# CHALMERS

| SPEED | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Preparation | | | | Clinic | | | | Analysis | | | |
| Book | Install | Measure | Update | Drive | Measure | Photo | Ask | Compile | Compare | Conclude | Document |

# Exploring Drivers' Seated Position
*Method Development within Automotive Ergonomics*

Master of Science Thesis in the Master Degree Programs
Industrial Design Engineering and Product Development

NADJA LEJON

HENRIK THORSÉN

Master of Science Thesis

# Exploring Drivers' Seated Position
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Master of Science Thesis PPUX05

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# Foreword

Completing this master thesis has been a rewarding journey where many aspects of seated position for driving have been investigated. Numerous interviews have been held with interesting and kind people who have been generous with their time and knowledge. We have learned that there are many parameters that affect the seated position, and the new awareness now makes the adjustment of seat and steering wheel to a time consuming task whenever we are to drive.

We especially want to thank the Ergonomics department at Volvo Cars Corporation for all help and feedback along the project, and send a special thank you to the supervisors of the project; Magnus Jerksjö and Pernilla Nurbo. We would also like to thank the departments of Crash and Safety, Seat, Measuring and Equipment who have been of great support when developing the method. We would also like to thank Erik Kristiansson for guidance with statistics at the Statistics department at Chalmers University of Technology.

Last but not least we want to thank our examiner and supervisor from Chalmers, Lars-Ola Bligård, who has been a great support for the method development of SPEED.

Nadja Lejon and Henrik Thorsén, Göteborg, 27 May of 2013

# Abstract

The Master Thesis project "Exploring Drivers' Seated Position – Method Development within Automotive Ergonomics" by Nadja Lejon and Henrik Thorsén was carried out at the department of Product and Production Development at Chalmers University of Technology. The project has been conducted in cooperation with the Ergonomics department at Volvo Car Corporation in Gothenburg.

Volvo is expanding in Asia and to make it possible to develop cars for the wider range of drivers it is necessary to evaluate and understand how and why drivers are positioned the way they are. If an early evaluation of the car's ergonomics is made, including information about reference points for the seated person, problems can be visualized to allow potential design changes before expenses go up.

The purpose of this Master Thesis is to develop a method that should give answer to *how* and *why* people sit the way they sit when driving, and be applicable to all of Volvo's car models. The method will be used by different people at the Ergonomics department why repeatability and usability are important factors to consider as well as time. Finally the method is used for evaluation of one car model, a Volvo XC60.

The developed method is called SPEED, Seated Position Evaluation from Elicited Data, and consists of three phases; preparation, clinic and analysis. The clinic is conducted while driving and the analysis is divided into basic and further analysis where some results shown in the basic analysis are coordinates for eye point, heel point, H-point and distance between head and headrest. To complete SPEED, instructions, a compilation document, a questionnaire and a coordinates program are included.

Keywords: H-point, heel point, eye point, seated position, method development and automotive ergonomics

# Glossary

| Key word | Explanation |
| --- | --- |
| **Anthropometrics** | The study concerned with the measurements of the proportions, size and weight of the human body. |
| **CAN bus** | CAN bus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. |
| **CATIA** | Computer Aided Design (CAD) software used by VCC. |
| **Clinic** | A field evaluation with chosen test participants. |
| **DiCE** | Diagnostic Communication Equipment. For example used to diagnose and troubleshoot Volvo vehicles from and including model year 1999. |
| **Eyellipse** | The distribution of drivers' eye locations. |
| **Eye point** | Reference point of the driver's eye location |
| **Eye tracking** | An eye tracker is a device for measuring eye positions and eye movement. A popular variant uses video images from which the eye position is extracted. |
| **Excel** | Computing software from Microsoft used for handling data and performing analyses. |
| **GGD DHA** | A program developed by VCC. A diagnose tool where one can see for example seat motor steps. |
| **GoPro** | GoPro is a company producing cameras that can be used in various environments and can for example have adhesive mounts. |
| **Heel point** | A SAE defined point where the heel touches the floor. |
| **H-point** | A point corresponding to the pivot centre of the human torso and upper leg. |
| **Manikin** | Full size model of a human, digital in CATIA or physical, which can be adjusted to represent the different percentiles. |
| **Occupant packaging** | Occupant and interior packaging involves: determining the necessary amount of vehicle interior space for the customer, arranging interior and structural components in order to enhance the performance of the customer, and increasing overall satisfaction, comfort, accommodation and safety for all occupants (SAE International, 2013). |

| | |
|---|---|
| **Photoshop** | Adobe Photoshop is a graphics editing program from Adobe Systems. |
| **RAMSIS** | RAMSIS is a CAD tool for ergonomics design and analysis of vehicle interiors and working places. It can be used for e.g. analysis of visibility, comfort and ergonomics. |
| **SgRP** | A specific H-point used by manufacturers as a design reference point, which establishes the rearmost normal design driving or riding position of each seating position. In this point all modes of adjustment, horizontal, vertical and tilt, are included. |
| **SIMCA** | Statistics software. |
| **Testkliniklistan** | A list with employees at VCC and their measured anthropometrics. |
| **VCC** | Short for Volvo Car Corporation. |
| **VESC** | Short for Volvo Engineering Student Concept, a program initiated providing summer job and master thesis at VCC. |
| **Wide angle** | A wide-angle lens has smaller focal length than normal lenses. More of the scene is included in the photograph. |

# Contents

# 1 Introduction

In the future, Volvo Car Corporation's (VCC)[1] market share in Asia will increase meanwhile body measures such as height and weight will continue to increase in Europe and USA leading to a wider span in user anthropometrics. To make it possible to develop cars for this wider range of drivers it is necessary to evaluate and understand how and why drivers are positioned the way they are. With information about reference points of the driver such as H-point[2] and eye point[3] validation and verification can be done of human modelling programs such as RAMSIS[4] where digital manikins are positioned. Making changes to a design is more expensive the further the process has come. With the possibility of early evaluations potential problems can be visualized and changed before expenses go up.

A previous master thesis at VCC (Bergström and Grahn, 2003) investigated with clinics[5] if there is a difference to how people position themselves in cars in different environments; car driven on road, car in car park and mock-up. Their conclusion was that the seated position differs between the environments but that control questions and simulations to some extent reduce the difference in seat adjustments. With Bergström and Grahn's work as a base this master thesis was formed. This thesis is conducted by two VESC[6] students, Nadja and Henrik (in this report referred to as 'the team') who has worked one summer at VCC Ergonomics[7]. The educational background is from Chalmers University of Technology Master Programmes Industrial Design Engineering (IDE) and Product Development (PD) with focus on Human Factors Engineering (HFE).

Different parameters are connected to the driver's seating position, such as the primary controls (steering wheel, gear shift, pedals) and also the field of sight, comfort, manoeuvring and ability to reach other functions. VCC Ergonomics expected that the seated positioning in cars can depend on body measures, personal preferences and type of

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[1] Volvo Car Corporation will hereafter be shortened VCC
[2] H-point, see glossary on page v
[3] Eye point, see glossary on page v
[4] RAMSIS, see glossary v
[5] Clinic, see glossary on page v
[6] VESC, Volvo Engineering Student Concept, see glossary on page v
[7] Department 91320 Craftsmanship and Ergonomics will be referred to as VCC Ergonomics in the text.

car. The exact reason behind the positioning is however not known why this master thesis aims to develop a method for finding out why and how people sit the way they sit when driving a Volvo car.

## 1.1   Purpose

The purpose of this master thesis is to elicit information about how people sit when driving and why they sit the way they do. The information will be used for comparing car models and the different seating options they provide as well as provide VCC Ergonomics with information that can be used to validate and develop their computer aided evaluations with RAMSIS. To enable seated position in RAMSIS different tasks are set for the manikins to do and with more information from real seated positions this method can be more exact in its predictions of seated position.

VCC Ergonomics has measured cars to find out H-point and eye points for manikin positioning and comparison between cars but an effective and efficient way of doing these measurements does not exist. Earlier measurements have been time consuming but consistent to enable comparison. A new method is needed because a vast amount of measurements have been done earlier and some have been irrelevant. For more efficient comparisons a repeatable method is necessary, which collects important data without taking too much valuable time from the employees at VCC Ergonomics.

## 1.2   Goal

The goal of this master thesis is to develop a method for VCC Ergonomics to use for finding out how and why people sit the way they sit when driving different car models. The result from using the method will be data to use for validation and verification of human modelling programs, such as RAMSIS, and for comparing car models to each other.

## 1.3   Vision

This master thesis should primary result in a method, which two summer employees who have completed 4th year of a technical

education including ergonomics should be able to use; for gathering of data and for executing a basic analysis of the seated positions. A secondary goal is to deliver a result of an analysis made on the car model Volvo XC60 with the developed method.

The method should include a description of its purpose and what is needed in order to perform it. This involves preparation of the car, prepare and book participants to the clinic, gathering and compilation of data and finally an analysis of the result. The method should allow a Seat Position Evaluation from Elicited Data, why the method hereafter will be referred to as SPEED.

VCC Ergonomics should with the developed method be able to analyse the driver's positioning in all of their cars and understand how and why people sit as they do.

## 1.4   Outline of thesis

In this thesis a method for evaluation of seated position is developed. A literature study was conducted and the result from it and the initial interviews and workshops formed assumptions regarding seated position. The assumptions then served as a base for the development of the method and the coming analysis of the result. Throughout the project evaluations have been made and finally the method was used on Volvo XC60.

In the theory chapter, chapter 2, information about SAE standards are found with information about important points such as H-point, eye point and heel point. Findings from previous clinics, master theses and dissertations regarding seated positions are listed according to categories of comfort, reachability, visual references, anthropometrics, limitations of the car and car model. Clinics are explained in general and for how they are conducted at VCC Ergonomics with information about use of instructions, environment for the studies, equipment that is used, selection of test participants and the use of questionnaires.

The Human factors process of which this thesis has been conducted is explained in chapter 3. The different stages of the process are explained and an adaption of the process to fit this thesis is described. The stages of the process form the structure of this report and include needfinding, assumptions, overall design, detailed design, a description of the developed method SPEED, an evaluation of SPEED and the result from the commissioning in Volvo XC60. Parallel throughout the project evaluations and documentations are made.

In chapter 4 the needs of primary and secondary users are noted and delimitations for the thesis are listed. The primary users are employees at VCC Ergonomics that will be the test leaders for SPEED and analyse the result. The secondary users are the test participants that will attend the clinics. Important needs from VCC Ergonomics are that the time for completion of SPEED is 160 man hours or less and that each test participant will finish their participation in 45 minutes. Another need is that the method elicits information about SAE points for each test participant. The delimitations concern type of car, programs that are to be used and the level of detail for the instructions.

Assumptions regarding what affect the seated position and possible ways of measuring the impact of the different factors on the seated positions are described in chapter 5. The assumptions are sorted into categories of comfort, reachability, visual references, anthropometrics, limitations of the car and personal attitude.

The overall design of the developed method SPEED is described in chapter 6. In this chapter the evaluation of concepts and the evaluation approach is described, the test approach with the early conditions for SPEED is set out and means for standardisation is listed. SPEED is divided into three parts; preparation, clinic and analysis. The clinic shall be performed while driving and objective measurements, subjective questions and observation of behaviour will elicit information regarding how and why people sit the way they sit when driving.

More detailed information about the testing of different potential methods and tools are described in chapter 7. This chapter describes how to elicit information about H-point position and back inclination from the car's computer system and CATIA drawings. It is described how to retrieve eye point position, steering wheel position and distance between head and neckrest, through the use of GoPro cameras, Photoshop and pixel analysis as well as how to retrieve information about heel point position. Further on this chapter describes the selection of test participants and the three stature groups that were formed, how the questionnaire was formed and how the analysis was divided.

In chapter 8 SPEED is described in short bullet points concerning preparation, clinic and analysis.

An evaluation of SPEED can be found in chapter 9. The time used for the method as a whole and for each test participant, the usability of the instructions, the equipment that has been used and the quality of the result and found connections have been evaluated.

The result from using the method in Volvo XC60 can be found in chapter 10 where the result is divided into the assumption categories as well answering the questions of how and why. Scores and priorities for different parameters in the car are shown in tables divided into the three stature groups and diagrams of H-point, eye point and heel point position is shown.

Finally the thesis is discussed in chapter 11 regarding result, design and the quality of the elicited data as well as the process of developing the method SPEED.

# 2  Theory

In this chapter information about SAE standards are explained with information about important points such as H-point, eye point and heel point. Findings from previous clinics, master theses and dissertations regarding seated positions are listed according to categories of comfort, reachability, visual references, anthropometrics, limitations of the car and car model. Clinics are explained in general and for how they are conducted at VCC Ergonomics with information about use of instructions, environment for the studies, equipment that is used, selection of test participants and the use of questionnaires.

The theory used for this work regards existing automotive standards, SAE standards, and previous research regarding driving position, how to perform a clinic (user study) and how this is utilized at VCC Ergonomics.

## 2.1  SAE Standards

The automotive industry uses certain standards when developing and designing cars due to laws and requirements that have to be fulfilled. Ghikas (2013) describes *The society of Automotive Engineers International* (SAE) as an organisation that develops standards for engineering industries such as the aerospace, automotive and commercial vehicle industry. It provides over 1600 standards relating to the design of cars, where a number of ergonomic standards useful for occupant packaging[8] are included. These standards are recommendations for the initial package and must be remade with human evaluations in the actual architecture and for the preferred market. Especially since the SAE standards are more applicable to the U.S. population (Ghikas, 2013). With help of standards that normally are used for the automotive industry, e.g. the H-point (SAE J826), The Driver's Eye Range (SAE J941), Driver and Passenger Head Position (SAE J1052), it is possible to develop vehicle seating packages that describe levels of accommodation (90, 95 and 99 per cent) (Peacock, 1993). The standards of higher importance for VCC when creating the occupant packaging are H-point (SAE J826), eye point and eyellipse (SAE J941).

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[8] Occupant packaging, see glossary on page v

### 2.1.1   H-point (SAE J826)

The H-point is the point on the human body that work as a pivot centre of the torso and thigh (Peacock, 1993). The point provides a landmark showing where people sit in the seat. The H-point is created by using an H-point manikin with the weight of a 50th percentile male and the length of 95th percentile male legs. By using this manikin a reliable design reference point can be established that takes the deflection of the seat into account. When the physical manikin is positioned in the car it makes it possible to locate the H-point relative the physical seat and also to relate the physical seat with a virtual geometry. Because of the adjustable seat the H-point can have a number of different positions and the extremes of these are creating the seat movement envelope. To have one consistent reference point for occupant packaging, one specific design H-point is selected and called the seating reference point (SgRP) (Ghikas, 2013), see Figure 2.1.

### SgRP

SgRP is a specific H-point used for definition and description of both the occupant package and the vehicle dimension, leading to that many factors related to occupant and requirements refers to the SgRP (Ghikas, 2013). Since SgRP makes the relationship between the physical and virtual environment possible it also provides a consistent method for comparisons between the company's own cars and competitors' cars.

### 2.1.2   Eye point and eyellipse (SAE J941)

Locations of eye points are represented with the use of eyellipses, which help forming the vehicle's architecture ensuring that the driver has a sufficient visual field (Ghikas, 2013). Eyeellipses are outer limits of envelopes that are formed in both side and plan view by an infinite number of planes dividing the eye positions, leading to P per cent are on one side and 100-P per cent are on the other side, see Figure 2.2. Since the data is normally distributed this results in ellipses by statistical definition. Each individual plane represents accommodation for the selected 99 or 95 per cent of the users. A proper application of the eyellipse includes drawing sight lines from the eyellipse to points of interest according to a vision task. Using this procedure ensures the car being configured to ensure that 99 (or 95 per cent depending on which eyellipse is employed) per cent of the drivers will be accommodated (Peacock, 1993).

### 2.1.3   Heel point (SAE J1517)

The accelerator heel point is the lowest point at the intersection of the manikin heel and the depressed floor covering with the shoe on the

undepressed accelerator pedal; see Figure 2.1 (SAE International Standards, 2001). The ball of foot is a point on a straight line tangent to the bottom of the manikin's shoe in side-view 203 mm from the accelerator heel point. The lateral (y-coordinate) location for the ball of foot is mid-width on the shoe at the side view ball of foot location (SAE International standards, 2001).



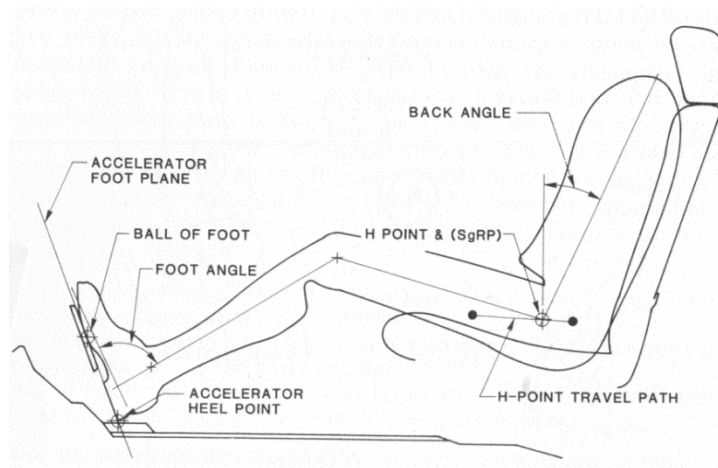**Figure 2.1 - SAE picture of the manikin (Peacock & Karwowski, 1993)**
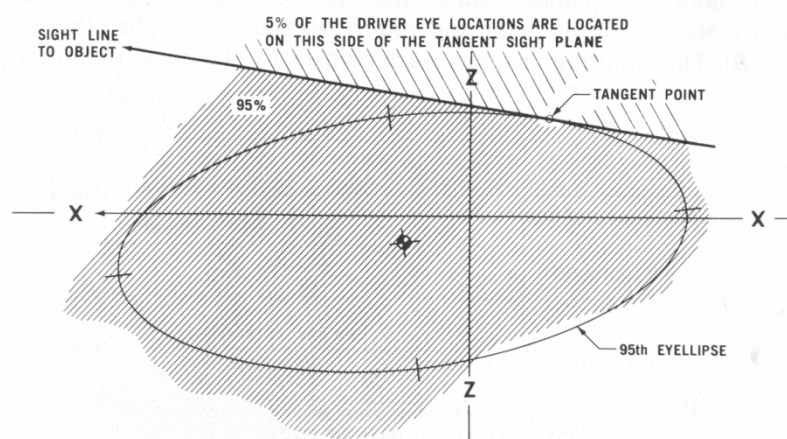


**Figure 2.2 –Eyellipse tangent cutoff sight planes (Peacock & Karwowski, 1993)**

## 2.2   Parameters for seated position

For driving there are tasks, or physical requirements, which need to be possible to perform simultaneously. Reed (1998) summarise these as vision to the external environment, manipulation of steering wheel,

manipulation of pedal controls, vision to internal displays and manipulation of shifters and other hand controls. These factors can be considered as comfort, reachability, visual references, anthropometry and limitations of the car.

### 2.2.1 Comfort

Earlier clinics VCC Ergonomics have indicated that comfort is a factor for seated position, often in combination with limitations of the car. Test participants in earlier seated position clinics were asked to rank the importance of vision, reachability, roominess and personal attitude in the context of seat comfort. Very tall or very short people can for example experience discomfort regarding leg roominess, which could be compensated through adjustments of the seat into a different position than what would be ideal. There have also been situations where test participants have adjusted the seat to a position not optimal for them because of the seat belt chafing their neck[9]. According to Ghikas (2013), a comfortable driving position is when primary and secondary controls can be reached and operated comfortably, displays are easily seen and when the all-round vision out of the vehicle is good.

### 2.2.2 Reachability

Test participants in earlier seated position clinics by VCC Ergonomics were asked to rank the importance of reach of primary controls such as pedals, steering wheel, controls and gear shift. The reachability to the pedals was said to be the most important factor for seated position. Bhise (2012) supports the theory about reachability being important when the occupant packaging is developed.

### 2.2.3 Visual references

According to Peacock (1993) vision is the primary source of information intake when driving a car. A driver must be able to see changes in road alignment (parts delineated by topography, street furniture and road markings), other vehicles (coming both from behind and the other direction in various speeds), warning and information signs beside the road, road signs placed higher up, which also makes upward vision important in addition to forward, rearward and side vision. The forward field of view is limited by the downward angle determining the nearest visible points in front of the car, the upward angle and the binocular obscuration by the A-pillar, see Figure 2.3. The field of view in mirrors is dependent on how they are positioned, more or less inwards will cause losses in the outer part of mirrors. The selection of mirror position is dependent on the seated position. People positioned closer

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[9] Lotta Jakobsson (Crash and Safety, VCC), included in workshop 20th of February 2013.

to the windshield will turn the mirrors more inward which leads to a higher loss of sight.
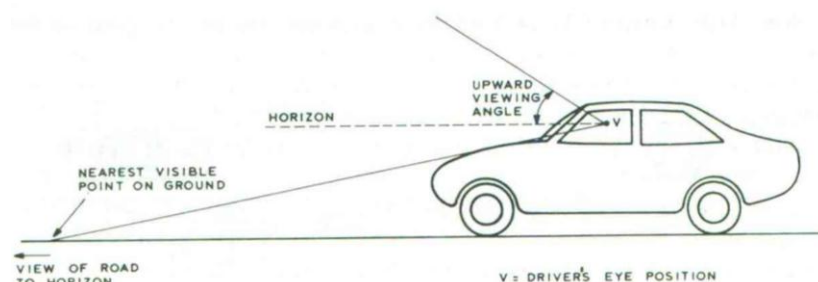


**Figure 2.3 - Specification of the driver's forward field of view (Peacock and Karwowski, 1993)**

### 2.2.4 Anthropometrics

Many SAE-standards are based on anthropometry[10] and is considered when designing and evaluating cars. According to a study performed by Park et al. (2000), short people prefer to sit closer to the steering wheel compared to tall people. The result of the study also implies that shorter people preferred to heighten the bottom cushion to get a better vision and for easier handling of the steering wheel. From analysing earlier seated position clinics by VCC Ergonomics it can be strengthened that shorter people choose to position themselves more forward and upward towards the windshield. Earlier clinics also show that the field of view is dependent on eye location, which is dependent on the selected seat position which in its turn is dependent on the stature height.

According to Jangwoon Park (2013), female drivers move their upper body towards the steering wheel because of their shorter arm-length. Females, who also have a shorter sitting height, therefore moves the upper body towards the steering wheel to get enough view angle. Park's research also showed that men have a tendency to sit more inclined and women sit more erect and that men have their knees more bent than women. This could be because the women used in their studies were the shortest and no men had the same stature height as the women. According to Jonsson (2009) who has investigated seated positions, there are no connections between men and women that have the same stature.

In another study the limited connection between gender and seated position is supported by Matthew Reed (1998). In his tests a difference was seen between men and women's back inclination; however the hip-to-eye angles were not significantly different between men and women.

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[10] Anthropometrics, see glossary on page v

It should also be noted that there has been no overlap between the groups in stature or other anthropometric variables. Therefore it cannot be determined whether the differences are because of gender or if it is because of the anthropometric differences. Reed continues by saying that results implying differences between genders can rather be attributed to anthropometric differences.

### 2.2.5  Limitations of the car

Previous clinics have shown limitations in the car, such as shorter people not having as good sight out of the car as taller people. Limitations such as this one is to some extent compensated by adjustment of cushion height, but the adjustability is sometimes not enough for people in the extreme percentiles. According to Peacock (1993) design limits are set for the adjustment range, for example how much the seat's length can be adjusted, and these design limits are used to express to what percentage of the population the design is accommodated. If the seat position versus percentile is plotted, a rather straight line includes approximately 90 per cent in the middle of the population for a certain length adjustment range of the seat, see Figure 2.4. To include more of the population the adjustment range must be extended much more because of diminishing returns. According to Park et al. (2000), people might also want to have the seat positioned further back from the windshield but are not able to due to difficulties with for example using the steering wheel.
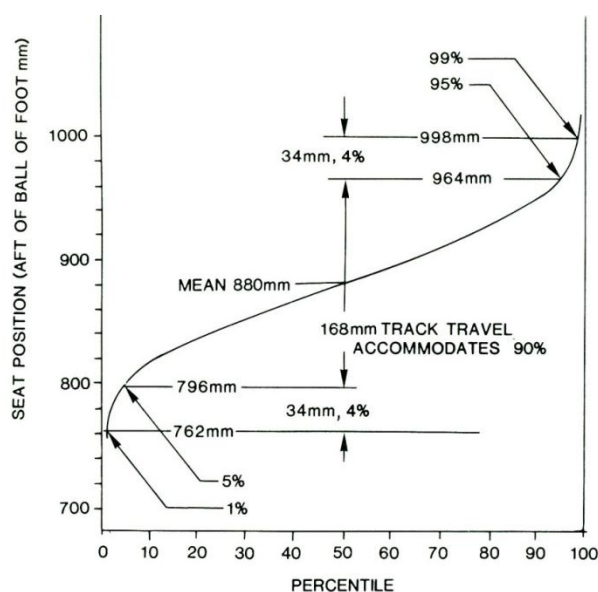


**Figure 2.4 – To include more than 90 per cent of the population demands much more effort (Peacock, 1993).**

### 2.2.6 The car model

Jangwoon Park (2013) describes the occupant package layout (SUV, coupe and sedan) as a parameter with large effect on the lower-body sitting strategies. His study showed that 84.2% of the test participants wanted a bent knee posture in the SUV car model but only 2.6% wanted a bent knee posture in a coupe model. The result indicates that the measure H30 (floor of car to H-point) affects the lower-body posture since the sitting height in the SUV is higher compared to a coupe car model and thus drivers pulled the seat closer to the pedals to be able to control the pedals comfortably. According to Ghikas (2013) there are differences such as the wanted feeling of sitting "in" a lower car (the example is a Jaguar sports car) rather than "on" a higher car (SUV). Sitting in a SUV (the example is Land Rover) should make the user feel that he or she also being in command of the car.

## 2.3 Clinic

A clinic, or user trial, is a test situation where people with for example certain anthropometrics are chosen to evaluate selected parameters in a car model, either an existing model or a mock-up of a car being developed (Ghikas, 2013). An appropriate number of test participants are required and must be chosen carefully and at the same time represent the intended customer. Ghikas (2013) explains the clinics as being on a one-to-one basis including both subjective and objective data as well as observations. The purpose of the clinic is to elicit information from the participants regarding user satisfaction, perception and expectations.

### 2.3.1 Instructions

When conducting a clinic the standardisation of proper instructions, for both the test leaders and participants are important in order to ensure later comparisons between results (Trost, 2007). The instructions to the test leaders are important since this will ensure that all parts of the clinic will be fulfilled and performed in the same way for all participants. Having instructions provided for the test participants will make them know what they are expected to do and what they are allowed to do.

### 2.3.2 Environment

The environment in which the clinic is conducted influence the result from the clinic. According to Ghikas (2013) it is important that a permissive environment is used allowing the test participant to criticise the design, making both positive and negative statements without being

judged by the experimenter. Bergström and Grahn (2003) showed in their thesis that there is a difference to how people position themselves in cars depending on if they drive or if they are parked. Therefore a clinic that aims for deciding a seated position should be performed while driving for best precision.

### 2.3.3   Equipment

The equipment used in the clinic depends on what is evaluated; it varies between just questionnaires to advanced cameras tracking a test participant's movements. Some types of evaluations require the car to be measured, to get all data of the car in use, to compare the measurements with nominal data from drawings.

Using photographs for evaluation of seated positions is a valid and reliable indicator of the underlying spine (Niekerk et al, 2008). A study made of 39 high school students show that photographs proved to be accurate in angle compared with the radiographs made simultaneously of a seated position. In the study they used retro-reflective markers on certain anatomical points, which were used to calculate the sagittal head angle, the cervical angle, the protraction/retraction shoulder angle, the arm angle and the thoracic angle. The results from the study indicated that relevant data could be collected from one photograph only to provide an accurate representation of the spinal posture for that individual.

### 2.3.4   Test participants

To accommodate a large population and to be user centred is difficult and the manufacturer needs to consider different parameters of their users, included in the anthropometrics. The users, called test participants, will have their anthropometrics measured making it possible to understand the human variation and provide guidance for the ergonomic evaluations and design (Ghikas, 2013). Depending on what is evaluated different test participants are chosen to participate, often the extreme percentiles from short female to tall male, this to ensure that the car fits everyone.

### 2.3.5   Questionnaire

The question formulation in a questionnaire is important in order to retrieve the desired information. How to create a questionnaire is described in *Enkätboken* (Trost, 2007). The questions in a questionnaire should be easily understood; negations, complicated words and leading questions should be avoided and questions relating to the same area should be clustered together. There should be just one question per question to avoid confusion; ranking of different parameters should be done separately on a scale and not in comparison to each other. Open

questions are difficult to compare to each other but offer qualitative data. The questionnaire should have an open question at the end for the test participant to speak his/her mind.

Standardisation of questions and tasks are important for the possibility of comparing the results. Subjective scales can only be validated for intra-personal comparisons (Coehlo and Dahlman, 2000) why the objective measurements are a necessary complement to subjective answers from test participants.

## 2.4   Seated position clinics at VCC Ergonomics

Seated position clinics at VCC Ergonomics are conducted by one or two test leaders. When VCC Ergonomics use this type of evaluation, they select test participants from *Testkliniklistan[11],* a list of people working at VCC whose anthropometrics have been measured. The clinic is prepared with subjective questions, observation of behaviour and objective measurements. It is documented with photos and written answers and the collected data is compiled and potential statistic connections are established.

### 2.4.1   Test participants
The test participants in VCC Ergonomics' clinics are chosen from *Testkliniklistan,* The anthropometrics of each person is noted before the clinic and can therefore be used for analysis of the result. The test participants are selected based on percentiles of height and represent both men and women. Measures such as leg length and arm length may come to be analysed in a later stage. Earlier clinics have had 60 test participants, where 20 have been < 20%ile women, 20 between 35%ile women - 85%ile men and the last 20 have been > 90%ile men. The number of test participants has been chosen by experience from previous clinics and because the result becomes statistically good enough with that amount of people.

### 2.4.2   Instructions
Initial instructions to test participants regarding location, conditions and time are sent via e-mail. Instructions to what to do during the clinic are told by a test leader.

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[11] Testkliniklistan, see glossary on page v

### 2.4.3  Environment

Seated position clinics are performed while driving. All test participants drive the same route and stop the car four times. Then the test leader reset the seat to the starting position and the test participant set it in a comfortable position.

### 2.4.4  Equipment

Before a seated position clinic the car is measured by the Crash Test Preparation at VCC, especially certain points of interest, such as seat height, the seat adjustment area, steering wheel and hood in order to establish a coordinate system to compare with the CAD drawings of the car. Information about the seat settings for a power driven seat is retrieved from the CAN bus[12].

To retrieve H-point values from the information from the CAN bus VCC has calculated a formula, which takes two inflexible points on the seat and creates a triangle with the H-point being the third point. This is not time efficient due to a lot of measuring needs to be done and VCC Ergonomics are not satisfied with this method. To elicit the back inclination of the seat, information is read from the CAN-bus and then translated into a degree of inclination. The result of this measuring is presented as numbers, which is difficult to understand due to lack of references, such as the extreme positions.

To measure where the steering wheel is positioned, the steering wheel has been equipped with two measuring tapes on the side, in x- and z-direction. These measuring tapes gives measures that later are put in a formula created by the VCC Ergonomics department. This formula then recalculates these two measures to coordinates in x- and z-direction. When the team looked into data from previous seated position clinics, it was difficult to follow how the data was elicited, which lead to problems understanding what had been done and for comparing the results.

A camera was used to locate eye location and the inclination of the back. The camera was always put in a position at the passenger seat to the right of the driver, giving a profile picture of the driver. Different cameras have been used and for each new setup a remote control program or hardware is needed. A problem with the camera equipment is that it is old and not gives photographs of high quality. Therefore a new setup needs to be configured.

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[12] CAN bus, see glossary on page v

For extraction of eye points from photos Photoshop[13] analysis has been used. During the measurement of the car photos of a square have been taken and its position been measured in many positions. These photos have then been combined in Photoshop and equations been made for coordinate extraction after pixel analysis.

For analysis of results CATIA, Excel[14] and Photoshop are used. Questionnaires and questions are printed and filled out together with test participant and the test leader.

### 2.4.5  Questionnaire

In earlier seated position clinics subjective data was gathered through questionnaires where the test participants were asked to rate different features, some of them were to be compared and rated with each other. Both the team's earlier experiences and theory according to *Enkätboken* (Trost, 2007), proved this to not be a good way and a way of hinder test participants to value different parameters equally. The test participants were also asked yes or no questions as well as open questions, which was combined with parameters for the test leader to observe.

## 2.5  Summary of theory

For evaluating seated position SAE points such as H-point, heel point and eye point are important to establish. Findings from previous clinics, master theses and dissertations regarding seated positions have been listed according to categories of comfort, reachability, visual references, anthropometrics, limitations of the car and car model and serve as base for coming assumptions, found in chapter 5. Literature has shown the importance of detailed instructions to enable standardisation. The basic structure of clinics at VCC Ergonomics serves as base for the development for SPEED with instructions, environment, test participants and questionnaire.

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[13] Photoshop, see glossary on page v
[14] Excel, see glossary on page v

# 3 Process/method

The Human factors process of which this thesis has been conducted is explained in this chapter. The different stages of the process are explained and an adaption of the process to fit this thesis is described. The stages of the process form the structure of this report and include needfinding, assumptions, overall design, detailed design, a description of the developed method SPEED, an evaluation of SPEED and the result from the commissioning in Volvo XC60. Parallel throughout the project evaluations and documentations are made.

For the development of SPEED an iterative process based on the developing process of human machine systems as described by Bligård (2011) was used. The process is used within Human Factors Engineering (HFE) for designing effective machines to suit human needs and abilities. The team consider this process suitable for developing and designing the method for VCC because of the needs for an easy to understand usage for beginner users. The team also uses this process with the reason that it is thought to help going through the work thoroughly and finding potential problems early in the process.

The process involves planning, data collection, evaluation and documentation as four parallel continuous activities and six sequential blocks that is needfinding, function and task design, overall design, detailed design, structural design and commissioning, see Figure 3.1. For the process to function as a whole Bligård (2011) lists the most important factors to employ to the process. The team should have knowledge of HFE methods, the human machine interaction should be in focus, an iterative approach to be employed as well as work with parallel activities for effectiveness. Further on should users be involved in all steps of the development for evaluation, the usage should be the foundation of the product development and the process should be adapted for the specific project. An adaption of the process for the development of SPEED can be seen in Figure 3.2.
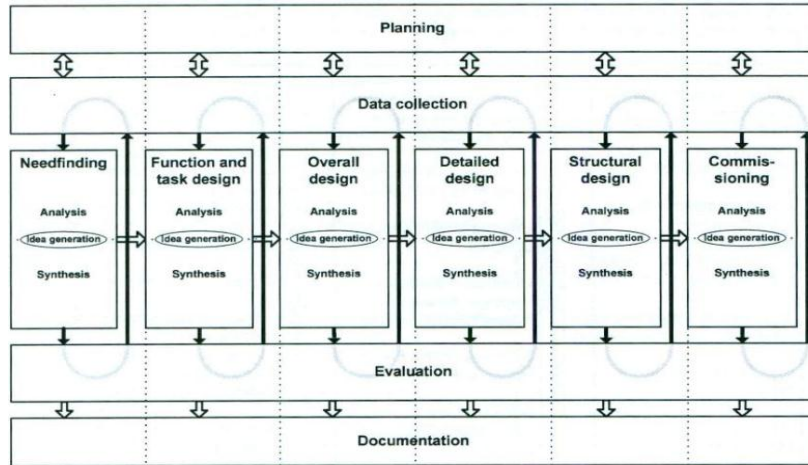
**Figure 3.1 - The development process of HFE (Bligård, 2011)**
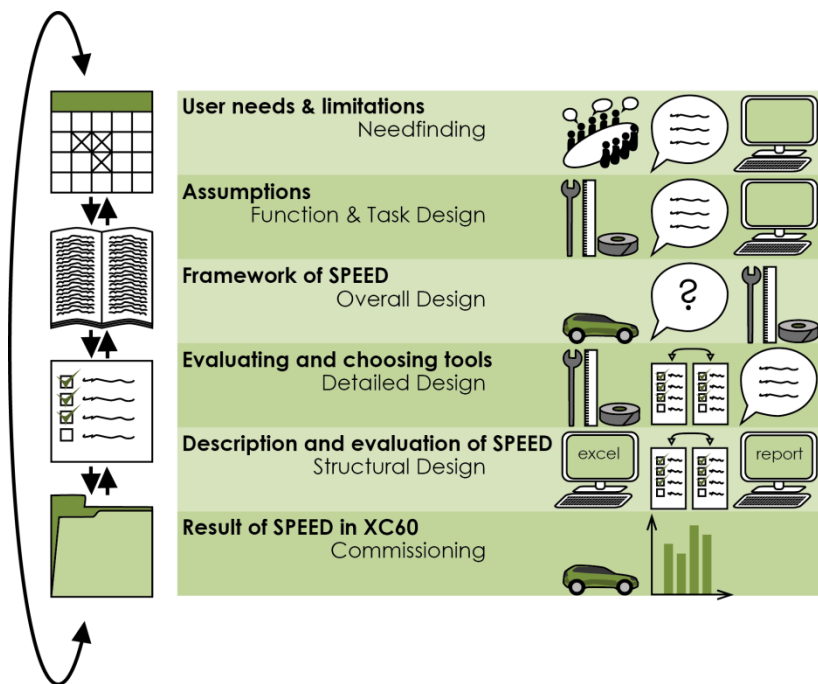


**Figure 3.2 – An adaption of Bligård's process to suit the development of SPEED.**

## 3.1   Needfinding

The team's previous experience from clinics for VCC Ergonomics serves as a base for the needfinding. The needs and requirements for the frames of the development of SPEED are gathered though a literature study of automotive ergonomics and method development

including creating questionnaires. Interviews, workshops and literature provide information about how to gather data about reference points in the car and on the test participants.

## 3.2  Assumptions

Assumptions are made to allow falsifying and/or strengthen the importance of different ideas. The assumptions derive from workshops at VCC Ergonomics and within the team. The assumptions are supported by theory and can be measured in different ways.

## 3.3  Overall design

The questions and measurements that will be used for SPEED will be investigated early in the process and validated through evaluations with users. This includes evaluations including deeper interviews to elicit much data, evaluations using the actual method and comparing these to each other. The evaluations also include letting students act as test leaders using SPEED and provide feedback on the method. Questions and measurements that give reliable results will be developed to a detailed design that will be further investigated to later be developed to the final design of the method.

## 3.4  Detailed design

The detailed design is based on the overall design and results from evaluations. By investigating and evaluating different tools and the quality of the provided data, tools and questions will be chosen for the final design of SPEED.

## 3.5  Description of SPEED

From the detailed design the team combines the final result and a summary of how SPEED is performed will be presented in this section. The chapter highlights the main parts, all from the process of booking the car to when the result is analysed.

## 3.6   Evaluation of SPEED

The method will be performed on one car model for this work and the team will afterwards compile a result describing how well SPEED worked. The result will give an answer to whether the team's assumptions were correct. Analysis of the data will provide the team with information regarding whether all questions asked are necessary and if they provide the information that the team want to elicit. Method evaluations are done in smaller scale during the overall design but when performing the evaluation in larger scale the team can get more information about how the method works and recommendations for future work can be compiled.

## 3.7   Result of SPEED in XC60

The clinic included in the method will be performed during two weeks with several Volvo employees as test participants. During this clinic the team members will act as test leaders and follow the instructions which are included in the method.

After the commissioning of SPEED the outcome is to be analysed, giving answers about the specific car used in the work, and the correlations that were found between the car, test participants and the seated position.

# 4 Needfinding

In this chapter the needs of primary and secondary users are noted and delimitations for the thesis are listed. The primary users are employees at VCC Ergonomics that will be the test leaders for SPEED and analyse the result. The secondary users are the test participants that will attend the clinics. Important needs from VCC Ergonomics are that the time for completion of SPEED is 160 man hours or less and that each test participant will finish their participation in 45 minutes. Another need is that the method elicits information about SAE points for each test participant. The delimitations concern type of car, programs that are to be used and the level of detail for the instructions.

For SPEED there are different user groups and stakeholders. The main users are people working at VCC Ergonomics who will use SPEED, acting as test leaders in the clinic and performing the basic analysis. This includes both summer employees and people employed at the department. Secondary users are test participants attending the clinics. The stakeholders are VCC Ergonomics who invest in this work. Another department at VCC with interests in the result of the method and their needs are listed in chapter 4.3.

## 4.1   User needs

It should be easy and intuitive to use the method SPEED. Previous clinics have shown that these evaluations can be difficult to compare and understand. Therefore it is needed to standardise and have explanations of the whole method structure; all equipment and questions. Another reason for having a high level of standardisation is to deliver the same result independent of who is using SPEED. Instructions should be provided to ensure that future users are able to understand completely how the method is built up and what is needed to change it and how this could done. Due to short preparation time it should be a short learning curve and difficult to do wrong.

It is important that the instructions regarding the method's structure, all measurements and questions are adapted to the knowledge that the main users possess.

## 4.2 VCC Ergonomics' needs

For VCC Ergonomics it is also important to provide instructions of what needs to be done. Some parts included in the method have to be prepared and booked before the summer employees arrive. The equipment is being bookable for anyone at VCC and certain equipment is more popular and rare than other.

To understand where people sit in the car information regarding H-point, eye point, heel point and a point describing the steering wheel position needs to be in the result. VCC Ergonomics also want to know why people sit the way they do, which leads to a need of retrieving qualitative data from test participants regarding their position. This data need to contain subjective thoughts of different parameters in the car, how these affect the test participant when deciding position and how well they are in the car used in the clinic. Subjective thoughts about the seated position; if it is comfortable, if there are limitations in the positioning, how easy a comfortable position is found should be elicited. VCC Ergonomics want to use this information for setting their future requirements.

VCC Ergonomics has expressed the need of using test participants from *Testkliniklistan* and that short, medium stature and tall people should be represented. This to ensure that conclusions can be made regarding peoples' stature. To enable test participants to participate in the clinic, VCC Ergonomics stated a need regarding the time used for the clinic to be maximum 45 minutes. Due to economics and time available for clinics, VCC Ergonomics has a need for a time constraint for the whole method of 160 man hours.

## 4.3 Further external needs

Another department interested in the method is the VCC Crash and Safety department that expressed a need of having a camera filming the clinic. This was due to their interest in finding out why people sit the way they do in different traffic situations, and the need to see changes in the drivers' position over time. VCC Crash and Safety also expressed needs regarding the headrest, to find out if it is used, if people want to use it and the distance between the driver's head and headrest.

## 4.4  Delimitations

The team has together with VCC Ergonomics set frames and delimitations for this project, which have to be considered:

- When SPEED is developed and used in this work it will consider one car model, Volvo XC60, with automated gearbox and a motorized seat.

- SPEED shall be possible to apply to all Volvo's car models.

- The tools required for the development of the method and using it should be available for VCC's Ergonomics department.

- SPEED shall later be possible to use by summer employees, master students who have completed the 4th year of their education at university and have knowledge about mathematics and ergonomics.

- SPEED will require knowledge of Microsoft Excel and CATIA.

- Test participants for the clinic will be taken from *Testkliniklistan* provided by VCC Ergonomics.

- SPEED shall not require intervention on the car.

- The instructions and the questions posed within SPEED will be in Swedish.

- SPEED will not consider the seat's lumbar support.

# 5 Assumptions

Assumptions regarding what affect the seated position and possible ways of measuring the impact of the different factors on the seated positions are described in this chapter. The assumptions are sorted into categories of comfort, reachability, visual references, anthropometrics, limitations of the car and personal attitude.

From the results of the literature study and the workshops held at VCC Ergonomics, assumptions regarding seated position were made. The assumptions and how to measure them are listed below. The team assumes that seated positions depend on comfort, reachability, visual references, anthropometrics, limitations of the car and personal attitude. Some of these have been investigated by VCC Ergonomics and are considered important to include in this type of evaluations. Other assumptions are built on theory and previous experience. Earlier evaluations of seated position have contributed with basic assumptions that form the base for the following assumptions. There is a comfort zone in which an individual can sit comfortably; the starting position of the steering wheel has effects on how the seat is positioned and the seated position depends on the car model.

The assumptions will be the base during the analysis and evaluation of the results, both results of SPEED itself and the result when using it in Volvo XC60.

## 5.1 Assumption: Comfort is a factor

> 1)  How one experiences comfort regarding some or all of the following influence the seated position: foot support, arm rest, seat belt, leg roominess and neck rest.

### 5.1.1 How to measure
The measurement of comfort can be investigated through interviews with subjective questions and through a ranking list, where the test participant can rank the importance of the different factors separately in a questionnaire.

Keywords: *Questionnaire*

## 5.2 Assumption: Reachability is a factor

> 2) The reachability to functions such as pedals, steering wheel and controls, affect the seated position.

### 5.2.1 How to measure

The importance of reachability to certain functions can be measured through a ranking list in a questionnaire. By using the same setting of the seat and steering wheel one can see if people set the seat in the same position every time if they perform multiple settings. The heel point position could be retrieved by taking photos of the feet.

As explained in chapter 2.4.4 the steering wheel can be calculated by using measuring tapes. Another method could be to use photographs to locate the position of the steering wheel.

> Keywords: *Photographs, questionnaire, measure steering wheel*

## 5.3 Assumption: Visual references are a factor

> 3) The visual references outside the car, hood height, lanes, traffic and mirrors affect the seated position.
>
> 4) Visual references inside the car such as windshield, rear-view mirror and dashboard affect the seated position.

### 5.3.1 How to measure

The importance of different visual references can be measured through a ranking list in a questionnaire. Photographs can be taken continuously when driving for comparison of potential differences in postures for varied driving. For analysis in CATIA the establishment of eye points are important.

An eye tracking[15] device can be used for analysing the eye movements of the test participants when doing the settings for the seat and steering wheel. Unconscious priorities regarding visual references can be spotted if the device is configured. At a workshop held with VCC Crash and Safety (workshop 20th of February 2013) it was said, that if correctly calibrated it would be possible to establish eye points with the eye tracking device.

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[15] Eye tracking, see glossary on page v

The eye points can also be retrieved by taking photos from the side and extract the coordinates after analysis in Photoshop.

To get more information regarding visual references a varied drive route can be used, including both small and big roads as well as crossings and roundabouts. Standardisation of the instructions and the drive route, with for example GPS, minimise the influence of the driver.

Keywords: *Eye tracking, questionnaire, photographs, Photoshop, CATIA, drive route, GPS*

## 5.4 Assumption: Anthropometrics is a factor

5) The seated position varies between people with different anthropometric measurements.

### 5.4.1 How to measure

To measure the importance of anthropometrics all test participants have had their anthropometrics measured prior to the clinic, according to conventional static measurements because of the repeatability they allow. Analysis of the settings of the seat and steering wheel as well as eye point, heel point and H-point compared to the anthropometrics would show if anthropometrics is a factor to the seated position.

The settings of the seat can be measured manually with a ruler or by retrieving information from the CAN bus in the car by connecting a computer and measuring equipment. The connection to the CAN bus enables that motor activity from the seat can be elicited from the car. As described in chapter 2.1.1 the SAE way of deciding the H-point is by using a manikin. Based on the SAE method, an H-point can be referenced to the seat and an estimated H-point for a driver can therefore be retrieved by knowing the position of the driver's seat. The position of the seat can be measured in the physical car, be compared with the seat in CATIA and after the comparison seat motor activity can be translated to an H-point.

Keywords: *Measure seat settings, DiCE, CAN bus, analysis, and anthropometric analysis.*

## 5.5 Assumption: Limitations of the car is a factor

6) Limitations of the car such as sight considering A-pillars, hood height and roof height affect the seated position.

7) The adjustment range of the seat and steering wheel affect the seat adjustment.

### 5.5.1 How to measure

The importance of different limitations can be elicited through a questionnaire. Questions about how the test participant would sit if adjusting the seat differently can give indications to whether they would prefer to sit differently than they do and if the adjustment range is sufficient. Eye tracking can be used to visualise what the test participants look at and for how long, when setting the seat and steering wheel as well as for driving.

According to Reed (1998) the steering wheel position is very important as by moving it forward by 100 mm the response is to move the seat forward with about 45 mm, accounting for half of the change in steering wheel position. To reduce the potential effects of the steering wheel position on the settings, the steering wheel should be placed in the middle of its adjustment range before each setting.

If the back and the backrest are measured the correlation between the inclination of the backrest and the actual back inclination can be analysed. Information about inclination of the backrest can be retrieved from the CAN bus or, if precision is not prioritised, by using a digital inclination meter. A way of measuring back inclination is by taking photographs in the same angle for all participants and analyse them in Photoshop with references, for example the shape of the window, tape markings in car and on test participant and the settings of the seat.

> Keywords: *Eye tracking, steering wheel position, questionnaire.*

## 5.6 Assumption: Personal attitude is a factor

8) Personal style and attitude affect the seated position.

9) People prioritise differently depending on personal preference regarding comfort, vision and reachability.

### 5.6.1 How to measure

The test participants can be asked about their personal style for driving to see whether there is a correlation to their answers and the settings they make to the seat and steering wheel. The test participants could also be asked to explain their seated position and how they would like to sit in the car. Unconscious thoughts of the positions could be retrieved by using pictures for choosing ones position.

Keywords: *Pictures of seated positions, personal style.*

## 5.7 Summary of assumptions

1) How one experiences comfort regarding some or all of the following influence the seated position: foot support, arm rest, seat belt, leg roominess and neck rest.

2) The reachability to functions such as pedals, steering wheel and controls, affect the seated position.

3) The visual references outside the car, hood height, lanes, traffic and mirrors affect the seated position.

4) Visual references inside the car such as windshield, rear-view mirror and dashboard affect the seated position.

5) The seated position varies between people with different anthropometric measurements.

6) Limitations of the car such as sight considering A-pillars, hood height and roof height affect the seated position.

7) The adjustment range of the seat and steering wheel affect the seat adjustment.

8) Personal style and attitude affect the seated position.

9) People prioritise differently depending on personal preference regarding comfort, vision and reachability.

# 6 Overall design

In this chapter the overall design of the developed method SPEED is described as well as the evaluation of concepts and the evaluation approach. The test approach with the early conditions for SPEED is set out and means for standardisation is listed. SPEED is divided into three parts; preparation, clinic and analysis. The clinic shall be performed while driving and objective measurements, subjective questions and observation of behaviour will elicit information regarding how and why people sit the way they sit when driving.

From the start of the project it was decided that the method would include a clinic in which test participants drive and their settings and seated positions are measured and documented, and that they would be asked questions. The exact measurements, questions and documentation to be included in SPEED were based on the assumptions from chapter 5 and further developed and evaluated in three evaluation sessions described in chapter 6.1. The main priorities during the development were usability, time and relevance of the acquired result.

SPEED as a method includes preparations, a clinic and analysis, see Figure 6.1. In the preparation phase equipment and appointments will be booked, the equipment will be installed, the car will be measured and the documents and programs included in SPEED will be updated. During the clinic a number of test participants will drive a car making three sessions of settings of seat and steering wheel. The settings will be measured, the test participants' postures will be photographed and they are asked questions. The elicited data will then be compiled and analysed through comparisons between parameters, some conclusions will be made and afterwards be documented. The analysis will be divided into a basic analysis and a further analysis. Three documents and a program will be created and will provide the means for completing SPEED; the SPEED Coordinates program, the SPEED Compilation document and the SPEED Instruction document.
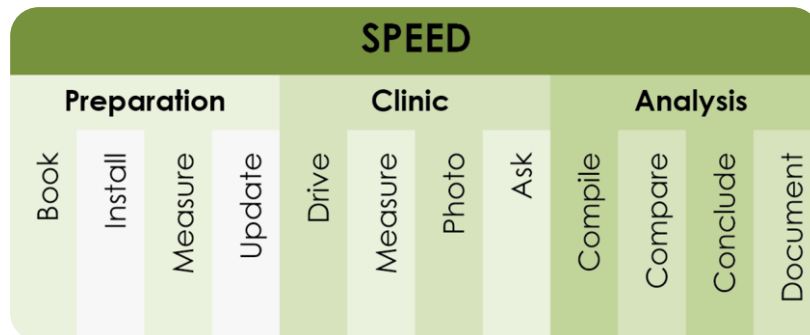
Figure 6.1 – The overall design of SPEED.

## 6.1 Evaluation of concepts

The development of SPEED has been done with three concept evaluations together with master students with the same profile as the upcoming summer employees. The evaluations will be referred to as evaluation 1, 2 and 3. Evaluation 1 was an in depth evaluation of different tools and methods for gathering the data needed and was divided in two sessions. Evaluation 2 was the first trial of SPEED as a method and the results were compared to those of evaluation 1. This to see if the results were exact enough and if the results were reliable and relevant. Evaluation 3 was conducted with two master students who were new to SPEED and acted as test leader and test participant, this to evaluate the instructions.

Evaluation 1 was broad with open interview questions and with an extended testing of the impact on the final seated position when having different starting positions of the seat and steering wheel. Different types of question formulations were tested and evaluated as well as the possibilities of different tools and methods for finding out how and why they sit as they do. The input from evaluation 1 was used for sorting the relevant tools for SPEED.

Before evaluation 2 the tools and methods for SPEED were combined and tested within the team to see if the timeframe was held. In the evaluation focus was on repeatability, to see if the same results would come the second time of evaluation. The questions and the test situation were more refined and more like the final version of SPEED. The same two participants were used as in evaluation 1 to allow comparison.

In evaluation 3 further alterations had been made to SPEED and two new master students helped evaluating the third concept. Focus in this

evaluation was the understandability of the instructions, the usability of the technique and the interaction between test leader and test participant.

## 6.2  Test approach

For deciding the test approach for SPEED an important factor has been time, without compromising on the gathering of data for finding out how and why people sit when driving. To find out how people sit test participants will drive during the clinic. To keep the test situation as realistic as possible different traffic environments should be included in the drive route. Measuring of the settings of seat and steering wheel will be done and the seated position will be documented. Documenting the position does not answer the question of why they sit as they do so additional questions to the test participants is needed. The different tools and methods that can be used for eliciting the data needed are further described and evaluated in chapter 7.

Because of the limited man hours allowed for the clinic, see chapter 4.2, it was soon decided there would only be one test leader during the clinic. To save time, reduce the work load for the test leader and to achieve a more standardised clinic it was decided that the questions would be read and answered directly on the computer by the test participant in the SPEED Compilation document. Additional benefits of this are that the amount of printed papers will be reduced and that the compilation of data will be easier done than what have been the cases in earlier clinics, described in chapter 2.4. After evaluation 1, described more thoroughly in chapter 6.1, it was decided that SPEED would include objective measurements to answer how people sit, subjective questions to answer why people choose their seated position and observation of behavior to show how people act while driving.

### 6.2.1  Objective measurements
The most important points to find out according to VCC Ergonomics are H-point, eye point, heel point and the distance between head and neck rest. Therefore these points will be elicited from the clinic. Prior to the clinic the car and the installed equipment will be measured by VCC Crash Test Preparation to allow comparison with CATIA models and drawings. All calculations to coordinates will be performed in the SPEED Coordinates program made in Excel.

### 6.2.2   Subjective questions

Open questions and ranking lists will allow gathering of qualitative and quantitative data. This can be used for obtaining deeper knowledge of why people position them as they do as well as comparing subjects with quantitative data. Questions about comfort, reachability, vision, priorities, ratings and personal style will be asked. Different scales and question formulations were evaluated in evaluation 1, evaluation 2 and together with VCC Ergonomics and more about that can be seen in chapter 7.7.

### 6.2.3   Observation of behaviour

To reduce the workload for the test leader during the clinic, observation will be done afterwards with videos of the test participants' settings and driving. Cameras that take still photos also allow some observation of behaviour in certain traffic situations. From the photos and video the test leader can observe the behaviour of the test participant to see if something triggers a change in posture and if certain functions in the car are used, e.g. arm rests. Situations that will be documented are junctions, highway and parking.

## 6.3   Instructions

To allow replication of SPEED for other car models instructions will be provided in the SPEED Instruction document. The starting point was from the team's own experience of being a summer employees at VCC Ergonomics. The instructions should be written so anyone with the required background (master students with ergonomic background) is able to complete SPEED with assistance from someone at VCC Ergonomics. The usability of the test leader instructions have been tested in evaluation 3. The instructions for the method should:

- Be in Swedish
- Provide explanatory pictures and checklists
- Instruct what needs to be prepared early
- List the equipment needed
- Instruct how updates and alterations to documents can be done
- Include instructions needed for booking test participants
- Instruct how the clinic is performed
- Instruct how compilation of result and analysis is done
- Include instructions to test participants

The fonts were chosen to be easy to read; the headers are san serif (Century Gothic) to be easily separated visually from the body and the body is serif (Garamond) to be easily read, and is consistent throughout the report, instructions and documents. Bullet lists are provided when a quick overview is needed and deeper explanations where something more complicated needs to be done. The chapters are to be divided depending on underlying context and ease finding the right information.

## 6.4   Standardisation

The results from evaluation 1 and evaluation 2, described briefly in chapter 6.1, showed that the settings of the seat vary each time and that the starting point for the seat did not matter for the final setting. For SPEED the seat and steering wheel should have the same starting point for all test participant and all three setting sessions, this to allow a standardised test setup. The seat's starting point is to be furthest back, with lowest height and with lowest tilt. The back inclination should be in a position where no one will sit comfortably to force everyone to adjust it. The steering wheel should be in the middle of the adjustment range.

Evaluations of previous measurements from seated position clinics showed that there were no significant differences between the mean value of H-point and the four different settings that the test participants did between each driving. There was no connection or differences in between setting 1&2, 2&3 and 3&4. The conclusion was therefore that more sessions of adjusting the seat and steering wheel would not lead to a more "exact" or "true" position but rather that either of the positions was good enough for driving. Moreover previous clinics and evaluation 1 and 2 showed that people found a comfortable position faster and easier after a few sessions because of recognition of buttons and the rest of the car. It was therefore decided that there would be three sessions of setting the seat and steering wheel and that the values from the third setting would be analysed in the basic analysis.

For comparing driving in different situations the route should be prepared for driving on highway, in junctions and on parking lot. The route shall be the same for all test participants for a standardised environment.

## 6.5 Summary of overall design

SPEED is divided into three parts; preparation, clinic and analysis. Documents and programs will be provided for this method, including the SPEED Coordinates program, the SPEED Compilation document and the SPEED Instruction document. The clinic will be conducted while driving according to a drive route and the test participants will answer questions in a questionnaire. Three driving sessions will take place and the set and steering wheel are to be reset to a starting point before each new session. The means of eliciting information are objective measurements, subjective questions and observation of behaviour.

# 7 Detailed design

Detailed information about the testing of different potential methods and tools are described in in this chapter. How to elicit information about H-point position and back inclination from the car's computer system and CATIA drawings is described. Further on retrieving of eye point position, steering wheel position and distance between head and neckrest is described and is done with the use of GoPro cameras, Photoshop and pixel analysis. How to elicit information about heel point is also described. Further on this chapter describes the selection of test participants and the three stature groups that were formed, how the questionnaire was formed and how the analysis was divided.

The tools and methods that can be used for testing the assumptions listed in chapter 5 have been tested for validity and reliability and are described in this chapter. They have been evaluated towards each other with the parameters time, usability, precision and result, see Appendix B, and thereafter been chosen and combined to form SPEED. The preparations, the selection of test participants, instructions, test approach and an idea of future analysis have been formed and are the start for the final design of the test description that can be seen in chapter 8.

## 7.1 Retrieving H-point

The method of establishing the H-point comes from knowing the adjustment range for the seat regarding length, height, tilt and the motor activity (information from the CAN bus) when moving the seat. To elicit this information it is required to have an electrical adjusted seat and connect measuring equipment, such as DiCE[16] combined with software called GGD DHA[17], establishing connection with the seat. The software needs to have information from a database created for the specific seat due to all seats' different behaviour in the car. The elicited information was translated into formulas to be used in Excel, the SPEED Coordinates program, which is translating the motor steps to coordinates of an estimated H-point. For the translation from motor

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[16] DiCE, see glossary on page v
[17] GGD DHA, see glossary on page v

steps to coordinates the seats kinematic model was investigated in CATIA. This model shows seat movement and allows eliciting of coordinates of the H-point in different positions. Since the seat does not move linear in all directions, see Figure 7.1, the movement had to be calculated. To calculate the H-point position contribution from adjustment in length, height and tilt needed to be calculated separately and then be combined.

To calculate the contribution from the linear length movement the total length of the seat's rail and the angle of the seat cushion against the horizontal ground plane were used, see c respectively α in Figure 7.4. The non-linear movement in height was calculated by eliciting coordinates from the CATIA model, the extreme positions when the seat is in its lowest and rearmost position and also in its highest and rearmost position. Between these two extreme positions an amount of positions were noted, and then the motor steps were distributed over the movement. The positions between the two extreme positions were interpolated to get all possible positions of the height adjustment. The same method was used to calculate the tilt's contribution to the H-point. When all contributions had been calculated they were combined to get the final H-point and shown in a diagram, see Figure 7.2.

It was decided to use this way of eliciting the H-point instead of the way VCC Ergonomics made it during the previous clinics, presented in chapter 2.4.4, due to the simplicity and repeatability. When a new seat is selected in the future, neither all H-point measurements needs to be recalculated manually nor any triangulating formulas between the seat and H-point be recalculated. The finalised SPEED Coordinates program was then evaluated and compared to the result from the measured physical car with manikin, the CATIA drawings and the CATIA kinematic model.

When the comparison between coordinates from the seat model in CATIA and from the measurement was made, it showed similar results. To compare points from the CATIA model with the points measured in the real car, two inflexible points were chosen called PT1 and PT2, seen in Figure 7.3.
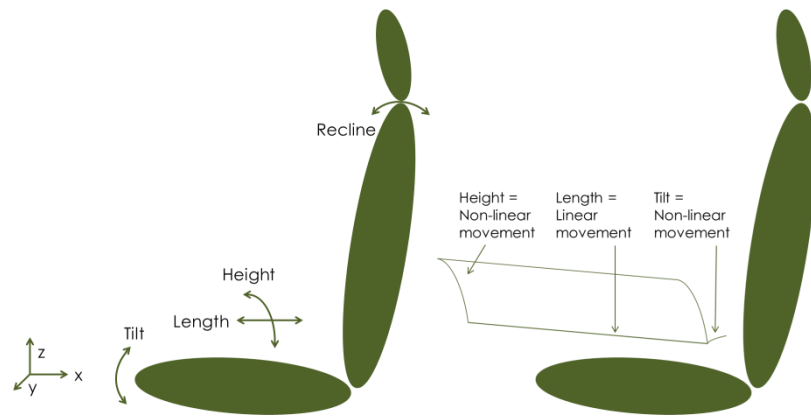
**Figure 7.1 – Left; the adjustment possibilities for the seat. Right; the H-point movements within the seat's adjustment range.**
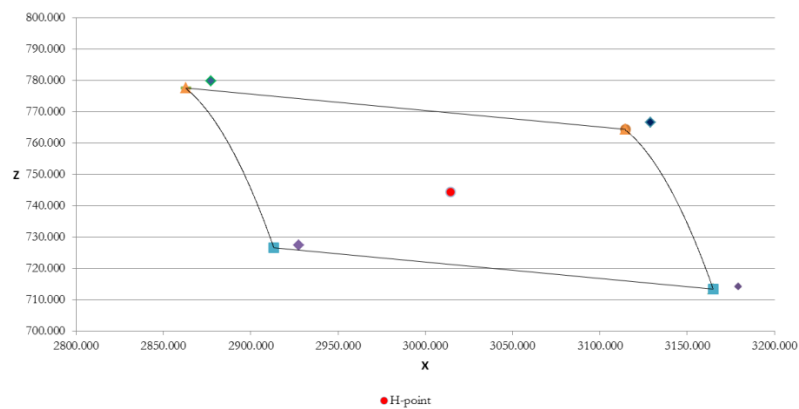


**Figure 7.2 – H-point as displayed in SPEED Coordinates program.**



**Figure 7.3 – The two inflexible points PT1 and PT2 in the physical car**
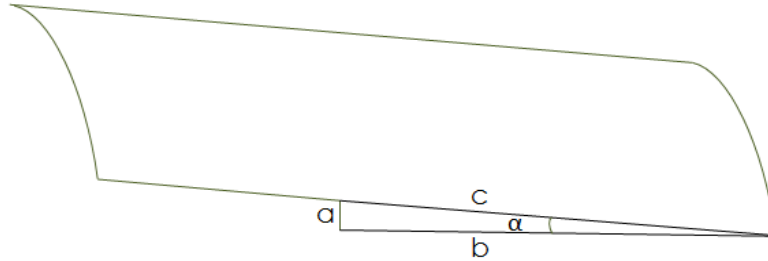
**Figure 7.4 – Movement of seat**

Average differences between the measurement of PT1 and PT2 in the physical seat and the one in CATIA were calculated for each coordinate, x, y, z and showed a difference of 1.97, 4.83, 0.86 mm respectively. These average measures show that the physical car is not exactly the same as in the CATIA model and its drawings due to tolerances during the whole developing and manufacturing processes. The differences in the measures need to be applied to the calculations used in the method to be able to locate where the persons H-point actually is.

### 7.1.1   Back inclination

The inclination of the backrest is calculated with help of points and angles from the measurement made of the physical car. The measurement was made by using a manikin sitting in the seat and changing the seat's back inclination with the electrical seat motor to a defined angle. The measurement started with the seat in the rearmost position, with its highest inclination. For the starting position and all further positions the angle of the manikin was noted, x-, y- and z-coordinates of two points on the seat's back were noted and data of motor activity from the car's CAN bus was read. To get all possible angles of the backrest it was interpolated in the same way the H-point and tilt was interpolated. The presented angles in the result present the angle of the manikin in the seat sitting with the chosen back inclination. This angle was the one VCC Ergonomics selected as the primary angle to know, but in the SPEED Coordinates program both manikin inclination and backrest inclination can be calculated.

This method was chosen because it elicits the back inclination of the manikin and the inclination of the backrest. Furthermore it presents data of the actual angle together with extreme positions of the seat's back, see Figure 7.5, unlike the previous method explained in chapter 2.4.4.
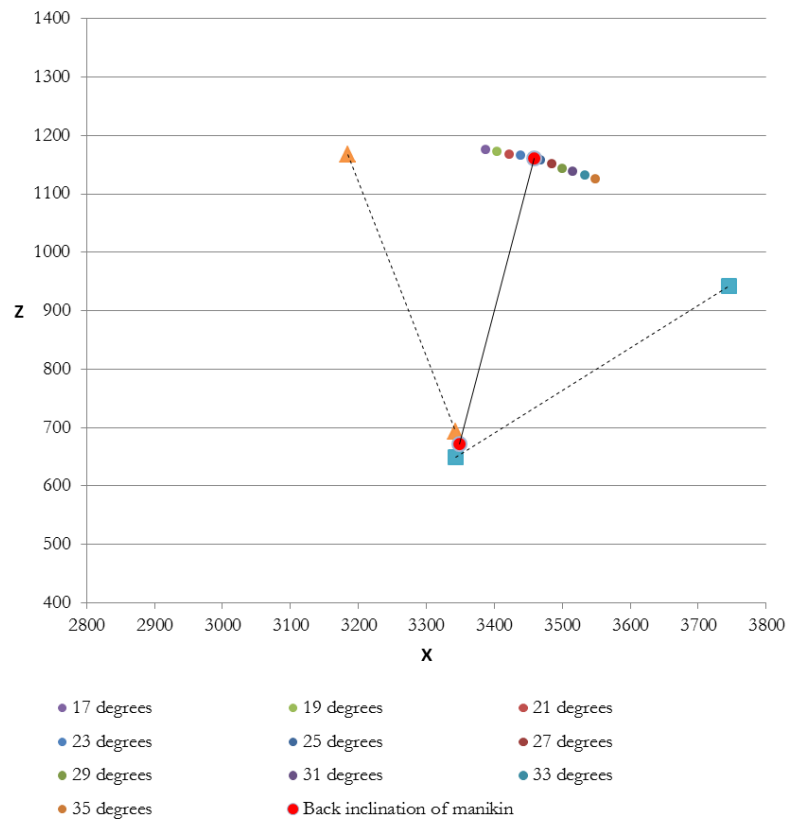
**Figure 7.5 – Back inclination as displayed in the SPEED Coordinates program.**

## 7.2 Retrieving Eye point

The possibilities of retrieving coordinates for eye points through eye tracking, photographs and video was investigated. The evaluations showed that the most time efficient and precise method was through photographs and it was decided that the picture to be evaluated for eye point extraction were to be taken while driving straight forward on the third driving session, more explained in chapter 6.4.

### Eye tracking

The eye tracking device was easy to install, however the calibration took long time and proved to be too imprecise to give usable information about eye location. The original information that the position of the eye could be established in coordinates by using the equipment proved to be wrong and that using the eye tracking device would only give information about where the person looks. This could give good indications to what are important visual references when adjusting the

seat; although it demands more method development and more time from the test participants before it would give enough answers. Therefore will eye tracking not be a part of SPEED.

### Photo analysis

The cameras needed are assembled in the car before the measuring so their exact position relative the car coordinates can be measured for future references. Photos were taken with GoPro[18] cameras during the measurement to enable analysis in Photoshop.

One camera was placed on the passenger side window taking photos in approximately a perpendicular angle of the driver and another camera was placed on the ceiling taking photos from above. A third camera was placed on the passenger side panel for video recordings. The positioning of the cameras were done while viewing the recordings and photo angles through iPads and reference marks were placed in the car so the same angle could be achieved with the passenger side camera even if the camera had to be moved.

To save time it was decided to use a checkered reference plane large enough to make it sufficient to analyse just one photo instead of the multiple photos that were needed for the old method, see chapter 2.4.4. A measuring stand was made to allow placing the reference plane in the position wanted in x-, y- and z-direction during the measuring and photographing of it, see Figure 7.6. The reference planes were set in different y-planes related to the driver seat; 100 mm apart. The measuring stand held the reference plane on place; however it was difficult to position it in the right position to keep the x- and z-coordinates stable when moving it in y-direction. The difficulties in keeping the correct position in x- and z-direction were due to the stand having turnable wheels thus making it difficult to push it straight. Furthermore the material was of high density making it difficult to keep the beam straight when elongated. The measured points differed up to 3 mm in x- and z-direction but it was decided that it would be sufficient for this evaluation. This since the team used the points to create equations, translating pixels in photos to coordinates, and the tolerance of 3 mm does not affect these equations. Due to time constraints it was not possible to construct a new stand for the measuring of XC60.

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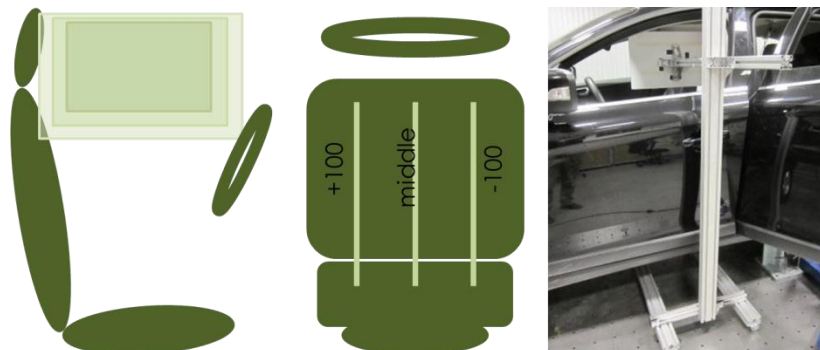
**Figure 7.6 – Left: The checkered reference plane seen in relation to the seat from the passenger side. Middle: Reference plane from above. Right: The measuring stand.**
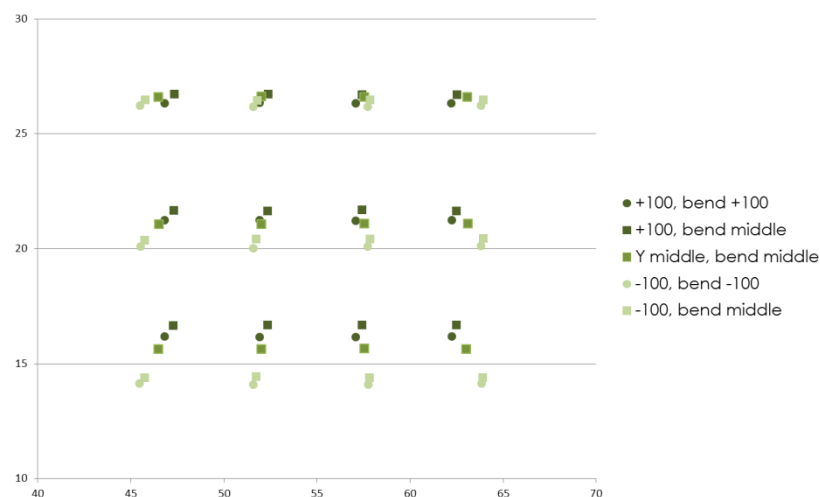


**Figure 7.7 – Plotted pixel values from different wide angle corrections. The squared dots represent middle correction and the circles represent special corrections depending on the y plane.**

**Table 7.1- The measured coordinates in comparison to the converted pixel values based on different wide angle correction.**

|  | | **Y plane** | | |
|---|---|---|---|---|
|  | [mm] | +100 | Middle of seat | -100 |
| **Type of correction** | Measured X coordinate | 3261,6 | 3262,77 | 3262,05 |
|  | +100 | 3262,077 | - | - |
|  | Middle of seat | 3261,439 | 3263,663 | 3262,878 |
|  | -100 | - | - | 3262,392 |

Depending on where the eyes are located in y-direction the pixel values give different coordinates. Therefore different formulas were created in the SPEED Coordinates program where the pixel values were connected to the measured coordinates for each of the measured y-planes. For testing its reliability, fisheye removing was used separately for the different y-planes and compared to the result from when using the same degree of fisheye removing independent on y-plane, see Figure 7.7. The result showed that the formulas to convert the pixel values to coordinates gave a difference of on average 1 mm between the different wide angle[19] corrections, see Table 7.1. This lead to the decision that all photos taken with the side camera can be altered with the same fisheye removing and still give an exact location of eye point if the pixel value is converted with different formulas depending on which y-plane the eye is located.

In the SPEED Coordinates program the pixel values extracted from Photoshop are inserted and converted through the formulas and interpolation to a coordinate. The original thought was that one would chose different formulas depending on the eyes position in y-direction, something that would be seen in the pictures from the roof camera. This is something that would work if all test participants had their heads on the same height. The angle of the roof camera combined with the different heights of test participants did however make it difficult to see the y-position of the head as the camera view in some cases only showed the test participants hair. This was seen too late in the making of SPEED so another solution should be made for the next car evaluation. It was decided, after discussions with VCC Ergonomics, that the eye point to be analysed in the basic analysis were from driving straight forward. Thus is the eye points analysed from driving straight from the third session of driving. For the basic analysis it is sufficient to use the formula for the y-plane in the middle of the seat as most people sit in the middle of the seat when driving straight forward. For further analysis of seated positions in other traffic situations the other y-planes need to be used and the method therefore be more developed.

## 7.3   Retrieving steering wheel position

The previous method of finding out steering wheel position has been difficult to use, see chapter 2.4.4. Therefore a new way of finding out the position was developed by the team where the middle point of the steering wheel was in focus.

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[19] Wide angle, see glossary on page v

A crash test sticker was placed in the centre of the steering wheel and its centre was measured and photographed in five positions; the four extreme positions and in a middle position. Thereafter the checkered reference plane was measured and photographed in the same way as for the eye point. The fisheye effect was reduced in relation to the y-plane in the middle of the seat, the same that is used for retrieving eye point position. The photographs were then analysed in Photoshop and the pixel values were converted to coordinates in the SPEED Coordinates program.

The converted values from the photos were compared with the measured values. This showed that there was a tolerance level up to 4.1 mm in z-direction and up to 8.5 mm in x-direction. The reason for the larger difference in x-direction could depend on the fisheye effect on the camera used and the angle of the camera as it is not perpendicular to the steering wheel. Another reason for the inaccuracy could be that the measured points on the reference plane were too far apart and that better accuracy could be achieved if the squares were smaller. Whether this tolerance level is considered to be acceptable or not depend on the required accuracy and usability the method should have. The new method is of high usability but deliver a result presenting if test participants have adjusted the steering wheel to any extreme position. Comparing the new method to the previous method used by the Ergonomics department, the previous deliver more correct results but is of higher complexity and is more time consuming. Depending on what accuracy the Ergonomics department want to have in future evaluations, decides which of the two methods to use.

## 7.4   Heel point

The heel point position is easiest retrieved through photographs because the area below the steering wheel and instrument panel is hiding the feet thus making it impossible to observe feet position for a test leader. Different camera positions were tried and the conclusion was that it was easiest to determine heel position when the camera was placed directly behind the feet with a grid on the floor mat.

The first position for the camera was from the left, see the left photo in Figure 7.8, where the stripes only allowed the x-position of the heel to be determined. To allow finding out the heel position in y-direction as well a grid was attached to the floor mat and other placements of cameras were investigated. The best accuracy of the pictures was

delivered when the camera was attached to the seat. The final setup for finding out heel point can be seen on the right in Figure 7.8.

After a meeting with VCC Ergonomics it was decided that the accuracy level for the heel position was accepted to be in centimetres, which was the base for the reference system attached to the floor mat. The floor mat was prepared with black and white stripes in a grid, and 20 points were measured. The coordinates for the 20 points were then included in the SPEED Coordinates program where interpolation between the points gives an answer to where the heel is positioned. In order to get the approximate coordinates one write which square in x- and y-direction the heel is positioned.



**Figure 7.8 - Left; evaluating camera angles and references. Right; the stripes and camera angle that were implemented in SPEED.**

## 7.5   Drive route

At first a GPS with a programmed route was tried as a way to standardise the driving and to not affect the test participants while driving. The type of GPS that was possible to borrow at VCC was however not intuitive and the drive route with its several stops was difficult to programme, therefore the GPS was excluded. The drive route has instead been written as instructions and is told to the test participant while driving. A possible risk of having a GPS could be that the test participants' eye movements would be affected by the added information source and possibly affect the seated position.

## 7.6 Test participants

The selection of test participants is made from Testkliniklistan. According to Erik Kristiansson[20] the best from a statistical view would be to have a totally randomised selection to get a representation of the entire population. However, since one important reason for making the analysis of cars is to provide information for future requirement specifications it is of essence that the critical groups are represented. Kristiansson therefore suggested that there could be three groups of test participants, short (shorter than 10%ile women), normal (either in the middle span or people from the whole range of heights) and tall (taller than 90%ile men). For the method it would be better to have fewer setting sessions and more test participants if there is a need to prioritise the time.

Before deciding the selection of test participants, interviews were held with people at Design and Human Factors at Chalmers [21]. This department of Chalmers performs clinics themselves and helps VCC with some of their clinics. Design and Human Factors at Chalmers mostly performs qualitative studies and analyses and has used between 6 and 30 persons in their clinics.

The final selection of test participants was to have three groups of 46 short, medium statured and tall people with 15, 16 and 15 people in each. The reason for choosing this number of people is because of the benefits of having more people for statistical purposes but having few enough to manage to complete the clinic within the time frame. In the medium heighted group there are 8 women and 8 men. In the short group women of 20%ile or shorter are included; in the tall group men taller than 90%ile are represented and in the medium heighted group both men and women are equally represented with women taller than 20%ile and men shorter than 90%ile. The reason for choosing the larger height span for the short group than what Kristiansson suggested is because of the limited amount of short people in *Testkliniklistan*.

## 7.7 Questionnaire

The questionnaire was developed with input from evaluation 1 and sought after being easy to fill out on the computer. The questions were

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[20] Erik Kristiansson (Matematisk statistik, Chalmers), interviewed 21st of February 2013.
[21] Pontus Wallgren and Ida Hansson (Design and Human Factors, Chalmers) interviewed 28th of February 2013.

formulated so they could be answered by a single click and that potential comments could be added if wanted but not to be mandatory. The full list of evaluated question formulations and scales can be seen in Appendix A.

The usual scale used at VCC is a 10 graded scale with colours, see Figure 7.10. This is easily recognised for Volvo employees; however people have predefined thoughts of the scale and use it differently depending on whether they use the scale for other evaluations. Some people use the whole scale whereas others just use a small part of the upper part of the scale. By using the recognition of colours and therefore maintain the usability of the scale; the colours was kept but instead of having the usual 10 graded scale it was condensed to a 5 graded scale, see Figure 7.11. The change of scale was also strengthen by the result of evaluation 1, where the 10 graded scale was considered to be complex and consisting of too many numbers.

To find out how people want to sit an Excel program was developed where people would be able to choose the preferred inclination, height and length adjustment for the evaluated car, see Figure 7.12. However the evaluations of the program did not give additional information of how and why the seated position was chosen so it was excluded from SPEED. Instead the test participants answer how much certain body parts are in contact with the seat as shown in Figure 7.9.
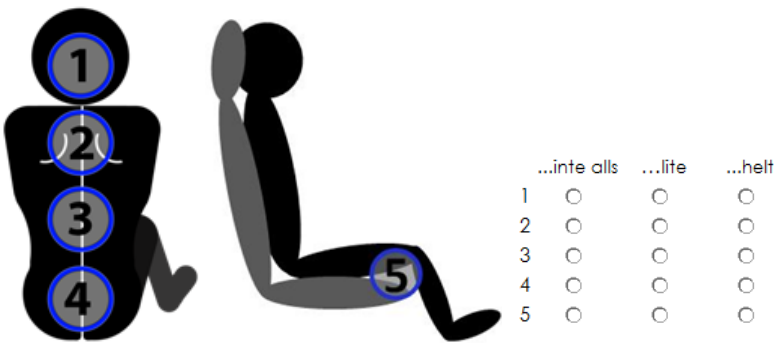


**Figure 7.9 – Which parts are in contact with the seat? The options translates to "…not at all", "…little" and "…completely".**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|----|
| Väldigt dåligt | | Dåligt | | Ok | | Bra | | Mycket bra | |

Figure 7.10 – The VCC scale for subjective rating

5a)

Hur sitter du där du sitter nu?

Hur skulle du sitta om du satt:

| | Väldigt dåligt | Dåligt | OK | Bra | Mycket bra |
|---|---|---|---|---|---|
| Hur sitter du där du sitter nu? | ○ | ○ | ○ | ○ | ○ |
| Högre upp? | ○ | ○ | ○ | ○ | ○ |
| Längre ner? | ○ | ○ | ○ | ○ | ○ |
| Längre fram? | ○ | ○ | ○ | ○ | ○ |
| Längre bak? | ○ | ○ | ○ | ○ | ○ |
| Högre tilt? | ○ | ○ | ○ | ○ | ○ |
| Lägre tilt? | ○ | ○ | ○ | ○ | ○ |

| 5b) Hur är det att hitta en bekväm sittposition? | Omöjligt | Krångligt | Möjligt | Enkelt | Väldigt enkelt |
|---|---|---|---|---|---|
| | ○ | ○ | ○ | ○ | ○ |

Figure 7.11 – The scale used for SPEED



Figure 7.12 – A seated position program in Excel

## 7.8  Analysis

The analysis of the result will be divided in two parts, basic analysis and further analysis. The basic analysis will include the most basic information from the objective measurements and subjective questions. Further analysis will not be a part of the method and are for VCC Ergonomics to complete when they want more information about a specific person and his or her seated position and opinions. What should be analysed have been discussed both with VCC Ergonomics and VCC Crash and Safety. The analysis is made with consideration to the team's assumptions, listed in chapter 5.7, since those are seen as most important to investigate together with the possibility of comparing the different car models in a later stage. The parameters that are to be presented in the basic analysis and the parameters that will be saved for further analysis can be seen below in Table 7.2.

For comparisons of parameters and to get statistics of the result Microsoft Excel will be used, both since the program makes it possible compiling all data and is sufficient enough to perform the basic analysis. To be able to compare the parameters regression analysis will be used to find correlations. The analysis is made by plotting two parameters; draw a linear curve of the plotted values so a value of correlation can be elicited. This type of analysing was used due to recommendations from Erik Kristiansson, and also because of its easy way of showing the correlations.

**Table 7.2 – Division for basic and further analysis**

| Parameter | Basic analysis | Further analysis |
|---|---|---|
| H-point | X | |
| Eye point | X | |
| Heel point | X | |
| Back inclination | X | |
| Limitations seat | X | |
| Limitations steering wheel | X | |
| If the desired position is found | X | |
| Reachability pedals | X | |
| Distance between head and headrest | X | |
| Roominess head | | X |
| Roominess legs | | X |
| Driving personality | | X |
| What is wanted and not wanted in field of sight | | X |
| Reachability steering wheel, buttons | | X |
| Comfort; arm support, lumbar support, foot support, seat belt | | X |

### 7.8.1   Basic analysis

The basic analysis should be easily made and therefore be prepared for in the SPEED Compilation document. Some diagrams can be prepared so they appear automatically in the SPEED Compilation document as soon as the information is inserted from the clinic. For other diagrams preparation is needed before completion, such as sorting of certain parameters, but these can be prepared with descriptions of how to achieve them.

### Objective measurements

For the basic analysis visualisations of H-points, eye points, heel points and steering wheel position are to be shown in diagrams. Distance between head and headrest will be visualised in a histogram.

### Subjective questions

A presentation of potential limitations of adjustment capabilities of the seat and steering wheel are to be included and in that case also present the stature of those people. The basic analysis will also show results in form of charts displaying how comfortable the test participants feel for different settings, the importance of certain parameters in the particular car when setting their seat position and what they think of the same parameters in the car. The answers of these limitations and parameters will be analysed in a first stage because they give a subjective answer on why people choose their seated position.

### Observation of behaviour

No observed behaviour will be included in the basic analysis.

### 7.8.2   Further analysis

Further analysis is going to be made by VCC Ergonomics when certain situations or individual scores from a specific test participant are evaluated. The further analysis can include reading test participants' comments and correlations between them and their rating as well as comparing more specific body measures. Observation of behaviour will be further analysed by VCC Crash and Safety. The filmed material will also be available for VCC Ergonomics to be used when performing further analysis.

## 7.9   Tools used for SPEED

The potential tools and methods for SPEED evaluated in this chapter has been rated regarding time consumption, usability, precision and the result that they give. The complete list of tools can be seen in a matrix in Appendix B. The tools chosen for SPEED had high scores in most of the categories and contribute to relevant result and can be seen in Table 7.3. Some equipment was built for SPEED, for example the measuring stand described in chapter 7.2. To ease the commissioning of SPEED two aid equipment were built; one to ease the handling of iPads and one to ease the computer usage for the test participants, see Figure 7.13.

Table 7.3 – The chosen tools for SPEED

| Tool | What for? |
|---|---|
| **Anthropometrics** | Analysis |
| **CAN bus** | H-point |
| **CATIA** | H-point |
| **DiCE** | H-point |
| **Drive route** | Reliability, repeatability, standardisation |
| **Excel** | Analysis, subjective, eye point, heel point, steering wheel position, distance neck rest |
| **GGD-DHA** | H-point |
| **Grid** | Heel point |
| **Measure car** | H-point |
| **Photoshop** | Eye point, steering wheel position, distance neck rest |
| **Photo with GoPro** | Eye point, heel point, steering wheel position, distance neck rest |
| **Questionnaire** | Subjective |
| **Squares in y-planes** | Eye point, steering wheel position, distance neck rest |



**Figure 7.13 – Built equipment for easing computer and iPad usage in the car.**

## 7.10 Summary detailed design

Different tools and methods and ways to measure have been evaluated and are presented here. The H-point, heel point and eye point positions are calculated in the SPEED Coordinates program. Information of the seat's motor movements, a kinematic model in CATIA and the positions of two fixed points, PT1 and PT2 are used to retrieve the H-point position. The presented back inclination is the measured angle of a manikin in the seat but in the SPEED Coordinates program information about the seat's back inclination can be found. Eye points and steering wheel position is retrieved through photos and pixel analysis in Photoshop after reduction of lens effects and measuring of a

checkered reference plane. The heel point is retrieved through photo analysis and inserting the visual input from the grid in the SPEED Coordinates program. The test participants to be included in the clinic are divided into three stature groups with 15 people in each. There are short women in the short group, medium to tall women and short to medium men in the medium group and tall men in the tall group. The analysis of the result is divided into basic and further analysis and will be made in Excel.

# 8 Description of SPEED

In this chapter the Detailed and Structural design of SPEED is described briefly and divided into chapters of preparation, clinic and analysis. SPEED as a method contains the SPEED Instruction document (Appendix G) with instructions for how to prepare and conduct the clinic; the SPEED Compilation document (Appendix E) where the test participants answer the questionnaire (Appendix D) and the analysis is conducted; and the SPEED Coordinates program (Appendix F) where all data from the measuring is updated and the calculation of H-point, eye point, heel point and steering wheel is done. More detailed descriptions can be seen in these documents.

## 8.1 Preparation

Before the clinic some preparations are needed and are presented below divided into the parts *book, install, measure* and *update*.

Book

- Book the needed equipment, car and time for measurement. The equipment needed can be seen in Figure 8.1, 4 cameras, 3 iPads, DiCE, 2 computers and charging possibilities.

- Invite test participants to the clinic. First choose the test participants as described in chapter 7.5, send thereafter e-mails to invite them to the clinic. Examples of e-mails can be seen in the SPEED Instruction document.

Install

- Install the equipment in the car. A schematic picture of the installations can be seen in Figure 8.3. Two cameras are placed on the passenger window, one camera on the driver's seat and one in the roof.

- Install the DiCE equipment to read the seat's motor movements.

**Figure 8.1 – The equipment needed for SPEED.**



**Figure 8.2 – Some of the measured points on the seat, PT1 and PT2 and the centre of the steering wheel.**
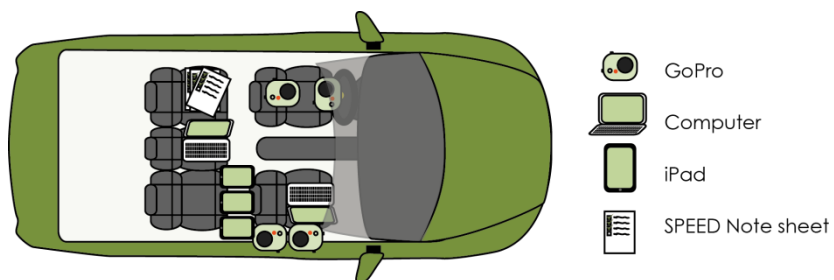


**Figure 8.3 – The rough placement of cameras, iPads and computers needed for the clinic.**

### Measure

- Measure the car. Points on the seat and steering wheel should be measured in different positions, the cameras should be measured and parts of the car should be scanned. Some of the most important points are shown in Figure 8.2.

- Measure points on the reference plane for later extraction of eye point and steering wheel position.

### Update

- Evaluate the seat motor movements in CATIA and in the car at the measurement. The values should be inserted into the SPEED Coordinates program and be updated for each new evaluated car model.

- The anthropometric measures for each test participant should be updated in the SPEED Compilation document.

- Conduct a photo analysis of the photographed reference plane, reduce lens effects and insert the pixel values into the SPEED Coordinates document.

## 8.2  Clinic

For the clinic there are instructions regarding what the test leader should say to the test participants and driving directions. These instructions are found in the SPEED Instruction document. The instructions also explain how the setup with cameras and measure equipment are done. The clinic is divided into parts of *drive, measure, photo* and *ask*.

An introduction should be held for the test participant, showing all possible adjustments of the seat and steering wheel in the driver position. Also a summary of what is included in the clinic will be told to the test participant before driving.

### Drive

- Test participants will drive according to detailed instructions told by the test leader. There will be three different driving distances to a total of 8 km.

- In the end there is a parking situation where the test participant park towards cones and estimate the distance between the registration plate and the cone.

## Measure

- Measure equipment such as DiCE and a computer for reading the seat position needs to be connected to the car's CAN-bus. The GoPro cameras need to be put in correct position and connected to the Apple iPads which will be the remote controls.

- The motor steps are measured after the first, second and third driving session. First and second reading will be made during the stop after first and second driving and the third reading while driving the third route. All readings are noted using the SPEED Note sheet.

- Measure the distance between the car and the cones for the parking situation.

## Photo

- Photos are taken when driving straight ahead, standing by traffic lights in intersections and at the parking situation. Photos should be taken during the two first situations for all three settings if possible, by using three iPads controlling the GoPro cameras.

- Observed behaviour such as if the person is changing position during driving can be noted on the SPEED Note sheet.

- One of the cameras is filming with the purpose of observing the test participants' behaviour in different situations.

## Ask

- Notes are to be written for all three settings regarding how they position themselves, using the SPEED Note sheet, found in Appendix C.

- The test participant answer questions regarding their current seated position when the car stands still after driving route one, two and three. After route three more questions regarding other parameters in the car and a parking situation are asked. All questions will be answered in a computer standing in the front passenger seat.

## 8.3 Analysis

The analysis is divided into basic and further analysis. Further analysis is for VCC Ergonomics to decide in a later stage. How to conduct a basic analysis is explained below. The analysis of the result will be made in the SPEED Compilation document, where data from all test participants is gathered. In this document there are diagrams and charts prepared for the basic analysis. In the SPEED Compilation document all data available about the test participants will be included from *Testkliniklistan*, to have all body measures available. Selected parameters shown in Table 7.2 will be shown in diagrams.

### Compile
- All motor steps are put in each individual test participant sheet in the SPEED Compilation document and then converted to coordinates by copy and paste in the SPEED Coordinates program to later be pasted back into the SPEED Compilation document.

- The photos are to be moved to a computer and sorted by situation and setting, thereafter remove fisheye effect with Photoshop using predefined actions. Then a selection of photos is made and the eye points analysed with help of Photoshop and the SPEED Coordinates program, thereafter to be put into the SPEED Compilation document.

- The position of the steering wheel is elicited through photos with the same procedure as eye points.

- The heel points are analysed with photos of the test participant's feet and in the SPEED Coordinates program. The test leader will manually look in the photos where the heel of the right foot is located and put this location in SPEED Coordinates program, which in return gives coordinates and that are pasted into SPEED Compilation document.

### Compare
- In the SPEED Compilation document diagrams, tables and charts are prepared and appear automatically. Through the diagrams and the displayed mean and median values of priorities and scores parameters can be compared.

### Conclude
- From the charts and colour coordinated tables conclusions can be made in combination with analysis of the comments.

### Document

- The result is to be documented and presented, with help of diagrams and the results from the created charts along with some written conclusions. For this documentation VCC uses Powerpoint.

# 9 Evaluation of SPEED

An evaluation of SPEED can be found in this chapter. The time used for the method as a whole and for each test participant has been evaluated as well as the usability of the instructions, the equipment that has been used and the quality of the result and the found connections.

SPEED has provided a Seated Position Evaluation from Elicited Data and delivers versatile information about how people sit when they drive. The elicited points enable making virtual manikins with the same body measures as the test participants and position these in the virtual car model. The team has found correlations between people's anthropometry and their answers on the subjective questions, the reasons behind the positioning, and thereby why they sit as they sit. How test participants are positioned is clearly answered by the use of SPEED. Why test participants sit as they sit is answered and further analyses of other car models can validate the existing correlations and extract more correlations. It was discovered that people of the same stature can sit completely different when driving but be equally happy about their position. The clinics are easy to lead and complete and take little time for the test participants.

SPEED as a whole demands a lot of technical equipment that need to be installed in the car. With detailed instructions to the equipment and how to use and install it in the car the team believes that the usability is sufficient and that the amount of gathered data justify the work that is needed. During the clinics it was discovered that some instructions were unnecessary and redundant, for instance the driving instructions. Many VCC employees know about the area and how to drive there, but instructions are useful for new users of the method and in case test participants do not have knowledge about the geographical area. With the SPEED documents and programs the handling of data, alterations and commissioning should go fast enough. A rough estimation of how many man hours the different steps of SPEED should take can be found in Table 9.1. It is based on that two summer employees' work together and divide work tasks in-between themselves and that they get initial support from VCC Ergonomics. A complete evaluation of how much time it takes to conduct a full clinic using SPEED is possible next time a car is evaluated.

The clinic when using the SPEED method takes between 43 and 47 minutes per test participant. On average the 45 minutes that were put as a limit for the time consumption. Many test participants expressed liking of the clinic and that it was fast and easy to complete. That the test participants were satisfied with the easy clinic compensates the fact that not all the answers about why they sat as they did were obtained. When more car models are evaluated in a later stage, conclusions might be drawn about this matter in further analyses. One cannot be sure that the question *why* would be answered even if the test approach had been different because of the subconscious nature of setting the seat.

There were some technical issues during the clinic. In the beginning of the clinics the cameras kept running out of battery why extra equipment was installed in the car to allow charging the cameras continuously. This means that there is more equipment to install, however the reduced time and effort during the clinics compensate the initial extra work needed. The problems that arose for the team have been documented so these will not be repeated for future SPEED users.

All clinics were held with help of one test leader and it worked well. Due to created tools, such as the aid for the iPads described in chapter 7.9, it was easy to handle equipment during the clinics and to switch between different tasks.

All the parameters that were compared to each other in the analysis can be seen in Table 9.2. In the table the connections between parameters are defined as Yes or No. If the connection says *yes* it means the team saw at least a weak connection. A connection between two parameters should, according to VCC Ergonomics, have at least a $R^2$ value of 0.7 to be considered as valid. Connections between parameters that have $R^2$ less than 0.7 are in some cases considered as weak connections. These parameters have been compared pairwise, and in some cases the results have also been divided in the three stature groups. The analyses have been made in Excel but if a more thorough analysis in another program, such as SIMCA[22], more connections might be seen. This will be a topic for further evaluation. After the XC60 clinic some further alterations were made to the instructions and the placement of the roof camera has been questioned. The camera placement will be an issue of further investigation and should be altered or excluded for the next clinic.

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[22] SIMCA, see glossary on page v

**Table 9.1 – Estimated time consumption for SPEED**

| Task | Time [h] |
| --- | :---: |
| Read the SPEED Instruction document | 6 |
| Book car and equipment | 1 |
| Install equipment in car | 6 |
| Measure car | 8 |
| Invite test participants | 8 |
| Find out the seat movement in steps | 8 |
| Prepare Photoshop actions | 3 |
| Update SPEED Coordinates program | 16 |
| Preparation of car before and after clinic sessions | 20 |
| Clinic | 47 |
| Combine the SPEED Note sheet with the SPEED Compilation document | 1 |
| Convert steps to coordinates | 2 |
| Rename pictures | 8 |
| Prepare pictures for pixel analysis | 2 |
| Convert pixels to coordinates | 5 |
| Retrieve heel point | 2 |
| Conduct basic analysis | 16 |
| Document the results | 1 |
| | **160** |

**Table 9.2 – Evaluated parameters from elicited data.**

|  | 1st parameter | 2nd parameter | Relation |
|---|---|---|---|
| **Comfort** | Stature | Score foot/knee roominess | **Yes** |
| **Comfort** | Leg length | Priority/score foot area | **No** |
| **Comfort** | Stature | Score arm rest middle | **Yes** |
| **Comfort** | Stature | Seat belt | **Yes** |
| **Comfort** | Distance head to headrest | Back inclination | **No** |
| **Reachability** | Score pedal | Back inclination | **No** |
| **Reachability** | Score steering wheel | Back inclination | **No** |
| **Reachability** | Score gear stick | Back inclination | **No** |
| **Reachability** | Score buttons | Back inclination | **No** |
| **Reachability** | Leg length | Heel point x | **No** |
| **Reachability** | Leg length | Heel point y | **Yes** |
| **Reachability** | Back inclination | Steering wheel x | **No** |
| **Reachability** | H-point | Steering wheel | **No** |
| **Reachability** | Arm length | Steering wheel | **No** |
| **Vision** | Eye point z | Score hood | **No** |
| **Vision** | Upper body length | Score hood | **No** |
| **Vision** | Apprehended distance parking | Score hood | **No** |
| **Vision** | Distance parking | Score hood | **No** |
| **Vision** | Eye point z | Upper body length | **Yes** |
| **Vision** | H-point z | Priority vision | **No** |
| **Vision** | Eye point z | Priority vision | **No** |
| **Vision** | Stature | Score lower windshield |  |
| **Anthropometrics** | Stature | H-point | **Yes** |
| **Anthropometrics** | Stature | Average seat change | **No** |
| **Anthropometrics** | Leg length | H-point | **Yes** |
| **Anthropometrics** | Leg length | Stature | **Yes** |
| **Anthropometrics** | Arm length | Stature | **Yes** |
| **Anthropometrics** | Stature | Eye point | **Yes** |
| **Anthropometrics** | Heel point | Stature | **Yes** |
| **Anthropometrics** | Heel point | Foot length | **No** |
| **Anthropometrics** | Heel point | Leg length | **No** |
| **Anthropometrics** | Arm length | Back inclination | **No** |
| **Anthropometrics** | Stature | Back inclination | **No** |
| **Anthropometrics** | Stature | Distance parking | **No** |
| **Anthropometrics** | Tilt steps | Stature | **No** |
| **Anthropometrics** | Tilt steps | Leg length | **No** |
| **Anthropometrics** | H-point z | Upper body length | **Yes** |
| **Anthropometrics** | Arm length | Stature | **Yes** |
| **Limitations** | Seat adjustment | Stature | **Yes** |
| **Limitations** | Steering wheel adjustment | Stature | **Yes** |
| **Limitations** | Eye point z | Score on limitations in seat | **Yes** |
| **Personal attitude** | Personal attitude | Stature | **No** |

# 10  Result of SPEED in XC60

The result from using the method in Volvo XC60 can be found in this chapter where the result is divided into assumption categories as well answering the questions of how and why. Scores and priorities for different parameters in the car are shown in tables divided into the three stature groups and diagrams of H-point, eye point and heel point position is shown.

For this work SPEED as a whole has been used for evaluating Volvo XC60. The results from XC60 have been evaluated towards the assumptions listed in chapter 5 and is displayed here. Scores ranges from 1 to 5 where 1 means either "very bad", "impossible" or "not at all" whereas 5 mean "very good", "very easy" or "very much".

## 10.1 Assumption: Comfort is a factor

1)  How one experiences comfort regarding some or all of the following influence the seated position: foot support, arm rest, seat belt, leg roominess and neck rest.

The result from the questionnaire shows that comfort has little influence on the positioning, see Table 10.1. Foot and knee roominess does however affect the seated position for tall men (scores: 3.4 and 3.5) whereas medium statured (scores: 3 and 2.8) and short women (scores: 2.7 and 3) were not affected as much. There has not been any connection observed between leg length and the priority or scoring of foot support and foot roominess.

The arm rests, both in the door and in the centre, have about the same average points and do not seem to be important for either of the groups (score around 2).  Shorter do not reach the arm rest in the centre and one reason can be the support on the side of the seat.

The comfort of the seat belt is most important for short people but the scores do not differ a lot between the groups (scores: short 2.7, medium 2.5 and tall 1.9), which indicates that other factors are more important and prioritized than the seatbelt.

On the question "is the neck rest where you want to have it when you drive" 25 answered yes and 22 answered no. Three of those who said

no had their head against the head rest while driving and complained about it pushing the head forward. For the taller people the head rest was instead too far away (6 tall, 7 medium). No connection between distance between head and neck rest and back inclination was seen, not even between those who answered the same on the neck rest question.

**Table 10.1 – How comfort affect the seated position and the scores for XC60.**

|  | Affect position | | | Score | | |
|---|---|---|---|---|---|---|
|  | Short | Medium | Tall | Short | Medium | Tall |
| **Foot support (roominess)** | 2.7 | 3.0 | 3.4 | 4.2 | 4.1 | 3.6 |
| **Foot support (comfort)** | 2.7 | 2.7 | 2.8 | 3.9 | 3.9 | 3.4 |
| **Arm rest door** | 2.1 | 2.6 | 1.9 | 3.1 | 3.3 | 3.6 |
| **Arm rest middle** | 2.0 | 2.5 | 2.2 | 2.5 | 3.8 | 3.8 |
| **Seatbelt** | 2.7 | 2.5 | 1.9 | 3.5 | 4.0 | 4.1 |
| **Knee roominess** | 3.0 | 2.8 | 3.5 | 3.6 | 4.1 | 3.5 |
| **Head roominess** | 1.9 | 2.3 | 2.8 | 4.4 | 4.7 | 4.1 |

## 10.2 Assumption: Reachability is a factor

2) The reachability to functions such as pedals, steering wheel and controls, affect the seated position.

According to the result the reachability to pedals (short: 4.8, medium: 4.8, tall: 3.6) and the steering wheel groups (short: 3.9, medium: 4.5, tall: 3.8) were the most important ones for all three participant groups. Gear shift and buttons/regulators were by most seen as barely important, see Table 10.2.

**Table 10.2 - How the reachability affect the seated position and the scores for XC60.**

| | Affect position | | | Score | | |
|---|---|---|---|---|---|---|
| | Short | Medium | Tall | Short | Medium | Tall |
| **Pedal** | 4.8 | 4.8 | 3.6 | 4.5 | 4.4 | 4.3 |
| **Steering wheel** | 3.9 | 4.5 | 3.8 | 3.9 | 4.3 | 4.2 |
| **Gear stick** | 2.0 | 3.0 | 2.1 | 4.1 | 3.9 | 4.2 |
| **Buttons** | 2.1 | 2.5 | 2.3 | 4.0 | 3.9 | 4.1 |

**Table 10.3 - How the visual references affect the seated position and the scores for XC60.**

| | Affect position | | | Score | | |
|---|---|---|---|---|---|---|
| | Short | Medium | Tall | Short | Medium | Tall |
| **Hood** | 3.0 | 2.5 | 2.0 | 2.6 | 2.7 | 3.3 |
| **Mirrors** | 3.1 | 2.7 | 2.0 | 4.0 | 4.3 | 4.0 |
| **Upper wind shield** | 2.2 | 2.3 | 2.3 | 4.3 | 4.1 | 3.5 |
| **Lower wind shield** | 3.3 | 3.0 | 2.1 | 3.7 | 3.8 | 4.1 |
| **Instrument cluster** | 2.4 | 2.9 | 2.7 | 3.9 | 4.0 | 4.2 |

## 10.3 Assumption: Visual references are a factor

3) The visual references outside the car, hood height, lanes, traffic and mirrors affect the seated position.

The rear-view and side mirrors affect the seated position more for shorter people than tall; however there are no significant scores that indicate this (scores: short 3.1, medium 2.73 and tall 2), see Table 10.3. The hood affects the settings of the seat, not very much but more for short than for tall people (scores: short 3, medium 2.5 and tall 2). 14 people give the hood bad or very bad scores (6 short, 5 medium and 3 tall). No connection has been seen between the difference between apprehended distance at parking and real distance at parking and the score for the hood.

4) Visual references inside the car such as windshield, rear-view mirror and dashboard affect the seated position.

Those who put low scores on the lower edge of the windshield were short or medium statured women (4) and it is less important for taller people (scores: short 3.3, medium 3 and tall 2). The scores of the top edge of the windshield do not seem to have any connections to the groups and have an average score of 2.28, see Table 10.3.

## 10.4 Assumption: Anthropometrics is a factor

> 5) The seated position varies between people with different anthropometric measurements.

The result from the evaluations regarding H-point, eye point and heel point show that there are differences among people with different anthropometrics, in this case stature, when it comes to their decision of driving position.

The H-point varies between the three groups, which can be seen in Figure 10.1. Shorter people often put the seat higher up and more forward while taller people put the seat lower and further back. In these two cases it is often seen to be some of the extreme positions, putting the seat in its highest or lowest position and also for taller persons in the rearmost position. People of medium stature are more varied and can put the seat in its highest as well as in its lowest position. Connections are also found when comparing H-point with test participants' total leg length. People with longer legs choose to sit further back and down compared to those with shorter legs.

All three groups have said that they sit well at all three setting sessions and the lowest score of 3.8 have been given by the tall group with a total average of about 4.1, see Table 10.4. The average difference between the three settings is 11.53 mm in x-direction and 4.13 in z-direction.

The eye point result shows that all of the shorter people in this evaluation have their eyes more forward than taller people and those of medium stature are in between and are overlapping the other two groups, see Figure 10.2. It is also seen that it is not the shortest (woman, 146 cm) test participant having the eye point most forward, it is a woman of 157.8 cm. The difference in x-led is 95 mm.

Another correlation was investigated regarding eye points. The team thought that if all eye points of shorter people who thought they should sit better at a higher position and those of taller people who thought they should sit better at a lower position were discarded, the remaining eye points would represent an area where test participants would prefer

to have their eyes. The diagram showed a higher correlation between these eye points than the correlation between all eye points, $R^2$ went from 0.4 to 0.7, see Figure 10.3. This was then developed by putting the eye points from all these test participants into the CAD-model of the car to see if any correlation between the car's structure and the eye point positions could be found. No particular correlations were found but this should be further investigated when comparing evaluated cars with each other.

**Table 10.4 – Scores for seated position and if the seat would be adjusted in another direction.**

|  | 1st setting | | | 2nd setting | | | 3rd setting | | |
|---|---|---|---|---|---|---|---|---|---|
|  | S | M | T | S | M | T | S | M | T |
| **How do you sit now?** | 4,2 | 4,2 | 3,9 | 4,1 | 4,4 | 3,9 | 4,1 | 4,3 | 3,8 |
| **If higher?** | 3,3 | 2,8 | 2,7 | 3,1 | 2,8 | 2,6 | 2,8 | 2,8 | 2,5 |
| **If lower?** | 2,2 | 2,9 | 3,3 | 2,1 | 2,9 | 3,4 | 2,4 | 2,9 | 3,3 |
| **If forward?** | 2,6 | 2,3 | 2,1 | 2,5 | 2,4 | 2,1 | 2,6 | 2,4 | 2,1 |
| **If backward?** | 2,2 | 2,0 | 3,3 | 2,3 | 2,2 | 3,4 | 2,1 | 2,2 | 3,4 |
| **If more tilt?** | 2,5 | 2,7 | 3,6 | 2,3 | 2,8 | 3,6 | 2,6 | 2,8 | 3,6 |
| **If less tilt?** | 2,9 | 2,3 | 2,2 | 2,9 | 2,5 | 2,0 | 2,8 | 2,3 | 2,0 |
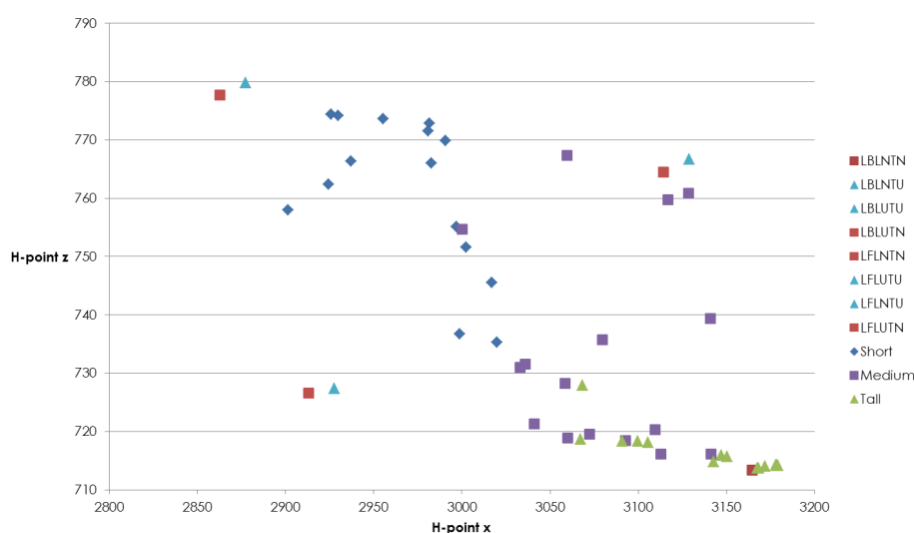


**Figure 10.1 – Diagram displaying H-points of all test participants divided in three stature groups.**
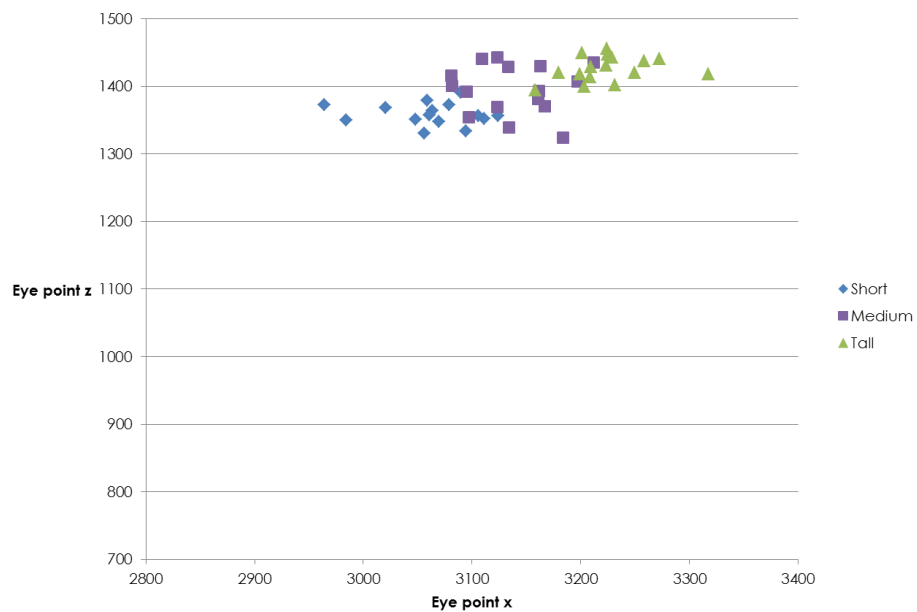
**Figure 10.2 – Diagram displaying eye points of all test participants divided in three stature groups.**



$R^2 = 0.7011$
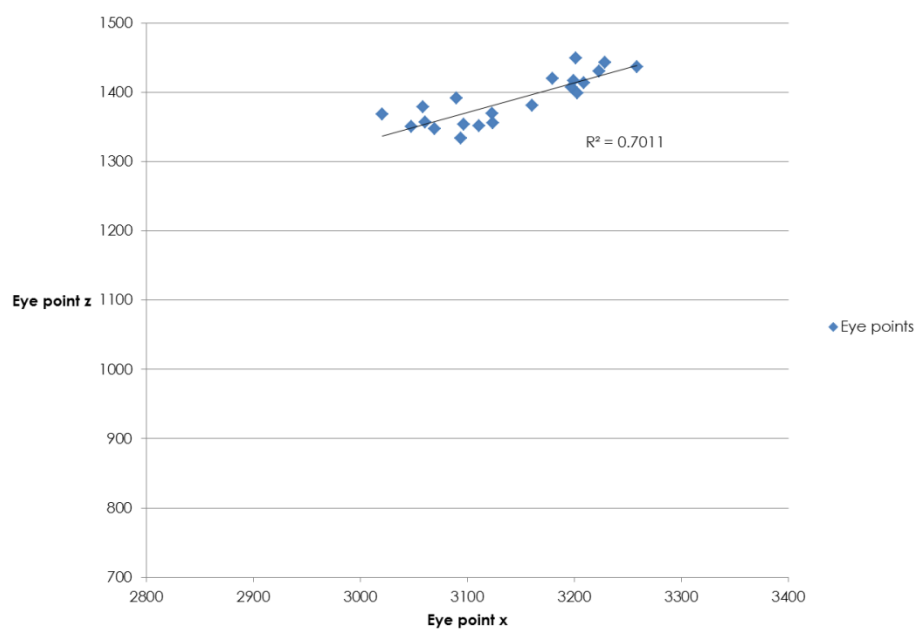
**Figure 10.3 – Diagram showing eye points of test participants who think they have a good seated position.**
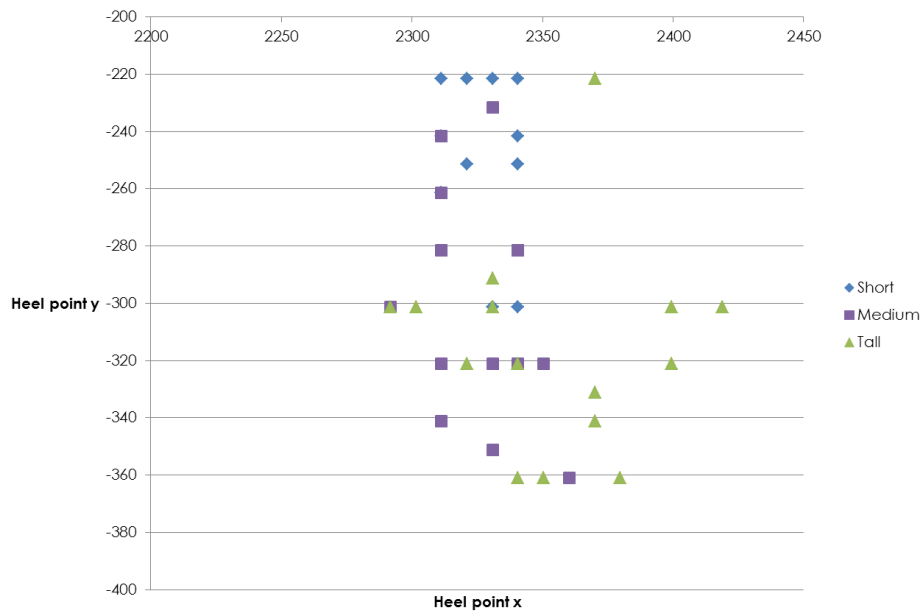
**Figure 10.4 – Diagram displaying heel points of all test participants. Values with a low y-coordinate are to the left in relation to the driver and a high x-coordinate is closer to the driver.**

There are indications of connections between stature and heel point. The result show that heel points of shorter people are located more inward the car's centre and forward in the car, in contrast with the majority of taller people and those of medium stature who have their heel points further away from the car's centre. Taller people also have their heel points further back than medium and short people. This can be seen in Figure 10.4. An explanation to this can be that taller people tilt their legs to fit under the steering wheel and thus their heel is positioned further to the left compared to shorter that does not need to tilt their legs.

The back inclinations do not seem to have any strong connection with arm length. Connections can be found between arm length and the steering wheel's position in x-direction, since shorter people seems to position the steering wheel more forward than taller and medium statures people. Except for this connection there are no connections between total arm length and the steering wheel's position.

## 10.5 Assumption: Limitations of the car is a factor

6) Limitations of the car such as sight considering A-pillars, hood height and roof height affect the seated position.

These factors affect the seated position. Especially shorter test participants have mentioned that they adjusted themselves higher because of the hood height.

7) The adjustment range of the seat and steering wheel affects the seat adjustment.

This clinic shows that the adjustment range of XC60 was too narrow to satisfy the short and the tall. Of those who answered no to the question "do you sit where you want to sit?" five have been short, six tall and two medium statured men. The tall want to adjust themselves further back, three want to have more tilt (thigh support) and four want to adjust themselves further downwards. The short want to adjust themselves further up (3) for better sight over the hood and more tilt downwards (3).

The adjustment range for the steering wheel also seemed to be too small for XC60. Four short commented that they would want to adjust the steering wheel further from themselves and downwards. Tall people wanted it closer to them and further up to avoid contact with knees. Medium statured men wanted it further down and closer. Three have commented that they would like to adjust the angle of the steering wheel.

Many test participants adjusted the steering wheel but did this after they had adjusted the seat. Depending on how much they adjust the steering wheel they sometimes have to adjust the seat again to match the two settings.

## 10.6 Assumption: Personal attitude is a factor

8) Personal style and attitude affect the seated position.

Many of the test participants feel comfortable, safe, relaxed and in control of the car, independent of where they sit. The result shows that a person can feel in a certain way but be positioned differently than others that feel the same. There are no tall test participants that feel "sporty" or "speedy" and no short test participants feel precautious. Overall participants have answered very similar between the groups as well as between genders, see Table 10.5.

9) People prioritise differently depending on personal preference regarding comfort, vision and reachability.

Tall test participants prioritized space around the foot support and knees more than the other two groups while the lower windshield seems to be more important the shorter the person is. The shorter group also prioritized outer/inner mirrors and hood more.

Participants in the shorter group mention they want closer to the pedals, they want to get higher to either see the hood or see above it, they do not like to sit too straight with the back inclination but do not want to lie down.

The tall test participants choose to have their seated position in the extreme position of lowest and most backward position by habit and select the position by feeling, they want to sit comfortably.

No result show which personal attitudes have effect on the seated position. Perhaps more can be seen when more car models have been evaluated.

Table 10.5 – The distribution of answers to how the drive style is divided by gender first and then stature.

|             | Men | Women | Short | Medium | Tall |
|-------------|-----|-------|-------|--------|------|
| **Safety**      | 13  | 13    | 7     | 12     | 7    |
| **Emotional**   | 0   | 0     | 0     | 0      | 0    |
| **Active**      | 7   | 7     | 6     | 5      | 3    |
| **Nervous**     | 0   | 0     | 0     | 0      | 0    |
| **Sporty**      | 3   | 3     | 2     | 4      | 0    |
| **Comfortable** | 22  | 18    | 12    | 14     | 14   |
| **Insecure**    | 0   | 1     | 0     | 1      | 0    |
| **Relaxed**     | 22  | 16    | 10    | 14     | 14   |
| **Precautious** | 0   | 4     | 0     | 2      | 2    |

## 10.7 Summary of result in XC60

The result of the evaluation of XC60 can be summarised by answering the questions how and why people sit the way they sit when driving. The objective measurements answer the question "how" and the subjective questions answer the question "why".

### 10.7.1 How people sit

H-point and seat adjustments depend on stature, tall participants adjust the seat down and back and short participants adjust themselves forward and upward, see Figure 10.1. The extreme percentiles tend to use the whole adjustment range and are restricted by the limits. Short people and those who want to have a better visual view want to sit higher than possible and tall people want to sit lower and/or further back than is possible.

The eye points also depend on stature where tall participants have their eye points both higher and further back than short participants, see Figure 10.2. When removing the eye points of those who would sit better elsewhere the eye points strive to be on a line, with an $R^2$ value of 0.7, see Figure 10.3.

Tall test participants have their heel points further to the left than short people. Short people have their heels closer to the pedals and in roughly the same y-coordinate as the pedal, see Figure 10.4.

### 10.7.2 Why people choose their seated position

Test participants expressed that reachability to pedals and steering wheel are the most important parameters for the seated position. The visual references affected the seated position for a number of people who explained that they wanted to have control and feel in control of the surroundings by seeing more over the hood. Others felt more comfortable when sitting low and had the seat in the lowest position independent of stature height. The limited adjustment range affects the seated position.

Why people strive for having their eye points on this line should be further evaluated. The distance to the headrest varies between the test participants and half of them experienced that it was not placed the way they wanted to. Some wanted to be closer to it and some wanted the opposite.

A reason for the placement of heel point could be that short people cannot reach the pedal unless they are placed close in y-direction and that tall people have feet big enough to flip their foot from the break to the gas without moving the foot. Another reason could be that tall people cannot fit their long legs under the steering wheel without bending the leg and that the heel therefore needs to be placed further to the left. This should be further evaluated.

# 11 Recommendations

Recommendations for future analysing and for VCC Ergonomics are listed below.

- The reference grid should have smaller squares to enable making better transforming between pixel coordinates to car coordinates, especially because of the smaller adjustment area of the steering wheel. The squares should also be on both sides of the sheet, making it easier to put in the correct position on the measuring stand.

- The measuring stand used for holding the reference plane should be improved to allow more exact positioning and become more stable.

- The measurement area of heel points should be resized and made larger. Some test participants had their heels in the very outer area of the measured points.

- For the measurement it is recommended to include a measuring of how much the seat's tilt function affect the H-point on the manikin sitting in SRP.

- During the clinic it is recommended to have a smaller computer in the front seat for test participants to use. This will make it easier to move and handle for test participants.

- A new version of Excel, version 2010 or later, should be installed on the CAN computer. This allows the test leader to work with the SPEED Compilation document and transfer notes from the clinic while test participants answer other questions on their own. This because notes might also be difficult to interpret when they are not fresh and newly written.

- VCC Ergonomics should use analyse programs such as MiniTab or SIMCA to analyse the results further and see correlations between more parameters at the same time.

- Further analysis should be made regarding eye point position in relation to the estimated line.

VCC should discuss VCC Crash and Safety whether the video recording show any relevant data and are necessary to include in the method.

# 12 Discussion

This chapter discusses the final result of SPEED, the design and how the methods and tools worked during the development. The development process, the priorities during the work and the consequences of different choices will also be discussed. The team will consider the benefit of the method to its need of usability.

## 12.1 Result discussion

This work has resulted in a method, named SPEED, which includes complete instructions of how the method is performed, Excel programs for calculations of specific points, prepared documents and programs for evaluations and for analysing results. The evaluations of the clinic and the clinic instructions with master students proved that it was easy to perform the clinic and that the instructions were sufficient. In this stage the method SPEED gives answers to how people sit when driving but not as much about why people sit the way they do.

### 12.1.1 Design

The design of SPEED was to be simple and the need for a high usability was specified. The whole method and its instructions are made and written by the team, who also has experience as summer employees of VCC Ergonomics, which leads to the instructions being easy to understand and not too advanced. The instructions are based on the level of knowledge the team had before they started working as summer employees. For an example the instructions also includes names and contact information of people that are to be contacted and prepared lists and instructions of what these people should do to contribute.

To keep the method's usability high, including time efficiency and easy understanding some tools that were investigated early in the process, such as eye tracking, was excluded. Keeping usability in mind when developing SPEED might have restricted the team. If the method was for someone working at VCC Ergonomics with good knowledge of everything that needs to be done, not as much time would have been put to write clear instructions for every procedure.

Due to the time constraint of 45 minutes per test participant and 160 hours in total for preparation, clinic and analysis, certain parameters cannot be investigated. If it was possible to have test participants for more than 45 minutes more data and situations could be investigated. All data elicited in the method cannot be analysed due to constraints in programs and in time. One example is when only the third setting is analysed in the current method. Maybe other connections could be found if time was put to analyse the other settings as well.

Since the method is not supposed to measure the seat comfort, due to this being VCC Seating Comfort's area of expertise, the team tried to not have this included in the method. Comfort is something that is individual and very difficult to measure. The team decided that the method should include instructions for the test participants to put the seat in a position where they want to have it when driving. The information elicited from the method is the objective measurements of where test participants sit and also how good they think their seated position is.

The team's choices during the development have had effects on how the method became. One example, mentioned in chapter 7, is whether the team was to use eye tracking or not. In the first stage eye tracking seemed to be a good tool, the possibilities were discussed in several meetings. The tool seemed very easy to handle in the beginning and it was decided to use it together with all test participants and to help the team measuring eye points. During the development of SPEED the use of this tool went from using it on all test participants, to use it only on a few and at last to not use it at all.

In evaluations of this tool the team could determine that it could not be used for eliciting eye points, calibration was time consuming and if not calibrated correctly it was inaccurate when showing where the eye was resting. Therefore eye tracking was discarded. By discarding this method the team had to go back and use another method, measuring eye points with help of photographs. When the eye tracking device was correctly calibrated it did however show where the eye rested, areas of interests could be programmed and information about how many times and for how long the eye rested in the area of interest. If the method of eye tracking was further developed tacit knowledge about why people adjust themselves could be elicited by being able to see what they look at when adjusting themselves. Possible sight targets could then be observed and included as a task for RAMSIS.

Because of the limited time frame there was a balance act between the quality level and the time. If more time had been available a more exact position of the steering wheel could be established by developing an

additional method whereas now the position is elicited simultaneously with the eye point. This was a conscious decision for saving time yet gain "good enough" result because even if the exact position is elicited the rough placement of the steering wheel is gained. Another reason for wanting to keep the method easy to use is the level of competence of the user. The users of SPEED could be an experienced employee at VCC Ergonomics but could as well be a summer employee why the method should be adapted for the knowledge of the inexperienced user. This means that the complication level of computer programs should be kept to minimum and detailed instructions to be included. The more detailed information that is to be elicited the more accuracy and preparations are needed and thus decreasing the level of usability.

### 12.1.2 Elicited data

The method elicit much information, including measurements of where test participants sit, their subjective thought of different parameters in the car and these parameters' contribution to their seated position. One problem with the previous method was that a lot of data were gathered but not used. This is a problem with the new method, but since the team was not supposed to make the further analysis, parameters can later be seen as unnecessary.

The team has understood that the information regarding where and how people position themselves is to some part silence knowledge and is therefore difficult to elicit. Test participants are describing this as "deciding the position by feeling" and cannot clearly describe why. But yet the team has made success when it comes to understand where people sit and also being able to find correlations between different groups and certain parameters. The method is successful since it can show where people sit and also show correlations and information of what is important to them when it comes to finding a comfortable seated position in the specific car being evaluated.

The information elicited from SPEED has been compared with information from deeper evaluations with other master thesis workers at VCC. Comparing these types of evaluations showed results that strengthen SPEED's elicited data. The same data was possible to elicit and was elicited from both evaluations.

In comparison with the previous method, which had the test participants answering to a test leader who later wrote down the answers, SPEED is developed in a way where test participants answers the questions directly on a computer. Now test participants do not have to formulate answers to a test leader. This way test participants answer themselves and they seem to feel free to write what they want. The way

of answering questions directly was also appreciated by the test participants evaluating SPEED in an early stage.

The video recordings have not yet been analysed. The camera recording the clinic often malfunctioned due to its low battery capacity. Since VCC Ergonomics are not interested in behaviour, which is the camera's purpose for VCC Crash and Safety, the time used to install and handle the camera can be put on other things during the clinic if it does not give any relevant information.

### 12.1.3 Sustainable development

SPEED is developed to be used for all cars made by VCC to investigate information from different types of cars and then compare this information. The method will enable to make changes early in the developing process of a new car, to give information of where and how people want to sit. When having this information early in the developing process, VCC can reduce developing costs to material and time put on development, when making changes before the process have gone too far. It will prevent some late changes, which often are expensive.

The method is made to fit all type of VCC's cars and it is adaptable to future features in the cars. Since the method includes instructions of how it is built it will be easy to change if conditions change. SPEED uses less printed pages than previous methods. There will only be one sheet printed per test participant and instructions for the test leader. The rest of the method is performed digitally.


## 12.2 Method and process discussion

As described in chapter 3, a defined development process has been used for the work. The process has helped the team structure the work and not forget important stages in the development process. The process stated was an outline and was adapted to this work. Same stages in the process were kept but the order and the names of the parts were changed, explained in chapter 3.

The process was conducted in a way which can be seen as a funnel, where the team started with much information during the needfinding stage. In this first stage investigations of previous clinics and literature studies were conducted. After the needfinding the team could narrow the work and had better knowledge of what was important and thereby assumptions could be created. Assumptions were created to falsify and strengthen parameters affecting the seated position, later these were set as base for further developing and analysis. The work was more

narrowed when the concept generation started and led to the final method SPEED with a commissioning in Volvo XC60. The use of SPEED was the last part of the work and thereby the outer end and tip of the funnel. Along the project the team has had continuous documentation and evaluations which have helped eliciting correct information and structure the work during the whole process.

### 12.2.1 Needfinding

Needfinding was the first part in the process where all needs for the project were to be listed. The needs came from literature regarding car evaluations, automotive ergonomics and looking into previous clinics and methods used at VCC. The car manufacturers that the team looked into seemed to do similar things and elicit similar information from seated evaluations in a wide aspect. There were no problems finding literature on the subject and VCC had literature and documentations from investigations.

VCC Ergonomics expressed needs from the beginning regarding the basic structure of the method, such as the total time it should take. As explained earlier in chapter 7, the team developed a proposal for which questions and measurements were important to elicit in the clinic and then discussed these during several workshops with VCC Ergonomics and Crash and Safety. The needs set from VCC did not constrain the team too much, it did not hinder the team in the evaluations but as in many cases time was an important need. The time constraint governed how much was possible to perform in the clinics, which in turn limited how much information was possible to elicit.

If more time was available an interview could be combined with the questionnaire to elicit more qualitative data. The information gained from interviews should answer to why the seated position is chosen more in detail even if the information wanted to some extent is tacit knowledge for the test participant and therefore difficult to express. Additional information in combination with more time to analyse the result with e.g. SIMCA, to compare multiple parameters to each other, could result in more reliable data and more clear answers to how people sit when driving and why.

### 12.2.2 Assumptions

The next stage in the process was to write down and discuss what could be of importance for positioning in cars. The team discussed what parameters could affect the choice of seated position based on earlier clinics. The use of assumptions provided structure for the development. It was easy to strengthen that all sections were covered and that the questionnaire elicits information regarding all assumptions.

Some assumptions were confirmed and for some of the assumptions no correlations could be found. The team found different types of correlations, both strong and weak. Indications of correlations were also found, for example it could be seen that taller people positioned their feet differently than shorter people. Indications such as this one could be elicited and strengthened with help of all the different documented data, such as measurements, comments and also photos taken during the clinics.

Some of the assumptions were seen as not strengthened and some were not possible to investigate due to only one car model being evaluated in this work. The team felt that these assumptions should not be discarded because correlations might be found in other car models and when comparing evaluations of different car models. This is for VCC to investigate in the further evaluations.

### 12.2.3 Overall design

In the section of overall design the framework for the method was designed, deciding the big parts that were to be included. The design of the method and the framework was compared to the assumptions helping the team not to forget any important parts. The evaluations gave valuable information regarding what was important both regarding questions and measurements and instructions for how the method is to be performed.

### 12.2.4 Detailed design

For the detailed design the team evaluated all tools that had potential for the method. This was a rewarding part of the process since the team came in contact with different departments at VCC and could look into several interesting methods and tools. The team could in this stage of the process eliminate tools that did not yield the sought result.

Continuous evaluations were held to keep the usability of the method on track and to ensure the correct information were elicited. Because the evaluations were held with master thesis workers of the sought profile it could be ensured that the method was evaluated and developed for future summer workers.

### 12.2.5 Commissioning

The result of the commissioning can be seen in chapter 10, where the result of Volvo XC60 is presented. Using the method in XC60 worked well and all equipment were easy to install. The time for the clinics was enough and people thought it worked well to perform the method, questions were understood and the instructions were sufficient.

### 12.2.6 Supervising

The team has had one supervisor at Chalmers, Lars-Ola Bligård, and two supervisors and VCC Ergonomics, Magnus Jerksjö and Pernilla Nurbo. The supervisor at Chalmers has helped the team in the developing process and been of great support regarding keeping focus on the method development. The team had continues meetings almost every week with the supervisors at VCC Ergonomics. The regular meetings have helped the team stay on track and also understand how things are done at VCC, in what order particular parts of the method need to be done.

## 12.3 Lessons learned

When conducting this work the team has got insight of being at a large company, especially the importance of timing to be able to keep deadlines. Booking of equipment and appointments need to be done early due to lack of resources when many people desire to use the same equipment. The team has also learned about method developing, its similarities with product development including concept generations, iterations of processes and evaluations.

In order to extract and display the wanted information the team has learned how to use Excel, Photoshop and VCC specific software and written detailed instructions to how to use these. Extracting the H-point position proved to be more difficult than expected and demanded involvement from different departments at VCC.

If this work was to be done now with the information that was learned the same process would be used because of the structured work flow it allowed. A few things would be altered, for example the development of the "animated" choosing of preferred seated position would be reduced or removed completely because of the time it consumed and the limited use and benefit it would offer even if completed. Additionally the camera placed in the roof would have been placed in another location to fully utilize the benefits of the measurements of the reference plane in y-direction. This to allow a more exact coordinate position for other traffic situations, where the head is likely to be placed sideways unlike when driving straight ahead.

# 13 Conclusion

The result of this work is a method, SPEED, which includes instructions of how the method is performed, documents for the test leader, excel programs calculating objective measurements and a prepared compilation document for analysing the result. VCC stated a need for an easy performed method that everyone at VCC Ergonomics should be able to use. To be sure that the instructions suits the employees all instructions have been made regarding the kind of knowledge the team had before being summer employees at VCC Ergonomics.

The final method, SPEED, is definitely usable for eliciting the important and wanted information that VCC Ergonomics asked for in the beginning; how a driver's seated position is and why it is that way. The team feels that SPEED shows how people sit and why they have chosen their individual seated position. To find more answers of why test participants sit the way they do further analysis is needed as well as comparisons to other car models.

The result of the evaluations made in SPEED gives a basic analysis which shows correlations between different groups of stature and parameters in the car. The correlations that have been found are some of those correlations that VCC Ergonomics was certain about but also new interesting correlations that they have not seen before. Anthropometric measurements affect the settings of the seat and steering wheel hence affecting the eye point and H-point. New findings regarding eye point (the test participants strived to have their eyes on a line) and heel point position (the position in y-direction depended on stature) are for VCC Ergonomics to further analyse.

SPEED is an easy performed method with high usability and made with instructions enabling changes in the future to fit newer cars. The team is satisfied with the work performed at VCC and consider SPEED to be a successful method that delivers result that can be implemented in computer analysis with RAMSIS. It will help VCC Ergonomics in their future work of developing cars suitable for future drivers of new explored markets.

# 14 References

## 14.1 Literature

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## 14.2 Oral resources

Bligård, Lars-Ola, *(Design and Human Factors, Chalmers)* supervisor and examiner at Chalmers University of Technology

Eriksson, Lotta, (*Crash and Safety, VCC*) included in workshop 20th of February 2013.

Hansson, Ida (*Design and Human Factors, Chalmers*) interviewed 28th of February 2013.

Jerksjö, Magnus (Ergonomics*, VCC)* supervisor at Volvo Car Corporation

Nurbo, Pernilla (Ergonomics, *VCC*) supervisor at Volvo Car Corporation

Kristiansson, Erik *(Matematisk Statistik, Chalmers*), interviewed 21st of February 2013.

Wallgren, Pontus (*Design and Human Factors, Chalmers*) interviewed 28th of February 2013.

# 15  Appendix

Appendix A:          Questionnaire evaluation sheet

Appendix B:          Matrix for tool selection

Appendix C:          SPEED Note sheet

Appendix D:          SPEED Questionnaire

Appendix E:          SPEED Compilation document

Appendix F:          SPEED Coordinates document

Appendix G:         SPEED Instruction document

# A. Questionnaire evaluation sheet

**1)** **Hur upplever du framåtsikten i den här bilen? Sätt en siffra i rutan som bäst motsvarar din åsikt.**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Väldigt dåligt | | Dåligt | | Ok | | Bra | | Mycket bra | |

| Väldigt dåligt | Dåligt | Tillräcklig | Bra | Mycket bra |
|---|---|---|---|---|

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Dåligt | | Ok | | Bra |

**2)** **Hur upplever du framåtsikten i den här bilen? Sätt ett kryss på linjen där det passar bäst.**

Mycket dålig _____ Mycket bra

**3) Hur upplever du framåtsikten i den här bilen? Sätt ett kryss i rutan som passar bäst.**



**4) Hur upplever du framåtsikten i den här bilen? Sätt ett kryss där det passar bäst.**

Mycket dåligt                                               Mycket bra

**5) ”Framåtsikten är bra”**

Instämmer inte alls                                         Instämmer helt

**6) Vad anser du om framåtsikten?**

Mycket dålig           Varken bra eller dålig           Mycket bra

**7) Vad anser du om framåtsikten? Kryssa i det alternativ som passar bäst.**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |
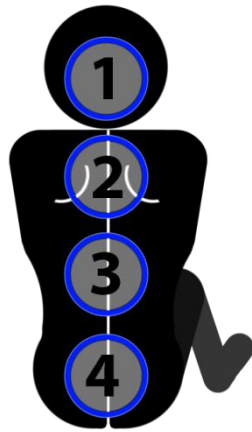
Vilka delar av din rygg och nacke tar i ryggstöd och nackstöd när du sitter i den här bilen. Fyll i det som bäst motsvarar din sittposition du har mestadelen av tiden. 1) Bakhuvud, 2) skuldror/axlar, 3) mitt på ryggen och 4) korsrygg.

|   | Tar inte i alls | Tar i ibland | Tar i helt |
|---|---|---|---|
| 1 | ☐ | ☐ | ☐ |
| 2 | ☐ | ☐ | ☐ |
| 3 | ☐ | ☐ | ☐ |
| 4 | ☐ | ☐ | ☐ |

|   | Inget stöd | | Mycket stöd |
|---|---|---|---|
| 1 | ☐ | ☐ | ☐ |
| 2 | ☐ | ☐ | ☐ |
| 3 | ☐ | ☐ | ☐ |
| 4 | ☐ | ☐ | ☐ |

Appendix A – Questionnaire evaluation sheet

# B. Matrix for tool selection

| Tool | What for? | What it does | Time | Usability | Precision | Result | Score |
|---|---|---|---|---|---|---|---|
| Anthropometrics | Analysis | Use anthropometrics for the selection of test participants. | 2 | 3 | 2 | 3 | 10 |
| CAN bus | H-point | Shows the motor movement in steps. | 3 | 3 | 3 | 3 | 12 |
| CATIA | H-point | Can be used for preparing the H-point extraction. | 2 | 1 | 2 | 2 | 7 |
| DiCE | H-point | Shows the motor movement in steps. | 3 | 1 | 3 | 3 | 10 |
| Drive route | Reliability | Allows for consistency and reliability. | 3 | 3 | 2 | 2 | 10 |
| Excel | Analysis Subjective Eye point Heel point Steering wheel position Distance neck rest | Used for analysis, retrieving points of interest, making statistical statements etc. | 2 | 2 | 3 | 3 | 10 |
| Eye tracking | Eye point | Shows what the test participant is looking at. Can be translated to time and areas. | 1 | 1 | 1 | 1 | 4 |
| GGD-DHA | H-point | Shows the motor movement in steps. | 3 | 1 | 3 | 3 | 10 |
| GPS | Reliability | Allows for consistency and reliability. | 1 | 1 | 3 | 1 | 6 |
| Grid | Heel point | Visualise where the heel is positioned on the floormat. | 3 | 3 | 2 | 3 | 11 |
| Measure car | H-point | By measuring the car and the seat settings one see how this particular car is and how it differs from the drawings. | 3 | 3 | 3 | 3 | 12 |
| Photoshop | Eye point Steering wheel position Distance neck rest | With Photoshop analysis the wide angle can be reduced, pixel values be extracted for future analysis and thereby be converted to coordinates. | 2 | 1 | 3 | 3 | 9 |
| Photo with GoPro | Eye point Heel point Steering wheel position Distance neck rest | Give high quality pictures with wide angle. | 3 | 2 | 3 | 3 | 11 |
| Questionnaire | Subjective | Let test participants share their thoughts in a quick and easy way. | 3 | 3 | 2 | 3 | 11 |
| Ruler | H-point Steering wheel position | Measure seat position, steering wheel position. | 1 | 1 | 1 | 3 | 6 |
| Seated position program in Excel | Subjective | Visualise different seated positions and allow test participants to show which position they prefer. | 3 | 1 | 1 | 1 | 6 |
| Squares in y-planes | Eye point Steering wheel position Distance neck rest | Allows converting pixels to coordinates in relation to the car. | 1 | 2 | 3 | 3 | 9 |

# C. SPEED Note sheet

## Att fylla i av testledaren

**Bakgrundsfrågor**

9) Namn:

Skotyp vid klinik:

Vill TP ta del av resultatet?

○ Ja    ○ Nej

10)

| Nr | | Inställning 1 | Inställning 2 | Inställning 3 | Kommentarer vid inställning |
|---|---|---|---|---|---|
| Längsled | | | | | |
| Höjdled | | | | | |
| Rygglutning | | | | | |
| Tilt | | | | | |
| Ratt | | | | | |

| Steps från motorer | Inställning 1 | Inställning 2 | Inställning 3 |
|---|---|---|---|
| Nr | | | |
| Slide | | | |
| Recline | | | |
| Height | | | |
| Tilt | | | |

| Kortnummer | Korsning | | | Raksträcka | | | Parkering |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 3 |
| Sida | | | | | | | |
| Tak | | | | | | | |
| Fot | | | | | | | |
| Inst. | | | | | | | |

| Nackstödskort | |
|---|---|
| Kortnr sidokamera | |

| Parkeringsavstånd | | |
|---|---|---|
| TP's uppfattning | | cm |
| Verkligt avstånd | | cm |

# D. SPEED Questionnaire

## Sittpositionsklinik - SPEED

### Del 1. Ställ in stolen - första gången

| 1) Hur sitter du där du sitter nu? | Väldigt dåligt | Dåligt | OK | Bra | Mycket bra |
|---|:---:|:---:|:---:|:---:|:---:|
| Hur sitter du där du sitter nu? | ○ | ○ | ○ | ○ | ○ |
| Hur skulle du sitta om du satt: | | | | | |
| Högre upp? | ○ | ○ | ○ | ○ | ○ |
| Längre ner? | ○ | ○ | ○ | ○ | ○ |
| Längre fram? | ○ | ○ | ○ | ○ | ○ |
| Längre bak? | ○ | ○ | ○ | ○ | ○ |
| Högre tilt? | ○ | ○ | ○ | ○ | ○ |
| Lägre tilt? | ○ | ○ | ○ | ○ | ○ |

Övriga kommentarer

### Del 2. Ställ in stolen - andra gången

| 2a) Hur sitter du där du sitter nu? | Väldigt dåligt | Dåligt | OK | Bra | Mycket bra |
|---|:---:|:---:|:---:|:---:|:---:|
| Hur sitter du där du sitter nu? | ○ | ○ | ○ | ○ | ○ |
| Hur skulle du sitta om du satt: | | | | | |
| Högre upp? | ○ | ○ | ○ | ○ | ○ |
| Längre ner? | ○ | ○ | ○ | ○ | ○ |
| Längre fram? | ○ | ○ | ○ | ○ | ○ |
| Längre bak? | ○ | ○ | ○ | ○ | ○ |
| Högre tilt? | ○ | ○ | ○ | ○ | ○ |
| Lägre tilt? | ○ | ○ | ○ | ○ | ○ |

Övriga kommentarer

## Del 3. Ställ in stolen - tredje gången

3a)

| | Väldigt dåligt | Dåligt | OK | Bra | Mycket bra |
|---|---|---|---|---|---|
| Hur sitter du där du sitter nu? | ○ | ○ | ○ | ○ | ○ |
| Hur skulle du sitta om du satt: | | | | | |
| Högre upp? | ○ | ○ | ○ | ○ | ○ |
| Längre ner? | ○ | ○ | ○ | ○ | ○ |
| Längre fram? | ○ | ○ | ○ | ○ | ○ |
| Längre bak? | ○ | ○ | ○ | ○ | ○ |
| Högre tilt? | ○ | ○ | ○ | ○ | ○ |
| Lägre tilt? | ○ | ○ | ○ | ○ | ○ |

Övriga kommentarer

| | Omöjligt | Krångligt | Möjligt | Enkelt | Väldigt enkelt |
|---|---|---|---|---|---|
| 3b) Hur är det att hitta en bekväm sittposition? | ○ | ○ | ○ | ○ | ○ |

## Del 5. Parametrar för inställning av stol och ratt



4) Hur påverkar följande parametrar dig när du ställer in din sittposition inför körning i den här bilen?

**Min sittposition och stol/ratt-justering påverkas av följande parameter...**

| | | ...inte alls | ...knappt | ... | ...ganska mycket | ...väldigt mycket |
|---|---|---|---|---|---|---|
| | **Nåbarhet** | | | | | |
| 1 | Pedaler | ○ | ○ | ○ | ○ | ○ |
| 2 | Ratt | ○ | ○ | ○ | ○ | ○ |
| 3 | Växelspak | ○ | ○ | ○ | ○ | ○ |
| 4 | Knappar och reglage | ○ | ○ | ○ | ○ | ○ |
| | **Rymlighet** | | | | | |
| | Huvudutrymme | ○ | ○ | ○ | ○ | ○ |
| | Fotutrymme, fotstöd | ○ | ○ | ○ | ○ | ○ |
| | Knäutrymme | ○ | ○ | ○ | ○ | ○ |
| | **Sikt** | | | | | |
| 5 | Överkant vindruta | ○ | ○ | ○ | ○ | ○ |
| 6 | Underkant vindruta | ○ | ○ | ○ | ○ | ○ |
| 7 | Inre/yttre backspegel | ○ | ○ | ○ | ○ | ○ |
| 8 | Kombiinstrument | ○ | ○ | ○ | ○ | ○ |
| 9 | Huv | ○ | ○ | ○ | ○ | ○ |
| | **Komfort** | | | | | |
| | Bälte | ○ | ○ | ○ | ○ | ○ |
| | Fotstöd | ○ | ○ | ○ | ○ | ○ |
| | Armstöd i dörr | ○ | ○ | ○ | ○ | ○ |
| | Armstöd i mitten | ○ | ○ | ○ | ○ | ○ |
| | | ○ | ○ | ○ | ○ | ○ |

5) Hur bedömer du följande parametrar i den här bilen?

| | | Väldigt dåligt | Dåligt | Varken bra/ dåligt | Bra | Mycket bra |
|---|---|---|---|---|---|---|
| | **Nåbarhet** | | | | | |
| 1 | Pedaler | ○ | ○ | ○ | ○ | ○ |
| 2 | Ratt | ○ | ○ | ○ | ○ | ○ |
| 3 | Växelspak | ○ | ○ | ○ | ○ | ○ |
| 4 | Knappar och reglage | ○ | ○ | ○ | ○ | ○ |
| | **Rymlighet** | | | | | |
| | Huvudutrymme | ○ | ○ | ○ | ○ | ○ |
| | Fotutrymme, fotstöd | ○ | ○ | ○ | ○ | ○ |
| | Knäutrymme | ○ | ○ | ○ | ○ | ○ |
| | **Sikt** | | | | | |
| 5 | Överkant vindruta | ○ | ○ | ○ | ○ | ○ |
| 6 | Underkant vindruta | ○ | ○ | ○ | ○ | ○ |
| 7 | Inre/yttre backspegel | ○ | ○ | ○ | ○ | ○ |
| 8 | Kombiinstrument | ○ | ○ | ○ | ○ | ○ |
| 9 | Huv | ○ | ○ | ○ | ○ | ○ |
| | **Komfort** | | | | | |
| | Bälte | ○ | ○ | ○ | ○ | ○ |
| | Fotstöd | ○ | ○ | ○ | ○ | ○ |
| | Armstöd i dörr | ○ | ○ | ○ | ○ | ○ |
| | Armstöd i mitten | ○ | ○ | ○ | ○ | ○ |
| | | ○ | ○ | ○ | ○ | ○ |

Appendix D-v

**Frågor**

6a)  Sitter du där du vill sitta?  ○ Ja  ○ Nej
     Om nej, varför inte och vad begränsar?

6b)  Önskar du att det fanns fler eller större justermöjligheter för stolen?
     Om ja, vilka och i vilken riktning?  ○ Ja  ○ Nej

6c)  Önskar du att det fanns fler eller större justermöjligheter för ratten?
     Om ja, vilka och i vilken riktning?  ○ Ja  ○ Nej

6d)  Använder du armstödet i mittkonsollen?  ○ Ja  ○ Nej
     Om nej, varför?

6e)  Använder du armstödet i dörren?  ○ Ja  ○ Nej
     Om nej, varför?

6f)  Är nackstödet där du vill ha det när du kör?  ○ Ja  ○ Nej
     Om nej, varför?

6g)  Ändrar du sittställning när du parkerar?  ○ Ja  ○ Nej
     Om ja, hur och varför?

**Hur sitter du när du kör?**

7) Vilka delar av din rygg och nacke tar i ryggstöd respektive nackstöd när du sitter i den här bilen? Fyll i det som bäst motsvarar din sittposition under körning. **När jag sitter i stolen är denna delen i kontakt…**
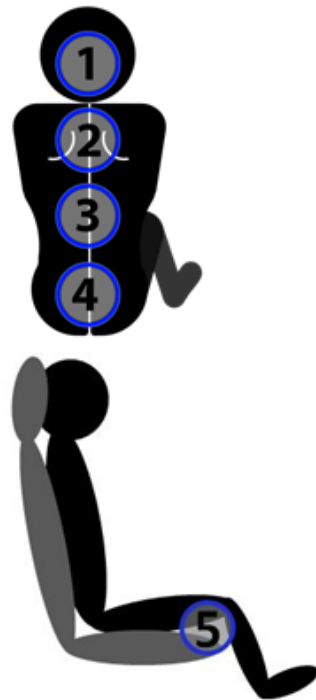


|   | …inte alls | …lite | …helt |
|---|---|---|---|
| 1 | ○ | ○ | ○ |
| 2 | ○ | ○ | ○ |
| 3 | ○ | ○ | ○ |
| 4 | ○ | ○ | ○ |
| 5 | ○ | ○ | ○ |

8a) Hur är din körstil i den här bilen? Kryssa i **den** eller **de** rutor som bäst passar, fyll också gärna i varför. Finner du inte något alternativ som passar får du gärna lägga till ord i rutan "annat".

☐ Säkerhetsmedveten
☐ Osäker
☐ Avslappnad
☐ Känsloladdad
☐ Aktiv
☐ Fartglad
☐ Nervös
☐ Har kontroll
☐ Försiktig
☐ Bekväm
☐ Sportig
☐ Självsäker
☐ Annat:

8b)  Varför har du valt den körstil du har valt?

[ ]

8c)  Är det denna körstil du vill ha i den här bilen?  ○ Ja  ○ Nej
     Om nej, varför?

[ ]

## Tack för din medverkan!

Sista sidan är för testledaren att fylla i.

**Bakgrundsfrågor**

9)  Namn: [                    ]

    Skotyp vid klinik: [              ]
    Vill TP ta del av resultatet?  ○ Ja  ○ Nej

10)

|  | Inställning 1 | Inställning 2 | Inställning 3 |
|---|---|---|---|
| Längsled |  |  |  |
| Höjdled |  |  |  |
| Rygg-lutning |  |  |  |
| Tilt |  |  |  |
| Ratt |  |  |  |

Samtliga steps från motorerna och de olika inställningarna läggs in i "H-punktsfilen", kopiera därefter in koordinaterna till H-punktstabellen nedan.

| Steps från motor | Inställning 1 | Inställning 2 | Inställning 3 | Genomsnitt |
|---|---|---|---|---|
| Slide |  |  |  | 0 |
| Recline |  |  |  | 0 |
| Height |  |  |  | 0 |
| Tilt |  |  |  | 0 |

Koordinaterna för inställning 3 är de som används i basanalysen i sammanställningen, och de koordinater som ska motsvara det valda kortet på ögon- och hälpunkt för raksträcka.

| H-punkt | x | z | x | z | x | z | x | z |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | 0 | 0 |

I tabellen nedan ska ordningsnummer för de korten som tagits i de olika situationerna matas in. Välj sedan ut en serie som används att ta ut ögonpunkter på.

| Kortnummer | Korsning | | | Raksträcka | | | Parkering |
|---|---|---|---|---|---|---|---|
| Sida | | | | | | | |
| Tak | | | | | | | |
| Fot | | | | | | | |
| Inst. | 1 | 2 | 3 | 1 | 2 | 3 | 3 |

**Nackstödskort**    Kortnr sidokamera

**Parkeringsavstå** TP's uppfattning        Verkligt avstånd

| | cm | | cm |
|---|---|---|---|

**Ögonpunkt**

| X | Z |
|---|---|
| | |

**Ögonpunkt parke**

| X | Z |
|---|---|
| | |

**Rattposition**

| X | Z |
|---|---|
| | |

**Hälposition**

| X | Z |
|---|---|
| | |

**Rygglutning**

| Grader |
|---|
| |

# E. SPEED Compilation document

In this appendix there are some views taken of the SPEED Compilation document. The views are only parts of the document and show the top part of the program, where questions are stated, as well as the bottom part where the diagrams and analyses are made. Between the top and bottom part, there is a large matrix including all data about test participants and answers from the evaluations.

| 10l | | | | | 10a | 10b | 10c | 10d | 10e |
|---|---|---|---|---|---|---|---|---|---|
| Parkeringsavstånd | | | | | Kommentarer från testpersonens tre inställningar | | | | |
| | | | | | Kommentarer från alla tre olika inställningarna hamnar under respektive justeringsmöjlighet men en mellan. | | | | |
| I's uppfa | erkligt av | Diff | | . | Längsled | Höjdled | Ryggluta | Tilt | Rat |
| | | | | | Fram till pedalerna. | . Vill upp för att | Vill sitta mer rakt | . . Lyfter upp lite i | Ställer fram |

I diagrammen nedan ska det visas hur parkeringsavståndet varierar med kroppslängden hos testpersonerna. Först ett diagram som visar samtliga testpersoner med en R-square på dessa, men sedan också ett som är uppdelat på längdgrupperna i olika serier.



Totallängd - Parkeringsavstånd

| | 1a1 | 1a3 | 1a4 | 1a5 | 1a6 | 1a7 | 1a8 | 1a9 |
|---|---|---|---|---|---|---|---|---|

### Del 1. Ställ in stolen - första gången

| r sitter du där du sitt | Högre u | Längre r | ängre fr | Längre b | Högre t | Lägre t | Övriga komme |
|---|---|---|---|---|---|---|---|
| 4 | 5 | 5 | 5 | 5 | 5 | 5 | |

| | 2a1 | 2a3 | 2a4 | 2a5 | 2a6 | 2a7 | 2a8 | 2a9 |
|---|---|---|---|---|---|---|---|---|

### Del 2. Ställ in stolen - andra gången

| r sitter du där du sitt | Högre u | Längre r | ängre fr | Längre b | Högre t | Lägre t | Övriga komme |
|---|---|---|---|---|---|---|---|
| 4 | 5 | 5 | 5 | 5 | 5 | 5 | |

| | 3a1 | 3a3 | 3a4 | 3a5 | 3a6 | 3a7 | 3a8 | 3a9 | | 3b |
|---|---|---|---|---|---|---|---|---|---|---|

### Del 3. Ställ in stolen - tredje gången

| r sitter du där du sitter | Högre | Längre | ängre f | Längre | Högre | Lägre | Övriga komment | er | | Hur är det att hitta en bekväm sittp |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 4 | 4 | 4 | 4 | 4 | 4 | | | | 5 |
| | | | | | | | Kan ej justera högre. Vill sitta högre. Önskar | | | |

| | 4 | 2 | 4 | 3 | 2 | 3 | 1 |
|---|---|---|---|---|---|---|---|
| Medel | 4.1875 | 2.8125 | 2.9375 | 2.3125 | 2 | 2.6875 | 2.3125 |

**Del 1 - Lång**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 4 | 2 | 4 | 2 | 2 | 3 | 2 |
| | 4 | 2 | 3 | 2 | 3 | 5 | 2 |
| | 4 | 4 | 4 | 3 | 2 | 4 | 3 |
| | 5 | 4 | 2 | 2 | 3 | 4 | 2 |
| | | 4 | 3 | 2 | 4 | 2 | 3 |
| | 4 | 3 | 4 | 4 | 3 | 4 | 3 |
| | 5 | 3 | 5 | 3 | 3 | 5 | 1 |
| | 3 | 1 | 4 | 2 | 5 | 5 | 1 |
| | 3 | 2 | 4 | 2 | 4 | 4 | 2 |
| | 4 | 3 | 3 | 1 | 4 | 4 | 2 |
| | 4 | 2 | 3 | 2 | 2 | 2 | 2 |
| | 4 | 3 | 3 | 2 | 2 | 3 | 3 |
| | 4 | 2 | 3 | 2 | 3 | 3 | 2 |
| | 4 | 3 | 3 | 1 | 5 | 2 | 2 |
| | 4 | 3 | 3 | 3 | 2 | 3 | 3 |
| | 2 | 2 | 2 | 1 | 5 | 5 | 1 |
| Medel | 3.866666667 | 2.6875 | 3.3125 | 2.125 | 3.25 | 3.625 | 2.1875 |

Nedanstående tabell är en sammanställningstabell för den stora matrisen ovan som är indelad efter längdgrupperna. För att skapa en bra överskådlig tabell kan man också lägga på en färgkodning. Så att det går snabbare att se bra och dåliga poäng. Detta görs genom att trycka på "Conditional Formatting" -> "New rule" -> Välja en "3 color scale" under format -> Välja färgerna röd, gul, grön -> Välja 1 som minimun number, 3 som middlepoint och 5 som maximum number. Gör denna färgkodning för del 1, 2, 3, 5

**Del 1 - Sammanställning - Medel**

| | Hur sitter du där du sitter nu? | Högre upp? | Längre ner? | Längre fram? | Längre bak? | Högre tilt? | Lägre tilt? |
|---|---|---|---|---|---|---|---|
| Kort | 4.2 | 3.2857143 | 2.2142857 | 2.5714286 | 2.2 | 2.5 | 2.8666667 |
| Medellång | 4.1875 | 2.8125 | 2.9375 | 2.3125 | 2 | 2.6875 | 2.3125 |
| Lång | 3.866666667 | 2.6875 | 3.3125 | 2.125 | 3.25 | 3.625 | 2.1875 |
| Total | 4.086956522 | 2.9130435 | 2.8478261 | 2.326087 | 2.4893617 | 2.9565217 | 2.4468085 |

Del 5 - Sammanställning - Model

| | Pedaler | Ratt | Växelspak | Knappar och reglage | Huvudutrymme | Fotutrymme, fotstöd | Käsutrymme | Överkant vindruta | Underkant vindruta | Inedytre backspegel | Kombiinstrument | Hjw | Bälte | Fotstöd | Armstöd i dörr | Armstöd i mitten |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kort | 4.8 | 3.3333 | 2 | 2.1333333333 | 1.333333333 | 2.1333333333 | 3 | 2.2 | 3.3333333333 | 3.0114285714 | 2.4 | 3 | 2.67 | 2.733 | 2.0114285714 | 2 |
| Modelling | 4.8 | 4.4667 | 3 | 2.3333333333 | 2.3333333333 | 3 | 2.8 | 2.3333333333 | 3 | 2.7333333333 | 2.866666667 | 2.5 | 2.53 | 2.733 | 2.6 | 2.5333333333 |
| Läng | 3.5625 | 3.8 | 2.125 | 2.5 | 2.75 | 3.4375 | 3.5 | 2.3125 | 2.0625 | 2 | 2.6875 | 2 | 1.93 | 2.8 | 1.9333333333 | 2.1875 |
| Total | 4.3655217 | 4.0667 | 2.36957 | 2.318181818 | 2.34782607 | 3.0652173391 | 3.1066957 | 2.2826008696 | 2.782608696 | 2.577777778 | 2.652173913 | 2.5 | 2.36 | 2.756 | 2.2045454545 | 2.239130435 |

Sikt

Överkant vindruta

| Betyg | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Kort | 6 | 3 | 3 | 3 | 0 |
| Model | 4 | 6 | 3 | 0 | 2 |
| Läng | 5 | 5 | 3 | 2 | 1 |

Underkant vindruta

| Betyg | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Kort | 3 | 2 | 0 | 7 | 3 |
| Model | 2 | 0 | 3 | 4 | 0 |
| Läng | 6 | 5 | 3 | 2 | 0 |

Speglar

| Betyg | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Kort | 3 | 1 | 5 | 3 | 3 |
| Model | 5 | 0 | 4 | 6 | 0 |
| Läng | 5 | 6 | 5 | 0 | 0 |

Här nedan presenteras det hur många av vardera testperson som anser vilka olika siktparametrar är viktiga vid inställning av körposition. Det visas i diagrammen till höger. Det som måste göras är att med hjälp av countif-funktionen beräkna hur många som angett respektive betyg.


Påverkan överkant vindruta


Påverkan underkant vindruta


Påverkan speglar


Påverkan kombiinstrument

Hur påverkar följande parametrar dig när du ställer in din sittposition inför körning i den här bilen?

Del 5. Parametrar för inställning av stol och ratt

**Öppna frågor**

6a) Sitter du där du vill sitta?

6b) du att det fanns fler eller större justermöjligheter du att det fanns fler eller större justermöjligheter

6d) Använder du armstödet i mittkonsollen?

6e) Använder du armstödet i dörren?

6f) Är nackstödet där du vill ha det när du kör?

**Del 6 - Sammanställning - Summa**

| 6a) Sitter du där du vill sitta? | Ja | Nej |
|---|---|---|
| Kort | 10 | 5 |
| Mellång | 14 | 2 |
| Lång | 10 | 6 |
| Total | 34 | 13 |

| 6b) Önskar du att det fanns fler eller större justermöjligheter | Ja | Nej |
|---|---|---|
| Kort | 7 | 8 |
| Mellång | 8 | 8 |
| Lång | 14 | 2 |
| Total | 23 | 18 |

| 6c) Önskar du att det fanns fler eller större justermöjligheter just ratten | Ja | Nej |
|---|---|---|
| Kort | 4 | 11 |
| Mellång | 4 | 12 |
| Lång | 5 | 11 |
| Total | 13 | 34 |

| 6d) Använder du armstödet i mittkonsollen? | Ja | Nej |
|---|---|---|
| Kort | 1 | 14 |
| Mellång | 11 | 2 |
| Lång | 14 | 5 |
| Total | 26 | 21 |

| 6e) Använder du armstödet i dörren? | Ja | Nej |
|---|---|---|
| Kort | 4 | 11 |
| Mellång | 8 | 8 |
| Lång | 10 | 5 |
| Total | 22 | 24 |

| 6f) Är nackstödet där du | Ja | Nej |
|---|---|---|
| Kort | 8 | 7 |
| Mellång | 8 | 8 |
| Lång | 10 | 5 |
| Total | | 25 |

Antal Ja 10
Antal Nej 6

Nedanstående stapeldiagram är gjorda utefter den sammanfattade matrisen ovan, där varderas diagram hämtar "Antal Ja" och "Antal Nej" för respektive fråga.

**6a) Sitter du där du vill sitta?**

**6b) Önskar du att det fanns fler eller större justermöjligheter för stolen?**

**6c) Önskar du att det fanns fler eller större justermöjligheter för ratten?**

**6d) Använder du armstödet i mitten?**

**6e) Använder du armstödet i dörren?**

7) Vilka delar av din rygg och nacke tar i ryggstöd respektive nackstöd när du sitter i den här bilen?

8j) Hur är din körstil i den här bilen?

Hur sitter du när du kör?

| | 1 | 2 | 3 | 3 | 3 |
|---|---|---|---|---|---|
| Medel | 1.0625 | 2.4375 | 2.866666667 | 2.9375 | 2 |

**Del 7 - Sammanställning - Medel**

| | Bakside huvud | Övre rygg | Mitten av ryggen | Ländrygg/Rumpa | Bakside lår |
|---|---|---|---|---|---|
| Kort | 1.73333333 | 2.571428571 | 2.8 | 2.933333333 | 2.733333333 |
| Medellång | 1.375 | 2.5 | 2.9375 | 3 | 2.5 |
| Lång | 1.0625 | 2.4375 | 2.866666667 | 2.9375 | 2 |
| Total | 1.382378723 | 2.5 | 2.863565217 | 2.351446809 | 2.404255319 |

| | 1 | 0 | 14 | 0 | 3 | 0 | 0 | 11 | 2 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|
| Summa | 1 | 0 | 14 | 0 | 3 | 0 | 0 | 11 | 2 | 14 |

**Del 8a - Sammanställning - Summa**

| | Säkerhetsmedveten | Osäker | Avslappnad | Känslokald | Aktiv | Fartglad | Nervös | Har kontroll | Försiktig | Bekväm |
|---|---|---|---|---|---|---|---|---|---|---|
| Kort | 7 | 0 | 10 | 0 | 6 | 4 | 0 | 9 | 0 | 12 |
| Medellång | 12 | 1 | 14 | 0 | 5 | 2 | 0 | 11 | 2 | 14 |
| Lång | 7 | 0 | 14 | 0 | 3 | 0 | 0 | 11 | 2 | 14 |
| Total | 26 | 1 | 38 | 0 | 14 | 6 | 0 | 31 | 4 | 40 |

Nedanstående tabell visar en översikt över var testpersonens tyckte att sitet tog i och hur mycket. Det är ett diagram som visar resultatet i sammanställningen ovan.

| | |
|---|---|
| | Ja |
| | Ja |
| | Ja |
| | Ja |
| | Ja |
| | Ja |
| | Ja |
| Antal Ja | 15 |
| Antal Nej | 1 |

**Del 8c - Sammanställning - Summa**

| | Ja | Nej |
|---|---|---|
| Kort | 13 | 2 |
| Medellår | 15 | 1 |
| Lång | 15 | 1 |
| Total | 43 | 4 |

**8c) Är det denna körställning du vill ha i den här bilen?**



Legend: Nej, Ja

Rotated text (right side):

8b) Varför har du valt den körstil du har valt?

8b

Stämmer med den känsla man får i bilen det känns säkert bra kontroll
För att det känns som vanligt. Jag sitter lika illa i alla bilar, vilket känns igenkännande. Är van vid

Ja/Nej

Ja

8c

Kommentar

8c) Är det denna körstil du vill ha i den här bilen?

8ck

# F. SPEED Coordinates program

In this appendix parts from the coordinates program is shown. The information displayed here is copied directly from the SPEED Coordinates program in Excel the way it will be seen for the user. Formulas are not shown. The information is displayed in order of appearance in the program with h-point first, eye point and steering wheel and they heel point.

# H-point

## SPEED Coordinates program

I detta program räknas H-punkten samt ryggutningen ut. Det består av 4 olika delar, varav första delen handlar om inmätning av STEPS från SPEED Compilation document, del 2 visar resultaten för H-punkt och även Ryggutning. Del 3 är hela H-punktsberäkningen, här ska a data hämtas från CATIA och Uppmätning, del 4 handlar om Ryggutning och dess uträkningar, data till denna del kommer från Uppmätningen. Mer instruktioner för var del finns att se i SPEED Instructions document.

## Del 1 - Ange steps från TP-formulär

Ange steps som motorerna har gått i det gröna fältet. Bredvid räknas de riktiga antalet steps ut och även hur långt stolen har färdats i längsled. De riktiga stepsen räknas ut då ryggen är nollställd på ett läge som egentligen inte är ett extremläge. De räknas också ut pga att antalet steps som matas in kan vara negativa, detta skulle ge felaktiga resultat. Då negativa värden matas in, antas att stolen är i något extremläge.

| | Steps från formulär | Riktiga steps | totalt mm/step |
|---|---|---|---|
| Length | 800 | 800 | 146.9518248 |
| Recline | 400 | 1923 | |
| Height | 400 | 400 | 0 |
| Tilt | 300 | 300 | |

## Del 2 - Koordinat och lutning

**Slutlig H-punktsposition med tilt**

| x | z |
|---|---|
| 3014.574 | 744.444 |

**Ryggutning**

| | |
|---|---|
| Stolsryggslutning | 12.58399 grader |
| Manikinlutning | 24.38834 grader |

**Slutlig H-punktsposition utan tilt**

| x | z |
|---|---|
| 3002.117 | 743.656 |

**OBS!** Det är endast de grönmarkerade fälten som man ska mata in siffror i. Resten sköts automatiskt.

I de två diagrammen nedan visas den uträknade H-punkten med tilt medräknat, röd, även H-punkten utan tilt medräknad, grönt kryss, även ryggslutningen som manikinen bör haft med stolens inställda motorsteps visas.

## H-point calculation

Legend:
- X H-point without tilt
- ● H-point with tilt
- LFLUTN
- ◆ LFLNTU
- ◆ LFLUTU
- + LFLNTN
- ● LBLUTN
- ◆ LBLUTU
- ◆ LBLNTU
- ▲ LBLNTN

## Del 3 - H-punktsberäkning
### Del 3.1 - Jämförelser
**Kontrollering av koordinater mellan CATIA - Cvspec - Uppmätning**

Jämförelse CV-spec vs. Stolsritning i XC60-läge

| | | |
|---|---|---|
| **SRP i CV.spec** | 3105.336 | 737.5 |
| LBLN | 3165.972 | 713.862 |
| LBLU | 3116.744 | 765.291 |
| LFLN | 2912.121 | 727.166 |
| LFLU | 2862.893 | 778.595 |
| | | |
| **SRP i CATIA** | 3105.336 | 737.5 |
| LBLN | 3168.404 | 713.758 |
| LBLU | 3118.098 | 765.188 |
| LFLN | 2916.749 | 726.942 |
| LFLU | 2866.443 | 778.372 |

| **Skillnader** | Skillnad spec | Skillnad CATIA | **Diff** |
|---|---|---|---|
| Upp-ner | 51.429 | 51.430 | **-0.001** |
| bak-fram | 253.851 | 251.655 | **2.196** |

I nedanstående tre stycken jämförs punkt PT1 och PT2 på stolen mellan CATIA och datan från uppmätningen. Mata in samtliga värden för de olika lägena. I tredje stycket anges differensen mellan de olika.

| **Från uppmätningen** | | x | y | z |
|---|---|---|---|---|
| M_PKT_1_LFLN | | 2616.6 | -572.4 | 586.6 |
| M_PKT_2_LFLN | | 2924.3 | -585.3 | 601.5 |
| M_PKT_1_LFLU | | 2580.5 | -572.4 | 611.5 |
| M_PKT_2_LFLU | | 2885.6 | -585.7 | 654.2 |
| M_PKT_1_LBLU | | 2836.5 | -571.3 | 598.4 |
| M_PKT_2_LBLU | | 3141.9 | -584.3 | 641 |
| M_PKT_1_LBLN | | 2872.6 | -571.4 | 573.3 |
| M_PKT_2_LBLN | | 3180.4 | -584.6 | 587.5 |
| M_PKT_1_SRP-POS_BEL | | 2816.7 | -571.6 | 581.7 |
| M_PKT_2_SRP-POS_BEL | | 3123.6 | -584.3 | 611.6 |

| **Från CATIA** | | x | y | z |
|---|---|---|---|---|
| M_PKT_1_LFLN | | 2619.531 | -576.155 | 585.32 |
| M_PKT_2_LFLN | | 2927.351 | -590.155 | 600.66 |
| M_PKT_1_LFLU | | 2583.352 | -576.156 | 610.28 |
| M_PKT_2_LFLU | | 2888.497 | -590.156 | 653.58 |
| M_PKT_1_LBLU | | 2835.006 | -576.155 | 597.096 |
| M_PKT_2_LBLU | | 3140.152 | -590.156 | 640.396 |
| M_PKT_1_LBLN | | 2871.186 | -576.155 | 572.136 |
| M_PKT_2_LBLN | | 3179.006 | -590.155 | 587.477 |
| M_PKT_1_SRP-POS_**OBEL** | | 2815.906 | -576.155 | 580.508 |
| M_PKT_2_SRP-POS_**OBEL** | | 3122.501 | -590.155 | 611.947 |

Nedan räknas differensen mellan PT1 och PT2 ut som är mellan CATIA- och Uppmätningskoordinater. Denna differensen ska kontrolleras så att den ej är för stor. När den är kalkylerad kan man se hur stolen är positionerad i verkligheten jämfört med nominellt läge.

| **Differens** | | x | y | z |
|---|---|---|---|---|
| M_PKT_1_LFLN | | 2.931 | 3.755 | 1.28 |
| M_PKT_2_LFLN | | 3.051 | 4.855 | 0.84 |
| M_PKT_1_LFLU | | 2.852 | 3.756 | 1.22 |
| M_PKT_2_LFLU | | 2.897 | 4.456 | 0.62 |
| M_PKT_1_LBLU | | 1.494 | 4.855 | 1.304 |
| M_PKT_2_LBLU | | 1.748 | 5.856 | 0.604 |
| M_PKT_1_LBLN | | 1.414 | 4.755 | 1.164 |
| M_PKT_2_LBLN | | 1.394 | 5.555 | 0.023 |
| M_PKT_1_SRP-POS_BEL-**OBEL** | | 0.794 | 4.555 | 1.192 |
| M_PKT_2_SRP-POS_BEL-**OBEL** | | 1.099 | 5.855 | 0.347 |
| *Medeldiff* | | 1.967 | 4.825 | 0.859 |

| **SRP i Uppmätning** | **H-punkt vänster sida** | | **H-punkt höger sida** | |
|---|---|---|---|---|
| | x | z | x | z |
| | | | | |
| | **Medel-x** | **Medel-z** | | |
| | #DIV/0! | #DIV/0! | | |

Nedan räknas den skillnaden ut som är mellan den uppmätta medel-H-punkten och H-punkten som är insatt i CATIA. Med dessa diffar ska sedan uppmätningsextrempunkterna uppdateras.

**Skillnad i koordinater på H-punkt i SRP mellan uppmätning och CATIA**

| | x | z | |
|---|---|---|---|
| | #DIV/0! | #DIV/0! | |

## Del 3.2 - Extremvärden

Mata in koordinater för extremvärden för stolen från CATIA och värden som är från uppmätningen. Sist ska även totala antalet möjliga steps från ett nolltställt läge på stolen matas in när den färdas till samtliga extremlägen. De värden som står i fältet CATIA, kommer från CATIA och de under Uppmätning kommer från uppmätningen. Det är ALLTID de koordinater som står under uppmätning som formlerna i dokumentet kommer hämta information ifrån. För att då testa metoden innan uppmätningen kan man lägga in CATIA-koordinaterna även under uppmätning.

| CATIA | H-punkt x | H-punkt z | | |
|---|---|---|---|---|
| LBLNTN | 3164.781 | 713.401 | | |
| LBLNTU | 3179.283 | 714.203 | | |
| LBLUTU | 3128.892 | 766.621 | | |
| LBLUTN | 3114.523 | 764.503 | | |
| LFLNTN | 2913.126 | 726.585 | | |
| LFLNTU | 2927.628 | 727.386 | | |
| LFLUTU | 2877.237 | 779.805 | | |
| LFLUTN | 2862.868 | 777.686 | | |

Under uppmätning ska uppdaterade koordinater matas in. Dessa koordinater fås när stolen har blivit uppmätt och H-punkten i CATIA-modellen blivit uppdaterad med de koordinater som fås som medel-H-punktskoordinater i Uppmätningen. Dessa koordinater är sedan de som används i samtliga delar för att de då ska visa den "riktiga" H-punkten.

| Efter uppmätning | H-punkt x | H-punkt z | | |
|---|---|---|---|---|
| LBLNTN | 3164.781 | 713.401 | | |
| LBLNTU | 3179.283 | 714.203 | | |
| LBLUTU | 3128.892 | 766.621 | | |
| LBLUTN | 3114.523 | 764.503 | | |
| LFLNTN | 2913.126 | 726.585 | | |
| LFLNTU | 2927.628 | 727.386 | | |
| LFLUTU | 2877.237 | 779.805 | | |
| LFLUTN | 2862.868 | 777.686 | | |

Ange totalt antal steps stolens olika motorer kan gå från dess nolläge till samtliga extrempositioner.

| Steps | | | | |
|---|---|---|---|---|
| Lägen | Length | Recline | Height | Tilt |
| LBLNTN | 0 | 0 | 0 | 0 |
| LBLNTU | 0 | 0 | 0 | 348 |
| LBLUTU | 0 | 0 | 1034 | 348 |
| LBLUTN | 0 | 0 | 1034 | 0 |
| LFLNTN | 1370 | 0 | 0 | 0 |
| LFLNTU | 1370 | 0 | 0 | 348 |
| LFLUTU | 1370 | 0 | 1034 | 348 |
| LFLUTN | 1370 | 0 | 1034 | 0 |

## Del 3.3 - Längd

Nedan räknas h-punkten för längdjusteringen ut. Det enda som ska matas in är vinkeln alfa. Sedan räknas avståndet i mm som stolen rör sig i längsled, c. Det vi vill räkna ut är hur x- och z-koordinaten påverkas av enbart längdjusteringen. Vi vill därför räkna ut avståndet b som görs genom att ta cosinus (alfa) * avståndet c. När vi sedan har avståndet b kan vi ta x-värdet för extremvärdet längst ner och längst bak, subtrahera avståndet b och därmed flytta oss åt vänster och få en x-koordinat som motsvarar om man bara skulle justera i längsled. Samma sak förs för z-koordinaten fast a används.

Nedan är den totala längden uträknad som stolen kan röra sig i längsled. Denna längden divideras sedan med antalet steps stolen kan gå i längsled för att sedan användas nedanför när vi räknar ut längsjusteringens påverkan på H-punkten.

Ange hur många mm stolen kan gå åt olika håll

**mm**

**Length**

251.655

Visar hur många mm det är per step som motorn har gått

**mm/step**

**Length**
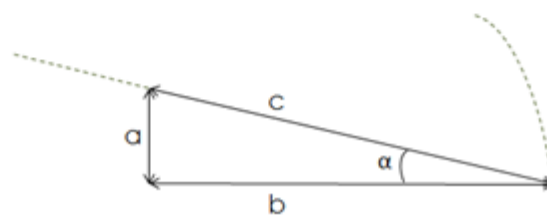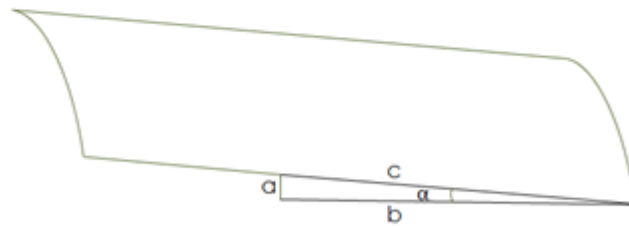
0.183689781

|  | alfa | c (mm/s | a | b |
|---|---|---|---|---|
| Lutning på stol | 3 | 146.9518 | 7.690864 | 146.7504 |
| deg -> rad | 0.05236 | | | |

| **H-punkt från längduträkning** | |
|---|---|
| **x** | **z** |
| 3018.031 | 721.092 |

## Del 3.4 - Höjd

Nu när alla extremlägen har uppdaterats med en ny H-punkt i CATIA är det dags att skriva in i excel hur H-punkten rör sig i höjdled. Justera stolens höjd med förvalt steg (+4) i slidebarsen i CATIA, börja LBLNTN. Detta görs genom att dubbelklicka på "Seat Adjuster", punkt 1 i bilden ovan, vilket man finner under "mechanics". Därefter trycka på prickarna vid punkt 3 och sedan skriva in 4 i rutan för "increments". Sedan mäts H-punkten, punkt 2 på bilden, vid varje steg och dess x- och z-koordinat skrivs in nedan. Övrig information om steg, max- och minslide ska också matas in.

| HÖJD | H-punkt x | H-punkt z | Antal step | Steps/ste | Maxslide | Minslide |
|------|-----------|-----------|------------|-----------|----------|----------|
| LBLNTN | 3164.781 | 713.401 | 0 | 20.076812 | -33.0312 | 18.471 |
| +4 | 3161.780 | 718.140 | 80.307249 | | | |
| +4 | 3158.705 | 722.781 | 160.6145 | | **Näst sista steg innan maxslide** | |
| +4 | 3155.533 | 727.317 | 240.92175 | | -29.529 | |
| +4 | 3152.240 | 731.742 | 321.229 | | | |
| +4 | 3148.802 | 736.047 | 401.53625 | | **"Reglage"-steg** | |
| +4 | 3145.199 | 740.222 | 481.84349 | | 4 | |
| +4 | 3141.412 | 744.258 | 562.15074 | | | |
| +4 | 3137.423 | 748.144 | 642.45799 | | **Sista "reglage"-steg** | |
| +4 | 3133.215 | 751.868 | 722.76524 | | 3.5022 | |
| +4 | 3128.772 | 755.418 | 803.07249 | | | |
| +4 | 3124.077 | 758.778 | 883.37974 | | | |
| +4 | 3119.110 | 761.930 | 963.68699 | | | |
| LBLUTN | 3114.523 | 764.503 | 1034 | | | |
| | | | 1035 | | | |

Nedan sköts interpoleringen för höjdkoordinaten

**Interpoleringen för höjdkoordinater**

| | |
|---|---|
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 3148.868 | 735.964647 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 3148.868 | 735.964647 |

**H-punkt från höjdinterpolering**

| x | z |
|---|---|
| 3148.868 | 735.964647 |

Nedanstående beräkningar finns endast för att skapa den andra höjdkurvan i diagrammet. Denna skapas automatiskt då värdena för den första är inskrivna. Så **ingenting** behöver göras med dessa beräkningar.

| HÖJD | H-punkt x | H-punkt z |
|------|-----------|-----------|
| LFLNTN | 2913.126 | 726.585 |
| +4 | 2910.125 | 731.324 |
| +4 | 2907.050 | 735.965 |
| +4 | 2903.878 | 740.501 |
| +4 | 2900.585 | 744.926 |
| +4 | 2897.147 | 749.231 |
| +4 | 2893.544 | 753.406 |
| +4 | 2889.757 | 757.442 |
| +4 | 2885.768 | 761.328 |
| +4 | 2881.560 | 765.052 |
| +4 | 2877.117 | 768.602 |
| +4 | 2872.422 | 771.962 |
| +4 | 2867.455 | 775.114 |
| LFLUTN | 2862.868 | 777.687 |

## Del 3.5 - Tilt

Här är det samma tillvägagångssätt som på höjdberäkningen. Man använder sig ac Seat adjuster under mechanics i den kinematiska modellen som bilden ovan visar. Fast nu justerar man stolens tilt med förvalt steg (+2) i slidebarsen i CATIA, börja LBLNTN. Motsvarande information för tilten som matades in för höjden ska matas in nedan.

| TILT | H-punkt | H-punkt z | Antal steps | Steps/ste | Maxslid | Minslide |
|---|---|---|---|---|---|---|
| LBLNTN | 3164.781 | 713.401 | 0 | 21.284404 | -4.275 | 12.075 |
| +2 | 3166.457 | 713.579 | 42.56880734 | | | |
| +2 | 3168.166 | 713.738 | 85.13761468 | | **Näst sista steg innan maxslide** | |
| +2 | 3169.91 | 713.875 | 127.706422 | | -3.925 | |
| +2 | 3171.687 | 713.991 | 170.2752294 | | | |
| +2 | 3173.493 | 714.082 | 212.8440367 | | **"Reglage"-steg** | |
| +2 | 3175.319 | 714.149 | 255.412844 | | 2 | |
| +2 | 3177.152 | 714.189 | 297.9816514 | | | |
| +2 | 3178.969 | 714.203 | 340.5504587 | | **Sista "reglage"-steg** | |
| LBLNTU | 3179.283 | 714.203 | 348 | | 0.35 | |
| | | | 349 | | | |

Nedan sköts interpoleringen för tiltkoordinaten

**Interpolering för tiltkoordinat**

| | |
|---|---|
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 3177.238 | 714.1897 |
| 0 | 0 |
| 0 | 0 |
| 3177.238 | 714.1897 |

**H-punkt från tiltinterpolering**

| x | z |
|---|---|
| 3177.238 | 714.1897 |

# Del 4 - Ryggutning

## Del 4.1 - Data från uppmätning

Ange vilken grad manikinen sitter i under grad, skriv in uppmätningsdata (x- och z-koordinater) för punkt 3 och 4 på stolen, ange vilken loggvärde stolsmotorn har för vardera manikingradpunktavläsning. Den linje som är markerad som "0" i bilden nedan symboliserar stolsryggen. Anledningen att första kolumnen "Degrees" står som den står är för att diagrammet läser namnen på punkterna från denna kolumn. I kolumn B i detta avsnitt står rena siffror på "Grad", för att härifrån läses siffror längre ner i dokumentet, del 4.4.

| Degrees | Grad | Nedre stolspunkt, 3 | | Övre stolspunkt, 4 | | Stepsloggning med val | Totalsteps från längst bak |
|---|---|---|---|---|---|---|---|
| | | x | z | x | z | | |
| Längst bak | 35 | 3342.6 | 649.1 | 3745.8 | 942.5 | -1523 | 0 |
| 35 degrees | 35 | 3348.7 | 667 | 3548.7 | 1124.5 | -53 | 1470 |
| 33 degrees | 33 | 3347.3 | 667.9 | 3534.2 | 1311 | -6 | 1517 |
| 31 degrees | 31 | 3347.1 | 667.2 | 3515.4 | 1137.9 | 91 | 1614 |
| 29 degrees | 29 | 3348.7 | 667 | 3501 | 1143.3 | 173 | 1696 |
| 27 degrees | 27 | 3349.6 | 669.9 | 3485.3 | 1150.4 | 266 | 1789 |
| 25 degrees | 25 | 3350 | 672.2 | 3468.7 | 1157.4 | 349 | 1872 |
| 23 degrees | 23 | 3348.1 | 673.3 | 3439.4 | 1165.1 | 491 | 2014 |
| 21 degrees | 21 | 3348.2 | 673.1 | 3422.8 | 1167.5 | 578 | 2101 |
| 19 degrees | 19 | 3350 | 674.9 | 3404.4 | 1171.6 | 713 | 2236 |
| 17 degrees | 17 | 3350.6 | 677.3 | 3387.3 | 1175.7 | 797 | 2320 |
| Längst fram | | 3343.4 | 693.1 | 3184.5 | 1167.7 | 1766 | 3289 |

## Del 4.2 - Interpolering

Nedan interpoleras ryggutningens koordinater på samma sätt som höjden och tilten gjorde.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 3349.317606 | 672.5950704 | 3458.176761 | 1160.165493 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 0 | 0 | 0 | | |
| 3349.317606 | 672.5950704 | 3458.176761 | 1160.165493 | | | | |

## Del 4.3 - Vinkeluträkning

Då vi kunde få ut två punkter på stolens rygg i uppmätningen kan vi skapa oss en triangel mellan punkterna vi fick ut och när stolen skulle stå rakt upp. När vi räknat ut a och b med hjälp av koordinaterna av de två punkterna är det bara att räkna ut c med pythagoras sats. Med hjälp av o k an vi sedan räkna ut vinkeln som ryggen står i.

Stolsryggslutning i grader tas ut med pythagoras sats

| a | 108.8591549 |
|---|---|
| b | 487.5704225 |
| c | 499.575052 |
| vinkel i rad | 0.219632017 |
| vinkel i grader | 12.58398763 |



Ryggen längst fram

Ryggen längst bak

Stolspunkt 3

Stolspunkt 4

a

b

c

α
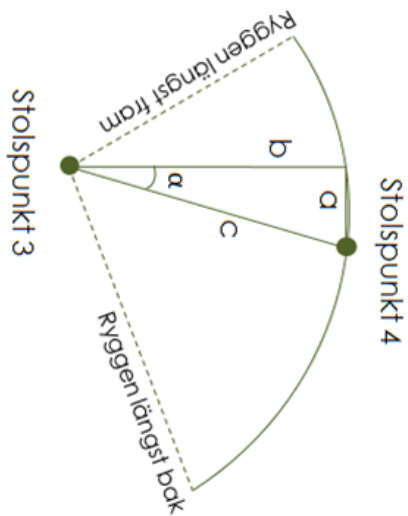
## Del 4.4 - Jämförelse

Nedan ska rygglutningen i grader skrivas in som fås i cell B250 för vardera step som finns i kolumn A i nedanstående del. Därefter räknas medeldiffen ut som är den medelvärdesdifferens mellan vardera manikin- och rygglutning. Denna medeldifferens kommer sedan att läggas på på rygglutningen som fås i B250 för att kan kunna räkna ut den tänkta manikinlutningen.

| Steps | Manikinlutn | Rygglutning | Diff i lutning |
|-------|-------------|-------------|----------------|
| -53 | 35 | 23.56883 | 11.43117 |
| -6 | 33 | 21.94303 | 11.05697 |
| 91 | 31 | 19.65676 | 11.34324 |
| 173 | 29 | 17.72134 | 11.27866 |
| 266 | 27 | 15.76447 | 11.23553 |
| 349 | 25 | 13.74391 | 11.25609 |
| 491 | 23 | 10.51613 | 12.48387 |
| 578 | 21 | 8.580342 | 12.419658 |
| 713 | 19 | 6.250226 | 12.749774 |
| 797 | 17 | 4.21402 | 12.788598 |
| | | Medeldiff: | 11.804356 |

## Eye point and steering wheel position

Här vill vi räkna ut ögonpunkter för testpersonen. Först krävs det att vi matar in värden från uppmätningen och pixelvärden från korten. När alla värden är iskrivna ska vi ta fram funktioner för pixel vs koordinat. Först x och sedan z.

### y + 100

| Punkt nr | +100 - böjning mitt photoshop | | I koordinat | | |
|---|---|---|---|---|---|
| | x | z | x | y | z |
| 1 | 47,27 | 16,65 | 3311,7 | -462,5 | 1481,8 |
| 2 | 52,33 | 16,67 | 3211,5 | -461,9 | 1481,7 |
| 3 | 57,43 | 16,67 | 3111,4 | -460,6 | 1482,1 |
| 4 | 62,49 | 16,67 | 3012,4 | -460,9 | 1482,5 |
| 5 | 47,29 | 21,66 | 3311,3 | -460,6 | 1381,7 |
| 6 | 52,33 | 21,64 | 3211,2 | -461,3 | 1382 |
| 7 | 57,43 | 21,69 | 3111,9 | -461,1 | 1382,2 |
| 8 | 62,49 | 21,64 | 3012,3 | -460,7 | 1382,3 |
| 9 | 47,32 | 26,73 | 3311,3 | -459,5 | 1282,2 |
| 10 | 52,36 | 26,73 | 3212 | -460,4 | 1282,5 |
| 11 | 57,43 | 26,7 | 3112,1 | -460,5 | 1283 |
| 12 | 62,52 | 26,7 | 3012,4 | -460,3 | 1283,5 |

### y mitt

| Y mitt i stol- böjning mitt Photoshop | | I koordinat | | |
|---|---|---|---|---|
| x | z | x | y | z |
| 46,48 | 15,63 | 3312,4 | -363,5 | 1481,3 |
| 52 | 15,63 | 3213,4 | -363,5 | 1482,1 |
| 57,53 | 15,66 | 3112,4 | -364,4 | 1480,7 |
| 63,02 | 15,63 | 3013,1 | -363 | 1480,7 |
| 46,51 | 21,08 | 3312,8 | -361,9 | 1381,9 |
| 52 | 21,08 | 3213,2 | -363,5 | 1381,5 |
| 57,53 | 21,1 | 3113,3 | -363 | 1381,5 |
| 63,1 | 21,1 | 3013,4 | -362,4 | 1381,4 |
| 46,48 | 26,6 | 3313,1 | -361,8 | 1281,5 |
| 52 | 26,63 | 3213,2 | -362,7 | 1281,8 |
| 57,55 | 26,6 | 3113,7 | -362,3 | 1282,1 |
| 63,07 | 26,6 | 3014,3 | -361,6 | 1281,9 |

### y - 100

| -100 - böjning mitt photoshop | | I koordinat | | |
|---|---|---|---|---|
| x | z | x | y | z |
| 45,73 | 14,4 | 3311,7 | -264,8 | 1481,2 |
| 51,74 | 14,43 | 3212,4 | -264,9 | 1482 |
| 57,81 | 14,4 | 3113,1 | -265,7 | 1481,2 |
| 63,9 | 14,4 | 3011,6 | -264,1 | 1479,9 |
| 45,73 | 20,38 | 3311,9 | -264,6 | 1382,3 |
| 51,74 | 20,41 | 3211,9 | -264,6 | 1382,3 |
| 57,84 | 20,41 | 3112,1 | -263,6 | 1382,6 |
| 63,94 | 20,44 | 3012,3 | -263,2 | 1381,7 |
| 45,76 | 26,48 | 3311,9 | -263,6 | 1283,2 |
| 51,8 | 26,45 | 3211,9 | -264,1 | 1282,5 |
| 57,84 | 26,48 | 3111,8 | -263,3 | 1283 |
| 63,94 | 26,48 | 3011,9 | -261,9 | 1282,1 |

### Takkamera

| | tak y + 100 | | | | tak y mitt i stol | | | | tak y - 100 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | x nedre | y nedre | x övre | y övre | x nedre | y nedre | x övre | y övre | x nedre | y nedre | x övre | y övre |
| vänstra punkt | 48,06 | 20,52 | 40,84 | 10,9 | 46,43 | 34,29 | 37,98 | 29,85 | 46,14 | 47,39 | 34,28 | 50,38 |
| högra punkt | 112,6 | 20,81 | 112,68 | 11,22 | 112,7 | 33,91 | 29,53 | 29,53 | 112,79 | 46,72 | 112,58 | 50,8 |

Här under stoppar man in pixelvärden för rattens
punkter och motsvarande koordinater.

| | Ratt | | | | |
|---|---|---|---|---|---|
| | -100 - böjning mitt photoshop | | I koordinat | | |
| Punkt nr | x | z | x | y | z |
| 1 | 70,12 | 32,45 | 2881,6 | -370,6 | 1175,6 |
| 2 | 72,71 | 32,45 | 2832,4 | -370,2 | 1176,4 |
| 3 | 75,26 | 32,41 | 2781,6 | -369,9 | 1175,9 |
| 4 | 77,78 | 32,36 | 2732,2 | -367,7 | 1176,6 |
| 5 | 70,03 | 35,15 | 2880,8 | -370,8 | 1125,5 |
| 6 | 72,66 | 35,09 | 2830,9 | -370,2 | 1126,5 |
| 7 | 75,22 | 35,04 | 2780,4 | -369,7 | 1126,6 |
| 8 | 77,73 | 35,01 | 2731,9 | -368,8 | 1127,3 |
| 9 | 70,01 | 37,74 | 2880,2 | -371 | 1078,8 |
| 10 | 72,59 | 37,67 | 2830,3 | -370,6 | 1076,9 |
| 11 | 75,14 | 37,62 | 2781,2 | -369,8 | 1078,3 |
| 12 | 77,61 | 37,57 | 2729,9 | -369,9 | 1076,3 |
| LFLN | 77,58 | 37,38 | 2735,6035 | | 1083,368 |
| LFLU | 78,56 | 34,96 | 2716,5366 | | 1128,598 |
| LBLN | 75,63 | 36,59 | 2773,9318 | | 1098,507 |
| LBLU | 76,57 | 33,83 | 2755,2541 | | 1149,717 |

I de grönmarkerade rutorna tyller man i pixelvärdena
i det uppskattade y-planet. I de vita rutorna får man
ut motsvarande koordinater. Formlerna i de vita
rutorna får dock uppdateras mot formlerna man får
ut av diagrammen!

| | x pixel | z pixel | x koordinat | z koordinat | |
|---|---|---|---|---|---|
| +100 | | | | | |
| **Mitt** | 55,88 | 19,79 | 3143,242 | 1405,537 | ögonpunkt |
| -100 | | | | | |
| Ratt | 77,58 | 37,38 | 2734,945 | 1083,005 | rattmitt |

Vilken av raderna man ska stoppa in sina pixelvärden
för får man avgöra efter en analys av motsvarande
bild uppifrån. +100 är ett plan 10 cm från mitten av
stolen närmare förardörren. Planet -100 är 10 cm
närmare mittkonsollen. Sitter testpersonen mitt i
stolen ska således pixelvärdena stoppas in i "Mitt"-
raden.

Här är x-värdena med pixelvärdet på x-axeln och koordinatvärdet på y-axeln.
Ekvationerna kommer i ordningen +100, mitt, -100.
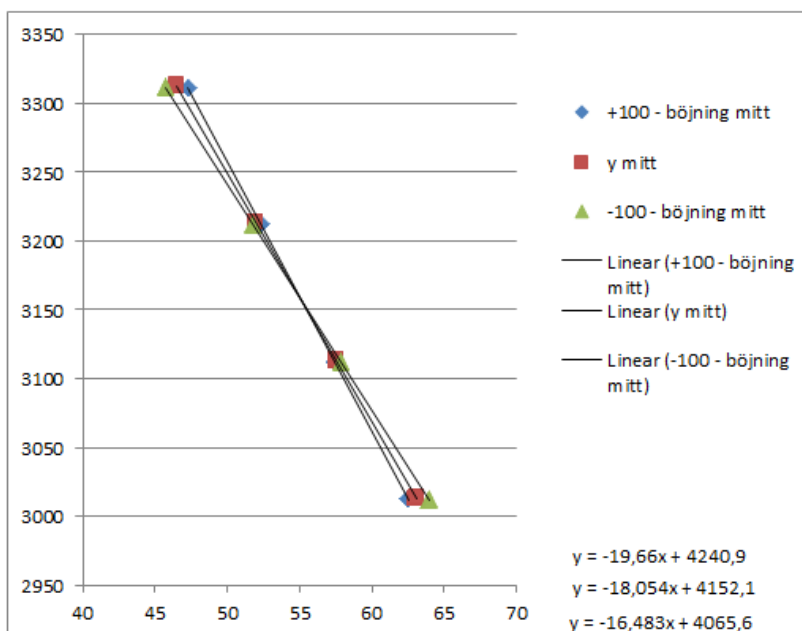


Här är z-värdena med pixelvärdet på x-axeln och koordinatvärdet på y-axeln.
Ekvationerna kommer i ordningen +100, mitt, -100.
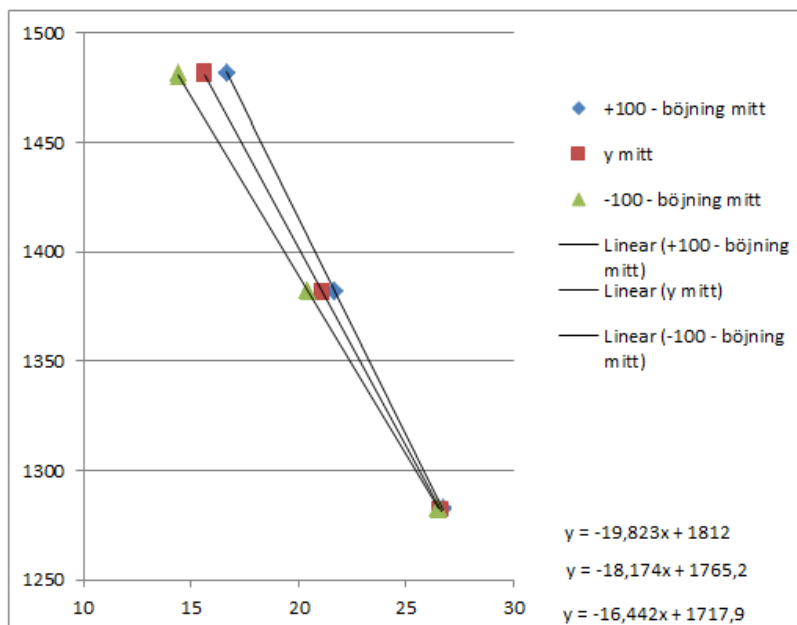
Här är x och z för rattens position med rutnätet. Ekvationerna kommer i ordningen x och z. Dessa ekvationer ska uppdateras i formlerna för att få ut koordinater.



$y = -19{,}44x + 4243{,}1$
$R^2 = 0{,}9991$

$y = -18{,}788x + 1785{,}3$
$R^2 = 0{,}9991$
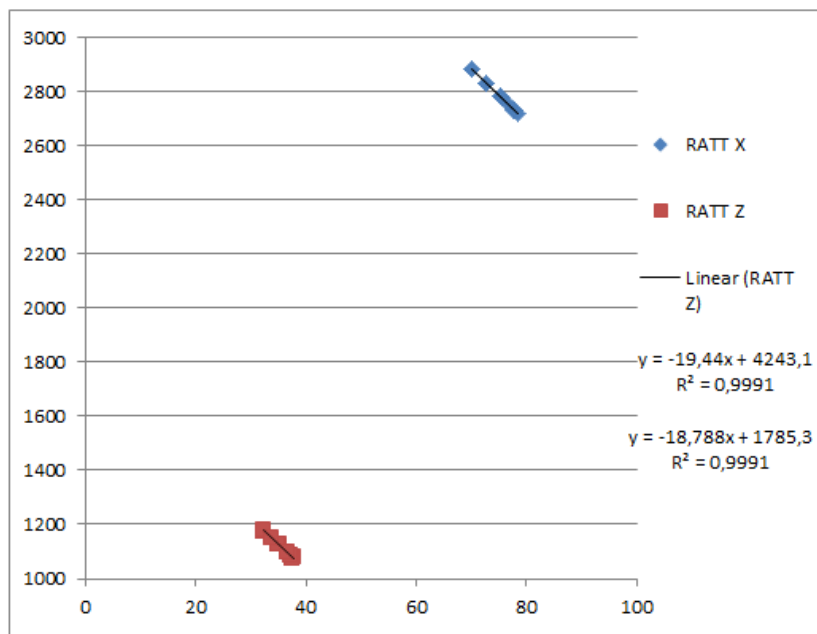
| | Rattens uppmätta extremlägen | | | från pixelbilder samma tillfälle | | | | Skillnad | Skillnad |
|---|---|---|---|---|---|---|---|---|---|
| XC60 | x | y | z | x | z | x pixel | z pixel | mm i x | mm i z |
| LFLN | 2726,4 | -368,2 | 1084,2 | 2735,604 | 1083,368 | 77,58 | 37,38 | 9,20352 | -0,8322 |
| LFLU | 2709,4 | -368,2 | 1127,7 | 2716,537 | 1128,598 | 78,56 | 34,96 | 7,13664 | 0,8976 |
| LBLN | 2770,4 | -367,3 | 1101,9 | 2773,932 | 1098,507 | 75,63 | 36,59 | 3,53184 | -3,3933 |
| LBLU | 2751 | -368,1 | 1150,2 | 2755,254 | 1149,717 | 76,57 | 33,83 | 4,25408 | -0,4827 |

Värdena ovan är bara för referens. De är inte kopplade till något.
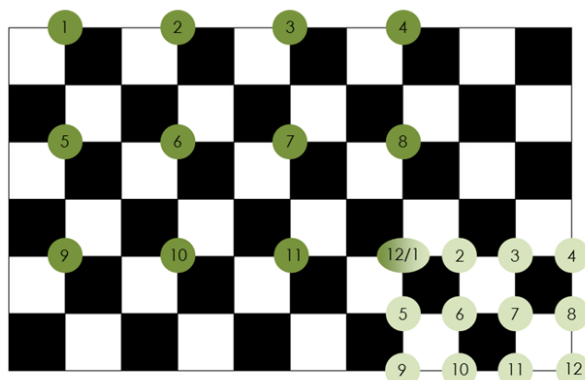


Bilden till vänster beskriver vilka punkter som det refereras till ovan. De mörka punkterna är punkterna använda för ögonpunkter och de ljusa är använda för rattposition.

## Heel position

Här ska vi få ut hälpunkten. På uppmätningen har man mätt upp 20 punkter.
Koordinaterna för dessa stoppar man in här under i de gröna fälten. Koordinaten får
man sedan ut efter man ha skrivit i antalet rutor i y-led och i x-led där hälen befinner sig.
Det ser man i korten.

| Punkt | i bilens koordinater | | | Antal rutor | | | Var är hälen? | x-led | y-led |
|---|---|---|---|---|---|---|---|---|---|
| | x | y | z | x-led | y-led | | Antal rutor | | |
| 1 | 2204,4 | -382 | 462,2 | 0 | 17 | | | 0 | 1 |
| 2 | 2205,1 | -341,1 | 465,2 | 0 | 13 | | | | |
| 3 | 2205,1 | -301,4 | 466,4 | 0 | 9 | | | | |
| 4 | 2205 | -261,9 | 466,5 | 0 | 5 | | Koordinat att | x-led | y-led |
| 5 | 2205 | -221,5 | 467,3 | 0 | 1 | | använda | 2204,92 | -221,675 |
| 6 | 2262,8 | -381,4 | 448,3 | 6 | 17 | | | | |
| 7 | 2263,1 | -341,2 | 448,9 | 6 | 13 | | | | |
| 8 | 2262,4 | -301,7 | 448,1 | 6 | 9 | | | | |
| 9 | 2262,2 | -262 | 448 | 6 | 5 | | | | |
| 10 | 2262,3 | -222,5 | 446,9 | 6 | 1 | | | | |
| 11 | 2332 | -380,7 | 448,2 | 13 | 17 | | | | |
| 12 | 2331,4 | -341,5 | 444,6 | 13 | 13 | | | | |
| 13 | 2330,4 | -301,6 | 442,5 | 13 | 9 | | | | |
| 14 | 2329,8 | -262 | 440,2 | 13 | 5 | | | | |
| 15 | 2330,7 | -222,5 | 436,2 | 13 | 1 | | | | |
| 16 | 2400,5 | -380,1 | 437,2 | 20 | 17 | | | | |
| 17 | 2399,7 | -340,6 | 438,2 | 20 | 13 | | | | |
| 18 | 2399,2 | -300,4 | 437,6 | 20 | 9 | | | | |
| 19 | 2398,5 | -260 | 437,8 | 20 | 5 | | | | |
| 20 | 2399,1 | -220,2 | 438,5 | 20 | 1 | | | | |

| | Interpolera | | | | Interpolera | |
|---|---|---|---|---|---|---|
| Antal rutor | x | | | Antal rutor | y | |
| 0 | 2204,92 | 2204,92 | | 0 | 0 | |
| 6 | 0 | 2262,56 | | 1 | -221,675 | -221,675 |
| 13 | 0 | 2330,86 | | 5 | 0 | -261,475 |
| 20 | 0 | 2399,4 | | 9 | 0 | -301,275 |
| 21 | | | | 13 | 0 | -341,1 |
| sum | 2204,92 | | | 17 | 0 | -381,05 |
| | | | | 18 | | |
| | | | | sum | -221,675 | |

Här har vi en guide till hur man räknar rutor enklast.

Här har vi en förklaring över vilka punkter som är uppmätta.

Break    Accelerator Pedal

# G. SPEED Instruction document

In this appendix the instructions to how to use SPEED is found.

Appendix G – SPEED Instruction document

# SPEED

## Instruction document

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2013-06-11
VCC Ergonomics

# Innehållsförteckning

# 1 Introduktion

SPEED är en metod för att utvärdera hur en förare har positionerat sig i bilen samt varför denna förare har positionerat sig som den har gjort. Detta dokument innehåller samtliga instruktioner som behövs för att kunna använda metoden SPEED.

Här finns grundläggande information, som till exempel hur bilen ska bokas, samt detaljerad information, som till exempel beskriver hur olika resultat ska göras i ordning för analys. Det finns information som både är riktat mot VCC Ergonomi och mot sommarjobbare som ska utföra metoden.

De inledande instruktionerna är för VCC Ergonomi som ska stå för att boka bil till utvärderingen, boka uppmätning av bilen samt en del utrustning som ska användas under utvärderingen, så som till exempel CAN-utrustning och kameror.

Metoden använder sig av fyra olika dokument, först detta instruktionsdokument som vi valt att kalla SPEED Instruction document, SPEED Compilation document, SPEED Coordinates program samt SPEED Note Sheet. Alla dokument läses med fördel parallellt för att få en bättre helhetsbild, då mer detaljerade instruktioner om hur vissa delar av metoden finns i respektive dokument/program. I instruktionerna finns också namn samt telefonnummer till personer/avdelningar som var till stor hjälp under respektive delar vid metodframtagningen. Dessa namn kan endast ses som en vägledning till rätt person då det ofta händer att personer byter tjänst och då också ansvarsområden. Detta innebär att om det skulle uppstå problem eller om vidare information behövs, kan avdelningschefen för den angivna avdelningen som nämnts i respektive stycke kontaktas, alternativt kan hjälp fås av Ergonomiavdelningen för att hitta den ansvariga personen.

# 2  Bokning av bil

## 2.1  Bokning

Ska göras innan sommarjobbare anländer. Men nedan kan vara bra att ha:

Bilen som ska användas ska bokas och dessa bokningar sköts av vagningenjörerna. För att hämta bilen måste man veta var nyckeln finns samt var bilen är parkerad, denna info kan hämtas ur interna systemet DRIP. Detta nås genom att:

1. Gå till VCC's intranätsida

2. Skriv "DRIP" i sökfältet

3. Välj första länken (http://drip.vcc.ford.com/)

4. Logga in med CDSID samt lösenord

5. Tryck på "Vehicle Engineer" i vänsterträdet

6. Tryck på "Week calender by reg no"

7. Välj en av de bokade veckorna (ex. 13w11 = vecka 11 år 13)

8. Ange regnr på bokad bil

9. När kalendern visas, vänsterklicka på någon av de bokade tiderna

10. Information kommer att visas och där bland annat "Parking lot/keys". Till höger om detta står det vilken parkering samt vilket nyckelskåp nycklarna befinner sig i. Kontakta vagningenjören om det är oklart vart dessa två befinner sig.

Kontaktperson: Vagningenjör

## 2.2 Körtillstånd

För att få köra ut genom portarna med den bokade bilen måste körtillstånd ordnas. Detta är något som man får skriva på för var dag bilen ska användas och ska undertecknas av avdelningschefen på Ergonomi samt vagningenjören. Körtillståndet är digitalt och nås via DRIP:

1. Gå till VCC's intranätsida

2. Skriv "DRIP" i sökfältet

3. Välj första länken ([http://drip.vcc.ford.com/](http://drip.vcc.ford.com/))

4. Logga in med CDSID samt lösenord

5. Tryck på "Standard User" i vänsterträdet

6. Välj "Issue A-Daytime (EJ tj. resa)

7. Fyll i följande info:

   a. Läs och acceptera "Affirmation"

   b. Under "Purpose", välj "Perform test"

   c. Fyll i "Reason for driving"

   d. Under "Planned mileage" ska det fyllas i ruttens längd multiplicerat med hur många testpersoner som ska köra under dagen. Ruttens längd är ca 8 km och finns att se i kapitel 8.5.

   e. Fyll i "Departure"

   f. Under "Method for vehicle selection", välj "Use existing reservation" då det redan är en bil bokad.

   g. Fyll i registreringsnummer på den bokade bilen

   h. Under "Enter reservation code", ska reservationskoden som erhålls av vagningenjören matas in.

   i. Under "Supervisor cdsid", fyll i cdsid för ergonomiavdelningens chef.

> j. Under "VING", välj rätt vagningenjör, fråga handledare på Ergonomiavdelningen om det är oklart vad denna heter.
>
> k. Tryck "Submit".

8. Nu är körtillståndet skickat till vagningenjören och avdelningschefen för bekräftelse.

# 3 Utrustning

Utrustning som behövs till kliniken för att mäta och ta ut de data som behövs för analysen ska lånas från olika avdelningar och delar av den måste riggas före bilen mäts upp då man måste veta dess exakta position relativt bilen. Utrustningen som behövs för kliniken finns beskrivet i det är här kapitlet, en översiktsbild över allt som krävs ses i bilden nedan i Figur 1.



**Figur 1 – All utrustning som ska vara riggad i bilen**

## 3.1  Instrumentutlåning

Ligger på bottenplan och har hand om en mängd utrustning. Här får man låna utrustning och ange sitt CDSID när man gör det. Då man ibland inte är tillåten att låna utrustning som sommarvikarie, får man fråga handledare om hjälp.

### 3.1.1  Utrustning för att läsa av stol
För att kunna ta reda på stolens position måste följande utrustning lånas:

- CAN-dator med installerad GGD-DHA-programvara

- DiCE mätanordning

### 3.1.2   Kameror

Här är det viktigt att låna kameror som har tillhörande programvara med fjärrstyrning så att testledaren kan styra kameran och ta kort från dator. Viktigt är också att tänka på hur kamerorna laddas så att de helst kan sitta på sin plats i bilen jämt men ändå laddas via cigarettuttaget exempelvis.

- GoPro-kameror 3-4 st

    - Kamera som sitter på fönster främre passagerarsida

    - Kamera som sitter på framkant förarstol

    - (Kamera som sitter i taket ovanför förarstol)

    - Kamera som filmar från dörrkarm främre passagerarsida

- "Öppna skal" till GoPro-kamerorna. Det ska finnas skal med uppborrade hål så man kan ladda dem.

- Fästen med klister så man kan fästa kamerorna, 4 st

- "Armar" och "leder", böjda, raka, i vinkel, för att kunna anpassa vinkeln på kamerorna. Ta så många som möjligt och lämna tillbaka de som inte används sedan.

- Förlängningssladdar USB, så många som antalet uttag som finns hos kamerorna. 2 för varje GoPro 2 och 1 för varje GoPro 3.

- MiniUSB-sladdar, 2 för varje GoPro 2 och 1 för varje GoPro 3.

- iPads med GoPro-program på, 2-3 st.

GoPro-kameror är att föredra då dessa går att ladda samtidigt som de används samt att de kan fjärrstyras med hjälp av iPad.

### 3.1.3   Strömförsörjning

För att kunna driva all utrustning i bilen kan cigarettuttagen användas. I ett av dessa kan en omvandlare kopplas in så att ett grenuttag går att sätta in i bilen, vilket möjliggör enklare drivning. Vissa bilmodeller kan ge ström hela tiden genom ett av de flera cigarettuttag som finns, även

då bilen är avstängd, koppla in omvandlaren i detta uttag. CAN-datorn som används i metoden har också i vissa fall möjlighet att drivas via cigarettuttaget med en adapter för detta.

- Omvandlare från 12V till 220V

- Grenuttag för att koppla in ev. laptopladdare samt laddare för iPad, övriga batterier etc.

- Cigarettladdare till CAN-dator

- USB-hub, 2 st, finns på gruppen

## 3.2   All utrustning som behövs

- CAN-dator med installerad GGD-DHA-programvara

- DiCE mätanordning

- GoPro-kameror 3-4 st

    o Kamera som sitter på fönster främre passagerarsida

    o Kamera som sitter på framkant förarstol

    o (Kamera som sitter i taket ovanför förarstol)

    o Kamera som filmar från dörrkarm främre passagerarsida

- "Öppna skal" till GoPro-kamerorna. Det ska finnas skal med uppborrade hål så man kan ladda dem. Skalen är olika beroende på modell. Prata med Peter Broberg på utlåningen.

- Fästen med klister så man kan fästa kamerorna, 4 st

- "Armar" och "leder", böjda, raka, i vinkel, för att kunna anpassa vinkeln på kamerorna. Ta så många som möjligt och lämna tillbaka de som inte används sedan.

- Förlängningssladdar USB, så många som antalet uttag som finns hos kamerorna. 2 för varje GoPro 2 och 1 för varje GoPro 3.

- MiniUSB-sladdar, 2 för varje GoPro 2 och 1 för varje GoPro 3.

- iPads med GoPro-program på, 2-3 st.

- Omvandlare från 12V till 220V

- Grenuttag för att koppla in ev. laptopladdare samt laddare för iPad, övriga batterier etc.

- Cigarettladdare till CAN-dator

- USB-hub, 2 st, finns på gruppen

- Linjaler, tejp, etc. (Förrådet)

- Mätremsor och prickar (Krockavdelningen)

## 3.3 Rigga utrustning

### 3.3.1 Kameror

Kameror ska riggas på tre (eller fyra) ställen; på främre passagerardörren sitter en kamera som tar korten från sidan, vilka man sedan utläser ögonpunkten och rattpunkten med. På främre passagerardörren ska även en filmkamera monteras som ska filma hela kliniken, se Figur 2. I förarstolens framkant ska det monteras en kamera vilken filmar testpersonens fötter och där kan man ta ut hälpunkten, se Figur 3. I taket ovanför testpersonen ska det också monteras en kamera med vilken man kan få en bild över hur testpersonen sitter i sidled, se Figur 4. Samtliga kameror ska sitta i bilen innan uppmätningen och då mätas upp, se kapitel 4.



**Figur 2 – Filmkameran och sidokamerans placering**
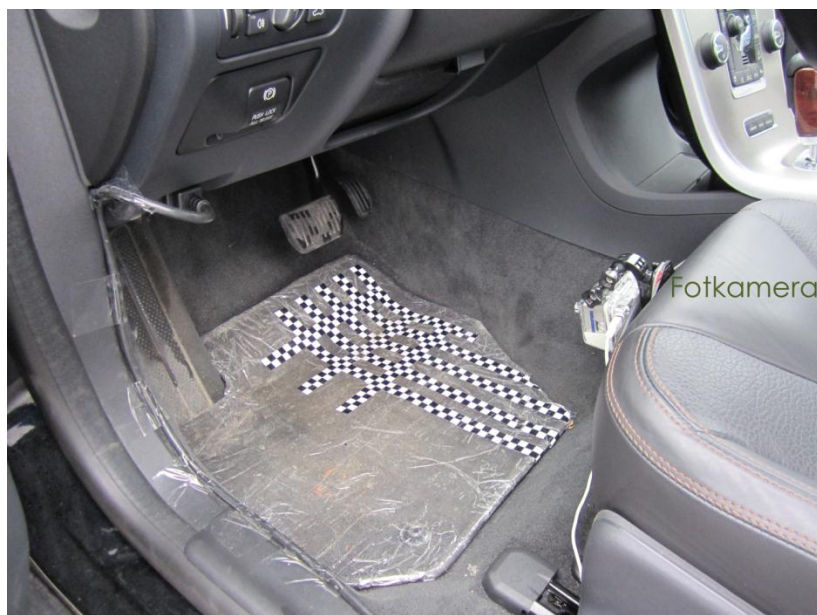
**Figur 3 – DiCE-kabeln upptejpad längs vänsterkanten, dörrmattans riggning med rutnätet och fotkamerans placering på stolen**



**Figur 4 – Takkamerans placering, kan eventuellt uteslutas**

### 3.3.2 Referensmärken

För att kunna positionera sidokameran ifall denna tas loss från sin uppmätta position ska det sättas ut referensmärken i bilen.

### 3.3.3 Styrning av kameror

För att kontrollera de tre fotokamerorna används tre Apple iPad, vilka har monterats i en "iPad-hållare" för att förenkla användandet av dessa, se Figur 5.



**Figur 5 – iPad-hållare**

### 3.3.4 DiCE

Efter uppmätningen är gjord och innan klinikerna börjar ska DiCE-utrustningen monteras in. Själva DiCE-dosan hängs i förarstolens bakre förvaringsficka och leder kabeln till CAN-bussen via sidan till vänster om förarstolen, denna tejpas hela vägen fram till anslutningen vid CAN-bussen, se Figur 3. Tänk på att tejpa så stolen går att justera fullständigt.

CAN-datorn som används till DiCE-utrustningen har placerats på det utfällbara armstödet i mitten av bakre passagerarsätet.

**Figur 6 – CAN-datorns placering**

### 3.3.5 Formulärdator

Testpersonen ska svara på frågor via en dator, denna dator ska stå i främre passagerarsätet. Denna dator kan placeras på någon form av ställning, vi använde ett bord byggt av kapaboard vilket tejpades fast i sätet, för att göra det bekvämare för testpersonen att använda datorn. Bordet som används vid metodframtagningen syns i Figur 7.



**Figur 7 – Ställning för att underlätta datoranvändandet för testperson**

# 4  Uppmätning av bil

Bilen som används i utvärderingen ska mätas upp för att se hur den riktiga bilen överensstämmer med nominell data för bilen. För att boka en uppmätning ska mätlabbets jobbplanerare kontaktas.

## 4.1  Att tänka på innan uppmätning

Innan uppmätningen ska genomföras är det bra att ha ett möte med personen som ska mäta bilen tillsammans med handledare på ergonomiavdelningen, för att stämma av så att det är klart vilka punkter uppmätningen ska behandla.

Innan uppmätningen ska ske ska bilen vara tvättad men tänk på att bilen inte får vara blöt när den ska till uppmätningen, då rostar deras golv.

Bilen ska finnas på plats vid uppmätningslokalen 12 timmar innan uppmätningen ska börja.

## 4.2  Vad ska mätas upp

- Stol

- Ratt

- Kameror

- Referensplan

- Markplan

- Golvmatta

Appendix G – SPEED Instruction document

# 5 Stol

## 5.1 Typ av stol

Olika årsmodeller av bilar använder sig av olika stolar och samma stolsmodell kan användas i olika bilmodeller. Detta gör att det ibland kan vara oklart vilken stol som sitter i vilken bilmodell. För att ta reda på detta kan man ta kontakt med stolsavdelningen om man vet vilken bilmodell och årsmodell av denna man har. Be stolsavdelningen om följande information:

- Vilken stol som sitter i den specifika bilen

- En kinematisk modell av stolen

- Vad denna stol har för modellnummer i TCE

Kontaktperson:

- Systemansvarig för framsäte

## 5.2 Läsa ut stolens position

Man läser ut stolens position genom att undersöka stolmotorernas rörelse. Genom att ansluta sig till bilen kan man läsa av motorernas pulser i vissa punkter och sedan får dessa översättas till koordinater. För att undersöka detta får man först ta ut hur stolen rör sig mellan sina extremlägen, jämföra detta med en kinematisk modell över stolen i CATIA, för att sedan få bilen (stolen) uppmätt och därmed möjliggöra att man kan jämföra stolens tänkta rörelse men den verkliga stolens rörelse. När man mätt upp bilen kan man sedan uppdatera beräkningarna med de riktiga värdena. Detta leder till att man med hjälp av utläsning av stolsmotorernas pulser kan få det antal mm som stolen rör sig, och tillslut få ut stolens position i koordinater.

När man mäter hur stolen rör sig så måste man koppla upp sig mot bilens dator och använda sig av speciell mätutrustning samt speciell

programvara. För att ta reda på hur man mäter och kopplar upp sig mot en viss stolsmodell kan man kontakta El-avdelningen.

- Berätta för El-avdelningen vilken stolsmodell som används, informationen som tillhandahållits av stolsavdelningen, så kan El-avdelningen hjälpa till med att förklara hur man kopplar upp sig mot stolen.

- De vet hur man kontrollerar stolen när man har anslutit sig till bilens dator samt vilken typ av data man kan få ut, samt hur stolens motorer har gått i varje specifik stol.

- Informationen som fås från El-avdelningen bör innehålla vilken mätutrustning (DiCE) samt vilken programvara som behövs (GGD-DHA). För att kontrollera mätutrustning och programvara behövs även en CAN-dator (även kallad mätdator). All denna utrustning tillhandahålls av instrumentutlåningen, se kapitel 3.1.

- För att kunna använda sig av DiCE och GGD-DHA behövs också en databasfil för den specifika bilen/stolen, denna måste också erhållas från El-avdelningen.

- Från El-avdelningen bör koder för att skriva till och läsa från stolen erhållas, de som sedan används i kapitel 0 och **Error! Reference source not found.**.

Kontaktpersoner är:

- Avdelningschefen på El

- Person på El som jobbar med koder till stolar

### 5.2.1  Koppla upp sig mot bilen/stolen

För att kunna läsa ut stolens position måste man koppla upp sig mot stolen i bilen, detta gör man genom att använda DiCE och GGD-DHA. Instruktioner för att använda GGD-DHA finns på Ergonomiavdelningens gruppdisk. För att göra det enklare vid beräkningar ska stolen nollställas i ett visst läge. Därefter får man läsa ut stolens position med hjälp av att läsa av hur många steps dess motorer har gåt. Till att nollställa och läsa ut information används två olika koder vilket kan tillhandahållas av El-avdelningen.

## 5.3   Kinematisk modell

Den kinematiska modellen är hur stolen rör sig i sitt justeringsområde. Detta behövs då stolen inte rör sig linjärt när höjd- och tiltfunktionen används, utan den rör sig som ett polynom, och därmed påverkar den h-punkten både i x- och z-led, se Figur 8.
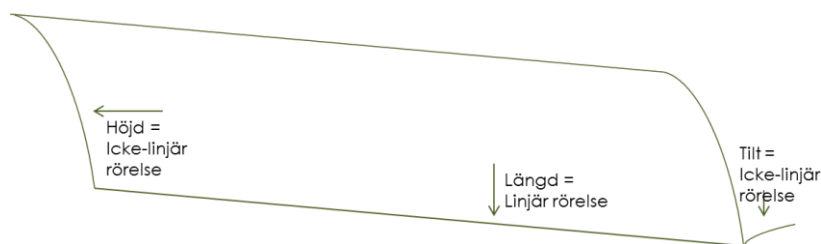


**Figur 8 – H-punktens rörelsemönster**

I SPEED Coordinates program räknas H-punkten fram genom att addera samtliga stolsinställningars bidrag till den. Detta innebär att H-punktens koordinat från längd-, höjd- och tiltjusteringen räknas ut individuellt, därefter kombineras dessa tre x- och z-koordinater till en gemensam H-punkt.

För att ta fram SPEED Coordinates program för en specifik stol behöver olika delar genomgås och dessa beskrivs i detta kapitel.

### 5.3.1   CATIA

Metodens upplägg bygger på att det finns en kinematisk CATIA-modell av den stol som sitter i bilen. För att veta vilken CATIA-modell man ska titta i måste man få information från stolsgruppen, se kapitel 5.1.

När rätt CATIA-modell erhållits och denna uppdaterats med en punkt motsvarande H-punkten i nominellt läge, vilket finns i CV-specen för aktuellt bilprojekt och kan fås av Ergonomigruppen, kan man gå in i CATIA och se hur stolen rör sig. För att kunna röra på stolen måste man aktivera licensen för kinematik genom följande steg:

- Öppna CATIA-modellen → Tools → Options → General.

- Under general finns "Sharable products". I denna rullist ska "KIN-DMU-OK" klickas i.

H-punkten som är nominellt inlagd i CATIA-modellen kan vara kopplad till "seat pan-parten" så att denna punkt hela tiden är fast relativt stolen. I vissa fall är denna punkt dold och för att se den måste just den parten väljas, detta görs genom att dubbelklicka på parten. När

man ser punkten kan man använda sig av kinematik-kontrollerna CATIA har, detta för att röra stolen i sitt justeringsområde. För att använda sig av kinematiken i CATIA gör man följande:

- Tryck på "Applications" i vänsterträdet i CATIA som visar parter och dubbelklicka på "Mechanics". Det fönster som nu kommer upp i CATIA visar att stolen står i en viss position, denna position ska vara SRP. En förklarande bild av detta ses i SPEED Coordinates program.

- De reglage som man kan dra i justerar stolen i längd, höjd och tilt. Alla marknader har inte samma justeringsområde på stolen, kontrollera därför med Ergonomiavdelningen att justeringsområdet är korrekt.

- Skulle justeringsområdet behöva ändras, görs detta genom att trycka på knappen med de tre punkterna längst till höger i rutan och sedan skriva in nya värden under "Lowest" och "Highest" value.

CATIA-modellen vill vi använda för att jämföra med den riktiga stolen hur pass bra de nominella värdena är, hur pass bra den riktiga stolen och stolsmodellen i CATIA stämmer överens.

Genom processen att läsa ut H-punkten ur stolen kommer x- och z-koordinater som motsvarar stolens extremlägen att behöva läsas ut vid olika tillfällen. Dessa är kombinationer av följande:

- LB = Längst bak

- LF = Längst fram

- LN = Längst ner

- LU = Längst upp

- TN = Tilt ned

- TU = Tilt upp

I CATIA ska också CV-specen öppnas och jämföras med den kinematiska modellen så att dessa stämmer överens. CV-specen är en CATIA-modell full av "linjer" som bland annat visar var olika percentiler sitter i bilen och bilens yttre linjer. Här finns även H-punktens extrempunkter utmärkta och även H-punkten i SRP. För att få fram CV-specen när man har CV-specnumret gör man följande:

- Starta CATIA

- Logga in på TeamCenter

- I TeamCenter anges CV-specnumret inom två *-tecken.

- Dubbelklicka på den översta filen som kommer upp. Enkelklicka på den översta filen i fönstret på TeamCenter.

- I programmets verktygsfält finns en flik "CATIA", under denna flik ska man trycka på "Load in CATIA". Om problem uppstår eller om man inte har tillgång till TeamCenter eller CATIA kan Ergonomiavdelningen hjälpa till med att ta fram CV-specen.

Kontaktpersoner är:

- Systemansvarig för framsäte

- Ergonomigruppen

## 5.3.2  Uträkning av H-punkt

För att räkna ut H-punkten kommer excelprogrammet SPEED Coordinates program att användas. Här finns förbereda formler som räknar ut H-punktens koordinater när data har matats in i dess grönmarkerade områden. Det första man ser när man öppnar detta program är diagram som visar H-punktens justeringsområde samt Rygglutning. Programmet består av olika delar, varav del 1 är där man matar in data från stolen för att programmet ska kunna räkna ut H-punkten och del 2 är där man kan utläsa H-punktens koordinater utifrån samtliga uträkningar. I programmet kommer först en del basdata angående stolen behöva matas in, det ska matas in data från både CATIA, CV-specen, hur motorerna rör sig i stolen och uppmätningen av bilen. All data ska jämföras så att man ser att den stämmer överens. När bilen är uppmätt får man uppdatera SPEED Coordinates program så att det är aktuellt och visar koordinater för den uppmätta bilen.

## Basdata

Till att börja med i SPEED Coordinates program ska en del basdata matas in, detta under del 3.1. Här börjar man med att använda sig av CATIA och se vad H-punkten har för koordinater i extremlägena samt

SRP i CV-specen samt i stolens CATIA-modell. Punkterna som ska läsas ut i båda CATIA-filerna är:

- SRP – seating reference point

- LBLN – Längst bak och längst ner

- LBLU – Längst bak och längst upp

- LFLN – Längst fram och längst ner

- LFLU – Längst fram och längst upp

Därefter kommer skillnaderna mellan dessa att räknas ut. Dessa kan diskuteras med handledare på Ergonomiavdelningen för att kolla av så att de stämmer tillräckligt bra med varandra.

Vid uppmätningen, se kapitel 4, kommer två punkter som är fasta på stolen att mätas, PT1 och PT2, i samtliga extremlägen och i SRP. Dessa punkter ska också mätas i CATIA-modellen och skrivas in under del 3.1 i SPEED Coordinates program. När punkternas koordinater för samtliga lägen på stolen har matats in kommer differensen mellan dem räknas ut för att sedan få en medeldifferens över hur mycket dessa skiljer mellan riktig bil och ritning.

I del 3.2 i SPEED Coordinates program, ska först koordinater för H-punkten i stolens extremlägen matas in. I ett första steg då inte uppmätningen inte genomförts än kan även dessa punkter matas in under delen "Efter uppmätningen" för att kunna se hur programmet fungerar.

### Längd

I del 3.3 i SPEED Coordinates program räknas totala justeringsområdet för stolens längdjustering ut. Därefter räknas det ut hur många mm det går på vardera step i längsled.

Vidare i del 3.3 räknas längdens påverkan på H-punkten ut. När man ska räkna ut H-punktens koordinat i längdjusteringsområdet behöver man veta i vilken lutning stolen står, α, som går att se i Figur 9. Denna ska sedan göras om till radianer för att Excel ska kunna räkna. Därefter räknas först sträckan c ut men sedan också sträckorna b och a, för att kunna ta ut x- respektive z-koordinaten.
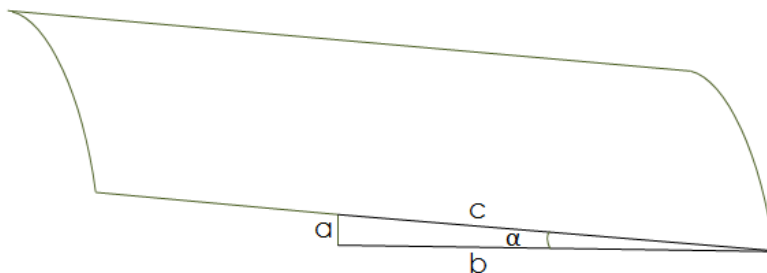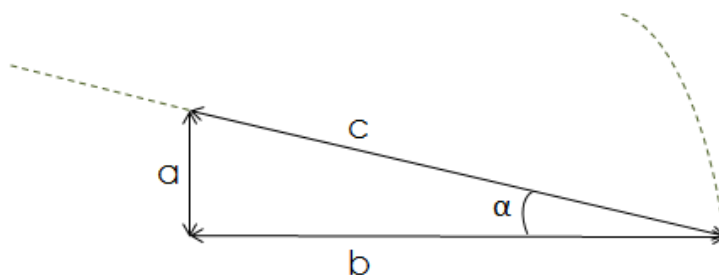
**Figur 9 – H-punktens rörelsemönster med stolens lutning**

Hur a, b, c räknas ut anges nedan och finns att se i Figur 10.

$$c = Totalt\ antal\ steps_{längdmotor} \times mm/step$$

$$a = \sin\alpha_{rad} \times c$$

$$b = \cos\alpha_{rad} \times c$$



**Figur 10 – Stolens lutning i närbild**

För att sedan få de totala koordinaterna för längden får man subtrahera b-värdet från x-koordinaten som H-punkten har i nolläget, då H-punkten rör sig mot origo när stolen rör sig, och a-värdet får adderas på z-koordinaten i nolläget för att H-punkten rör sig uppåt från origo när stolen justeras framåt.

## Höjd

Efter att ha räknat ut längdjusteringens bidrag till H-punkten går SPEED Coordinates program vidare med att räkna ut hur höjden påverkar H-punkten. Då man mätt upp stolen i uppmätningen, kontrollerat den kinematiska modellen i CATIA och har värden utlästa angående hur stolens motorer har rört sig, kan man med hjälp av beräkningar i SPEED Coordinates program få ut x- och z-koordinater för höjdjusteringens bidrag.

### Tilt

Tiltens bidrag till H-punkten räknas ut på samma sätt som höjdens bidrag i SPEED Coordinates program. Samma typ av data behövs för att sedan programmet ska räkna ut x- och z-koordinater.

### Ihopläggning till en H-punkt

Till sist läggs samtliga bidrag ihop i x- och z-led för att skapa den slutliga H-punkten. Därefter plottas denna ut i ett diagram vilket också visar extremlägen för H-punkten och ett område motsvarande alla de punkter denna kan ha.

### Rygglutning

Rygglutningen räknas ut i samma dokument som H-punktsuträkningen, under del 4. Denna kan räknas ut först då uppmätningen är gjord och man har fått koordinater för en nedre och en övre punkt på stolsryggen med steps loggade för vartdera koordinatpar, vilka symboliserar olika lutningar på manikinen.

I del 4.1 listas först de grader som manikinen satt i vid uppmätningen, sedan var grads motsvarande koordinatpar för den nedre (punkt 3) och övre (punkt 4) mätta punkten, därefter skriv även det loggade stepvärdet in. Längst till höger i 4.1 räknas det totala stepvärdet ut som är från det absolut bakersta läget på stolsryggen.

I del 4.2 görs en liknande interpolering som tidigare gjorts i del 3.4 och 3.5 för höjden respektive tilten, för att kunna få ut de koordinatpar för övre och nedre punkten som ligger mellan de uppmätta baserade på vilket stepvärde som matas in i del 1 i SPEED Coordinates program.

Vad vi egentligen vill ha i denna beräkning är vilken lutning som en testdeltagare har i stolen med det stepvärdet som motorn i stolsryggen har. I del 4.3 används pythagoras sats för att räkna ut vinkeln α, vilket är vinkeln mellan läget där stolen står rakt upp, b, och där den faktiskt är vid valt step, c. Dessa sträckor och vinkeln kan ses i Figur 11. Vinkeln som presenteras är alltså stolsryggsvinkeln. För att få rygglutningen hos manikinen får ytterligare en beräkning göras, del 4.4.
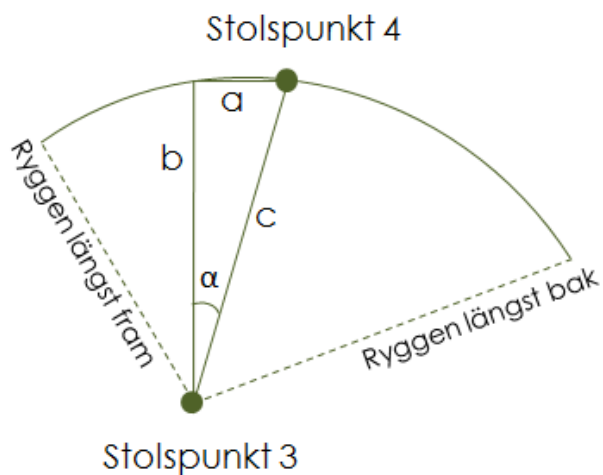
**Figur 11 – Stolsryggens lutning**

Del 4.4 i SPEED Coordinates program visar de loggade stepvärdena vid respektive manikinlutning och även motsvarade stolsryggslutning. Det gröna fältet för stolsryggslutningen är tomt och måste manuellt matas in. Detta görs genom att skriva in det stepvärde som finns i första kolumnen i del 1, därefter läsa ut vad stolsryggsvinkeln blir under del 4.3, denna vinkel ska sedan matas in för respektive stepvärde. Medeldifferensen mellan dessa räknas sedan ut till höger i del 4.4, detta för att kunna addera denna medeldifferens till stolsryggslutningen som var resultatet i 4.3. På så sätt fås lutningen som manikinen borde ha vid det angivna stepvärdet och resultatet presenteras i del 2.

# 6 Pixlar till koordinater

Att omvandla pixlar till koordinater behövs för att få ut ögonpunkt, rattposition och avståndet mellan huvud och nackstöd. Det hela är lite omständigt men smidigt när man vet vad man gör. Man ska skapa actions för att ta bort wide angle eller fisheye-effekten och skapa referenser i bilden. Sedan använder man Image Processor för att använda sina inspelade actions på mappar med bilder. För detta behöver man Photoshop.

Photoshop på svenska användes för att göra bilderna till XC60-projektet så vissa ord kan bli lite annorlunda.

## 6.1 Mappstruktur för bilder

Det kommer bli många bilder och därför är det lämpligt att vara konsekvent i mappstrukturen. Det tas bilder från tre kameror och filmas med en. I bilen när man för över bilderna drar man över alla testpersoner dittills till en tillfällig mapp som heter tpx_till_tpz. I den mappen finns tre andra mappar som heter *sida, tak,* och *fot,* filmerna läggs direkt i mappen. Bilderna från de olika kamerorna hålls separerade från varandra till dess alla Photoshopprocesser är klara. Detta för att göra det enkelt för sig och bara kunna göra alla sidobilder i ett svep. Man kan med fördel döpa om bilderna enligt instruktionerna i Figur 12 redan innan man behandlat dem.

Nästa steg är att använda Image Processor i Photoshop, se kapitel 6.2.2, och slutligen spara filerna i separata mappar för varje testperson, se Figur 12.

XC60_tpX
   XC60_film_tpX.mp4
   XC60_korsning_sida_tpX_instX.jpg
   XC60_korsning_tak_tpX_instX.jpg
   XC60_korsning_fot_tpX_instX.jpg
   XC60_rakstracka_sida_tpX_instX.jpg
   XC60_rakstracka_tak_tpX_instX.jpg
   XC60_rakstracka_fot_tpX_instX.jpg
   XC60_parkering_sida_tpX_inst3.jpg
   XC60_parkering_tak_tpX_inst3.jpg
   XC60_parkering_fot_tpX_inst3.jpg
   XC60_mot_nackstod_tak_tpX_inst3.jpg

**Figur 12 – Föreslagen mappstruktur för att hålla ordning bland filerna**

## 6.2 Bildhantering i Photoshop

För att på ett smidigt sätt ändra alla bilder på en gång och samtidigt behålla mappstrukturer kan man skapa en Image Processor i Photoshop. Först får man spela in sina "actions" (funktionsmakro) och namnge dem på något lämpligt sätt. Öppna alltid bilderna i den storlek som de är. Detta är viktigt för att pixlarna ska ge samma värde, alltså **lägg inte in bilderna i ett dokument av t.ex. A4-storlek!**

### 6.2.1 Göra en action i Photoshop
1. Gå in i action-menyn (funktionsmakro)

2. Skapa en mapp med ett namn du kommer ihåg, förslagsvis bilmodellen du utvärderar. Vår mapp hette exjobb.

3. Markera mappen och skapa ny action

4. Namnge din första action rak_jbg och spela in. Den andra kommer heta referenser_psd.

5. Nu spelar programmet in allt du gör. När du är klar trycker du på fyrkanten som indikerar stopp.
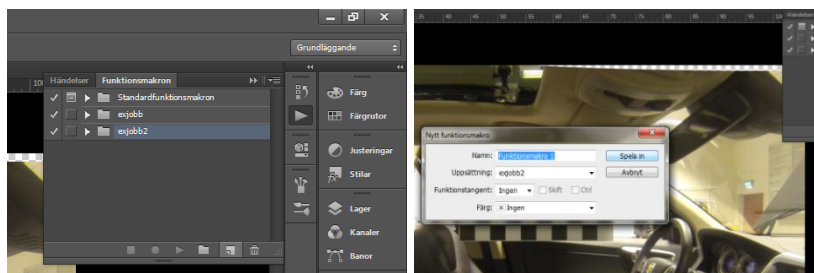


**Figur 13 – Actions och hur man spelar in dem**

### 6.2.2 Ta bort fisheyeeffekt

1. Öppna bilden med referensplanet i mitten av stolen

2. Starta inspelningen av rak_jpg (se beskrivning ovan)

3. Gå till filter → adaptiv vidvinkel

4. Ändra korrigering till fisköga eller fisheye

5. Zooma in bilden så rutnätet täcker större delen av skärmen

6. Klicka i ett hörn av rutnätet, håll inne shift och dra till motstående hörn. Då blir den linjen horisontell eller vertikal. Dra 3 horisontella och 3 vertikala linjer genom rutnätet, se Figur 14.

7. Spara bilden som jpg

8. Stoppa inspelningen
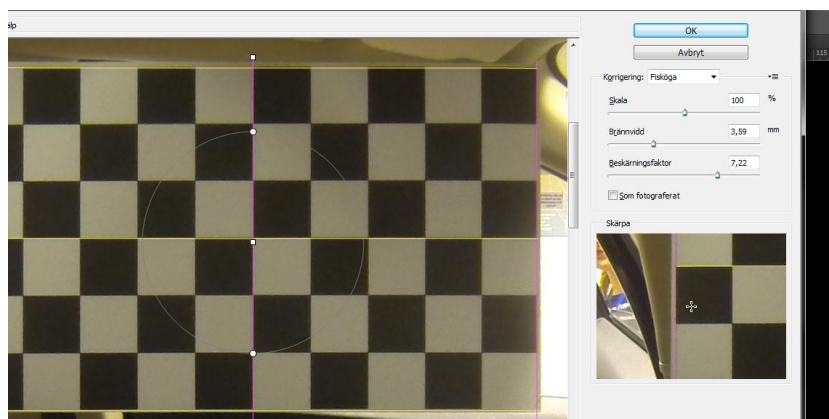


**Figur 14 – Hur man tar bort fiskögeeffekten från GoPro-bilderna**

### 6.2.3 Lägg till referenser

1. Öppna bilden som ändrades i kapitel 6.2.2.

2. Starta inspelningen av referenser_psd

3. Gör markeringar för framruta och taklucka och fyll med färg och gör genomskinligt ca 50% opacity, se Figur 15.

4. Spara filen som en psd-fil.

5. Stoppa inspelningen
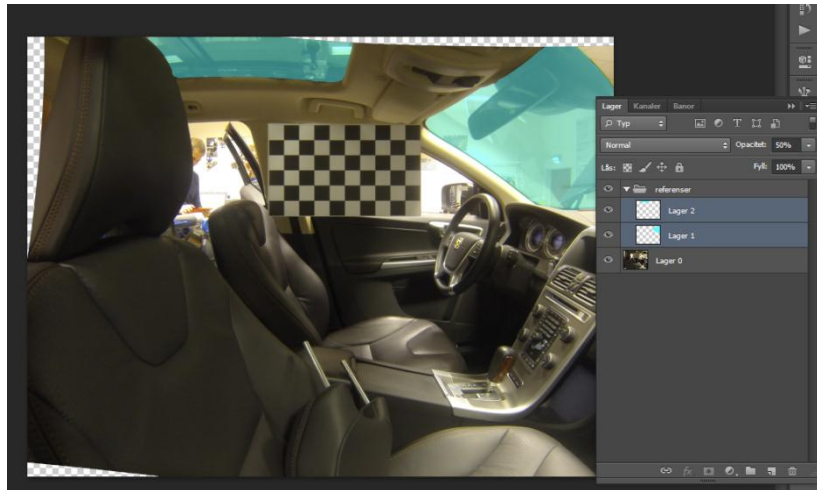


**Figur 15 – Lägg in referenser i bilden som redan fått reducerad fisheye-effekt och gör 50% genomskinligt**

### 6.2.4   Image Processor i Photoshop

När du sedan vill använda dina actions på andra filer får du se till att ha förberett dina bilder i lämpliga mappar som du kan göra alla samtidigt och att du har en målmapp förberedd.

1. File → script → image processor.

2. Kryssa för "include All sub-folders" och välj mapp som ska ändras.

3. Kryssa för "keep folder structure" och välj målmapp.

4. Kryssa för "save as JPEG"

5. Välj vilken action som ska genomföras. Se Figur 16.
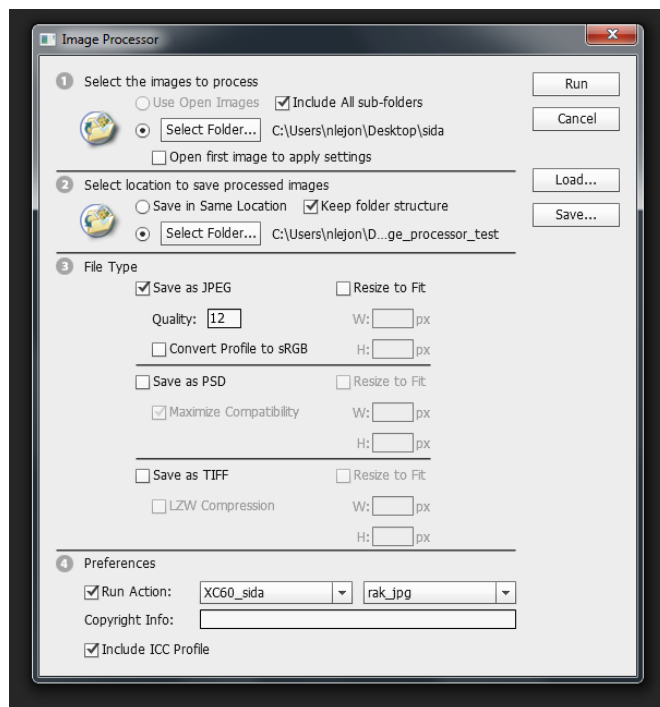
**Figur 16 – Hur man ställer in Image Processor i Photoshop**

## 6.3   Uppdatera SPEED Coordinates program

För att få ut ögonpunkter från bilderna från körning får man se till att bilderna har blivit raka, blivit inpassade enligt referenserna och sedan kan man mäta ut ögats position.

1. Zooma in i bilden $y_{mitt}$ (det är noga att det blir exakt med pixlarna).

2. Använd linjalverktyget och mät pixelvärdet i punkterna för punkterna på referensplanet som blivit uppmätta.

3. Detta upprepas för alla uppmätta y-plan.

4. Dessa värden stoppas in i excel under fliken "ögonpunkt och ratt".

## 6.4   Få ut ögonpunkter

Först får man uppdatera SPEED Coordinates program innan man kan få ut koordinater från ögats pixelvärde. När pixelvärdena från alla bilder och koordinaterna från uppmätningen är skrivna fylls diagrammen upp automatiskt och de tillhörande trendlinjerna uppdaterar man med i Excel-sheetet. Det står väl förklarat i SPEED Coordinates program hur man ska göra, hur det kan se ut ser man i Figur 18.

1. Öppna en bild från tredje körinställningen från raksträcka som är behandlad enligt beskrivningarna ovan.

2. Zooma in på ögat

3. Använd linjalverktyget och mät pixelvärdet i mitten av pupillen.

4. Skriv upp x- och y-värdet (se Figur 17) i ett Excel-dokument som du sedan kan kopiera över värdena till SPEED Coordinates program från.

5. Gör samma för motsvarande persons bild med huvudet mot nackstödet.

Om testpersonen har glasögon och ögat inte syns:

1. Mät ögonpunkten på kortet taget mot nackstödet utan glasögon

2. Hitta en referenspunkt på glasögonen på motsvarande persons kort med glasögon

3. Mät referenspunkten och ta ut en skillnad mellan ögats position och glasögonreferensens punkt.

4. Från kortet taget på raksträcka får man ta ut pixelvärdet för referenspunkten och räkna ut vad ögonpunkten borde vara.
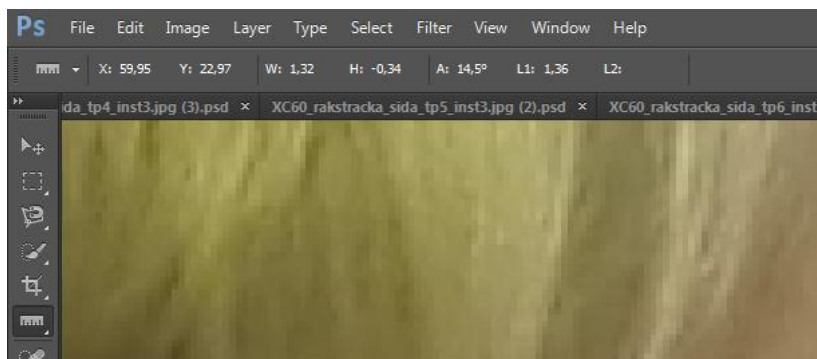
**Figur 17 – Anteckna x- och y-värdet från pixelvärdet uppe i vänstra hörnet**

ar vill vi räkna ut ögonpunkter för testpersonen. Först krävs det att vi matar in värden från uppmätningen och pixelvärden från korten. När alla värden är iskrivna ska vi ta fram nktioner för pixel vs koordinat. Först x och sedan z.

| | y + 100 | | | | | y mitt | | | | | y - 100 | | | | |
| | +100 - böjning mitt | | | | | Y mitt i stol- böjning mitt | | | | | -100 - böjning mitt | | | | |
| | photoshop | | I koordinat | | | Photoshop | | I koordinat | | | photoshop | | I koordinat | | |
| Punkt nr | x | z | x | y | z | x | z | x | y | z | x | z | x | y | z |
| 1 | 47,27 | 16,65 | 3311,7 | -462,5 | 1481,8 | 46,48 | 15,63 | 3312,4 | -363,5 | 1481,3 | 45,73 | 14,4 | 3311,7 | -264,8 | 1481,2 |
| 2 | 52,33 | 16,67 | 3211,5 | -461,9 | 1481,7 | 52 | 15,63 | 3213,4 | -363,5 | 1482,1 | 51,74 | 14,43 | 3212,4 | -264,9 | 1482 |
| 3 | 57,43 | 16,67 | 3111,4 | -460,6 | 1482,1 | 57,53 | 15,66 | 3112,4 | -364,4 | 1480,7 | 57,81 | 14,4 | 3113,1 | -265,7 | 1481,2 |
| 4 | 62,49 | 16,67 | 3012,4 | -460,9 | 1482,5 | 63,02 | 15,63 | 3013,1 | -363 | 1480,7 | 63,9 | 14,4 | 3011,6 | -264,1 | 1479,9 |
| 5 | 47,29 | 21,66 | 3311,3 | -460,6 | 1381,7 | 46,51 | 21,08 | 3312,8 | -361,9 | 1381,9 | 45,73 | 20,38 | 3311,9 | -264,6 | 1382,3 |
| 6 | 52,33 | 21,64 | 3211,2 | -461,3 | 1382 | 52 | 21,08 | 3213,2 | -363,5 | 1381,5 | 51,74 | 20,41 | 3211,9 | -264,6 | 1382,3 |
| 7 | 57,43 | 21,69 | 3111,9 | -461,1 | 1382,2 | 57,53 | 21,1 | 3113,3 | -363 | 1381,5 | 57,84 | 20,41 | 3112,1 | -263,6 | 1382,6 |
| 8 | 62,49 | 21,64 | 3012,3 | -460,7 | 1382,3 | 63,1 | 21,1 | 3013,4 | -362,4 | 1381,4 | 63,94 | 20,44 | 3012,3 | -263,2 | 1381,7 |
| 9 | 47,32 | 26,73 | 3311,3 | -459,5 | 1282,2 | 46,48 | 26,6 | 3313,1 | -361,8 | 1281,5 | 45,76 | 26,48 | 3311,9 | -263,6 | 1283,2 |
| 10 | 52,36 | 26,73 | 3212 | -460,4 | 1282,5 | 52 | 26,63 | 3213,2 | -362,7 | 1281,8 | 51,8 | 26,45 | 3211,8 | -264,1 | 1282,5 |
| 11 | 57,43 | 26,7 | 3112,1 | -460,5 | 1283 | 57,55 | 26,6 | 3113,7 | -362,3 | 1282,1 | 57,84 | 26,48 | 3111,8 | -263,3 | 1283 |
| 12 | 62,52 | 26,7 | 3012,4 | -460,3 | 1283,5 | 63,07 | 26,6 | 3014,3 | -361,6 | 1281,9 | 63,94 | 26,48 | 3011,9 | -261,9 | 1282,1 |

**Figur 18 – Hur det ser ut i SPEED Coordinates program där pixelvärden och uppmätta värden stoppas in.**

### 6.4.1 Vilket y-plan ska jag välja?

Det y-plan som ska väljas för ögonpunkten kan man få ut av referenserna från takkameran. Vi har inte hittat något bra sätt att göra detta så alternativ plats på kameran kan hittas eller någon typ av annan observation. På korten från raksträckan fungerar det dock oftast bra med uträkningarna från mitten. Helst skulle man vilja ha en indikation på vart mitten av huvudet befinner sig.

## 6.5 Avstånd huvud – nackstöd

På raksträckan på slutet tar man kort under körning och man ber testpersonen hålla huvudet mot nackstödet när bilen är parkerad. Då får man en referenspunkt när huvudet är mot nackstödet och mot vad det var under faktisk körning. Avståndet får man genom de två koordinaterna. Ta ut ögonpunkten på samma vis som för de andra bilderna och stoppa in värdet för ögonpunkt mot nackstödet i

sammanställningsdokumentet för testpersonerna. Avståndet räknas då ut automatiskt.

## 6.6  Rattposition

Ratten kan justeras in och ut och upp och ner och extremlägena är kombinationer av längst ner (LN), längst upp (LU), längst fram (LF) och längst bak (LB) alltså samma förkortningar som för stolsjusteringen. Längst fram är därför närmast huven. Rattens position mäts från mitten av ratten, i bilen som användes under metodutvecklingen var detta en punkt i volvomärket. Koordinaterna för rattens positioner får man ur uppmätningen.

Man går tillväga på samma sätt som för ögonpunkterna, se kapitel 6.3 och 6.4. Börja med att uppdatera SPEED Coordinates program för att sedan ta ut pixelvärdet för mittpunkten av märket placerat mitt på ratten.

### 6.6.1  Utläsning av rattposition

Rattens position läser man ut av korten som tas ur färd. Innan det måste man dock förbereda med rutnätet som beskrivs i kapitel □. Planet ska alltså placeras med y i rattens mitt och kort ska tas i samband med att uppmätningen sker. Hur man omvandlar pixlar till koordinater sker på samma sätt som för ögonpunkterna i samma sheet i excel. Ta även med extremlägena från uppmätningen och jämför med pixelvärdena.

# 7 Boka klinikpersoner

## 7.1 Testkliniklistan

Ur testkliniklistan tas testpersonerna, ansvarig person på Ergonomiavdelningen för denna lista vet vilken version som ska användas. Vi vill inte trakassera folk för mycket så en tumregel är att kalla de som varit med minst antal gånger. Detta är svårt för extremerna så försök att inte kalla folk som varit med mer än åtta gånger i en klinik.

## 7.2 Urval

Till sittpositionskliniken har vi tre urvalsgrupper. Korta, medel och långa. I korta gruppen har vi 15 kvinnor <20%il. I medel har vi 8 kvinnor >20%il och 8 män <90%il. I den långa gruppen har vi 15 män >90%il.

## 7.3 Bokning via doodle

Bokning sker lättast via doodle. Förbered de tider som ni ska ha till förfogande och tänk på att det kan vara lättare för folk att boka in sig tidigt på morgonen (07.30) eller vid lunch. Ha fler tider än personer ni behöver och boka in ett par extra per urvalsgrupp. Skicka ut en testversion till några i gruppen så ni ser att den fungerar. Gör inställningen att man bara ska kunna boka in en person per tid.

## 7.4 Mail för utskick

Man kan med fördel skicka ut kallelse till de korta först, efter en dag eller två till de långa och sist till medelgruppen. Detta är för att det är svårast att få de korta att anmäla sig. När det närmar sig tiden för kliniken kan det vara bra att skicka ut ett "påminnelsemail" som inte är ett påminnelsemail eller lägga till ytterligare detaljer i kallelsen. Skriv

bara till ett par extra detaljer och välkomna dem till kliniken så att de inte glömt bort att de anmält sig.

### 7.4.1 Mail 1

Mailet som man skickar ut först kan se ut så här:

Hej!

Avdelningen Craftsmanship and Ergonomics behöver din hjälp med att tycka till om möjligheterna för en bra sittposition i bilmodellen XC60.

Du finns med i den testpersonlista som avdelningen använder sig av när de behöver försökspersoner till något av deras tester och därför är du nu inbjuden att delta.

Utvärderingen kommer att ske under vecka 15, 16 och tar ca 45 minuter och vi har ett antal frågor där vi vill att man bedömer sittpositionen.

Under utvärderingen kommer man att köra en kortare sväng och sittpositionen kommer dokumenteras i form av några foton samt frågor som ställs efter man kört klart. Frågorna kommer att läsas och besvaras på en dator så eventuella läsglasögon kan vara bra att ha med.

Om du vill delta följer du bara länken nedan och bokar in dig på en tid som passar genom att skriva in ditt **namn, CDS ID** och **telefonnummer** på raden längst ned ("Ditt namn"). Man väljer tid genom att ställa sig över en blå tid och markera Ja i rutan som dyker upp. Gråa tider är redan upptagna. <u>Glöm inte att spara!</u>

Länk till tidsbokning: http://doodle.com/adzeg5t93srky2nv

Vi kommer att utgå från PV-porten och under vecka 14 kommer du som bokat in dig att få en bekräftelse av oss samt lite mer info.

Har du frågor kontakta gärna *Namn Efternamn* (*CDSID*, *telefonnummer*) eller *Namn Efternamn* (*CDSID*, *telefonnummer*)

Välkommen!

Med vänliga hälsningar
*Namn* och *Namn*

## 7.4.2  Mail 2

Eftersom folk inte alltid anmäler sig efter första mailet får man skicka ut ett till mail till de som <u>inte anmält sig</u>. Vi ska vara noggranna så vi inte skickar ut mail till de som varit duktiga och anmält sig redan. Mail 2 fungerar som en påminnelse men ska inte se ut som en påminnelse. Mail 2 kan se ut så här:

Hej!

Du har tidigare i veckan fått mail om möjligheten att delta i en ergonomiklinik för avdelningen Craftsmanship and Ergonomics vecka 15 och 16. Vi vill meddela att det fortfarande finns möjlighet att delta och tycka till om möjligheterna för en bra sittposition i bilmodellen XC60.

Om du vill delta följer du bara länken nedan och bokar in dig på en tid som passar genom att skriva in ditt **namn, CDS ID** och **telefonnummer** på raden längst ned ("Ditt namn"). Man väljer tid genom att ställa sig över en <span style="color:blue">blå</span> tid och markera Ja i rutan som dyker upp. Gråa tider är redan upptagna. <u>Glöm inte att spara!</u>

Länk till tidsbokning: <u>http://doodle.com/adzeg5t93srky2nv</u>

Vi kommer att utgå från PV-porten och under vecka 14 kommer du som bokat in dig att få en bekräftelse av oss samt lite mer info.

Har du frågor kontakta gärna *Namn Efternamn* (*CDSID*, *telefonnummer*) eller *Namn Efternamn* (*CDSID*, *telefonnummer*)

Välkommen!

Med vänliga hälsningar
*Namn* och *Namn*

## 7.5 Kallelse

Inom några dagar efter att folk börjat anmäla sig skickar ni ut en individuell kallelse för varje person. Där ska tid, dag och mötesplats vara aktuellt och en tillhörande text finnas med. Den tillhörande texten kan se ut så här:

Subject: Ergonomiklinik på Volvo Torslanda

Location: Parkeringen utanför PV-porten

Hej,

Vad kul att du har anmält dig att delta i ergonomikliniken! Under kliniken kommer man att köra ett par kortare sträckor och sittpositionen kommer dokumenteras med foton och genom frågor som ställs efter man kört klart. Inga frågor kommer att ställas under färd. Utvärderingen kommer utgå och avslutas vid parkeringen utanför PV-porten (se bild nedan) och det beräknas ta ca 45 minuter.

Eftersom du kommer köra bil kan det var bra att tänka på att ha körbara skor på sig. Vi ser helst att du inte har någon bylsig jacka på dig under färd, men mellan körningarna kommer du få gå ur bilen då stolens inställningar nollas. Då frågor kommer att läsas och besvaras av dig på en dator kan eventuella läsglasögon vara bra att ha med sig.

Har du frågor kontakta gärna *Namn Efternamn* (*CDSID*, *telefonnummer*) eller *Namn Efternamn* (*CDSID*, *telefonnummer*)

Välkommen!

Med vänliga hälsningar
*Namn* och *Namn*

Appendix G – SPEED Instruction document
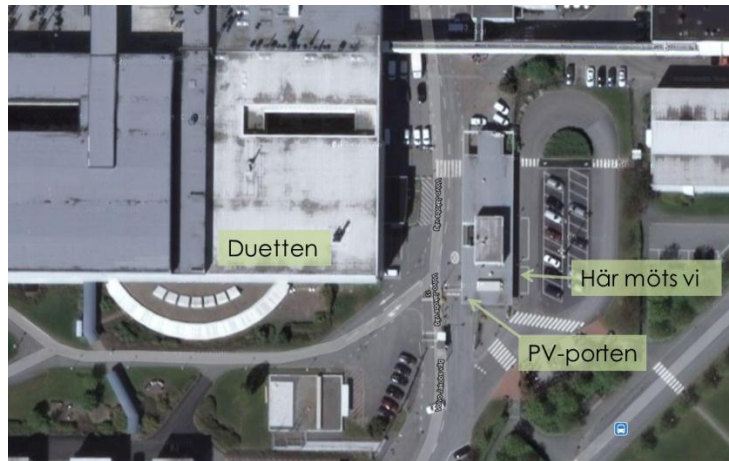
# 8  Klinik och sammanställning

För att kunna göra sammanställning av samtliga testpersoners ifyllda svarsformulär har ett sammanställningsdokument förberetts.

## 8.1  Klinikinstruktioner för SPEED

De instruktioner som finns här under kapitel 8.1 bör skrivas ut och finnas i bilen under utförandet av kliniken. De syftar till att kliniken ska utföras på samma sätt oavsett vem som är testledare och att utvärderingarna i framtiden ska kunna jämföras mot varandra.

### 8.1.1  Introduktion (2 min)

All text som är *kursiv* är för testledaren. Övrig text som inte är kursiv ska läsas upp för testpersonen.

### Instruktioner till testledare

1.  *Ställ stolen till den valda nollpositionen, LBLNTN, via minnesfunktion*
2.  *Ställ ratten i mittenpositionen*
3.  *Koppla in DICE-utrustning och koppla upp mot dator, gör en kontrollmätning*
4.  *Sätt igång kameror och deras WiFi*
5.  *Starta ipads och välj takkamera, sidokamera och takkameran till varsin iPad*
6.  *Kontrollera sidokamerans referenspunkter*
7.  *Skriv ned testpersonens namn i fältet "Namn" på löst papper*

### Bakgrundsfrågor

*Notera eller fråga vilken typ av skor testpersonen har vid kliniken*
*(ex. Klackskor, Finskor, Promenadskor, Arbetsskor, Sandaler, Sportskor, Ballerinaskor, Seglarskor)*

Skulle du vilja ta del av resultatet?
*Anteckna på löst papper.*

### Bakgrund till klinik

Testet görs för att utvärdera hur folk sitter och varför de väljer den positionen som de gör.

## Upplägg

Du kommer ställa in stolen tre gånger, tänk på att dessa inställningar är möjliga: *Visa hur man ställer in alla funktioner.*

- Fram/bak
- Upp/ner
- Tilt
- Ryggstödslutning
- Ratt upp/ner
- Ratt fram/bak

När du ställer in stolen är det uppskattat om du hela tiden tänker högt varför du ställer om stolen som du gör. Efter att du har ställt in stolen kommer du köra en bit och du kommer få vägen förklarad för dig. Vi kommer att stanna på utvalda ställen där vi tänker be dig svara på några frågor samt ställa om stolen. När vi har kört hela rundan kommer vi stanna på ett ställe och låta dig fylla i ytterligare några frågor.

Testet kommer sammanlagt att ta cirka 45 minuter och under det är tillåtet att justera stolen under körning. Var god rör inte fönsterhissar eller taklucka då vi har placerat utrustning på rutorna.

### 8.1.2   Del 1 – Sträcka 1 med korsning (8 min)

## Ställ in stolen

Nu kan du ställa in stolen första gången. Det är väldigt uppskattat om du berättar vad du gör för inställning och varför.

*Anteckna kommentarerna på löst papper, när TP ställt in sig färdigt fortsätter du fråga:*
Sitter du där du vill sitta eller vill du fortsätta justera dig?

## Ta kort
*Under körning ska kort tas (sidovy, toppvy, fotvy) synkroniserat när TP anländer till en korsning och vid raksträcka. Ta kort då tillfälle ges, då det finns risk att det är grönt vid trafikljusen.*

## Låt testdeltagaren köra en sväng
*Tänk på att inte ge TP för mycket köranvisningar på samma gång.*

Nu är det dags att köra första rundan.

1. Starta från PV-porten
2. Kör mot Volvohallen.
3. När vi närmar oss rondellen vid Volvohallen, håll vänsterfilen och följ skylt mot GÖTEBORG TORSLANDA Volvo.

4. Följ skylt mot TORSLANDA CENTRUM.
5. Följ skylt mot TK-porten och kör nästan hela vägen fram.
6. Vid TK-porten, sväng vänster och håll rakt förbi parkeringen till nästa korsning.
7. I korsningen ska vi svänga höger och sen kan du hålla till höger för att sedan direkt kunna svänga in till biltvätten/bensinstationen till höger.
8. Väl inne vid biltvätten/bensinstationen kan du stanna på en lämplig parkering och låta bilen vara igång.

## Logga stolsposition
*Efter ni stannat loggas första stolspositionen, och skrivs in på lösbladet.*

## Frågor om sittposition
*Se till att TP har datorn nära till hands.*

Nu ska du få svara på frågor om hur du sitter nu i den här bilen. Kryssa för det alternativ som passar bäst och säg till när du är färdig. För att kunna svara på de olika frågorna kan du justera stolen för att se hur det känns. Har du några övriga kommentarer eller om det är så att alternativen inte är möjliga att genomföra för dig, skriv gärna det i rutan "Övriga kommentarer".

## 8.1.3  Del 2 – Sträcka 2 (8 min)

### Ställ in stolen
Nu skulle jag vilja att du går ur bilen så ska jag ställa om omgivningen till ett startläge. *Ställ nu om stolen till sitt nolläge genom att hålla inne knappen för minnesfunktionen för startläget tills stolen har stannat. Ställ också in ratten till sitt nolläge.*

Nu får du sätta dig och ställa in en bekväm sittposition igen. Tänk gärna högt.

*Anteckna kommentarerna på löst papper, när TP ställt in sig färdigt fortsätter du fråga:*
Sitter du där du vill sitta eller vill du fortsätta justera dig?

### Ta kort
Under körning ska kort tas (sidovy, toppvy, fotvy) synkroniserat när TP anländer till en korsning och vid raksträcka. Ta kort då tillfälle ges, då det finns risk att det är grönt vid trafikljusen.

### Köranvisningar för runda 2
1. Kör höger ut från biltvätten/bensinstationen.

2. Håll dig i vänsterfilen och följ skylten mot GÖTEBORG, alltså vänster i den stora korsningen.
3. Efter korsningen så ska vi köra rakt fram och passera ett trafikljus.
4. Till höger vid nästa trafikljus finns en JET-bensinstation, sväng in på denna och stanna där på en lämplig plats.

### Logga stolsposition
*Efter TP har stannat ska andra stolspositionen loggas, denna skrivs in på lösbladet.*

### Frågor om sittposition
*Se till att TP har datorn nära till hands.*

Nu ska du få svara på frågor om hur du sitter nu i den här bilen. Kryssa för det alternativ som passar bäst och säg till när du är färdig. För att kunna svara på de olika frågorna kan du justera stolen för att se hur det känns. Har du några övriga kommentarer eller om det är så att alternativen inte är möjliga att genomföra för dig, skriv gärna det i rutan "Övriga kommentarer".

## 8.1.4 Del 3 – Sträcka 3 med raksträcka (8 min)

### Ställ in stolen
Nu skulle jag vilja att du går ur bilen så ska jag ställa om omgivningen till ett startläge. *Ställ nu om stolen till sitt nolläge genom att hålla inne knappen för minnesinställningen för startläge tills stolen har stannat. Ställ också in ratten till sitt nolläge.*

Nu får du sätta dig och ställa in en bekväm sittposition igen. Tänk gärna högt.

*Anteckna kommentarerna på löst papper, när TP ställt in sig färdigt fortsätter du fråga:*
Sitter du där du vill sitta eller vill du fortsätta justera dig?

### Ta kort
*Under körning ska kort tas (sidovy, toppvy, fotvy) synkroniserat när TP kör i korsning och **raksträcka**.*

### Logga stolsposition
*Synkroniserat med att korten tas ska också **stolens position loggas** och skrivas in på lösbladet.*

### Köranvisningar för runda 3
Nu ska vi köra tillbaka till PV-porten.

1. Kör ut från JET kör vänster i första korsningen tillbaka mot Volvo.
2. Följ skylt mot ÖCKERÖ TORSLANDA, efter första korsningen kan du lägga dig i högerfilen.
3. Ligg i högerfilen och följ skylt mot VOLVO TORSLANDA.
4. *Ligg kvar till höger och kör rakt fram, följ skylt mot GTG, GTC.*
   *Här är raksträckan där det ska tas kort och logga stolsposition.*
5. Följ skylt mot MALMÖ
6. Kör tillbaka till PV-porten och stanna i böjen av parkeringen.

### 8.1.5  Del 4 – Parkeringssituation (5 min)
*Här ska vi testa en parkeringssituation. Ställ fram koner strax efter övergångsstället framför bilen. Gå sedan in i bilen igen och stäng av parkeringssensorn, se Figur 19.*

### Ta kort
*Under tiden TP parkerar ska kort tas (sidovy, toppvy, fotvy) synkroniserat.*

### Anvisning
Nu ska vi testa en parkeringssituation och du ska nu parkera bilen vid konerna. Tänk att konerna symboliserar en annan bil och ställ dig så nära du vill. Parkeringssensorn är avstängd.

*Mäta avståndet mellan bilen(registreringsskylten) och konerna samt fråga TP vad TP tror om avståndet och anteckna båda avstånden på löst papper.*

Hur långt ifrån konerna tror du att du står, i cm?
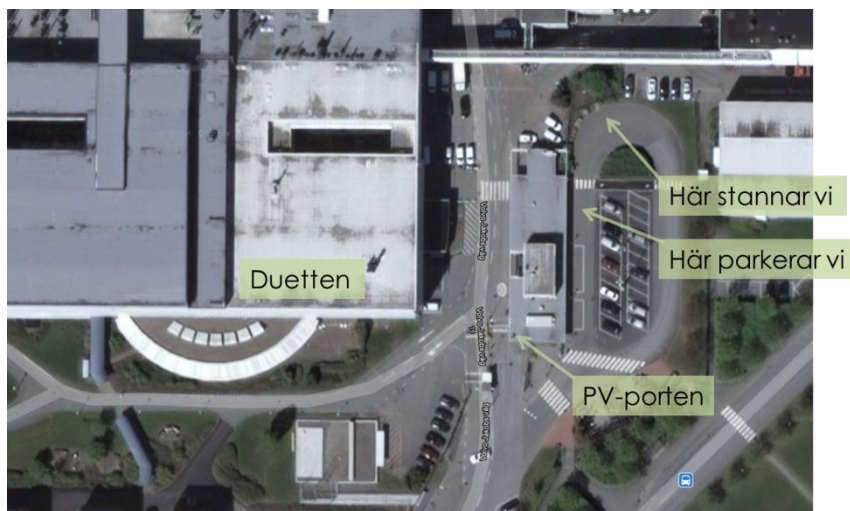


**Figur 19 – Där man stannar innan parkeringssituationen och där man ställer ut konerna.**

*Ta ett kort med sidokameran på TP när TP har huvudet mot nackstödet, anteckna vilket kortnr det är på löst papper.*

Nu skulle jag vilja att du lutar huvudet tillbaka mot nackstödet så att du tar mot det.

## Frågor om sittposition
*Se till att TP har datorn nära till hands.*

Nu ska du få svara på frågor om hur du sitter nu i den här bilen. Kryssa för det alternativ som passar bäst och säg till när du är färdig. För att kunna svara på de olika frågorna kan du justera stolen för att se hur det känns. Har du några övriga kommentarer eller om det är så att alternativen inte är möjliga att genomföra för dig, skriv gärna det i rutan "Övriga kommentarer". Här ska du även svara på den sista frågan, 3b, hur det är att hitta en bekväm sittposition.

### 8.1.6    Del 5 – TP ska fylla i listor/frågor (10 min)

Nu har vi kört färdigt med bilen så du kan parkera på korttidsparkeringen och stänga av motorn. Sedan ska du få fortsätta svara på frågor på datorn. Om du har några frågor är det bara att ställa dem.

*Under tiden som TP svarar på frågor i datorn kan t.ex. korten från GoPro-kamerorna flyttas till datorn och läggas i strategiska mappar eller anteckningarna från inställningarna skrivas in i CAN-datorn.*

## 8.2    Anteckningssida till testledare

Testledaren fyller i SPEED Note sheet under kliniken. Det finns att skriva ut från SPEED Compilation document om man markerar det man ska ha, markerar landscape layout och print selection.

| Steps från motorer | | Inställning 1 | | | Inställning 2 | | | Inställning 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nr | Slide | | | | | | | | | |
| | Recline | | | | | | | | | |
| | Height | | | | | | | | | |
| | Tilt | | | | | | | | | |

| Kortnummer | | Korsning | | | Raksträcka | | | Parkering | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sida | | | | | | | | | |
| | Tak | | | | | | | | | |
| | Fot | | | | | | | | | |
| | Inst. | 1 | 2 | 3 | 1 | 2 | 3 | | 3 | |

| Nackstödskort | Kortnr sidokamera |
|---|---|
| | |

| Parkeringsavstånd | TP's uppfattning | | Verkligt avstånd | |
|---|---|---|---|---|
| | | cm | | cm |

## 8.3 Eventuella ändringar i formuläret

Formuläret är gjort med olika sheets för varje testperson. I sammanställningen länkas de ifyllda svaren, därför ska man vara försiktig med eventuella förändringar i formuläret och tänka på att förändringar i så fall ska göras med alla sheets samtidigt. Tänk också på att göra förändringar i sammanställningen samtidigt så rätt fråga hamnar på rätt plats. För att ändra flera sheets samtidigt controlklickar man de sheets man vill ska ha förändringen och gör ändringen i ett av sheetsen. Förslagsvis i sheetet som heter "formulärmaster".

För att förändra de klickbara cirklarna, radioknapparna, får man vara observant. De är nämligen grupperade radvis och länkar till kolumn K. Gör man nya knappar så händer det att tidigare knappar länkar om och då får man felsöka. Om man vill ändra på knapparna får man lägga till så man har *developer* som tab. I Excel; gå till File, Option och Customize Ribbon där du kryssar för Developer.

För att visa de rutor som grupperar radioknapparna (Group Box) får man trycka Alt+F11 så VBE-fönstret öppnas (Visual Basic Editor). Där skriver man: ActiveSheet.GroupBoxes.Visible=True. För att dölja rutorna sedan skriver man: ActiveSheet.GroupBoxes.Visible=False. När man gör nya boxar och väljer vilken ruta som är referensruta måste fältet för rutan vara tomt! Annars blir det återkopplat till de tidigare boxarna och man måste göra om allt. Radera hellre boxen och gör en ny tills fältet för referensrutan är tom. Knapparna som finns i dokumentet nu är av typen Form Control och inte Active X Control.

## 8.4   Bilformulär till sammanställningsdokument

Börja med att kopiera formuläret som använts i bilen samt sammanställningsdokumentet vi vill kopiera allting till, till en mapp på skrivbordet. Fortsätt med att gå in i formuläret som använts i bilen, markera samtliga "sheet" och välj "Find & Replace". Här vill vi nu ersätta samtliga "=" med en text som inte används någon annanstans i dokumentet, man kan välja vad som helst, exempelvis "bart". Så under "Find", skriv in "=" utan citationstecken, under "Replace" skriver vi in "bart" utan citationstecken. Tryck sedan på knappen "Replace All".

Nästa steg är nu att kopiera samtliga blad in till det riktiga sammanställningsdokumentet. Detta gör vi genom att ha alla "TP-sheets" markerade och sedan högerklicka och välja "move or copy…". Här väljer vi till vilken "workbook" som vi vill kopiera det till, det är viktigt att dokumentet man vill kopiera från till i samma mapp som det man vill kopiera till och att båda dokumenten är öppnade. Sedan scrollar vi ner i rutan vilken innehåller alla sheets och väljer "move to end". Tryck sedan på OK.

Nu hamnar vi i sammanställningsdokumentet och sheetsen ska vara inklistrade. Nu får vi markera samma sheets som har flyttats hit, välja samtliga celler och använda oss av "Find & Replace" igen för att ersätta "bart" med "=", kom ihåg att inte använda citationstecken utan bara det inom dem.

Nästa steg är att avmarkera samtliga sheets och celler, sedan gå till sammanställnings-sheet. Här ser vi nu att det står #REF! på de TP-rader som vi klistrat in nya TP-sheets för. Nu får vi för respektive rad ersätta "#REF!" med rätt TP-sheet-referens samt spannet som matrisen befinner sig i, t.ex. ersätta "#REF!" med "'TP1'!$A$1:$L$265". Märk här att fot-tecknet (enkelfnutten) ska vara med men inte citationstecken.
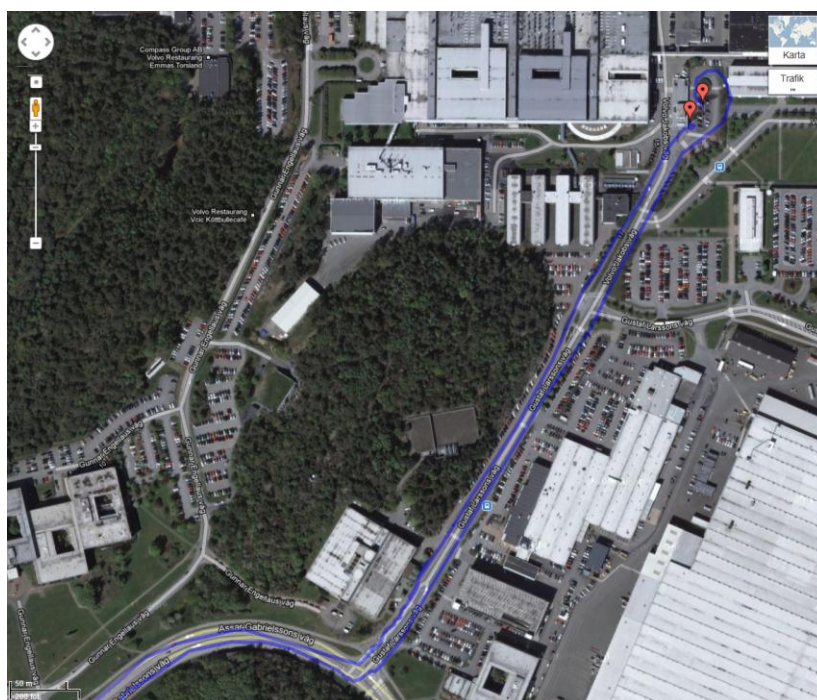
Nu ska det fungera!

## 8.5   Ruttbeskrivning för klinik

Ruttens totala längd är ca 8 km. Den består av tre delsträckor. En mera detaljerad ruttbeskrivning i text finns att läsa i kapitel 8.1.
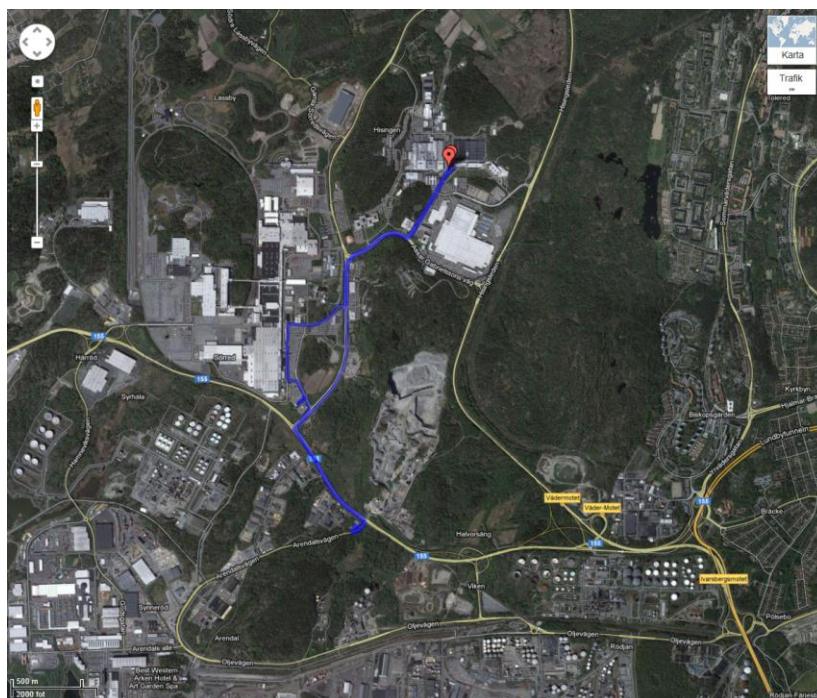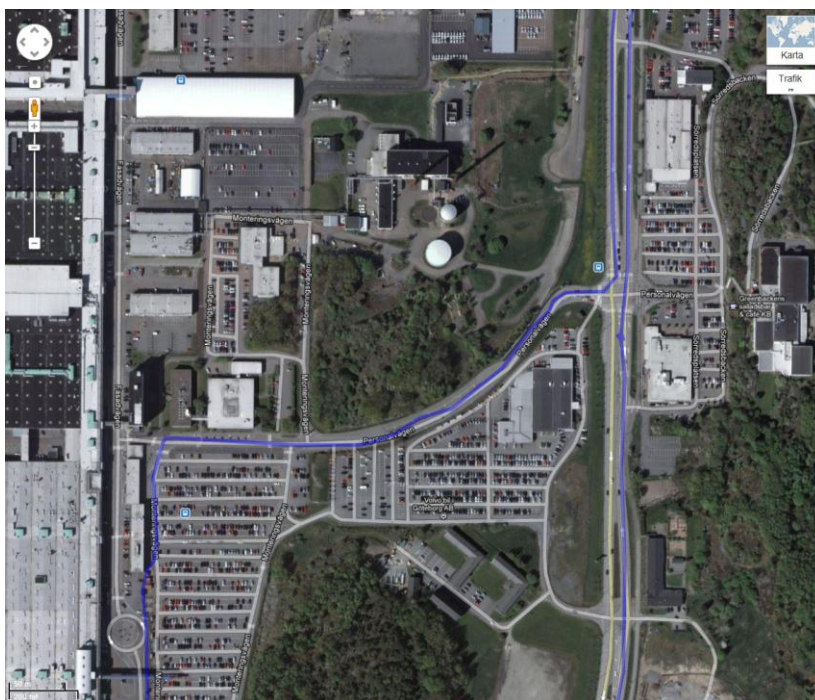
Första sträckan utgår från PV-porten och mot Volvohallen, sedan vidare mot TK-porten.
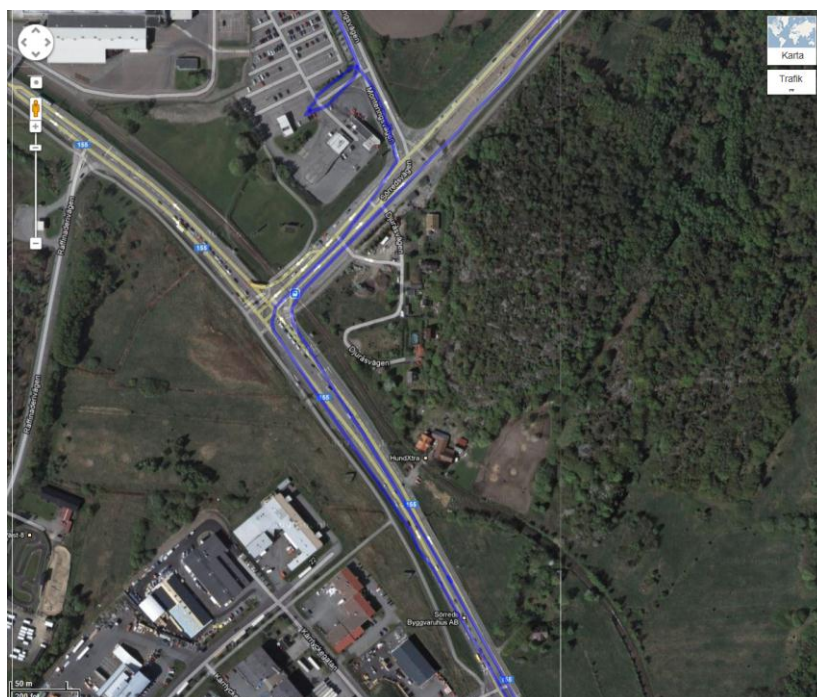
Nästan framme vid TK-porten ska TP svänga vänster och köra förbi parkeringen som kommer ligga till vänster mot bensinstationen.



Första rutten är klar och TP ska stanna på bensinstationen.

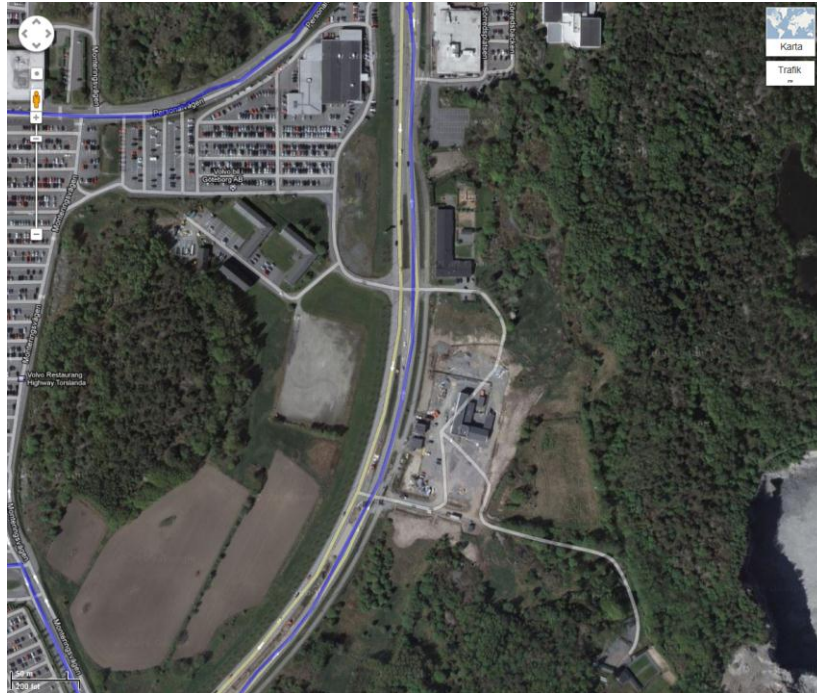Andra delen av rutten börjar på bensinstationen och sedan ut på stora vägen mot Göteborg.



Andra rutten är klar när TP stannar på Jet-bensinstationen till höger på vägen mot Göteborg.
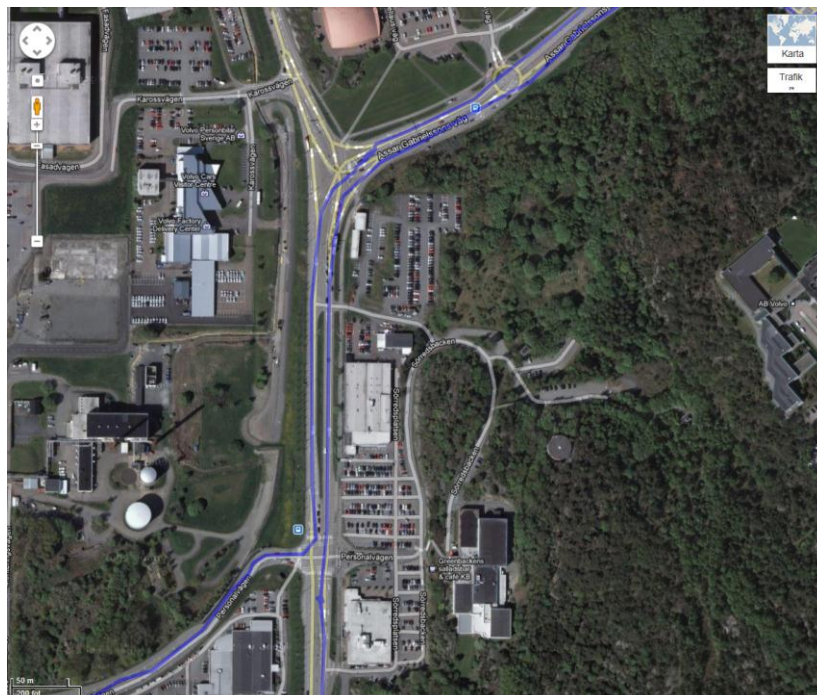
Tredje rutten börjar på Jet-bensinstationen och går tillbaka mot PV. Håll rakt fram förbi första bensinstationen (kör INTE in mot TK-porten igen).
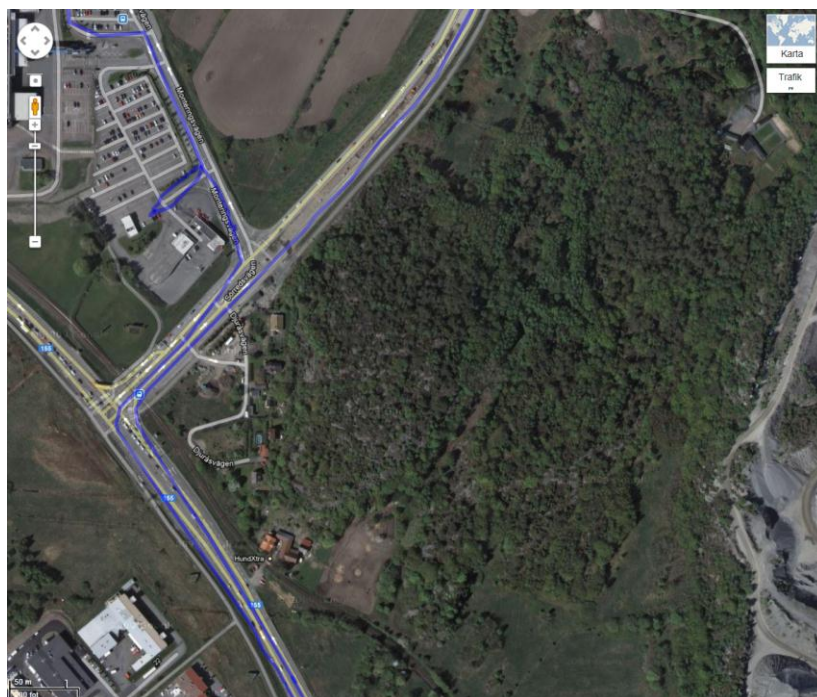
Håll rakt fram mot Volvohallen.



Passera Volvohallen och kör tillbaka mot PV-porten.

Stanna vid PV-porten.

# 9  Analys

De delar som ska analyseras i basanalysen finns förberedda i SPEED Compilation document, antingen med förberedda diagram eller med en förklaring till hur man ska åstadkomma dessa. För vissa analyser får man sortera alla testdeltagare efter kort/medel/lång och kopiera alla dessa svar som text, inte med formler, och lägga sorterade under svaren från sammanställningen. Därigenom kommer mycket att räknas ut automatiskt. Alla instruktioner till detta finns som sagt i SPEED Compilation document. Man ska vara försiktig med att sortera efter man gjort diagram. Kopiera eventuellt skapade diagram som bilder till t.ex. powerpoint för att inte riskera att de sorteras om.

Slutsatserna från kliniken kommer att presenteras i en Powerpoint. Ett tomt powerpointdokument med Volvo-mall kommer finnas på samma plats som alla andra dokument som krävs för SPEED.