduction of the number of KSI will be achieved as well in the target group for the DUI indicator. There are however currently no indications that the goal for the DUI indicator is likely to be met, unless more effective measures are implemented.

6 Summary and conclusions

6.1 Summary of scenarios

In order to estimate possible effects of changes of the indicators several scenarios were calculated for each indicator. The results for all scenarios are summarized in table 6.1.1 for all road users and in table 6.1.2 for pedestrians / cyclists and motor vehicle occupants separately. The tables show the estimated effects on the number of KSI in Stockholms stad in different scenarios for expected changes of traffic volumes, changes of the indicators, including additional effects of supplementary measures, and external effects.

Traffic volume scenarios: Traffic volumes are assumed to develop according to one of the following scenarios:

- ***Unchanged traffic volumes:*** Traffic volumes remain unchanged on the level of 2006-2009. This scenario is not realistic and therefore not included in the scenario calculations for the indicators in chapter 5. It is included in the summaries in tables 6.1.1 and 6.1.2 in order to show the isolated effects of changes of the indicators
- ***A Status quo:*** Moderate increases for all road user groups are assumed, +1.1% for motorized traffic and +22.3% for pedestrians and cyclists
- ***B Motorized:*** Moderate increases are assumed for pedestrians and cyclists (+22.3% as in scenario A) and a larger increase than in scenario A is assumed for motorized traffic (+5.1%)
- ***C Non-motorized:*** Larger increases as in A are assumed for all road users (+5.1% for motor vehicles and +64% for pedestrians and cyclists)

Indicator changes: Four scenarios are selected for changes of the indicators

- ***Goal attainment:*** The goals for all indicators are achieved in 2020
- ***Partial goal attainment:*** The goals for all indicators are partly achieved in 2020; partial goal attainment is defined differently for each indicator, depending amongst other things on the current trend and on measures that are planned to be implemented until 2020
- ***Unchanged indicators:*** All indicators remain unchanged on the level of 2006-2009
- ***Likely changes:*** Under likely changes the effects of the most likely changes of each indicator are calculated, including effects of additional measures that affect the same type of KSI as the indicators but not the indicator itself. The indicator changes that are regarded as the most likely ones are as follows:
    - *Speed:* Partial goal attainment (the current linear trend continues) and additional measures (reduced speed limits according to "Rätt fart i staden")

- *Safe main roads:* Partial goal attainment (the number of safe GCM-passages increases according to the current road safety plans) and additional measures (according to the mobility strategy and bicycle plan)
- *M&M:* Partial goal attainment
- *Safe local roads:* Partial goal attainment (the number of safe GCM-passages increases according to the current road safety plans) and additional measures (according to the mobility strategy and bicycle plan)
- *Bicycle helmet wearing:* Goal attainment
- *DUI:* The proportion of sober drivers is as estimated in 2006-2009 according to Trafikkontoret (2010), i.e. 99.75% (max. estimate), and the current linear trend continues

For the indicators speed, safe main roads and safe local roads possible effects of ***additional measures*** were calculated. These additional measures are likely to be implemented and likely to affect those KSI that are affected by these indicators, but not directly related to the indicators. Effects of additional measures are not included in the effects that are calculated for goal attainment, partial goal attainment and unchanged indicators.

External effects: As in Sørensen et al. (2009) external effects of -10%, -20% and -30% are assumed as possible scenarios; external effects are effects of measures that are not covered by the indicators and other changes that contribute to a reduction of the number of KSI. For example improved vehicle safety is likely to contribute to a reduction of KSI, also among pedestrians and cyclists.

In order to achieve the goal of a 40% reduction of the number of police reported KSI in Stockholms stad the number of KSI would have to be reduced

- From 278 ***by 111*** to 167 for all road users
- From 111 ***by 44*** to 67 for pedestrians and cyclists
- From 167 ***by 67*** to 100 for motor vehicle occupants

All scenarios in which the goal of a 40% reduction of the number of KSI is achieved are highlighted in green, scenarios in which a 40% reduction may be achieved with all additional effects are highlighted in light green. Increasing numbers of KSI are highlighted with red text.

As can be seen in table 6.1.1, the goal of a 40% reduction of the number of KSI may be achieved

- When the goals for all indicators are achieved and when there are external effects of at least -10% (at least -20% in scenario C which predicts a larger increase of pedestrian and bicycle volumes)
- When the goals for all indicators are partly achieved and when there are external effects of at least -30% and / or effects of additional measures
- In the scenario "Likely changes" only when there are considerable external effects of at least -30%, except in the traffic volumes scenario C that assumes larger increases of pedestrian and bicycle volumes.

The results for pedestrians / cyclists and motor vehicle occupants in table 6.1.2 show about the same picture. For pedestrians and cyclists a 40% reduction of the number of KSI seems somewhat more unlikely than for motor vehicle occupants and there are more scenarios that predict an increase of the number of KSI pedestrians and cyclists. The main reason for the less favorable predicted development for pedestrians and cyclists is the likely increase of the road user groups.

Table 6.1.1: Summary of scenarios, estimated changes of the numbers of KSI in Stockholms stad (police reported) for all road users (green: 40% reduction of KSI achieved; light green: reduction of KSI achieved with all additional effects; red text: increase of KSI).

	All (N = 278 in 2006-2009)							
Indicator:	**Goal attained[1]**		**Partial goal att.[1]**		**No goal attainment[1, 2]**		**Likely changes[3]**	
External eff.	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**
Unchanged traffic volumes								
None	**-45 %**	**-124.5**	**-24 %**	**-66.5**	**-3 %**	**-7.6**	**-31 %**	**-87.2**
-10 %	-50 %	-139.8	-32 %	-87.7	-12 %	-34.7	-38 %	-106.3
-20 %	-56 %	-155.2	-39 %	-108.8	-22 %	-61.7	-45 %	-125.4
-30 %	-61 %	-170.5	-47 %	-130.0	-32 %	-88.8	-52 %	-144.4
Increased traffic volumes scenario A (Status quo)								
None	**-39 %**	**-107.7**	**-14 %**	**-40.1**	**10 %**	**28.3**	**-23 %**	**-64.2**
-10 %	-45 %	-124.7	-23 %	-63.9	-1 %	-2.3	-31 %	-85.6
-20 %	-51 %	-141.7	-32 %	-87.7	-12 %	-33.0	-38 %	-107.0
-30 %	-57 %	-158.8	-40 %	-111.5	-23 %	-63.6	-46 %	-128.3
Increased traffic volumes scenario B (Motorized)								
None	**-36 %**	**-99.2**	**-10 %**	**-28.0**	**16 %**	**44.2**	**-19 %**	**-53.3**
-10 %	-42 %	-117.0	-19 %	-53.0	4 %	11.9	-27 %	-75.8
-20 %	-49 %	-134.9	-28 %	-78.0	-7 %	-20.3	-35 %	-98.3
-30 %	-55 %	-152.8	-37 %	-103.0	-19 %	-52.5	-43 %	-120.7
Increased traffic volumes scenario C (Non-motorized)								
None	**-28 %**	**-77.3**	**3 %**	**8.4**	**34 %**	**95.0**	**-8 %**	**-22.1**
-10 %	-35 %	-97.4	-7 %	-20.2	21 %	57.7	-17 %	-47.7
-20 %	-42 %	-117.4	-18 %	-48.8	7 %	20.4	-26 %	-73.3
-30 %	-49 %	-137.5	-28 %	-77.5	-6 %	-16.9	-36 %	-98.9

[1]Without additional effects; additional effects may contribute to an additional reduction of the number of KSI by about 28.5.
[2]All indicators are unchanged, except DUI and seat belt use for which the minimum expected changes are assumed
[3]Likely changes of the indicators (see text), including effects of additional measures.

Table 6.1.2: Summary of scenarios, estimated changes of the numbers of KSI in Stockholms stad (police reported) for pedestrians / cyclists and motor vehicle occupants (green: 40% reduction of KSI achieved; light green: reduction of KSI achieved with all additional effects; red text: increase of KSI).

	Pedestrians / cyclists (N = 111 in 2006-2009)								Motor vehicle occupants (N = 167 in 2006-2009)							
	Goal attained		Partial goal att.		Unchanged ind.		Likely changes		Goal attained		Partial goal att.		Unchanged ind.		Likely changes	
	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Unchanged traffic volumes																
None	**-51 %**	**-57.0**	**-26 %**	**-28.5**	**0 %**	**-0.2**	-35 %	-38.5	**-40 %**	**-67.5**	**-23 %**	**-38.0**	**-4 %**	**-7.5**	-29 %	-48.7
-10 %	-56 %	-62.4	-33 %	-36.8	-10 %	-11.3	-41 %	-45.7	-46 %	-77.4	-30 %	-50.9	-14 %	-23.4	-36 %	-60.6
-20 %	-61 %	-67.8	-41 %	-45.0	-20 %	-22.3	-48 %	-53.0	-52 %	-87.4	-38 %	-63.8	-24 %	-39.4	-43 %	-72.4
-30 %	-66 %	-73.2	-48 %	-53.3	-30 %	-33.4	-54 %	-60.2	-58 %	-97.3	-46 %	-76.7	-33 %	-55.3	-50 %	-84.2
Increased traffic volumes scenario A (Status quo)																
None	**-40 %**	**-44.9**	**-8 %**	**-8.6**	**25 %**	**27.4**	-19 %	-21.3	**-38 %**	**-62.7**	**-19 %**	**-31.5**	**1 %**	**0.9**	-26 %	-42.9
-10 %	-46 %	-51.5	-17 %	-18.9	12 %	13.6	-27 %	-30.3	-44 %	-73.1	-27 %	-45.0	-10 %	-15.9	-33 %	-55.3
-20 %	-52 %	-58.1	-26 %	-29.1	0 %	-0.3	-35 %	-39.3	-50 %	-83.6	-35 %	-58.6	-20 %	-32.7	-41 %	-67.7
-30 %	-58 %	-64.8	-35 %	-39.3	-13 %	-14.1	-43 %	-48.2	-56 %	-94.0	-43 %	-72.1	-30 %	-49.5	-48 %	-80.1
Increased traffic volumes scenario B (Motorized)																
None	**-38 %**	**-42.7**	**-4 %**	**-5.0**	**29 %**	**32.5**	-16 %	-18.2	**-34 %**	**-56.4**	**-14 %**	**-23.0**	**7 %**	**11.6**	-21 %	-35.1
-10 %	-45 %	-49.6	-14 %	-15.6	16 %	18.2	-25 %	-27.5	-40 %	-67.5	-22 %	-37.4	-4 %	-6.2	-29 %	-48.3
-20 %	-51 %	-56.4	-24 %	-26.2	3 %	3.8	-33 %	-36.8	-47 %	-78.5	-31 %	-51.8	-14 %	-24.1	-37 %	-61.5
-30 %	-57 %	-63.2	-33 %	-36.8	-9 %	-10.5	-41 %	-46.1	-54 %	-89.6	-40 %	-66.2	-25 %	-42.0	-45 %	-74.7
Increased traffic volumes scenario C (Non-motorized)																
None	**-19 %**	**-21.3**	**28 %**	**30.7**	**74 %**	**82.3**	11 %	12.5	**-34 %**	**-56.0**	**-13 %**	**-22.3**	**8 %**	**12.7**	-21 %	-34.5
-10 %	-27 %	-30.3	15 %	16.5	57 %	63.0	0 %	0.1	-40 %	-67.1	-22 %	-36.7	-3 %	-5.3	-29 %	-47.8
-20 %	-35 %	-39.2	2 %	2.4	39 %	43.7	-11 %	-12.2	-47 %	-78.2	-31 %	-51.2	-14 %	-23.3	-37 %	-61.0
-30 %	-43 %	-48.2	-11 %	-11.8	22 %	24.3	-22 %	-24.6	-53 %	-89.3	-39 %	-65.7	-25 %	-41.2	-44 %	-74.3

6.2 Other factors that affect the number of KSI

Several factors that are not part of the road safety program may affect the development of the number of KSI, favorably or unfavorably. Some examples that are described below are:

- Improved vehicle safety
- Road safety in Sweden, including the national road safety program in Sweden
- Economic development
- High risk groups

Among these, improved vehicle safety and the development of road safety in general in Sweden indicate that there may be a general downward trend of the number of KSI in Stockholms stad that continues until (at least) 2020. Other factors that may contribute to the number of KSI in Stockholms stad are

- Life styles and attitudes
- Measures that are part of Trafiksatsning Stockholm
- The mobility program for Stockholm

Unfortunately, for most of these measures it is hardly possible to make reliable predictions about how they will develop. The mobility program is as far as possible taken into account in the descriptions of the road safety indicators.

Improved vehicle safety

The most important factor that may contribute to road safety in Stockholms stad, besides the indicators, may be improving vehicle safety. Improved vehicle safety contributes to a reduction of the number of KSI car occupants and provides also better protection for pedestrians (and possibly cyclists) in collisions with cars. In Norway it has been estimated that improved vehicle safety has contributed to about 10% of the reduction of the number of KSI in the years 2000 to 2012 (Høye et al., 2014b). Improving vehicle safety is also likely to contribute to a reduction of the number of KSI in Stockholms stad as en “external factor”.

Road safety in Sweden

The number of KSI in the whole country has almost continuously decreased in the whole period 2006-2012 as is shown in figure 6.2.1.

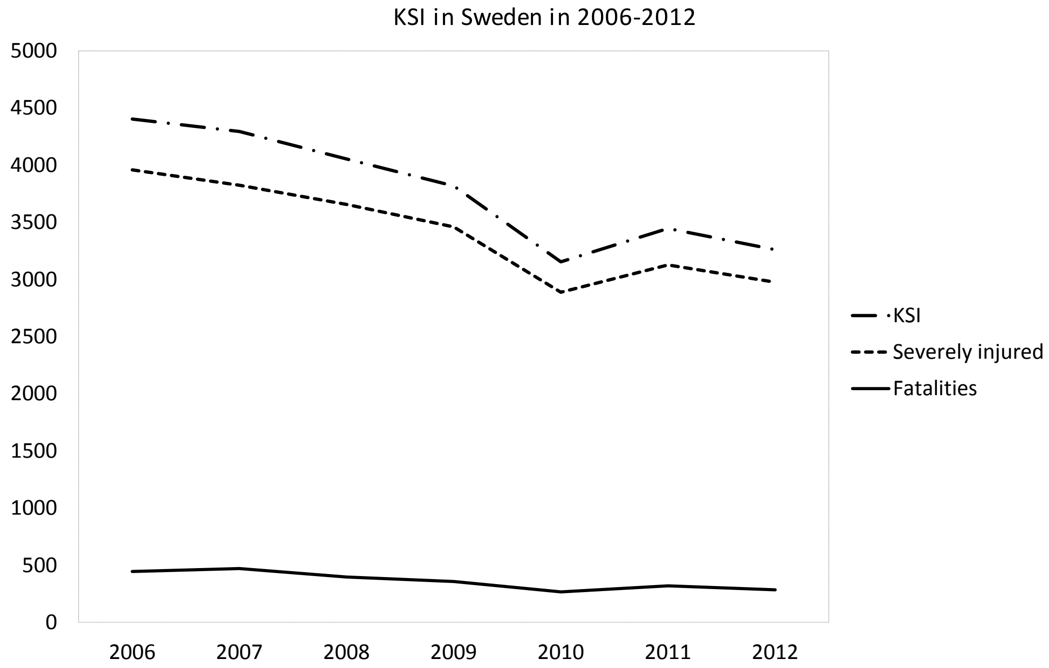

Figure 6.2.1: Numbers of fatalities, serious injuries and total number of KSI in Sweden in 2006-2012 (www.trafa.se).

According to Kolbenstvedt et al. (2007) and Elvik et al. (2009b) the number of KSI since has been decreasing since 1970. Factors that have contributed to the decrease are

- Safety measures with measurable effects (44% of the decrease)
- Other general developments such as changes of the numbers of young drivers (6% of the decrease)
- Random variation of the number of fatalities (7% of the decrease)
- Unknown factors (safety measures and other factors (42% of the decrease)

The analyses made by Kolbenstvedt et al. (2007) and Elvik et al. (2009b) show how difficult it is to explain an observed development. The fact that road safety in Sweden has continued to improve also after 2009 supports the assumption that the observed increase of the number of KSI in Stockholm after 2009 is mainly due to random variation. The general downward trend of the number of KSI that was observed until 2009 is therefore not unlikely to continue.

Economic development

The development of the economy in Stockholm is shown in figure 6.2.2 in terms of the proportion of unemployed in the population between 15 and 74 years and in figure 6.2.3 based on information from Stockholms stad (2013) about the total number of unemployed and the population age 16 to 64 years. Compared to 2008 and 2009, unemployment in 2010-2012 had about doubled according to figure 6.2.2. According to figure 6.2.3, unemployment was quite constant in 2009-2011, but about 1.5 times as high in these years as it was in 2008.

Increasing unemployment is for the most part related to decreasing numbers of KSI in road traffic (Høye et al., 2014b). Although somewhat inconsistent, the information that is summarized in figures 6.2.2 and 6.2.3 does not indicate that the economic development can have contributed to the increasing numbers of KSI in 2010-2012 as compared to 2006-2009. A prediction for future years is not possible based on these figures.

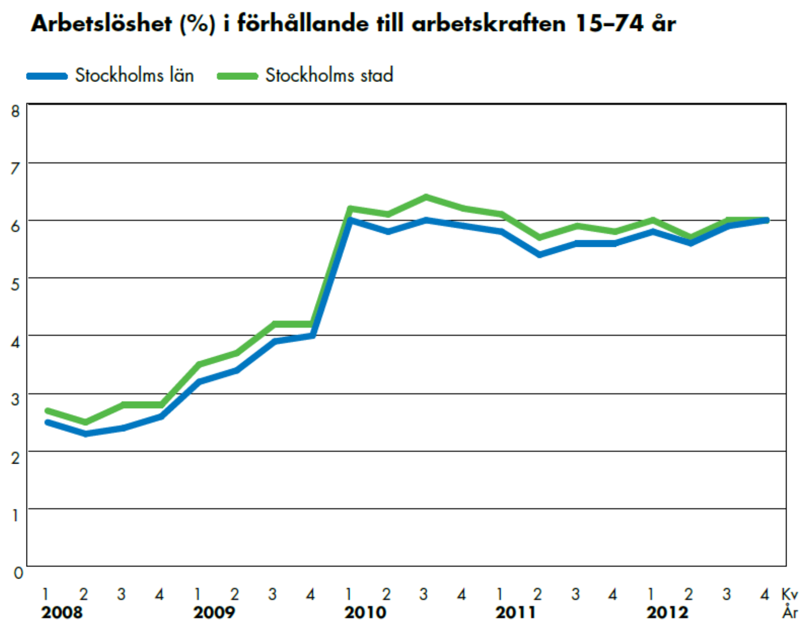

Figure 6.2.2: Unemployment in Stockholm (http://www.stockholmbusinessregion.se).

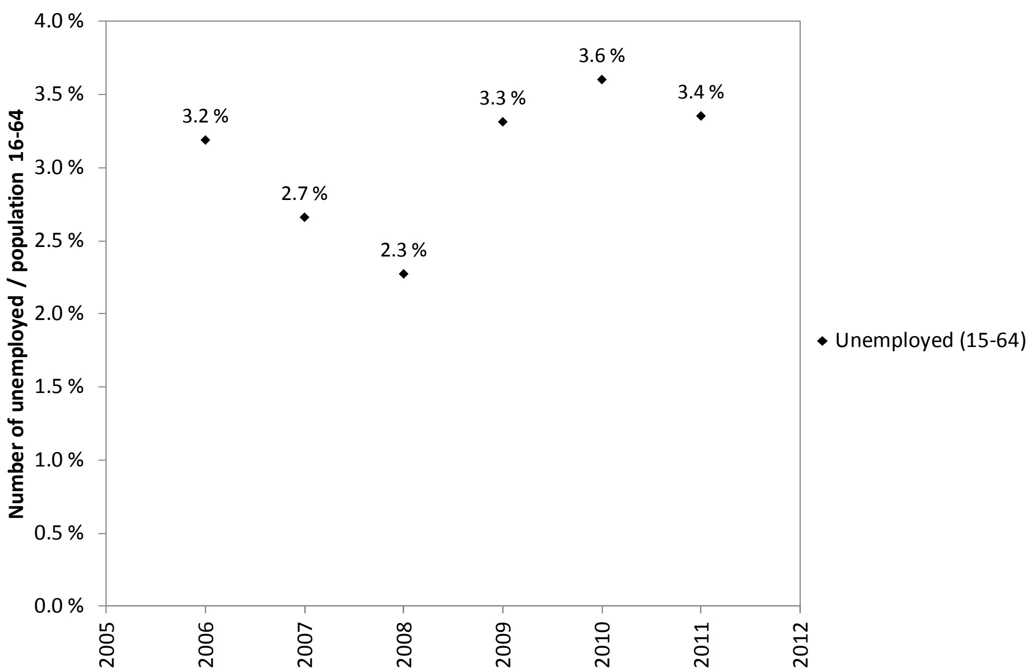

Figure 6.2.3: Unemployment in Stockholm (Stockholms stad, 2013): Number of unemployed divided by population age 16-64 years.

High risk groups

The development of the proportions of the population in some high risk groups is shown in figure 6.2.4:

- Older people (80+ years) have higher risk both as pedestrians and as car drivers (exposure is however usually decreasing with increasing age)
- Young drivers (especially young men) have far higher crash risk than most other road user groups
- Immigrants (Nordbakke & Assum, 2008) have also higher crash risk than other road users

There is no great change in the proportions of any of these high risk groups. The high risk groups increase at about the same pace as the population in general. In sum the proportion of high risk groups is expected to remain almost unchanged until 2020. Thus, no considerable contribution to the development of the number of KSI can be expected. However, information about proportions of the high risk groups with driving license is not available and if the proportion with a driving license in any of these groups increases (or decreases), this may negatively (or positively) contribute to the development of the number of KSI.

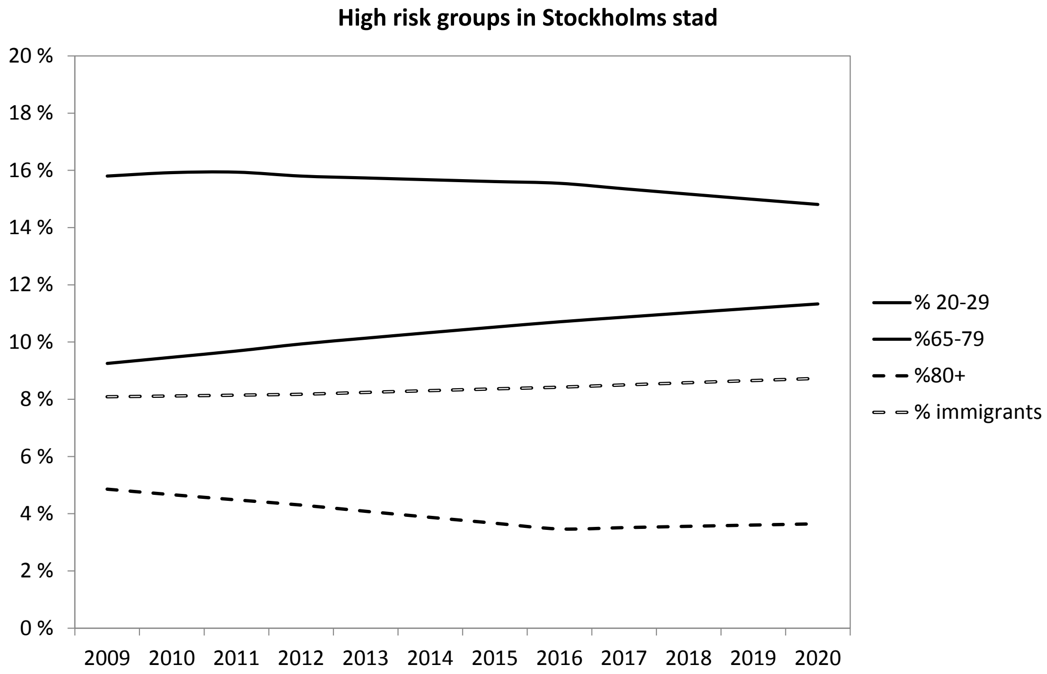

Figure 6.2.4: proportions of the population in some high risk groups (Stokcholms stad, 2013).

6.3 Conclusions

The following sections provide answers to the questions that were asked in chapter 1 about the present development of the indicators and the number of KSI in Stockholms stad, whether reporting from hospitals affects official crash statistics, how likely the goals for the indicators are to be attained, if any adjustments should be made to indicators (especially M&M), goal levels or priorities, and if current road safety plans and planned measures are sufficient to attain the overall goal of a 40% reduction of the number of KSI in Stockholms stad until 2020.

6.3.1 Present development

The present development of the numbers of KSI in Stockholms stad does not seem to be in the right direction. The total number of KSI has increased each year after 2009, especially among pedestrians and cyclists. A trend line for the numbers of KSI since 2000 does no longer indicate that the goal of a 40% reduction of the number of KSI will be met in 2020 if the trend continues (the trend from 2000-2009 did indicate that the goal would be met). However, the observed increase does not necessarily indicate that the long-term downward trend has reversed:

- In the whole country, the number of KSI has continued to decrease also after 2009
- The population based risk (number of KSI per 100,000 population) has remained about unchanged in Stockholms stad
- The increase of the number of KSI among pedestrians and cyclists in Stockholms stad may partly be due to increased focus of the police on specific crash types
- There were no negative developments of any of the indicators that might have contributed to an increase of the number of KSI; the only factor that may explain increasing number of KSI among pedestrians and cyclists is the increase of the numbers of pedestrians and cyclists and the resulting capacity problems

The expected developments of the indicators are summarized in table 6.3.1. Table 6.3.1 show for each of the indicators the status in 2006-2009, the general present development, the expected status in 2020 and the goal. The expected status in 2020 is the status of the indicator in 2020 if the present development continues, or if all planned measures are implemented. For the expected status in 2020 and for the goal the expected effects on the number of KSI are stated additionally. The expected effects on the number of KSI refer only to the *target group of each indicator* as specified in the leftmost column (*not* to the total number of KSI).

Table 6.3.1 show that the ***goals for most indicators most likely will not be attained*** in 2020 if the present trend continues and that even at goal attainment, the expected reductions of the numbers of KSI in the target groups for the indicators for the most part are well below 40%.

- For the ***speed*** indicator, the development is probably in the right direction, but the goal is at present not likely to be achieved without considerable additional efforts. However, available information is far from sufficient for making reliable estimates of the development until 2020. Moreover, the estimated changes of KSI in the target group are uncertain because they depend on the estimated changes of mean speed. The relationship between mean speed and the proportion driving at or below the speed limit could only be roughly estimated. Somewhat paradoxically, reduced speed limits (that are likely to be implemented) will affect the indicator unfavorably, even if they will contribute to reducing the number of KSI in the target group for the indicator.
- For the indicators ***safe main roads*** and ***safe local roads***, the present development is in the right direction as well, but far from sufficient to attain the goals. Even if it is assumed that those GCM-passages and junctions with most traffic and safety problems will be improved first, the likely effects on the number of KSI seem small. The empirical basis for estimating effects on the number of KSI in 2020 is however insufficient. Safe main roads include possible effects of measures at schools.
- For ***M&M*** it is difficult to estimate the likely development and effects on KSI because the status of the indicator in the present situation is not known. The empirical basis for estimating development until 2020 and effects on KSI is consequently insufficient.
- Only for the indicators ***seat belt use and bicycle helmet wearing*** the goals for the indicators will be attained if the present development continues. For the ***DUI*** indicator the trend is in the right direction but not quite sufficient to attain the goal. The expected effect on the number of KSI in the target groups for these indicators are however only small (bicycle helmet and seat belt wearing) and / or uncertain (DUI, seat belt wearing). For seat belt wearing the estimated effects on KSI depend on the assumed relative risk for serious crashes among those not wearing a seat belt in 2006-2009. For DUI, the estimates are uncertain mainly because there is contradicting information about the status in 2006-2009 from different sources. There is additional uncertainty in the estimates for seat belt wearing and DUI because of the general inclination of drunk drivers and drivers without a seat belt to high-risk behavior and involvement in serious crashes.
- For ***increased knowledge*** and ***heavy vehicles***, the indicators and goals are defined only imprecisely and no information is available about the development of a heavy vehicle strategy or a measurement and analysis plan. Consequently, no effects on the number of KSI in the target groups for these indicators in 2020 could be estimated.

The results from the aggregated calculations for all indicators that are summarized in section 6.1 show that the goal of a 40% reduction of the annual numbers of KSI in Stockholms stad until 2020 may be attained if the goals for all indicators are attained, and otherwise only if there are considerable effects of factors that are not covered by the indicators.

Table 6.3.1: Expected developments of the indicators.

	Status 2006-2009	Status in 2012	Expected in 2020[1]	Goal[2]
Speed				
▪ ***Proportion of vehicles driving at or below speed limit***	**50%**	**74%**	**83%** (-14% KSI)	**98%** (-28% KSI)
Target group: KSI in crashes involving a motor vehicle				
Safe main roads				
▪ ***Proportion of safe GCM-passages***	**18%**	**19%**	**22%** (-10% KSI)	**80%** (-17% KSI)
Target group: Pedestrians and cyclists in motor vehicle crashes at GCM-passages				
▪ ***Proportion of safe junctions***	**51%**	**52%**	**62%** (-0.8% KSI)	**80%** (-1.3% KSI)
Target group: KSI in crashes at junctions				
Increased knowledge about road safety				
▪ ***Measurement and analysis plan***	**None**	**None**	**?**	**Existence of a plan**
Target group: All KSI				
Management & Maintenance (M&M)				
▪ ***Standard of M&M on bicycle tracks***	**?**	**?**	**Opt. on main netw.** (-8.7% KSI)	**Opt. on whole netw.** (-29% KSI)
Target group: KSI cyclists in single crashes				
▪ ***Standard of M&M on pedestrian facilities***	**?**	**?**	**Opt. for 50% of ped.** (-14.5% KSI[3])	**Opt. for all pedestrians** (-29% KSI[3])
Target group: KSI pedestrians in falls				
▪ ***Standard of M&M on roads***	**?**	**?**	(KSI unchanged)	(KSI unchanged)
Target group: KSI motor vehicle occupants in single crash				
Heavy vehicles				
▪ ***Heavy vehicle strategy***	**None**	**None**	**?**	**Existence of a strategy**
Target group: KSI in crashes with a heavy vehicle				
Safe local roads				
▪ ***Proportion of safe pedestrian / bicycle crossings***	**16.7%**	**17.1%**	**19%** (-11% KSI)	**75%** (-32% KSI)
Target group: KSI pedestrians and cyclists in crashes involving a motor vehicle at GCM-passages on local roads				
Seat belt use				
▪ ***Front seat occupants in passenger cars using seat belt***	**90.1%**	**97.1%**	**98-99%** (-6 - -11% KSI)	**98%** (-6 - -10% KSI)
Target group: Adult KSI front seat occ. in cars				
Bicycle helmet use				
▪ ***Proportion of all cyclists wearing a helmet***	**56%**	**71%**	**92%%** (-1.3% KSI)	**80%** (-1.0% KSI)
Target group: KSI cyclists				
Driving under the influence of alcohol (DUI)				
▪ ***Proportion of sober drivers (BAC < .20)***	**99.56% or 99.76%**	**99.59% or 99.78%**	**99.63% or 99.82%** (-9%/-15%)	**99.90%** (-36/-46% KSI)
Target group: KSI in crashes with a motor vehicle				

[1] Expected status of the indicator in 2020 if present trend continues / if planned measures are implemented (bold) and expected change of the number of KSI in 2020 in the target group for the indicator if the indicator is as expected (in parentheses).

[2] Status of the indicator in 2020 at goal attainment (bold) and expected change of the number of KSI in 2020 in the target group if the goal for the indicator is attained (in parentheses).

[3] Refers to hospital reported KSI pedestrians.

6.3.2 The goal and hospital reported injury data

One of the questions to be answered is whether the goal should be revised in order to take into account hospital-reported injury statistics. Current official crash statistics contain only police reported crashes and are most likely not affected by the increased reporting of hospital data. Thus, hospital reported injury data need not be taken into account in interpreting results from official crash statistics.

If hospital reported injury data should be taken into account, it would be a problem that the number of reporting hospitals has increased considerably, especially from 2006 to 2010. Thus, the base of comparison (hospital reported crashes in 2006-2009) would not be adequate.

6.3.3 Road safety indicators and sub-goals

Ideally, the present indicators and sub-goals should be sufficient in order to achieve the main goal of a reduction of the annual number of KSI by 40%. As can be seen in table 6.3.1 in section 6.3.1, none of the indicators is likely to reduce the number of KSI in the target group for the indicator by 40% (except possibly the DUI indicator under the most optimistic assumptions). For the most part, the expected reductions of KSI are far below 40%. The combined effects of goal attainment for all indicators is likely to be a 45% reduction of KSI at unchanged traffic volumes (which is however not realistic) and a 39% reduction if traffic volumes increase moderately (scenario A). The reductions of the number of KSI will be smaller at larger volumes increased (-28% if pedestrian and bicycle volumes increase more than moderately).

Thus, if all goals for all indicators are attained, the overall goal may be (almost) attained if traffic volumes increase only moderately. The level of the goals seems therefore, overall, sufficiently ambitious. If the goals also are realistic (the likelihood of goal attainment) is discussed in more detail in section 6.3.6.

Some of the indicators might however benefit from revised (extended) definitions:

- ***Speed:*** A general problem with the speed indicator is that only the relationship between mean speed and KSI is well known, while the relationship of the proportion driving at or below the speed limit with both KSI and mean speed are not well known. Theoretically, the proportion driving at or below the speed limit may increase while mean speed remains unchanged. Moreover, reduced speed limits will affect the indicator unfavorably, even if they will contribute to reducing the number of KSI. Reduced speed limits are at present not covered by any of the indicators. The following suggestion is therefore made:

  The speed indicator should be supplemented by a goal for reduced speed limits. The revised goal might then be:

  "The proportion of all vehicles driving at or below the speed limit should not be below 98% and all roads should have reasonable speed limits".

A precise definition for reasonable speed limits would have to be elaborated in "Rätt fart i staden", according to the criterion that vehicles driving at or below the speed limit will not inflict disabling injury to any road users they may come into conflict with.

- ***Safe main and local roads:*** The definitions of safe main and local roads are quite narrow. This was a deliberate decision, the narrow definitions should make it feasible to identify and count safe junctions / GCM-passages. However, a number of measures that affect the safety of bicycles and pedestrians will not be covered by any of the indicators, even if they would favorably affect the number of KSI in the target groups for these two indicators. The following suggestion is therefore made:

  The safe main and local roads indicators should be supplemented with a goal for dedicated pedestrian and bicycle facilities. The revised goal might then be:

  "The proportion of safe junctions and GCM-passages should be at least 80% (75% on local roads),

  the proportion of the commuting and main bicycle network with dedicated bicycle facilities and sufficient capacity should be at least 90% and

  walkability audits should reveal safety deficits on no more than 5% of the pedestrian infrastructure."

- ***Increased knowledge about road safety:*** This indicator is at present not precisely defined and cannot be linked to any specific safety problem. It only specified that there should be a measurement and analysis plan in order to ensure a systematic review of the development of road safety in Stockholm, and a communication plan that ensures continuous dissemination of relevant information about road safety. A suggestion for a more precise definition is as follows:

  "A systematic review of the development of road safety in Stockholm should be conducted (with a more specific description of how and how often,

  all those responsible for measures that (directly or indirectly) affect road safety should be involved in the reviews and

  there should be economic or other incentives to improve road safety."

- ***Management & maintenance:*** A precise definition of an "optimal standard" of management and maintenance is still lacking. A definition should be developed, and it is suggested that the definition includes spring cleaning in addition to winter maintenance.

- ***Heavy vehicles:*** The heavy vehicles indicator is still lacking a precise definition. Since a considerable number of KSI is injured or killed in crashes with heavy vehicles each year (about 30 per year on average, about one third of these at junctions or GCM-passages) the indicator has a potential to contribute significantly to reducing the numbers of KSI. A suggestion for a more precise definition of the heavy vehicles indicator and corresponding goal for 2020 is:

"The most important safety problems with heavy vehicles are identified and measures have been taken that address the most important crash contributing factors (factors contributing to at least 50% of all heavy vehicle crashes with KSI)."

- ***Seat belt use:*** The seat belt use indicator is likely to contribute to a decrease of the number of KSI. However, no measures were identified that are under the responsibility of the municipality of Stockholm that might increase seat belt use. Moreover, an increasing proportion of cars with seat belt reminders is likely to contribute to attaining the goal, and it is not likely that seat belt use may increase far beyond what is possible with seat belt reminders. Those who still do not use the seat belt even if the car has a seat belt reminder are not likely to start using the seat belt unless the car had a seat belt interlock. Consequently, the indicator might be either dropped (because the municipality has no influence on the development) or kept but ignored in the action plans (in order to take into account effects of increasing seat belt use in future scenario calculations).
- ***Bicycle helmet wearing:*** The bicycle helmet wearing indicator has about the same problems as the seat belt use indicator. There is little the municipality can do to influence the development and helmet use is likely to continue to increase. Moreover, the possible effects on the number of KSI are very limited. Consequently, the indicator might be dropped or kept but ignored in the action plans. A third possibility might be to focus more on bicycle helmet use among school children. Among children, bicycle helmets are likely to have a greater effect than among adults. Bicycle helmets are obligatory for cycling children under 15 years. A possible redefined goal might be:

  "The proportion of cyclists under 18 (or 15) years who are wearing a bicycle helmet should be at least 80%, and no school children shall refrain from cycling because they do not have or do not want to wear a bicycle helmet."
- ***DUI:*** As for seat belt use and bicycle helmet wearing, there is little the municipality can do to increase the proportion of sober drivers. The proportion of sober drivers is already very high and the remaining drunk drivers have probably a generally high risk for being involved in serious crashes, in addition to being resistant against attempts to influence their behavior. Possible effects on the number of KSI are difficult to estimate (contradicting information about the status in 2006-2009 and uncertainty about the general crash risk among drunk drivers). Thus, the indicator might be either dropped, or kept but ignored in the action plans (see above under Seat belt use).

6.3.4 Goal level and priorities

According to the results for all indicators that are summarized in section 6.1 the goal of a 40% reduction of the number of KSI in 2020 is unlikely to be attained unless there are considerable external effects and a traffic growth that is no more than moderate. Goal attainment becomes more likely under the following conditions:

- The goals for all indicators, and especially for the speed and safe main roads indicators, are attained, which requires considerable additional efforts
- The speed, safe main roads and safe local roads indicators are supplemented as described in the previous section
- A heavy vehicles indicator and goal is developed (and set into action)
- An increased knowledge indicator and goal is developed (and set into action)
- Increasing bicycle and pedestrian volumes are met by an infrastructure with sufficient capacity (alternatively, it pedestrian and bicycle volumes do not increase, this is however not desirable)

Since the goal is not impossible to be attained, but requires considerable efforts, it can still be regarded as both ambitious and realistic. It is therefore not suggested to change the goal or priorities (other than those changes that are suggested in the previous section).

6.3.5 Management and maintenance (M&M)

The M&M indicator affects a considerable number of KSI pedestrians (those injured or killed in falls) that are not represented in official police reported crash statistics. The overall goal might therefore be extended to include KSI pedestrians in falls. The goal would remain the same, only the number of KSI in the present and goal situation would be adjusted from 278 to 278 + 66 = 344 in 2006-2009 and from 167 to 206 for the situation in which the goal is attained.

6.3.6 Road safety plans and measures

A number of measures are planned according to the road safety plans and according to the bicycle plan and mobility strategy. However, those measures that are currently planned to be implemented are not sufficient for attaining the goals for all indicators as has been discussed in the preceding sections. Specific plans that refer to the increased knowledge and heavy vehicles are still more or less absent.

The measures and plans that are described current road safety plans are only partly, and not explicitly, related to the road safety program and the nine indicators. The plans could improve the monitoring the progress towards goal attainment if each measure were directly related to one of the indicators (except measures that are not relevant to any of the indicators), and if an overview were provided for each indicator about the current status, the goal and the degree to which the planned measures will contribute to goal attainment.

As regards individual indicators, the greatest challenges at present are as follows:

- ***Speed:*** No measures are currently planned for increasing compliance with speed limits (except at junctions and GCM-passages, which are not directly relevant to the speed indicator); reductions of speed limits are planned, but at present not relevant to the indicator (it is suggested to extend the definition of the speed indicator to include speed limits; section 6.3.3).

- ***Safe main roads and safe local roads:*** A number of measures is planned, but not sufficient to attain the goal. Measures that improve pedestrian and bicycle infrastructure more generally are currently not part of the indicator (it is therefore suggested to extend the definition of the indicator; section 6.3.3).
- ***Increased knowledge:*** Planned measure are described only vaguely.
- ***Management and maintenance:*** There seem to be efforts to improve M&M; the greatest challenge seems to be a more precise definition of "optimal standard" and an overview of the actual standard.
- ***Heavy vehicles:*** Heavy vehicles are so far not mentioned in any of the road safety plans.
- ***Seat belt use:*** Seat belt use is so far not mentioned in the road safety plans. However, seat belt use is likely to increase and there is little the municipality can do to speed up the increase.
- ***Bicycle helmet wearing:*** As for seat belt use, bicycle helmets are not mentioned in the road safety plans and there is little the municipality can do to increase bicycle helmet wearing rates in general. However, among school children, targeted measures for increasing helmet wearing (along with bicycle promoting measures) might be implemented.
- ***DUI:*** Besides encouraging increased police enforcement, there is little the municipality can do to influence the amount of drunk driving and drunk driving is not mentioned in the road safety plans.

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