Towards Sustainable Business Travels

Environmental, Social and Economic aspects of Business Travels at SKF

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Summary

The threat of climate change makes it necessary for companies to work with greenhouse gas emissions in a wider perspective, than only focusing on emissions from production. This report deals with the effects from business travels, which for instance is a contributing factor to climate change. The aim is to study business travels at SKF with a focus on environmental, social and economical effects.

The results show that SKF in 2006 travelled 200 million km for business, which caused the emission of 44 400 tonnes of CO_2 equivalents. If only direct CO_2 emissions are included, the emissions were 23 700 tonnes of fossil CO_2, which corresponds to 5.7 % of the CO_2 emissions from SKF's production. Since SKF have their headquarters in Göteborg, almost 20 % of the CO_2 emissions from business travels come from people employed in Sweden. This is equivalent to 45 % of the emissions from SKF Sweden's production.

Air travels are responsible for 80 % of total CO_2 emissions from SKF business travels. SKF charters an aircraft from Göteborg to Schweinfurt that emits 3.7 times more CO_2 per passenger, than regular flights combined with train. The chartered aircraft saves 2.5 hours in travel time and decreases negative social effects for the journey.

The social results, including health aspects, show that business travels have a negative effect on the employees. Common effects are stress, fatigue and impaired family relations. The results also show that business travels sometimes have positive effects for the employees, mainly for less frequent travellers.

SKF can reduce their emissions by decreasing the amount of business travels in favour of different ways of communicating. WebEx combined with telephone is popular within the company, and virtual meetings have a potential to replace many physical meetings in the future. Improvements are also accomplished by travelling more by train and by changing current company cars to cars with lower CO_2 emissions. It is desirable that SKF introduce an international booking system, which includes all travel options and that their resulting CO_2 emissions can be compared before booking. If this is introduced, SKF can keep better track of their travels. Hence the emissions can be included in the annual report and in SKF's goal of emission reduction.

The report is a master thesis done in corporation between SKF and Environmental System Analysis at Chalmers. All SKF business travels globally are quantified and included in the calculated CO_2 emissions. The social effects are investigated through literature studies and interviews with travellers at SKF. Economical aspects are included in detailed studies of specific trips and as average costs for a business trip.

Sammanfattning

Hotet om klimatförändringar gör det nödvändigt för företag att arbeta med utsläpp av växthusgaser, i ett vidare perspektiv än enbart utsläpp från produktion. Denna rapport tar upp effekterna av affärsresande, som bland annat är en bidragande faktor till klimatförändringar. Syftet är att studera SKFs affärsresande med fokus på miljö, sociala och ekonomiska effekter.

Resultaten visar att SKFs affärsresande under 2006 totalt uppgick till 200 miljoner km och att detta gav upphov till utsläpp på 44 400 ton CO_2 ekvivalenter. Om bara direkta CO_2 utsläpp tas med blir utsläppen 23 700 ton fossilt CO_2, vilket motsvarar 5.7 % av CO_2 utsläppen från SKF’s produktion. Eftersom SKF har sitt huvudkontor i Göteborg, kommer nästan 20 % av affärsresandets CO_2 utsläpp från anställda på SKF Sverige. Detta motsvarar 45 % av utsläppen från SKF Sveriges produktion.

Flygresor står för ungefär 80 % av utsläppen från SKFs affärsresande. SKF chartrar ett flygplan från Göteborg till Schweinfurt, som släpper ut 3.7 gånger mer CO_2 per passagerare, jämfört med reguljärt flyg kombinerat med tåg. Chartern sparar dock över 2.5 timmar i restid samt bidrar till att minska de negativa sociala effekterna från resan.

De sociala resultaten som även innefattar hälsoaspekter, visar att affärsresande har en negativ inverkan på de anställda. Vanliga effekter är stress, trötthet och försämrade familjerelationer. Resultaten visar även att affärsresor ibland har positiva effekter för de anställda, främst för de som reser mindre ofta.

SKF kan reducera sina utsläpp genom att minska affärsresandet till förmån för andra sätt att kommunicera. WebEx i kombination med telefon är omtyckt på företaget, och virtuella möten har potential att ersätta många fysiska möten i framtiden. Förbättringar kan också nås genom att åka mer tåg och att byta ut tjänstebilar mot bilar som orsakar mindre CO_2 utsläpp. Det är önskvärt att SKF inför ett internationellt bokningssystem där alla resalternativ finns och CO_2 utsläppen kan jämföras innan bokning. Om detta införs får SKF bättre koll på sitt affärsresande, varvid utsläppen kan inkluderas i årsredovisningar och i SKF’s mål om utsläppsreduktion.

Rapporten är ett examensarbete utarbetat i samverkan mellan SKF och Avdelningen för Miljösystemanalys på Chalmers. Alla SKF’s resor har kvantifierats globalt och inkluderats i de beräknade CO_2 utsläppen. De sociala effekterna har undersökts genom litteraturstudier och intervjuer med affärsresande på SKF. Ekonomiska aspekter har vägts in i detaljerade studier av specifika resor och genomsnittliga kostnader finns presenterade.

Foreword

First we would like to thank our supervisors at Chalmers University of technology; Karl Jonasson and Örjan Lundberg for valuable thoughts, comments and many rewarding discussions regarding our work.
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At SKF we like to thank Mikael Holmyr, Rob Jenkinson, Leif-Göran Lundstedt and Ulf Andersson for helping us with the gathering of requested information, useful help concerning SKF, and all interviewees for participating. We are also grateful to persons at travel companies, Anders Hasselroth, Bengt Steen and others that helped us with this report.

Finally we would like to thank family and friends for their help and support, especially Linnea.

Table of contents

1 Introduction

The threat of climate change makes it necessary for companies to work with greenhouse gas emissions in a wider perspective than only focusing on emissions from production. This report deals with the effects from business travels, which for instance is an important contributing factor to climate change. The aim is to study business travels at SKF with a sustainability perspective, including environmental, economical and social effects.

In this report, business travels at the Swedish company SKF is investigated. SKF is a supplier of products, solutions and services in the area of rolling bearings, seals, mechatronics, services and lubrication systems. The company acts on a global scene with 100 manufacturing sites distributed globally in 25 countries and sales departments in 70 countries. This implies a large need for travels. As a part of the company's work towards sustainable development, it is needed to look further than the emissions from specific worksites. This means including activities such as business travels, logistics, suppliers and commuting.

1.1 Structure

The thesis is divided into three parts with their own methodologies and results. Part I focuses on environmental effects and Part II looks into social and economic effects from business travels. Part III consists of two different case studies. The first case study compares a chartered aircraft to regular flight combined with transfer. The second case study compares different means of transportation. The discussion focuses on the possibilities of improvement and is made in common for all three parts.

1.2 Aim and scope

The goal of this report can be summarised into three main questions:

- *What are the environmental effects of business travels at SKF?*
- *What are the social effects for the employees and the company costs of business travels?*
- *How can SKF decrease negative effects from business travels?*

The aim of this report is to assess the sustainability of business travels at SKF. The main focus is the environmental effect, but social effects for the employees that travel in terms of for example stress, personal life, circadian rhythm and positive aspects are included. The costs for tickets, loss of time and effects on work efficiency are studied as a minor part. The aim is to see the effects from all travels, but also to compare the effects from a small chartered aircraft, with regular flights on SKF's most frequent journey and to compare different means of transportations on a shorter distance. The purpose is also to come up with proposals of how to decrease the negative effects from business travels without losing their benefits.

To determine the total environmental, health and economical effects of the business travels, the scope includes all means of transportation, for every country where SKF is in business. Travel data are unfortunately not available for all travels, especially not from countries outside of Europe and North America. Travels without available data are included as estimations. For environmental effects, only climate effects are included in this study. Economical aspects are discussed from the case studies and an SKF travel investigation, instead of from the actual costs of each travel.

Our definition of sustainable development is based on the three dimensions[1] addressed in the report Our Common Future (United Nation General Assembly, 1987). In our report the definition is limited to SKF and the effects from their business travel. The environmental dimension focuses on climate change as discussed in the methodology. The economical dimension deals with the economy of SKF and the social dimension with the people working for the company and their families.

1.3 General methodology and boundaries

The report is mainly retrospective investigating the effects from SKF business travels and unless otherwise is stated, it handles data and presents results for business travels by SKF employees in 2006. The business travels by SKF are assumed to be responsible for a share of the total emissions from travels in a steady state and therefore are average data used for production of energy and fuels etc. as Sandén et al (2005) recommends. When changes in travels are discussed, marginal data are used as recommended by the Swedish Energy Agency (2006). This is further discussed in the methodology of Part III.

Data about SKF travels are collected country by country, mainly from American Express travel agency and SKF travel managers. The social aspects are investigated from literature studies and interviews with business travellers at SKF.

In this study all emissions are allocated by passenger, which means that the emissions from a flight are divided by the number of passengers. Allocation by passenger is chosen to make it easy to compare different means of transportation and to see each traveller’s contribution. It is also the allocation method used in all calculation tools investigated for this report.

SKF reports the CO_2 emissions from their own combustion of fossil fuels and the emissions from their heart and electricity suppliers. All these emissions are reported as direct emissions, without a life cycle perspective (SKF, 2007). If a life cycle perspective is added, all emissions from “cradle to grave” should be included. For example, for a fossil fuel this means that all the emissions emitted when the oil was prospected, through the refinery to final delivery to SKF should be included. To include a life cycle perspective is becoming more popular and the number of published articles on the subject is rapidly increasing (Baumann and Tillman, 2004). One reason to include a life cycle perspective in this report is that different vehicles use different fuels. The fuels are produced from different resources in different ways, they cause different emissions and are therefore not fairly comparable if a life cycle perspective is not included (Blinge et al, 2006). For the results to be comparable to other SKF emissions, and to be able to see the

[1] The three dimensions are environmental, social and economical development.

total effect, the CO_2 emissions are presented both with and without a life cycle perspective.

Only the effects on climate change from SKF business travel are included in this report, since CO_2 emissions and climate change is the environmental issue in focus at SKF (SKF, 2007). It is also motivated by the fact that the CO_2 emissions can be used as a screening indicator for total environmental performance (Huijbregts et al, 2006). The emissions from commuting to and from work are not included in this report, since SKF does not consider this to be business travels (Lundstedt, 2007). Emissions from trains, buses as well as other greenhouse gases than CO_2 from the combustion in vehicles at ground level are excluded, due to low significance (see appendix 1).

The CO_2 emissions from production and operation of capital goods[2] are excluded due to reasons of feasibility. This is supported by the fact that capital goods are rarely included in life cycle assessments (Baumann and Tillman, 2004). Including capital goods could therefore lead to a result that is less comparable to other analyses. Capital goods can have a significant impact of the total CO_2 emissions related to travels and are further discussed in the sensitivity analysis of Part I.

Methodologies and boundaries are further discussed in each part.

[2] In this report capital goods is referred to as goods needed to manufacture and use vehicles and their fuels. Examples of capital goods are roads, steel and factories.

2 Part I Environmental effects

This part presents the environmental effects from SKF business travels for 2006.

2.1 Scientific background

The main anthropological contributor to climate change is CO_2, but for example vapour, ozone (O_3) and methane (CH_4) also contribute to the climate change. The emissions from aircrafts mainly come from combustion of jet fuel. The combustion leads to the release of CO_2, nitrogen oxides (NO_x), vapour, sulphate and soot aerosols. All these gases and particles interact with the surrounding air in different ways and lead to changes in the chemistry of the atmosphere, which ultimately increase mean surface temperature (IPCC, 2007). When looking at the climate effects from aircrafts this means that all of the emissions mentioned above should be included. For vehicle emissions emitted on the ground, climate effects from other gases than CO_2 are very small. This is shown by a comparison of the global warming potential from vehicle emission on ground level (IPCC, 2001; Arnäs et al, 1997).

CO_2 molecules absorb outgoing infrared radiation from the earth, which leads to the warming of the earth's surface. CO_2 that is released into the atmosphere have a long lifetime (5-200 years[3]), and does not have any direct short time effects on other greenhouse gases (IPCC, 2007). This means that the effects from CO_2 emitted on the ground have the same effect on climate change, as if it is emitted higher up in the atmosphere. This is not the case for all gases as described below.

NO_x gases do not have an effect on the greenhouse effect themselves, but they start a series of chemical reactions, powered by sunlight, to produce O_3. Since the sunlight is more intense at high altitudes, more O_3 is produced compared to if the NO_x had been released close to the ground. Ozone produced at high altitudes is a greenhouse gas and adds to the total greenhouse effect (this O_3 in not to be confused with the ozone layer protecting the earth from ultraviolet radiation). NO_x also shorten the lifetime and lower the concentration of CH_4 in the atmosphere. CH_4 is a greenhouse gas, so the removal of this reduces the total greenhouse effect (IPCC, 1999).

Vapour released at high altitudes produce contrails, which are the trails that can be seen behind an aircraft. These trails trap heat inside the atmosphere and contribute to climate change. Contrails are not formed when flying at lower altitudes, but this generally leads to higher fuel consumption (IPCC, 1999). Contrails may cause the formation of high altitude cirrus clouds, which are believed to have a very large net warming effect on the climate, but it could also have no effect at all (Sausen et al, 2005). Still, more research is needed on the properties of these clouds before their effect on the radiation budget can be accurately calculated.

[3] According to IPCC (2001) a single lifetime cannot be defined for CO2 due to many different removal processes.

During combustion of jet fuel, sulphate aerosols are released, due to traces of sulphur in the fuel. These aerosols reflect incoming solar radiation and hence have a cooling effect on the atmosphere. On the other hand, soot particles produced from the combustion trap infrared radiation from the earth within the atmosphere and consequently have a warming effect. The effects of these two phenomena are believed to roughly cancel each other (IPCC, 1999; Sausen et al, 2005).

2.2 Methodology

This chapter describes the methodology for calculating the total CO_2 emissions from different transport modes. The background data are presented in appendix 2, 3, 4 and 5.

2.2.1 Emissions from air travels

The data for air travels are gathered from American Express, SKF's travel agency for nine European countries with large SKF activities. For personnel's travels in other countries, data are estimated from the number of employees with SKF email addresses. This estimation is further discussed in subsection 2.2.5.

When calculating the emissions from aircrafts there are many factors to deal with, such as type of aircraft, engines, weather conditions, cruise altitude, distance, take-off weight, occupancy, landing and take-off cycle etc. There are a number of existing models for calculating these emissions. In this report, a model called Hurdy-Gurdy, developed by the Swedish Defence Research Agency (FOI), is used. The first reason for choosing this model is that it is the base for two of the most respected calculation programs available online in Sweden (from NTM[4] and SAS). The second reason is that the model makes it possible to calculate emission factors[5] for specific distances and aircrafts. Hurdy-Gurdy is a simplified model based on a set of data from the PIANO[6] model (Hasselroth, 2007). We were able to get a small user friendly version from FOI, instead of buying the whole PIANO model.

The Hurdy-Gurdy model gives the emissions for a specific flight. It is not possible to run the model for each trip, thus the travels are divided into nine distance intervals. Within each interval the average distance is modelled and all distances within an interval are assumed to have the same emission factor per passenger kilometre (pkm) as the average distance. The model is based on a set of eight aircrafts. Assumptions are made regarding time for taxi[7] in and out, configuration in the aircraft, cruise altitude etc. The cabin factor[8] is also estimated. This estimation is crucial for the results. The cabin factor is set to 65 %

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[4] NTM (The Network for Traffic and Environment) is a Swedish non profitable organisation, aiming at establishing a common base of values, on how to calculate the environmental performance for various modes of transport (NTM, 2007).
[5] Emission factor is used in this report as a measure of CO_2 emissions per travelled distance.
[6] PIANO (Project Interactive Analysis and Optimisation Aircraft performance tool) is a software equipped with a complete set of aircrafts and engine data for aircrafts, making it possible to calculate everything from fuel consumption to specific aircraft performances.
[7] Taxi implies the aircrafts' transportation on the ground from gate to starting position and from the landing strip to the gate.
[8] Cabin Factor is used in this report as the percentage of occupied seats in an aircraft. For other means of transportation occupancy is used instead.

for shorter and 85 % for longer flights after a comparison of cabin factors used in different models from SAS, NTM, Climate Care and Greenhouse Gas Protocol (SAS emission calculator, 2007; NTM, 2007; Jardine, 2005; Greenhouse Gas Protocol, 2007). Estimations are shown in appendix 5 and the resulting emission factors are compared to those used by Greenhouse Gas Protocol in the sensitivity analysis (section 2.4).

Aircrafts often carry cargo as well as passengers, and especially on international flights cargo could account for a substantial part of the total load[9] (Jardine, 2005). In our model no emissions are allocated to the cargo. This is motivated by the facts that the cargo cannot be changed for extra passengers, because of it's location in the aircraft, and that it is difficult to estimate how large part of the emissions that should be allocated to the cargo. Another contributing reason is that SAS and NTM do not allocate any emissions to cargo (SAS emission calculator, 2007; NTM, 2007).

SKF has since august 2006 used a small chartered aircraft from Göteborg to Schweinfurt. The aircraft is not included in the data set for Hurdy-Gurdy and therefore the emissions are not possible to calculate with the model. Instead the fuel consumption for the aircraft, received directly from the airline company responsible for the charter, is used to calculate the emissions. This is done by multiplying the fuel consumption with a specific factor for CO_2 emissions when combusting jet fuel. This calculation is further described in Part III section 4.3.

Intergovernmental Panel on Climate Change (IPCC) estimated the total effects on radiative forcing[10] from aviation in 1999 and the TRADEOFF project[11] updated their calculations in 2004 (IPCC, 1999; Sausen 2005). According to the TRADEOFF project the total radiative forcing from aviation is 47.8 mW/m^2, and the effect from other emissions than CO_2 is 0.9 times the effect from the CO_2 alone (Sausen, 2005). TRADEOFF makes it possible to compensate for the extra greenhouse gas effect, by multiplying the CO_2 emissions with their factor of 1.9. This way of compensating for other emissions than CO_2 is done by for example Climate Care (Jardine, 2005) and is discussed by Whitelegg and Cambridge (2004). Due to too big uncertainties, the climate effect from aviation induced cirrus cloud formation is not included in our calculations. This effect is however included in the sensitivity analysis.

[9] There are no data available on how much cargo the passenger aircrafts take, but an estimation by Climate Care say that it could be around 10 % of the weight for long haul flights (Jardine, 2005)

[10] Radiative forcing is the change in the radiative balance at the tropopause (around 10 km over the earth's surface where the troposphere meets the stratosphere), in response to a change in concentration of greenhouse gases (Harvey, 2000). An increased radiative forcing consequently leads to an increased greenhouse gas effect.

[11] The TRADEOFF project is a project within the European Union's fifth framework, investigating the contribution to changes in radiative forcing from aviation (Institute for atmospheric and climate science, 2007).

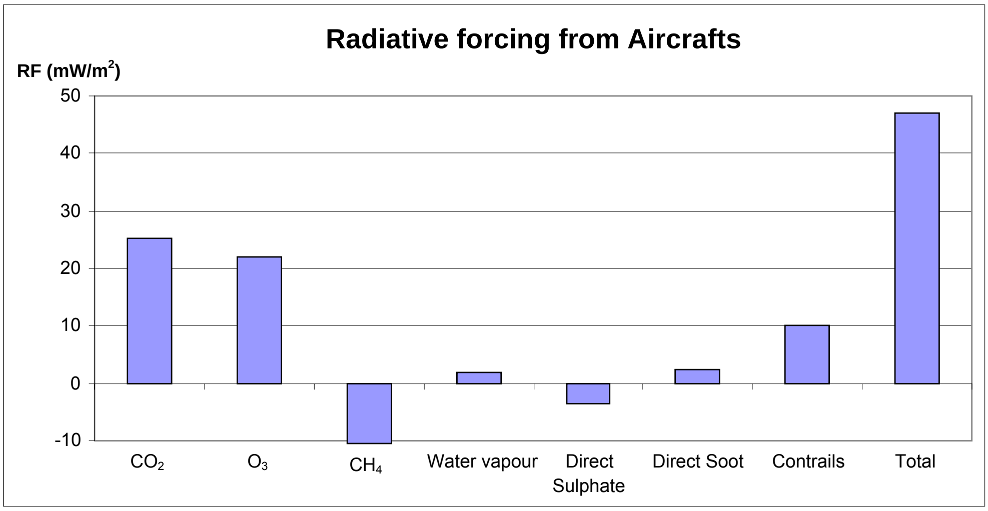

Figure 1: Shows Radiative forcing (RF) in mW/m^2 from aviation broken down into different sources (Sausen et al, 2005). The NO_x emitted from aircrafts are included in the effects from O_3 and CH_4 since they affect their concentration.

In this report, the actual CO_2 emissions and the global warming potential in terms of CO_2 equivalents is calculated. The CO_2 equivalents are calculated by multiplying the direct CO_2 emissions from SKF travels by aircrafts, with the effect from radiative forcing for the other emissions that affect climate change. The factors included in TRADEOFF's value and their contribution to radiative forcing is illustrated in figure 1. The CO_2 emissions are calculated as direct emissions, life cycle emissions and as CO_2 equivalents.

2.2.2 Emissions from car travels

There is no central record for SKF travels by car. For company cars the distances and CO_2 emission factors are investigated country by country. For most countries in Europe, the US and Canada local travel managers have the information about car models and distances. Generally only the total distance (business and private) is available. The business distances are in these cases estimated to be a third of the total distance. This estimation is done by a comparison with the countries where both private and business distances are available. For rental cars, information for most countries in Europe is from Europcar (2007) and for US and Canada from travel managers. For US, the driven distance is not available and is therefore estimated to be the same per rental day as in Canada. For travels with taxi, data are only obtained for travels in Sweden with Taxi Kurir, the contracted taxi company (Hassi, 2007). All other taxi travels are estimated. The Swedish taxi travels are the base for the estimations for all taxi travels.

The car models are generally obtained from travel managers, rental companies and Taxi Kurir. The model, engine alternative and distance are not specified for each vehicle. Therefore each car model in each country or region is sorted into different standard car models whose emission data are obtained from the Swedish Road Administration[12] (2006).

Due to the different traffic situation in Asia, Latin America and Africa, these regions probably have a different use of cars, compared to other SKF regions. Therefore is only the total car travels estimated in these regions, instead of from each type of car. No specification of different kind of car travels is done for Oceania either, due to very low SKF activity. There are no available data for how much car travels SKF have in these regions. The regions are estimated to have the same total CO_2 emission from cars per registered email address as Europe. This estimation is further discussed in subsection 2.2.5.

2.2.3 Transfer, train and buses

All air travels starts and ends with getting to and from the airport. The majority of the emissions from transfer are supposed to be from driving cars or taxis. Transfer is included in, but not separated from, the total car travel. The emissions from transfer with public transportation are neglected due to low significance on the total result.

Data for business travels by train are only available for SKF Sweden. CO_2 emissions from the travels by train are under 1 %, of the total emissions from business travels. If calculated with a European electricity mix (with higher emissions) and 10 % diesel trains, they are still under 1 % (see appendix 1). Europe is assumed to have a similar usage of trains as Sweden, while North and South America are assumed to have a smaller use. The distances between different locations in China are too far and the rest of the world have too little SKF activity, to make such an amount of train travels that it would affect the total CO_2 emissions from travel (Lundstedt, 2007). This leads to the conclusion that train travel can be ignored when calculating total emissions. The amount of bus travel is diminutive and is also neglected. Transfer and train travel is however included in the case studies, see Part III.

2.2.4 Including a life cycle perspective

All fuels consumed have a history of emissions emitted when they were extracted, transformed and transported. In this report these life cycle emissions are included as factors, which are multiplied with the total amount of used fuel. Different factors are used for different regions and types of fuel. The factors are obtained from one European and one North American report, which investigate the effects for cars from a "well-to-wheel" perspective (General Motor Corporation et al, 2001; 2002) and are presented in appendix 4. For jet fuel and fuels used in other regions than described above, no comparable life cycle data are available. Fuels in Asia, Latin America, Oceania and Africa are estimated to have the same life cycle emissions as in Europe. Jet fuel is estimated to have the same

[12] The Swedish Road Administration (Vägverket) is the national authority assigned the overall responsibility for the entire Swedish road transport system (the Swedish Road Administration, 2007).

life cycle emissions as diesel in Europe[13]. The CO_2 emissions are presented both with and without life cycle approach.

2.2.5 Important estimations

All travel data needed are not available from SKF. To be able to get a result for the total CO_2 emissions, unavailable data are estimated. The travels in regions without available data are estimated from the number of registered SKF email addresses. This is not an ideal method, but no better method is possible for this report. The method is motivated by the fact that many employees with SKF email addresses have business contacts that might require travels. Hence it is likely to be a better method of estimation than the regional number of employees or income. There are probably national differences in how frequently SKF email addresses are distributed. These differences hopefully cancel when Asia, Latin America, Africa and Oceania is compared to Europe. The method is approved by Rob Jenkinson, SKF Project Manager, Group Sustainability and Leif-Göran Lundstedt, SKF Group Travel Manager.

Other essential estimations include life cycle data for jet fuel, occupancies, aircraft and car models etc. Estimations are showed and commented on in appendix 5.

2.3 Environmental results

This section presents the environmental results directly from vehicle, in a life cycle perspective and as CO_2 equivalents.

2.3.1 Emissions directly from vehicles

In 2006, SKF travelled 200 million km for business, which caused the direct emission of 23 700 tonnes of CO_2. The distance is equivalent to 5000 laps around the world and the CO_2 emissions are the same as if every SKF employee would drive a car from Stockholm to Madrid[14]. Almost 80 % of the emissions come from air travels. Travels made by personnel in European offices are responsible for 62 % of the total emissions. The CO_2 emissions from business travel correspond to 5.7 % of the total CO_2 emissions from SKF production[15]. The average SKF flight distance is 1500 km and causes the direct emissions of 166 kilo CO_2, which is equivalent to combusting 70 litres of gasoline. The resulting emissions are summarised per region and means of transportation in table 1.

For SKF Sweden the emissions from business travels are 4500 tonnes and correspond to 45 % of the emissions from SKF Sweden's production[16]. This is explained by the fact that SKF have their headquarters in Sweden.

[13] Jet fuel is approximated to have the same life cycle emissions as diesel because it consists of a fraction from the production of fuels close to diesel (Wang et al, 2004). This approximation is also done by NTM, but with a reservation stating that this is a very rough estimation (NTM, 1998).
[14] Calculated using the emissions from the average SKF Europe rental car and 41 000 employees.
[15] The total emissions from SKF production 2006 was 420 000 tonnes (SKF, 2007).
[16] The total emissions from SKF Sweden's production 2006 was 10 000 tonnes (Jenkinson, 2007).

Table 1: Shows the direct CO_2 emissions from vehicles in tonnes for different means of transportation and regions (no life cycle data or CO_2 equivalents are included). Emissions from SKF Sweden are included in "Europe" and specified within parenthesis.

Means of transportation		Europe (Swe) (tCO_2)	USA and Canada (tCO_2)	Rest of the world (tCO_2)	All regions (tCO_2)
Cars	Company	2100 (270)	900	-	-
	Rentals	500 (50)	600	-	-
	Taxi	7 (2)	1	-	-
	Total	2600 (330)	1500	800	4900
Aircrafts		12500 (4200)	2300	4000	18800
Total		15100 (4500)	3800	4900	23700

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As illustrated in figure 2, the majority of the flights are in the shorter intervals (less then 1500 km). How many of these shorter flights that are connecting flights is not known, but it is likely to be a substantial part. The longer flights (over 1500 km) are responsible for most of the travelled distance and 58 % of the total emissions from aircrafts. For short intervals the part of the emissions are larger than the part of the flown distance, and for long intervals vice versa.

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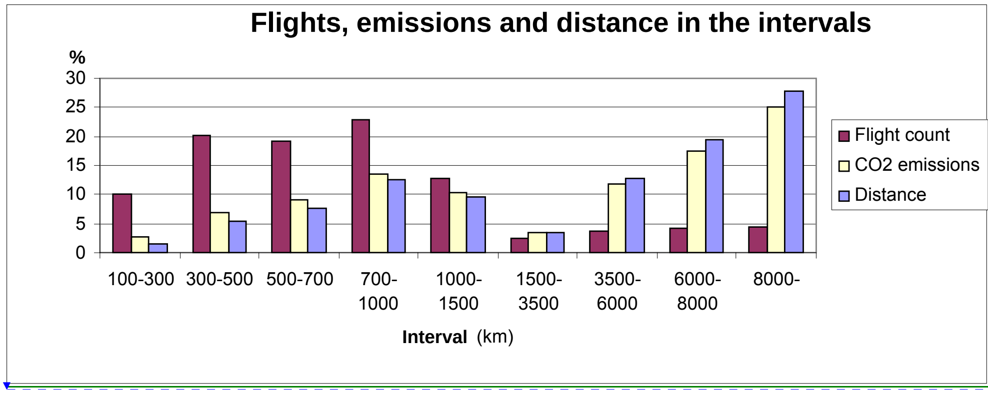

Figure 2: Shows the part of flights, CO_2 emissions and flown distance for the different intervals used in the calculation model.

The chartered aircraft from Göteborg to Schweinfurt is responsible for 1.4 % of the total emissions from business travel even though it was only used since August (see Part III Case studies for more results concerning the chartered aircraft).

2.3.2 Life cycle emissions and CO_2 equivalents

If the emissions caused by producing and transporting fuels are added to the total emissions from SKF business travel, the total emissions are increased by 16 % to 27 500 tonnes. The total global warming potential (GWP) with a life cycle perspective is 44 400 tonnes of CO_2 equivalents, or almost twice the direct CO_2 emissions from vehicles. The extra emissions by including a life cycle perspective, global warming potential for aircrafts and the total emissions are shown in table 2.

Table 2: Shows the total emissions from SKF business travel including life cycle perspective and CO_2 equivalents for cars, aircrafts and totally, in tonnes of CO_2 and CO_2 equivalents.

Means of transportation	**Directly from vehicles** (tCO_2)	**Extra for life cycle perspective** (tCO_2)	**Extra for GWP from aircrafts**[1] (tCO_2equiv.)	**Total** (tCO_2equiv.)
Cars	4900	900	-	5800
Aircrafts	18800	2900	16900	38600
Total	23700	3700	16900	44400

[1] Extra for GWP from aircrafts is the effects from other gases than CO_2 emitted by aircrafts at high altitudes. This is discussed in section 2.1 and subsection 2.2.1.

2.4 Sensitivity Analysis

This section analyses the reliability in the data looking at the direct CO_2 emissions, not CO_2 equivalents unless otherwise stated. The analysis is made for the sensitivities in travel data, in scientific knowledge and for the calculation methods.

A large effect in the sensitivity analysis comes from adding the effect of aviation induced formation of cirrus clouds. This does however only affect the result calculated for CO_2 equivalents which are dealt with separately because of its low accuracy. Other important factors are the estimated data, travels not included in data, capital goods and our calculation method for aircraft emissions. In our calculation method for aircrafts, the cabin factor is the most sensitive input. The analysed factors and their possible impacts are summarised in table 3 and further described in the following subsections.

Table 3: Presents the change and impact on the total emissions by different changes in five factors. The table does not include life cycle data and the total emissions are compared to the direct CO_2 emissions from vehicles, except for radiative forcing and capital goods.

Analysed factor	**Change**	**Change in emissions** (tCO_2)	**Total emissions and change** (tCO_2)
Calculation method	GHG-protocol's values	+ 1800	25300 (+ 8 %)
Cabin factor	65 and 85 to 90 %	- 3300	20300 (- 14 %)
	65 and 85 to 60 %	+ 4600	28100 (+ 19 %)
Allocation to cargo	0 to 10 %	- 1900	22400 (- 8 %)
Including RF from cirrus cloud formation	48 to 78 mW/m2	+ 21900	63000 (+ 53 %)[1]
	48 to 128 mW/m2	+ 56900	98000 (+ 138 %)[1]
Increased car travel	Extra 10 %	+ 500	24000 (+ 2 %)
Capital goods	Extra 16.4 %	+4500	32000 (+ 16.4 %)[2]

[1] The change in CO_2 emissions from including cirrus cloud formation are compared to the calculated value for CO_2 equivalents.

[2] The change in CO_2 emissions from including capital gods are compared to the total emissions from SKF business travels in a life cycle perspective.

2.4.1 Estimated travels

A key uncertainty in this report is the travels where no data are available. All emissions from these trips are estimated from a ratio of email addresses and could possibly be larger or smaller than estimated. For example, cars in Asia have different emissions than European cars. The average car in Asia is probably smaller, older and made by different manufacturers than European cars. The way SKF uses cars is possibly different due to cultural, traffic and infrastructural differences. Also the type of fuel used in cars is likely to vary between different regions. The ratio between the numbers of registered SKF email addresses in relation to the amount of travels may also differ between countries. This estimation relies on that the errors from different regions cancel each other out, and therefore the different estimated regions are not accounted for separately.

2.4.2 Trips not included in data

There are no guarantees that all trips are included in the data received from American Express travel agency, car rental companies and the SKF travel managers around Europe and North America. The number of business cars is probably near the real number because their quantity is important for economical accounting, but the distance for each car could differ.

The total amounts of air travels are possibly larger than the numbers received from American Express travel agency. The data include a few trips to places that do not exist and a number of travels with negative distances and light counts. According to American Express travel agency, all these trips are miss-registrations which can be deleted (Zdrilic Siljedahl, 2007). This means that other trips could have been registered wrong or not registered at all.

2.4.3 Calculation of emissions

If the emissions from aircrafts are calculated with emission factors used by the Greenhouse Gas Protocol[17], the total emissions from aircrafts become 8 % larger (Greenhouse Gas Protocol, 2003). Comparing the emission factors for each interval shows that our model is slightly lower in each interval, except on the shortest flights as seen in table 4. The difference is explained primarily by the fact that Greenhouse Gas Protocol's emission factors are from a set of only two aircrafts and that our model uses a higher cabin factor on long haul flights.

Table 4: Compares the emission factors from our model based on Hurdy-Gurdy, to the emission factors used by Greenhouse gas protocol. Our emission factors are generally lower, mainly due to a higher cabin factor on long haul flights.

Our Hurdy-Gurdy based model		**Greenhouse gas protocol's model**	
Distance (km)	**Factors** (gCO_2/pkm)	**Factors** (gCO_2/pkm)	**Distance** (km)
100-300	192	180	<452
300-500	140		
500-700	133	130	452-1600
700-1000	121		
1000-1500	119		
1500-3500	112	110	>1600
3500-6000	101		
6000-8000	101		
>8000	100		

[17] Greenhouse Gas Protocol is the most widely used international standard for calculating and reporting greenhouse gas emissions. The tool is developed by World Resources Institute and World Business Council for Sustainable Development (Greenhouse Gas Protocol, 2003). The Greenhouse Gas Protocol uses emission factors originating from the UK Department for Environment, Food and Rural Affairs (DEFRA, 2005) and a consultancy report (Netcen, 2003).

The radiative forcing from aviation induced formation of cirrus clouds is not included in the main results of this report, due to large uncertainties. It is however interesting to see how large the effect on climate change can be due to this formation. The TRADEOFF project gives an estimated mean value and an upper bound value for radiative forcing from these cirrus clouds (Sausen et al, 2005). If it is included in the results for total CO_2 equivalents, the result would be 63 000 tonnes of CO_2 equivalents for the mean value and 97 700 tonnes of CO_2 equivalents for the upper bound level. This is 53 % and 138 % higher, respectively, than the calculated emissions for CO_2 equivalents.

The calculation methodology for emissions from cars probably has a high accuracy. The driven distance is more likely to be miss-calculated. The effect from this is however small, compared to the sensitivity of the calculated emissions from aircrafts. A change of 10 % on the total distance by car only affects the total emissions from travels by 2 %.

2.4.4 Allocation of emissions

The cabin factor is an estimation with important impact on the emissions. If for example the cabin factor for all aircrafts is 90 %, SKF's part of the total emissions from aircrafts would be 14 % less, than with the calculated cabin factors. If the cabin factor is decreased to 60 % for all flights, the total emissions increase by 19 %.

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As discussed in the methodology, the aircrafts are often transporting cargo as well as passengers. If the cargo weight is estimated to be 10 % of the total load, 10 % of the emissions can be allocated to the cargo, and the rest to the passengers. This would lead to 10 % lower emissions from aircrafts and an 8 % decrease of total emissions from SKF business travels.

2.4.5 Capital goods

Frischknecht et al (2007) analysed 12 different passenger transport systems (including different sorts of aviation, railways, cars, buses and tramways). They find that on average capital goods are responsible for 16.4 % of the greenhouse gas emissions. If adding the general contribution from capital goods to SKF's CO_2 emissions, they are increased by 4500 tonnes to 32000 tonnes, in a life cycle perspective.

2.4.6 Other sensitivity factors

Other factors that have an input on the result are assumed to be of smaller importance, than the analysed sensitivity factors. These factors are for example all the estimations described in Appendix 5, such as that the business distances in business cars are assumed to a third of the total distance, when not specified, and that there is an estimated 10 % car rental in Europe with other companies than the contracted.

3 Part II Social and economic effects

This section deals with social and economic aspects related to business travels. The social aspect includes health effects, such as increased levels of stress and fatigue from working long hours. Positive sides of business travels are also studied, and the occasions when travels are most rewarding are highlighted.

3.1 Methodology

The two main sources of information for this part are literature studies and interviews that were performed with business travellers at SKF.

3.1.1 Literature studies

The main topics that are investigated in the literature are increased levels of stress related to business travels and social aspects, such as how a frequent business traveller's family deal with issues related to this. Positive sides of business travels are also studied.

Articles published in scientific journals are studied, in order to get a good scientific background. Articles in newspapers are used to find interesting quotes regarding business travels. A survey by Tandberg (2006) is also used, but it is not regarded as an objective source of information, since Tandberg is a global provider of video communication products and services.

3.1.2 Interviews

The main reasons behind the interviews were to validate the information found in the literature studies and to find out more specific information about SKF business travels. The interviews were performed with employees with different travel habits, geographical location and number of travel days per year, in order to get a comprehensive picture of business travels at SKF. Employees for the interviews were selected by SKF, and 71 % of the contacted employees participated in the interviews. The interviews were done over telephone.

A total of 10 interviews were conducted, with employees based in Sweden, England, USA, South Korea and China. The technique used during the interviews was that open questions were asked, to start a discussion about certain topics. The questions that our interviews were based upon can be found in appendix 6.

3.2 Social and economic results

The results from both literature studies and interviews are summarised in the following subsections.

3.2.1 Positive aspects of business travels

Face-to-face meetings are a good way of developing trust and build familiarity between team members, customers and suppliers. This is not as easily established in a virtual meeting. There are also moments, such as brainstorming, that require a free-form of interaction for long periods of time, and this is hard to achieve in virtual meetings

(Govindarajan and Gupta, 2001). The face-to-face contact that SKF employees get out of their business trips is regarded as one of the most positive aspects of business travels. This was discovered during the interviews. It is easier to address problems, share experiences, it adds extra value and understanding, it is easier to deliver a more balanced piece of information, there are less miss-understandings and it is easier to share and take part of ups and downs with customers, suppliers and co-workers when you meet in person. Another very important aspect is that it is easier to build a new relation and gain confidence, if you meet someone in person.

The president of the Air Travel Association, James May said in an article in the New York Times "*If you and I are talking and I can look at your face read you, that's a very important piece of the human interaction*." (Wald, 2006)

Often a business travel that is not a routine for the employee is regarded as a positive experience, and might inspire the employee to work more efficiently. Because of the absence of managers and supervisors, the employee may feel free and independent, which can lead to personal development (Gustafson, 2006). Some of the personal skills developed during international business travel are regarded as very useful for high positions in a global company. These include initiative taking, courage, open-mindedness and the ability to adapt to cultural differences (Oddou et al, 2000). Hence, business travels are beneficial for the development of future leaders in a company.

Some of the interviewed employees at SKF enjoy the possibility to see different places around the world. Travels can also decrease the feeling of isolation, which is further discussed in the subsection 3.2.3.

In the survey by Tandberg (2006), 69 % of the respondents said that being able to experience new cultures is one of the most positive aspects of their business travels. 58 % reported that they enjoyed socialising outside of the office and 47 % that the face-to-face contact is a big benefit of travelling.

3.2.2 Different ways of communicating

WebEx is a computer program that allows multiple users to connect to each other online, and share documents. One person at the time is able to control what is happening on the screen, and the same thing occurs on the other attendant's screens. WebEx is usually used together with phone conferencing.

Video conferences allow two or more users to interact through both video and audio transmission simultaneously. It can either be done with professional equipment, where a special room is set up to provide the best possible lighting, sound, sight etc. It can also be done by using a simple web camera on your personal computer, but this is not used within SKF since it does not provide the desired quality and use too much bandwidth.

During telephone or audio meetings the users have voice contact with each other. Everyone can remain in their offices and use their own material, but it is not possible to share documents as when WebEx is used.

Almost all of the employees interviewed are very happy with WebEx. It should not be used when there are too many persons involved, since it can be hard for everyone to be able to present their opinion. It is also popular to hold telephone meetings. Video conferences are however not very popular among the interviewed employees. One reason behind this is that the equipment does not always work as it should. Another employee thinks that this is mainly a reputation that videoconferencing received in the early days, before it was working properly. One employee also expressed the importance of being familiar with virtual meetings for them to work as intended. For many persons this is a new way of communicating and they need time to learn.

> *"To share the same documents is far more important than to see each others faces."*
>
> WebEx friendly SKF employee

Even though there are alternatives to travelling today, SKF business travels are not showing any decline (Lundstedt, 2007). Wald (2006) discusses around this subject, and comes to a conclusion on why business travels still are necessary; *"Because customers and clients expect it; because competitors still travel; because the march of technology has not managed to produce an equal to pressing the flesh."*

Despite the development of virtual meetings, most business people still consider face-to-face meetings to be more useful, productive and efficient, as shown in a study at the Virginia Community College (Martin et al, 1998). In this study, they also find that it is more important to know the other participants when attending a telephone meeting. This makes it important for a manager with a new position to travel and meet subordinates, customers and suppliers for the first time, to establish a good relationship. After the first social contact is made, it is easier to maintain the relationship using virtual meetings. This was also discovered during our interviews where the general opinion is that it is important to go and meet a customer, supplier or SKF facility when a new project just has started.

A chief executive officer of a global consumer products company said in a book by Govindarajan and Gupta (2001) "*There is an enormous premium on good, clean non-bureaucratic communication and that depends enormously on a high level of trust. That's why at the start of the team process, you have to be together personally. You can't start them with memos or telephone calls or things like that. You've got to get the group together to know each other and get a level of comfort and trust with one another. After that you can resort to the phone calls and videoconferences.*"

During the interviews, some employees said that most business travel related to a customer or supplier relation is very important, and almost never a waste of time. One employee said that he thinks that internal meetings between managers sometimes could be avoided. He also said that if everyone only talk about their own experiences regardless of the rest of the attendants, it might not be as rewarding. It is better to have a clear task with a meeting, so that everyone can be well prepared and share information.

The findings from the survey by Tandberg (2006) is that 29 % of business meetings could possibly be held via video conferences, and that 32 % of the interviewed persons think that video conferences would improve their work- and private life balance. The result also shows that 55 % of the interviewed business travellers think that some of their trips are unnecessary.

3.2.3 Stress, health and family concerns

Business travel stress is defined by DeFrank et al (2000) to be "*the perceptual, emotional, behavioural and physical responses made by an individual to the various problems faced during one or more of the phases of travel.*" This can be further explained by these examples; before the trip, pre-trip stressors include home and family issues, preparations for the trip and arrangements at work. During the trip itself, characteristics of travel, travel logistics, health concerns, host culture issues and job factors are all trip stressors. After returning home; job issues, family concerns and the physical and emotional recovery can all add to post-trip stressors (DeFrank et al, 2000). These different origins of stress may have negative effects on business travellers, such as mental and health problems, decreased work efficiency, personal and family problems, etc. (Gustafson, 2006).

Many of the interviewed employees feel a small increased level of stress when they travel and the origin of this stress comes from for example a tight schedule, concern about having a full inbox of emails, travelling through time zones, the occurrence of unforeseen events and anxiety about their families. However, it can sometimes be stressful not to travel as well. SKF employees often have their managers and co-workers in other countries. Not being able to meet with them regularly can create a feeling of isolation.

> *"On business travels one usually works long hours, exercise too little and eat too much food."*
>
> Frequent SKF traveller

The general opinion among the interviewed employees is that frequent business travels do affect health, but to what level differ among the interviewees. The schedule is usually tight on a business trips, and therefore it is hard to exercise at the same level that they are used to at home. One person said that he feels that it is hard to relax and sleep when they have to fly economy class on long flights, and as a result of this he feels very tired the following day.

Business travel can create a conflict between work obligations and career aspirations on one hand, and personal life and family obligations on the other hand (Gustafson, 2006). Some studies show that work-related travel becomes increasingly stressful when they create conflicts with family and personal life. The most important source of stress reported by international business travellers at the World Bank, is the effect that their travels have on personal and family life (Striker et al, 1999). Espino et al (2002) find that 50 % of spouses of travellers feel high or very high levels of stress, due to their partner's work travel. They also find that 53 % of the spouses report frequent changes in their children's behaviour, when their partners are away on business trips.

When a company only looks at the economic benefits from a business trip and excludes possible matters such as physical wear and tear, family disruptions and work overload, it seems as the view is short-sighted, and not in a sustainable way (Ivancevich et al 2003).

3.2.4 Costs for SKF business travels

In a cost study by SKF Group Travel Management for 2005, they find that the cost for the average SKF Sweden international business trip is € 2500 (Holmyr, 2007). This can be split up into the following parts; Airfare (32 %), travel hours and allowance (31 %), planning, ticket ordering and travel expense reports (9 %), hotel (9 %), meals, phone etc. (9 %), ground transports (8 %) and TMC fee[18] (2 %). The average trip lasts for 2.8 days; hence the average cost per day is € 900. The total costs for each part is shown in figure 3. In Part III the costs for loss of time is quantified.

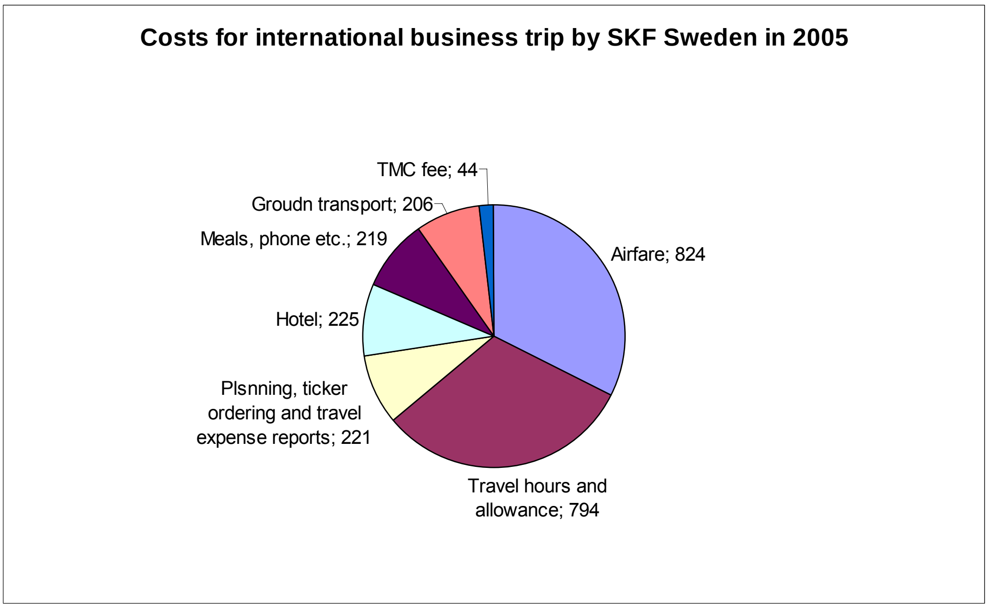

Figure 3: Illustrates the costs that are associated with an SKF Sweden international business trip. The cost for each part is included in Euro.

3.2.5 Work efficiency while travelling

Most interviewed employees try to work when travelling to their destination. How efficient they work depend on what time of day they are travelling, how long their flights, train or car rides are and if they use a direct connection. Some people think that it is very good to summarise their thoughts when going to a meeting, so that they are well prepared. There are usually fewer disturbances on flights compared to when they work in their offices, but still they do not reach the same level of efficiency as when working in

[18] TMC fee is the fee that SKF pays to their travel agency.

their office. One employee said that he valued his time on flights very much since it is his best time for reflection and thoughts concerning his work.

All interviewed employees try to check their email when they are away on business travels. This is often done after their working day is over, when they return to their hotel rooms. During the day it can be hard to find time for it, since their schedules are often tight during business trips. It is easier when they visit other SKF facilities, since then they can easily connect to their email and intranet.

3.2.6 Effects from the chartered aircraft

Some of the interviewees have used the chartered aircraft when going from Göteborg to Schweinfurt. They are all very happy with the charter and especially the amount of time that they can save instead of using a regular flight. It is also possible to work all day in Göteborg and then catch the charter in the evening. Another positive aspect of the charter is the possibility for employees to meet other people from SKF, and to chat with them during the flight.

A few negative aspects have arisen around the charter. First, that it does not fly on Sundays; hence you cannot attend or schedule meetings on Mondays. Second, some employees are more afraid of flying the small aircraft compared to regular flights. Third, space is limited on the aircraft which means that it is hard to work during the flight. Finally, if an employee needs to travel between Göteborg and Schweinfurt and is unable to fly with the charter, he or she needs a written permission to use a regular flight.

3.2.7 Other thoughts

For shorter trips most of the interviewed people try to take the train instead of flying or driving. The decisive factors are the time aspect, how good connections there are and how the time table agrees with their desired schedule.

One employee said that the SKF group has problems to coordinate its travels from different parts of SKF. An example is when managers from three different SKF factories go and visit the same supplier, to perform almost the same kind of inventory and work, during a very short period of time. This could be solved in a more efficient way, which reduces the amount of travels.

> *"One way to a more sustainable business travel is to reduce the amount of travels, and let the people who travel long distances either travel in business or in first class, to reduce the health effects that otherwise might occur from heavy travelling."*
>
> Free thoughts by an SKF employee

3.2.8 Key results

This section highlights the most important results from the interviews and literature studies.

- The most positive aspect of business travels for SKF employees is the face-to-face contact.
- Not all business travels at SKF are a necessity and it is mainly internal meetings that could be solved in other ways.
- WebEx is preferred before video conferencing, mainly due to its simplicity and lack of technical problems often experienced with video conferences.
- Travels are more important for establishing new relations than for communicating with existing contacts.
- Informative meeting are easier to have without face-to-face contact than debating or decision making meetings.
- Meetings with a high number of debating participants can be difficult to have without face-to-face contact, but if the participants are experienced with virtual meetings it is easier.
- Frequent business travels usually increase the level of stress among employees, which can lead to decreased work efficiency, damaged health and personal or family problems etc.
- Sometimes business travels have positive social effects.
- Generally the interviewed employees try to travel as little as possible to save time, money and environment.
- The chartered aircraft is very appreciated because of the amount of time that it saves for the employees.
- The average cost for an international business trip for SKF Sweden in 2005 was € 2500 or € 900 per day.

4 Part III Case studies

Two trips are thoroughly studied in this thesis. The first trip is from SKF headquarters in Göteborg to the SKF facility in Schweinfurt, Germany. The second trip is from Göteborg to Stockholm.

The reason for choosing the first trip is that it is one of the most frequent trips done by SKF and that they use a chartered aircraft for this trip. Hence, it is interesting to compare emissions from this chartered aircraft to that of a regular flight. The second trip is investigated since the length of the trip makes trains, cars and flights comparable when the time aspect of the trip is discussed. SKF does not have any facilities in Stockholm, but it is still a common trip for the employees. The results can be used as an approximation for other trips of the same length in other parts of the world.

4.1 Description of the case studies

The first case study is a comparison between two different ways of travelling from Göteborg to Schweinfurt. SKF charters a private aircraft which flies round trip from Säve airport to Hassfurt airport, where a taxi picks up the passengers. The aircraft carries a maximum of seven passengers and flies five days a week. The other investigated way of travelling is to use a regular flight from Landvetter airport to Frankfurt airport, take the train to Schweinfurt, and then a short taxi ride to the SKF facility.

The second case study is a comparison between different means of transportation, for the trip between Göteborg and Stockholm. For the train, the trip is done with X2000 from Göteborg Central Station to Stockholm Central Station. For car, the same distance is used and both the emissions from the average SKF Sweden company car and average SKF Europe rental car is investigated. For aviation, both Bromma and Arlanda airport are used and transfer between the central stations and the airports are included.

4.2 General methodology

In this section, a general methodology of calculating the emissions is presented. Specific information for the two case studies is then presented in two separate sections. The background data for the case studies are presented in appendix 7 and 8.

The case studies are performed with and without life cycle data. The emissions from trains are only presented with a life cycle perspective. The methodology for life cycle calculations on fossil fuels is further described in Part I, subsection 2.2.4. For fossil fuels marginal data[19] are estimated to be the same as average data, since the fuel production from non conventional oil[20] is diminutive (International Energy Agency 2006).

[19] Marginal data is used for production on “the margin”. The margin is the sort of production increase or decrease that a sudden change in use would lead to. In order to be able to see the potential environmental effects from a change in for example electricity use, the emissions from marginal electricity should be considered.

[20] Non conventional oil is from shales, sand-based heavy oil, derivates such as synthetic crude products and oil derived from coal and natural gas (International Energy Agency 2006). If the demand increases (or the

There are different possibilities for transfer to and from the different airports. The distances that are used for the different transfers are taken from Hitta.se and Mapquest (Hitta.se, 2007; Mapquest, 2007). Emissions from specific transfers are described further down. The emissions from all regular flights are calculated in the same way as in Part I.

Emissions from trains are calculated with average, specific and marginal data. The average energy use for the train is multiplied by the emissions associated with the energy production, and then divided by the number of passengers. Average electricity is used to calculate the emissions for the retrospective part of this study. The average electricity data are gathered from Andersson and Lukaszewicz (2006) and DB Energie (2006). Both the Swedish and the German train companies report the specific electricity[21] that they bought during 2006. Since this is the electricity production that the companies support, the emissions are also calculated from these specific electricity data. When calculating what a change in travels lead to, emissions from marginal electricity production are used instead of average electricity, as recommended by the Swedish Energy Agency (2006). The emissions from marginal electricity production are from the Swedish Energy Agency (2006).

As geographical boundary for the Swedish electricity market, the Nordic countries are used. As a time boundary a short time horizon is selected and hence this report does not consider long term changes in electricity production. The reason for the geographical boundary is that these countries share the same electricity market (Swedish Energy Agency, 2006). The power plants that produce marginal electricity for the Nordic market are coal condense plants. The Nordic market is however connected to both Germany and Poland, but these countries also have coal condense plants on the margin (Swedish Energy Agency, 2006). Therefore the same emissions for marginal electricity produced by coal condense plants as reported by the Swedish Energy Agency and IVL are used for both Sweden and Germany (Swedish Energy Agency, 2006; IVL, 2001).

The time consumption for the different trips is estimated from time tables and information from frequent travellers. It is used to compare economic aspects of the different trips when extra possible working hours are included in the costs. The average company cost for a business travelling employee is estimated by SKF (Holmyr, 2007). From this and an average of 180 work hours per month (180 work ours are used since overtime is included in the salary), the time aspect is included in the cost.

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supply decreases), the amount of non conventional oil probably increases. Fuels from non conventional oil are likely to have higher life cycle emissions.

[21] The Swedish train company SJ buys certified “Bra Miljöval” electricity (called specific electricity in this report). The electricity that is produced as “Bra Miljöval” will always be produced even if not explicitly sold. This means that when SJ increases its electricity usage, the extra produced electricity (which is produced by marginal electricity) is used by a different customer. It is not until all existing “Bra Miljöval” electricity has been explicity bought, that the producers will have to build new plants that are certified to produce “Bra Miljöval” electricity. When this scenario happens, the concept of buying “Bra Miljöval” electricity will have an effect on electricity production (Swedish Energy Agency, 2006; Kåberger and Karlsson, 1998).

4.3 Göteborg - Schweinfurt

In this section, first a specific methodology for this case study is presented, then the results, followed by a sensitivity analysis where the effect on the result from different input parameters are analysed.

4.3.1 Methodology

The transfer from SKF headquarters to Säve airport is done by the same kind of minivan every day, and the associated emission is obtained from the Swedish Road Administration (2006). The taxi that picks up the passengers in Hassfurt is assumed to be of the same size, and to have the same emissions.

When taking a regular flight from Landvetter to Frankfurt, a taxi ride from SKF headquarters is assumed. The specific kind of car is provided by Taxi Kurir and the emissions for this car are from the Swedish Road Administration (2006) and Hassi (2007). When travelling by taxi or rental car, the emissions are allocated to one person, except for the transfer to and from the charter. The taxi from Schweinfurt train station to the SKF facility in Schweinfurt is assumed to be the same as the taxi used in Sweden.

The fuel consumption for the chartered aircraft, a Piper Cheyenne III, is based on information from Air Alliance Express[22] (Kleindienst, 2007). The occupancy is based on statistical data since the daily flights begun in August 2006. Emissions from the regular flight are calculated as in part I. In this kind of comparative study, when emissions are calculated using two different methods, there is a greater risk for errors to occur. However, there is no way around this since the Piper Cheyenne III is not included in the Hurdy-Gurdy database. This is further discussed in the sensitivity analysis. In this case study, no CO_2 equivalents are calculated for the chartered aircraft since it flies on a lower altitude than commercial airplanes. No information is available on how other emissions than CO_2 from flying on lower altitudes affect radiative forcing.

In Germany a mixture of ICE1 and ICE3 trains are used when going from Frankfurt to Schweinfurt, and the energy consumption and number of possible passengers are taken as an average of these two sets of trains. Energy use for German trains is provided by DB Energie (Barth, 2007). The occupancy for German trains is estimated to be of the same as for Swedish trains. Distances for the German train rides are from Die Bahn (2007).

Costs for the chartered aircraft and the regular flight from Göteborg to Schweinfurt are from SKF (Lundstedt, 2007).

The total travel time for the chartered aircraft is based upon information from the time table. Regarding the regular flight, the necessary travel time is estimated after talking to frequent travellers about their travel habits and studying time tables.

[22] Air Alliance Express is the company from which SKF charter the aircraft.

4.3.2 Results case study I

The CO_2 emissions from the chartered aircraft (with life cycle data and including transfers) are 2220 kg per flight. This amount of CO_2 is emitted, regardless of how many employees that use the flight. The statistical average number of passengers (from August 2006 to February 2007) is 4.25. Hence the emissions per passenger are 523 kg CO_2 per flight including transfer. In table 5 below, the emissions from both trips are presented on a per passenger basis.

Table 5: Presents the emissions per passenger for the different ways of travelling from Göteborg to Schweinfurt with and without life cycle perspective.

	Without life cycle perspective		With life cycle perspective	
Part of trip	**Regular flight** ($kgCO_2$)	**Private charter flight** ($kgCO_2$)	**Regular flight** ($kgCO_2$)	**Private charter flight** ($kgCO_2$)
Transfer Sweden	4,9	1,2	5,6	1,4
Flight	107	450	124	520
Transfer Germany	11[1] (32[2])	1,4	11 (38[2])	1,7
Total	123 (144[2])	453	141 (167[2])	523

[1] Transfer in Germany is calculated with life cycle data for electricity since non life cycle data are not available for the emissions from the electricity production.
[2] If transfer in Germany is made by car instead of train (calculated on the emissions from an average SKF Europe rental car).

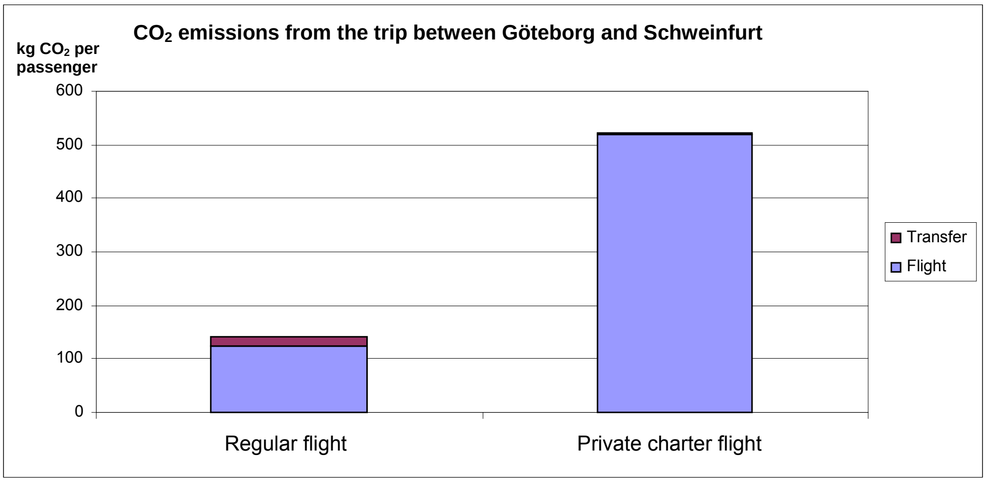

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Figure 4: Shows a comparison of the emissions per passenger, with a life cycle perspective for both the regular flight and the chartered aircraft. CO_2 equivalents are not included for either the regular flight or the charter.

In figure 4 the emissions are presented per passenger, and the emissions from all transfers are included. The chartered aircraft emits 3.7 times more CO_2 per passenger than a regular flight. The emissions from one flight with the chartered aircraft (maximum 7 passengers) are equivalent to the emissions generated by 16 persons travelling with a regular flight.

The price to rent and use the chartered aircraft is € 5000 per day. The cost for transfer to and from both airports is estimated to be € 137 per day for all the passengers. The average price per passenger for a regular flight is € 797 round trip and € 160 for all transfers. In order to make the chartered aircraft break even, it must carry at least 5.37 passengers per flight, compared to the current occupancy of 4.25. There are however other aspects involved. The time it takes from departure at SKF headquarters in Göteborg until arrival at the factory in Schweinfurt is around 3.5 hours with the chartered aircraft. With a regular flight it takes more than 6 hours, depending on different transfer times to and from the airports. The cost for salaries for the average business travelling SKF employee is € 37 per hour, which is added for every travelling hour. The costs and time consumption for a one way trip are summarised in table 6.

Table 6: Compares one way prices per passenger. The price per passenger for the chartered aircraft is calculated by using an occupancy of 4.25 passengers per flight.

Way of travelling	**Cost** (€)	**Cost (incl. loss of work time)** (€)	**Time Consumption** (h)
Chartered aircraft	604	732	3.5
Regular flight	479	698	6

If the costs for loss of work time are added to the travel costs for both travel options, the chartered aircraft is only € 34 more expensive per passenger compared to a regular flight.

Regarding the social aspects of the charter, the time saving and simplicity compared to choosing the regular flight with transfer are the dominating factors. All employees that were asked mentioned this as the best thing. Since it often is possible to save a day or two away from home, this means that employees can spend more time with their families, which is highly appreciated. The possibility to travel with and meet other employees at SKF is also positive.

4.3.3 Sensitivity analysis

The sensitivity analysis focuses on the emissions from the regular and the chartered aircrafts, without a life cycle perspective. For the chartered flight, the transfers account for 0.6 % of the emissions. Transfers for the regular flight option account for 13 %. Hence, the major part of the emissions originates from the two flights.

As was noted in the methodology for the aviation part of the trip between Göteborg and Schweinfurt, two different methods are used to calculate the emissions from the regular flight and the chartered aircraft. It would be ideal if the same method could have been used for both, but the chartered aircraft is not included in Hurdy-Gurdy. The possible error this may cause is hard to quantify, and the emissions calculated using the two methods are analysed separately.

However, some input parameters have been changed to be able to see which parameters that have the largest effect on the emissions. First, the fuel consumption for the chartered aircraft is changed by ±10 %. Second, the occupancy on the chartered aircraft is increased from 60.75 % (the current occupancy) to 80 %. Third, the emission factor (130 gCO_2/pkm) from Greenhouse Gas Protocol (2003) is used for the regular flight as in the sensitivity analysis of Part I. Finally, the occupancy of the regular flight is increased from 65 % to 85 %.

Table 7: Shows the changes in input parameters and the corresponding changes in emissions per passenger for the trip between Göteborg and Schweinfurt.

Analysed factor	**Change**	**Change in emissions** ($kgCO_2$/passenger)
Fuel consumption charter	±10 %	±45 (±9.9 %)
Cabin factor charter	4.25 → 5.6 passengers	-110[1] (-24 %)
Calculation method regular flight	GHG-protocol's value	+7.7 (+6.2 %)
Cabin factor regular flight	65 → 85 %	-22 (-18 %)

[1] The emissions per passenger are lowered by this amount. The total emissions from the chartered flight are relatively independent of the number of passengers.

In table 7 it can be seen that the cabin factors are important parameters, both for the chartered and regular aircrafts. A change in fuel consumption for the chartered aircraft and the use of GHG-protocol’s values for emission factors result in a smaller change of the emissions. If the comparison is made with 10 % lower fuel consumption and 5.6 passengers instead of 4.25, the charter emits 2.5 times more CO_2 per passenger than the regular flight.

4.4 Göteborg - Stockholm

This section compares different means of transportation between Göteborg and Stockholm. First, a description of how data have been gathered and used for calculations is presented, then the results and finally a sensitivity analysis.

4.4.1 Methodology

In Göteborg and from Bromma airport, half of the transfers are estimated to be done by taxi, and the other half by bus. From Arlanda airport, half of the transfers are estimated to be done by taxi and the other half by train (Arlanda Express). The emission data for buses are from NTM (2007) and the emission data for taxi are from the average car that Taxi Kurir uses (Hassi, 2007). Emissions from Arlanda Express are calculated in the same way as is done for trains in general, which is described in section 4.2. Data for energy consumption, occupancy and distance are from Arlanda Express (Byström, 2007).

For the flights between Göteborg and Stockholm, the distance used is from American Express travel agency data (Zdrilic Siljedahl, 2007), since both Arlanda and Bromma airport are used in Stockholm. Emissions from these flights are calculated in the same way as in Part I.

The high-speed train X2000 is investigated between Göteborg and Stockholm. Energy consumption and occupancy for this train is taken from the Royal Institute of Technology report Energy consumption and related air pollution for Scandinavian electric passengers trains (Andersson and Lukaszewicz, 2006). Emissions from the electricity that SJ purchases are from Vattenfall (2005). The distance used is from SJ’s homepage (SJ, 2007). The emissions from trains are calculated with average, marginal and specific data. This data refer to the emissions that are associated with the electricity production.

When calculating the emissions from driving a car from Göteborg to Stockholm, the emission factor from the average SKF Sweden company car is used, as well as the emission factor from the average rental car that SKF Europe uses. During these calculations, only the driver is assumed to be in the car. Hence, if passengers would join, the emissions per person would be lower.

Cost for the train ride from Göteborg to Stockholm is from American Express travel agency (Zdrilic Siljedahl, 2007). The price when flying is the sum of flight price, different taxes and the transfer to and from the airports. Some of these figures have been estimated based on information from taxi companies, Arlanda Express, SAS and Malmö Aviation. The cost for driving a company car includes the reduction in value of the car, insurance, fuel consumption etc. and is estimated based on data from the Swedish Consumer Agency (2007). The cost to drive a rental car from Göteborg to Stockholm vary substantially depending on what kind of car that is rented, which day of the week the car is rented, etc and is estimated based on information from Europcar (2007).

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The time consumption between Göteborg and Stockholm is calculated as the time it takes to go from Göteborg central station to Stockholm central station. For the train ride, this includes the actual travel time and 10 minutes transfer time. For the car, the time consumption is estimated from the distance and our experiences. In order to make this time applicable in other regions of the world, the road needs to be in good condition. When renting a car, 30 minutes extra time is added for picking up and leaving the car. The time consumption for the flight is the sum of transfers to and from the airports, checking in and out and for the flight itself. Some estimations are done after talking to frequent SKF travellers, about how much time they spend at airports.

4.4.2 Results case study II

The different kinds of data in the table 8 represent electricity produced in different ways. Average and marginal data refer to emissions caused by average and marginal electricity production, as is described in the methodology. Specific data represent the emissions from the electricity production purchased by the train companies. For emissions from cars, there is no significant difference in the emissions from marginal- and average petrol (International Energy Agency 2006). Hence, only average data are presented for emissions from cars. The emissions from the average SKF Sweden company car are lower than the average SKF Europe rental car because SKF Sweden uses a large part of greener cars[23]. The results are presented in table 8 and figure 5.

[23] Greener cars are cars that use alternative fules.

Table 8: Shows the emissions per passenger for different means of transportation. The emissions are calculated using life cycle data. For aviation, CO_2 equivalents are included in the parenthesis. The different kinds of data refer to electricity.

Kinds of data	Train ($kgCO_2$)	Aviation (including transfers) ($kgCO_2$ ($kgCO_2$ equiv.))	Company car (ave. SKF Sweden) ($kgCO_2$)	Rental car (ave. SKF Europe) ($kgCO_2$)
Average	3,4	74 (126)	79	101
Specific	0,002	73 (126)		
Marginal	34	75 (127)		

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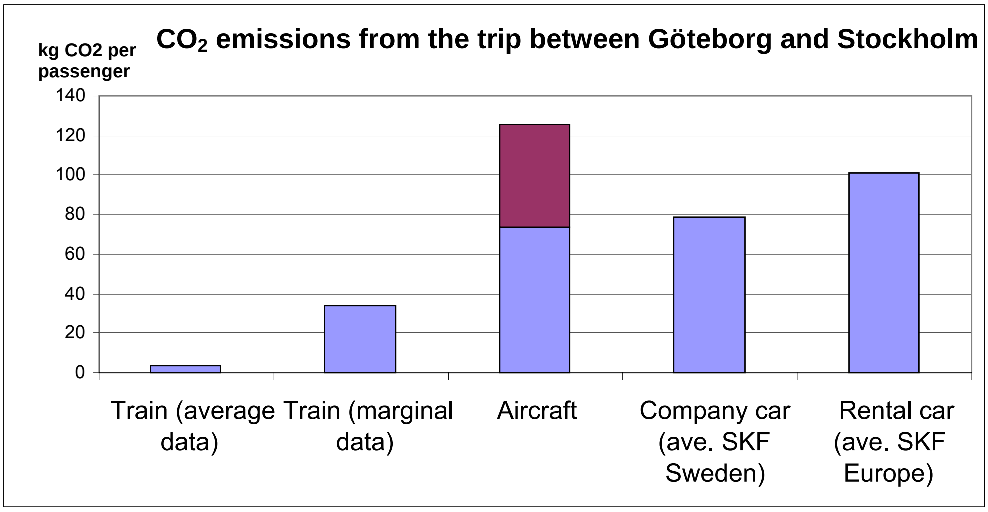

Figure 5: Compares the different means of transportation, using average data and a life cycle perspective. For aircrafts, CO_2 equivalents are included on top of the CO_2 bar.

It is possible to apply these environmental results to other trips than between Göteborg and Stockholm. The emissions from flying a trip of the same length are believed to be the same throughout the world, since the most common airplanes are used in this calculation. The emissions from the rental car are believed to best represent the emissions from SKF company cars in other countries.

The applicability of the emissions from trains is dependent on how the electricity is produced. Sweden has very low CO_2 emissions from their electricity production. Hence is the emissions calculated using Swedish average data not applicable for most countries. It is our interpretation that emissions from marginal electricity production are more correct to use internationally, but that the emissions from specific electricity production for each country or region should be considered.

The average cost for a train ride between Göteborg and Stockholm for SKF in 2006 was € 93 (Zdrilic Siljedahl, 2007). The price for SKF to fly from Göteborg to Stockholm in 2006 was on average € 200. The cost for driving a company car is € 150. The total cost for renting a car and driving the distance is estimated to be around € 150, based on prices from Europcar (2007).

The travel time for the train is 3.25 hours and this includes a quick transfer to and from the train in both cities. When flying, it is estimated that the transfer to the airport takes one hour, then the flight takes one hour and finally the check out and transfer takes on average 45 minutes, thus the total travel time is 2.75 hours. The time it takes to drive the distance is estimated to be 5 hours. Hence, for this particular distance, the flight is the fastest, closely followed by the train and then the car which is considerably slower. As in subsection 4.3.2, € 37 is added to the cost for every travelling hour. The costs and the estimated travel times are summarised in table 9.

Table 9: Summarises the costs (both with and without loss of work time) and time consumption for travelling between Göteborg and Stockholm.

Means of transportation	**Cost** (€)	**Cost (incl. loss of work time)** (€)	**Time Consumption** (h)
Train	93	210	3.25
Flight (including transfers)	200	300	2.75
Ave. SKF Sweden company car	150	330	5
Ave. SKF Europe rental car	150	350	5.5

4.4.3 Sensitivity analysis

The results from this study are compared to the results for the same means of transportation, but calculated with methods from NTM (2007) and Greenhouse Gas protocol (2003). The comparison is showed in table 10.

Table 10: Presents the fossil CO_2 emissions for different means of transportations and calculation methods for travelling Göteborg to Stockholm. Transfer and life cycle emissions are excluded except for trains where no life cycle data would result in zero emissions.

Method	**Train marginal data** ($kgCO_2$)	**Train specific data** ($kgCO_2$)	**Aviation** ($kgCO_2$)	**Car** ($kgCO_2$)
Our results	34	0.002	58	64 and 86[1]
NTM	-	0.002	74	94[2]
GHG-protocol	27[3]	-[4]	62	90

[1] The first value is for an average SKF Sweden car (including almost 50 % greener cars) and the second for an average SKF Europe rental car.
[2] The value from NTM is adjusted to respond for one person in the car instead of for 1.8 passengers.
[3] The data from GHG-protocol are for UK rail, with average electricity production. This type of electricity production is best compared to Swedish marginal electricity.
[4] The data for trains by GHG-protocol are not considered comparable with the specific emissions from trains in Sweden.

The different results for aviation are explained by the fact that NTM and Greenhouse Gas protocol calculate emissions with other aircrafts and occupancies. The difference in methods for calculating emissions from aviation is discussed in the sensitivity analysis in Part I. For cars the results are different because different car models are used. The value of 64 kg CO_2 is significantly lower than the other results, since SKF Sweden have almost 50 % green cars among their business cars.

5 Results

In 2006, SKF business travels caused the direct emissions of 23 700 tonnes of CO_2, which correspond to 5.7 % of the total CO_2 emissions from SKF production. The direct CO_2 emissions from business travels are the same as if every SKF employee would drive a car from Stockholm to Madrid. With a life cycle perspective, the CO_2 emissions increase to 26 200 tonnes of CO_2, and if the total global warming potential of aviation is included, the emissions are 44 400 tonnes of CO_2 equivalents. For SKF Sweden the emissions from business travels are 4500 tonnes, which correspond to 45 % of SKF Sweden's production. SKF charter an aircraft that flies daily between Göteborg and Schweinfurt. This charter emits 3.7 times more CO_2 than a regular flight combined with train transfer. When travelling from Göteborg to Stockholm, train is by far the most CO_2 effective way of travelling.

The most positive aspect of business travels is the face-to-face contact. Face-to face contact is most important for establishing new relations, decision making meetings, debating and relations with costumers and suppliers. Business travels at SKF do have a negative effect on health for some of the employees, but can occasionally have positive effects. The chartered aircraft decreases the negative social effects from business travels. All SKF business travels are not a necessity and some physical meetings can be substituted for virtual meetings. Interviewed SKF employees prefer WebEx over video conferencing, mainly due to its simplicity and lack of technical problems.

6 Discussion

Decreased amount of travel will lead to lower emissions, improve the social situation for frequent travellers and save money on travel expenses. If business travels are decreased in the wrong way, this can affect the production and sales effectiveness negatively. According to the results in Part II, some meetings can be substituted for other ways of communication, without negative effects on business. The results also show that some meetings are more suitable to change than others. Our suggestion is that a specific proportion of the meetings should be virtual meetings. The part of virtual meetings should be high for internal and informative meetings with few participants.

Increasing employee awareness of the problems related to business travels is an important part in reducing the negative effects. It is easier for the employees to change their travel habits if they are aware of the negative effects of travelling. One way of raising employee knowledge and to find solutions is through education and workshops, both specific for travels and for sustainability in general. This report also helps raising the knowledge. Another way, which is difficult for SKF to influence, is through external media. For raising employee awareness to have a good result on the employees' travel habits, it is important that senior managers lead by example. Employees, who succeed in lowering their amounts of travels, should be highlighted so that everyone can see that it is possible. To share good ideas is also a vital part of succeeding in this area.

One important step in taking control over, and manage the company's CO_2 emissions from business travels, is to become better at keeping track of all travels. This can be done by a web based booking system used globally. Then it is possible to see and measure emissions from individuals, business units, divisions etc. It would be ideal if this tool includes the CO_2 emissions from the trip that is about to be reserved, so that the employee can choose the best trip from price, travel time and CO_2 emissions.

The results from the comparison of different means of transportation in part III show that trains emit the lowest amount of CO_2 among the compared modes of transportation. It also shows that the CO_2 emission reduction, if changing one trip from Göteborg to Stockholm from aircraft to train, is over 40 kg (a 55 % reduction). Since this is calculated with marginal data, the results are fairly applicable on that distance in other countries as well. If 50 % of all the flights by SKF under 500 km are changed to train, with the same emission reduction per pkm as in the example between Göteborg and Stockholm, the benefit is 600 tonnes of CO_2 annually (1500 tonnes CO_2 equivalents, if including other gases from aircrafts affecting radiative forcing). With average data, the reduction if changing one trip from aircraft to train is 71 kg or 95 % per trip.

Big savings in CO_2 emissions can be reached by changing from heavy cars with big engines to smaller greener cars. SKF Sweden works actively with their car fleet and had almost 50 % greener cars in 2006. The background data of part I (see appendix 3) show that the average SKF Sweden business car emits almost 50 % less CO_2 per km than the average SKF US business car. If SKF business cars in USA and Canada had the same emissions per km as SKF Sweden, the reduction in CO_2 would be almost 500 tonnes annually. The emissions from cars can also be decreased by education in ecodriving. Ecodriving is an economical way of driving that reduces the fuel consumption and hence the CO_2 emissions by around 10 % (Johansson, 2003; Ecodriving, 2007).

If focusing only on the environment, the chartered aircraft from Göteborg to Schweinfurt should be stopped, since the CO_2 emissions are 3.7 times higher per passenger, than the emissions from a regular flight. From a social perspective the charter should not be removed, because it simplifies the trip, saves time and has a positive effect on social relations among the travellers. A removal of the chartered aircraft would therefore have a negative effect on the work environment. Our suggestion is that SKF have a discussion about how important the social and environmental effects are, and then make a decision about the future of the charter. The environmental effects from the charter can be reduced if the number of flights is decreased, without completely loosing its benefits.

The results from Part II state that some business trips have a positive effect on the social aspect. This is especially applicable on employees that do not travel frequently and therefore gets extra motivation, individual development and a feel of importance for the company. Hence, it could be positive for frequent travellers (often managers) to delegate responsibilities and tasks in need of business travels to non frequent travellers.

Better and earlier planning, from SKF and their business partners, would make it easier for employees to plan both their private and working time. This is likely to have positive effects both on stress and family relations. Early reservations save money on ticket expenses and might increase the possibility of getting direct flights which have a positive effect on CO_2 emissions and travel time.

The improvement of technology is likely to benefit virtual meetings in the future. The main negative inputs from SKF employees on video conferences are technical problems like quality of the picture, delays and time consumed to get started. WebEx has already changed the attitudes towards virtual meetings. So even if the results from the interviews are negative towards video conferencing, virtual meetings with live sound, picture and document sharing facilities can replace many business trips in the future.

Finally, we think that SKF should strive to include the emissions from business travels in the annual report, and in the CO_2 emission reduction plan. The plan is to reduce the CO_2 emissions from production by 5 % annually, independently of production increase. For business travels a 5 % reduction corresponds to 1200 tonnes the first year. This would force SKF to decrease the emissions and send clear signals to the employees that SKF have addressed the negative effects from business travels. It also means that SKF has to introduce some kind of system for reserving business travels online, as discussed above, to be able to keep track of all the travels and emissions.

7 Further work

SKF needs to get better at controlling the amount of travels in the regions where estimations had to be made in this report (Asia, Latin America, Africa, Oceania and parts of Europe). We think that further investigations of the business travels in these regions are important for assessing the total effects from business travels. This can be done by introducing a web based booking tool or local travel managers with control over the travels.

Some meetings require face-to-face contact and cannot be substituted for virtual meetings. Which trips and meetings that are a necessity can be investigated in different ways, for example by an internal survey among SKF business travellers, another master thesis or a consultant company. Another key issue is to increase the awareness among employees about the negative effects from business travels. We give some suggestions on how to do this in chapter 6, but think that it is an area suitable for further studies, both at SKF and other companies.

Climate change is not the only environmental effect affected by business travels. Other effects such as acidification and eutrophication can be studied. Capital goods can be included when analysing the environmental effects, since they may have a large effect on the result. For the social effects from business travels, it is desirable to include for example the number of sick days due to business travels in a sustainability report.

It is also important that the scientific research around aviation’s impact on climate change is further investigated. Today there are large uncertainties on how aircrafts affect climate change and the aviation induced formation cirrus clouds are still not included in the total effect on radiative forcing, due to too low scientific understanding. A better understanding of this in the future could result in a larger or smaller effect on climate change from aviation, than calculated in this report.

In this report the emissions are allocated equally among all passengers. Allocation by revenue is another way of allocating emissions. This allocation method is from some points of view fairer, since expensive business tickets generate the most income to the airline companies, and consequently contributes more to the fact that there is a flight than cheaper tickets. Hence, it can be motivated that business travellers with expensive tickets should be allocated a larger part of the emissions. Since the airline companies do not show the ticket income from different types of tickets, this type of allocation is not possible in this report. Allocation by revenue would however be suitable for further investigations, especially for airline companies offering their passengers the possibility to offset their CO_2 emissions.

During discussions close to the printing of this report a new incentive for business travels came to our knowledge. Travel allowance can sometimes be so high, that it motivates employees to go on business trips for the benefit of their personal economy. If this is the case for SKF is not known, but it might be worth investigating.

8 Conclusion

The environmental effect from SKF business travels is the emission of 44 400 tonnes of CO_2 equivalents or 23 700 tonnes of direct CO_2. The direct emissions are equivalent to 5.7 % of the emissions from all SKF production facilities, or the same as if every SKF employee would drive a car from Stockholm to Madrid.

Business travels at SKF do have a negative social impact on frequent travellers. The social effects include for example stress, fatigue, health problems and damaged family relations. These effects are likely to lead to decreased work efficiency and increased absence due to sickness. The social effects from business travels can also be positive, especially for non frequent travellers. The company costs for SKF Sweden is on average € 2500 for an international business travel.

The CO_2 emissions from the chartered aircraft, flying daily from Göteborg to Schweinfurt, are 3.7 times higher compared to regular flights. The charter has other advantages, which include time savings, social relations and health. Negative environmental effects from business travels on shorter distances (less than 500 km), can be decreased if SKF change their ways of travelling in favour of trains and greener cars.

For SKF to have a sustainable development of their business travels, they need to successively change physical- to virtual meetings and travel in ways that emit less CO_2. One way of doing this is to introduce an online booking system, so that all employees see the CO_2 emissions for all travel alternatives before the reservation. With this kind of system globally in use, SKF also gets more exact data on the CO_2 emissions from travels and can include these emissions in their annual report and emission reduction plan. Another way is to increase employee awareness concerning the effects of business travels and the benefits of virtual meetings. In order to decrease negative social effects from business travels, the SKF employees that travel most, need to delegate responsibilities and tasks in need of business travels.

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Appendix

1 Trains

Data are only available for the 15 most common train trips for SKF Sweden. The total distance for these trips is 730 000 km. The rest of the trips are assumed to be an extra 50 %, giving a total distance on 1.1 million km. For electrical trains, the energy consumption is from NTM (2007), representing the high speed train X2000 with an occupancy of 55 %. The emissions from electricity production in Sweden are from Andersson and Lukaszewicz (2006) and for Europe from Öko-Institut and Gesamthochschule Kassel (2006). For diesel trains the emission factor is from NTM (2007) for a train type Y2 with an occupancy of 40 %. The results are presented in table A1.

Table A1: In the table the emissions from trains in Sweden are calculated with different sets of trains and electricity production. In the right most column the emissions from train is compared to the emissions from SKF Sweden's total business travels.

Type of fuel for the trains	**Emission factor** (gCO_2/pkm)	**Emissions** (tCO_2)	**Part of total emission from business travel**[1] (%)
Ave. Swedish electricity	7	7.3	0.2
Ave. European electricity	33	36	0.8
Diesel	41	45	1.0
90 % European electricity and 10 % diesel	33	37	0.8

[1] SKF Sweden's total emissions are 4500 tonnes of CO_2.

There is no reason to believe that train travels by SKF have a bigger part of the emissions from the rest of the world than for Sweden, with European electricity and 10 % diesel trains. Since these emissions are under one percent of the total emissions from business travels, train travels are ignored in this report.

2 Aircraft

The aircrafts are selected to provide a good estimation of the most commonly used aircrafts, according to the big airline companies and an inventory made by The Federal Aviation Administration (Kim et al, 2005). For the seat configuration, cabin factor, cruise altitude and time for taxi, the default settings in Hurdy-Gurdy are used. For flights longer than 3500 km an increased cabin factor is used. This is also done by SAS emission calculator and is motivated by the high costs for empty seats on long haul flights (SAS, 2007). The modelled aircrafts and settings are shown in table A2. Our version of Hurdy-Gurdy cannot calculate emission factors with different cabin factors. According to Hassleroth (2007), the Airbus 340-300 has an increased fuel use of 6 %, at a distance of 13000 km at 9144 m of cruise altitude, if the cabin factor is changed from 65 % to 100 %. Assuming a linear increase in fuel consumption and the same relationship at shorter distances, this adds 3.4 % extra fuel consumption at 85 % cabin factor.

Table A2: Shows the different aircrafts and settings used to model aircraft emissions.

Aircraft	**Configuration** (number of seats)	**Cabin Factor** (%)	**Cruise altitude** (ft:m)	**Taxi in and out** (time in min)
Airbus 320	150	65	30000:9144	10
Airbus 340-300	263	85	30000:9144	10
Boeing 737-300	142	65	30000:9144	10
Boeing 747-400	414	85	30000:9144	10
Boeing 757-200	185	65	30000:9144	10
Fokker 50	50	65	30000:9144	10
MD 81	155	65	30000:9144	10
SAAB 2000	50	65	30000:9144	10

The data used for calculating the emissions from aircrafts are presented in table A3. The distance is the great circle distance, corresponding to the distance of a straight line between two airports with consideration to the curvature of the earth.

Table A3: Shows the data used for calculations of emissions from aircrafts and the resulting emission factor for each interval.

Interval	**Flight count** (No of flights)	**Average distance** (km)	**Modelled aircraft**	**Percentage**	**Emission factor** (gCO2/pkm)
100-300	6606	227.6	Saab 2000 Fokker 50	66 34	192
300-500	13265	406.3	B[1] 737-300 MD[2] 81	66 34	140
500-700	12694	591.2	B 737-300 MD 81	60 40	133
700-1000	15050	823.1	A[3] 320 B 737-300 MD 81	50 30 20	121
1000-1500	8512	1135.8	A 320 B 737-300 MD 81	50 30 20	119
1500-3500	1672	2018.0	A 320 B 737-300 B 757-300	50 30 20	112
3500-6000	2435	5252.9	B 747-400 A 340-300 B 757-300	50 40 10	101
6000-8000	2811	6847.8	B 747-400 A 340-300	50 50	101
8000-	2979	9305.7	B 747-400 A 340-300	50 50	100

[1] B is short for Boeing.
[2] MD is short for McDonnell Douglas.
[3] A is short for Airbus.

3 Cars

The CO_2 emissions from cars are calculated from a mixture of company cars, rental cars and taxi. Data are not available for all countries, but the following data are used as a base for estimating the total emissions from SKF business travels by car. The emission factors from different cars are primary from the Swedish Road Administration (2006) and life cycle data are from General Motor Corporation et al (2001, 2002). The emissions from company cars are calculated on data from SKF travel managers, and the results are shown in table A4.

Table A4: Shows the data used for calculating the emissions from company cars and the resulting emissions in total and for each country where data are available.

			Without Life Cycle perspective		**With Life cycle perspective**	
Country	**Number of cars**	**Distance** (km/car)	**Factor** (gCO_2/km)	**Emissions** (tCO_2)	**Factor** (gCO_2/km)	**Emissions** (tCO_2)
Austria	36	11479	194	80	213	88
Belgium	75	10275	176	136	196	151
Canada	49	9971	255	125	306	150
France	163	12500	149	304	166	339
Germany	313	8026	165	414	181	455
Italy	236	11613	154	421	170	466
Spain	42	14605	157	96	175	108
Sweden	240	8026	140	270	166	320
US	280	10476	255	748	306	898
Total	1434	10067	179	2593	205	2974

The rental cars from Europcar are only for the countries with a special contract. These countries are: Austria, Belgium, Germany, France, Italy, Portugal, Spain, Switzerland, Sweden and United Kingdom. For these countries, except Germany, 10 % extra emissions are added for rentals with other companies. For Germany, 20 % extra emissions are added due to more rentals with other rental companies (Lundstedt, 2007). Data for rental cars in USA and Canada are received from local travel mangers. The data used for calculations and resulting CO_2 emissions are shown in table A5.

Table A5: Shows the data used for calculating the CO_2 emissions from rental cars and the resulting emissions.

Country/ Rental company	**No of rental days**	**Distance** (km/day)	**Without Life Cycle perspective**		**With Life cycle perspective**	
			Factor (gCO_2/km)	**Emissions** (tCO_2)	**Factor** (gCO_2/km)	**Emissions** (tCO_2)
Europcar	8968	223	182	364	206	412
Canada	344	223	192	15	230	18
USA	14430	223	192	618	230	742
Total	23742	669	-	997	-	1172

For taxi, data are only available for Sweden from the contracted taxi company, Taxi Kurir. A vast majority of Taxi Kurir's cars are Volvo V70 D5 (Hassi, 2007). Trips from other taxi companies are added as an extra 30 %.

Table A6: Shows the data used for calculating the emissions from taxi for SKF Sweden. The emissions are presented both with and without a life cycle perspective.

Factor	Without life cycle perspective	With life cycle perspective
Distance	5340 km	5340 km
Emissions for a Volvo V70 D5	179 gCO_2/km	206 gCO_2/km
Emissions from taxi with Taxi Kurir	0.9 tonnes	1.1 tonnes
30 % from other companies	0.3 tonnes	0.3 tonnes
Transfer to chartered aircraft	0.8 tonnes	0.9 tonnes
Total emissions from taxi	2.1 tonnes	2.4 tonnes

4 Life cycle data

The life cycle data is added as extra emissions after the emissions from the combustion are calculated. The values from General Motor Corporation et al (2001, 2002) are presented in table A7.

Table A7: Shows the different values used for calculating the life cycle emissions.

Data for	**Value** (% extra emission)
Gasoline[1]	17.6
Diesel	15.3
Gasoline (US and Can)	26.1
Jet fuel	15.3

[1] Gasoline refer to all gasoline used in cars by SKF except in US and Canada

5 Estimations

All the travels reserved by employees from offices in Asia, Latin America, Africa and Oceania are estimated. This estimation is based on the number of SKF emails in the region in relation to regions with available data. The number of SKF email addresses is obtained for each country and table A8 summarises the emails regionally. The estimation is not ideal, since a comparison of the number of email addresses only corresponds reasonably well to the number of travellers, but it does not say anything of the emissions. This means that all the differences in travelled distances, frequency, size and modernity of cars etc. are neglected. This also means that no differences are included for activities in Asia, Latin America, Oceania and Africa.

Table A8: Shows the number of registered SKF email addresses in different regions.

Region	Number of SKF email addresses
Europe without Sweden	9519
Sweden	3761
USA and Canada	2472
Asia	2357
Latin America	1338
Rest of the world	683
Total	20130

The impacts from the most important estimations are described in the sensitivity analysis (section 2.4). The table A9 strive to present an overview of all essential estimations.

Table A9: Describes and comments on the essential estimations used in calculations for SKF business travels.

Estimated factor	Estimation	Comment
Aviation		
Air travel booked from all other offices than the countries with an American Express travel agency contract (Au, Be, Fr, Ge, It, Ne, Sp, Swe, UK).	From the number of registered SKF email addresses in the regions compared to the data from American Express travel agency.	The relationship between the number of email addresses and emissions from travels is the best (only) thing to estimate the emissions from.
Occupancy, aircraft models, cruise altitude, landing and take of cycle, aircraft seating configurations and standard weather conditions for all regular aircraft calculations.	From data received from airline companies, aircraft manufactures, and Hurdy-Gurdy standard settings.	Some of these estimations are crucial for the total emissions from business travel.
Distance in aircrafts.	The modelled distances are estimated to be the great circle distances (GCD) instead of the actual flight distances.	The actual flight distances are not available but the extra distances at takeoff and landing are included in the calculation model. Our interpretation is that the GCD is generally used when calculating emissions.

Estimated factor	Estimation	Comment
Car		
All car travels in Asia, Latin America, Mexico and Africa.	From the number of registered SKF email addresses in the regions compared to available data in Europe.	The relationship between the number of email addresses and emissions from travels is the best (only) thing to estimate the emissions from.
From company cars in Europe where no data is available (All countries except Au, Be, Fr, Ge, It, Sp and Swe).		
Company car models.	Most countries car models are divided into a couple of standard models.	The models are selected from the most common SKF cars in each country.
Distance in company cars for business in most countries.	The business distance is assumed to be a third of the total distance.	Based on the business and private distances from the countries that reported both private and business distances.
Taxi travels for Europe, USA and Canada.	From the taxi travels in Sweden and the number of registered email addresses.	Data for taxi is only available for the contracted taxi company in Sweden.
Taxi travels in Sweden with other companies than the contracted carrier.	As an extra 30 %.	
Rental cars in other countries than USA, Canada and Europcar contracted countries in Europe (Au, Be, Fr, Ge, It, Sp, Swe).	From the number of registered SKF email addresses in the regions compared to available data in Europe.	The relationship between the number of email addresses and emissions from travels is the best (only) thing to estimate the emissions from.
Distances for rental cars in USA.	To be the same per rental day as in Canada.	Canada is the best corresponding country.
Fuel life cycle		
Life cycle data for jet fuel.	Estimated to be the same as for European diesel.	No comparable Life cycle data is available for jet fuel. NTM also use the data for diesel.
Life cycle data for all fuels in other countries than Europe, USA and Canada.	Estimated to be the same as for Europe.	Motivated by practical reasons of finding comparable life cycle data for all other regions.

6 Interviews

The following questions have guided the interviews.

- What is your position at SKF and what kind of work do you usually do?
- To what countries do you usually travel?
- How many travel days do you have annually?
- What are the main purposes of your travels?
- By what means of transportation do you usually travel?
  Including to and from airports, short and long distances
- How relevant do you find your trips?
  Including both a personal and a company perspective and relevance for social and practical issues.
- How do you perceive your work efficiency?
  Both before, during the travelling, at the destination and after the trip.
- What do you consider is the most positive aspects of business travels?
- What do you think of different ways of communicating?
  Including video conferencing, WebEx and telephone meetings.
- How do you perceive your travels?
  Effect on health, stress, family and work burden.
- Do you need time to recover after your trips?

7 Göteborg - Schweinfurt

Swedish distances are from hitta.se (2007) and German distances are from Mapquest (2007). The car models in Sweden are provided by Taxi kurir (Hassi, 2007), and the emission factors are from the Swedish Road Administration (2006). The taxi cars in Germany are assumed to be of the same size, and to have the same emission factors as the Swedish taxi cars. The number of passengers in the taxi related to the charter is based on statistical data from SKF (Holmyr, 2007). The data are shown in table A10.

Table A10: Presents the data for calculating the emissions for transfer to and from airports and train stations with taxi. The emissions do not include a life cycle perspective.

Part of taxi transfer	**Distance** (km)	**Emission factors**[1] (gCO_2/km)	**Number of passengers**	**Emissions** ($kgCO_2$)
Charter				
SKF HQ - Säve airport	22,9	227	4,25	1,2
Hassfurt airport - SKF facility	27,1	227	4,25	1,4
Regular flight				
SKF HQ - Landvetter airport	27,1	179	1	4,9
Schweinfurt - SKF facility	1,9	179	1	0,3

[1] The emission factor is for the car and not per passenger.

Data for fuel consumption for the chartered aircraft is provided by Air Alliance Express, the company which SKF rents the aircraft from (Kleindienst, 2007). The CO_2 emissions are calculated by multiplying a factor from IPCC (1999) with the total consumption of jet fuel. The average number of passengers is from statistical data from SKF (Holmyr, 2007).

Table A11: Shows the data for calculating the emissions from the chartered aircraft. The emissions do not include a life cycle perspective.

Trip	**Fuel use** (kg)	**Total emissions** ($kgCO_2$)	**Number of passengers**	**Emissions** ($kgCO_2$)
Säve airport - Hassfurt airport	608	1915,2	4,25	450

The flight distance between Landvetter airport and Frankfurt airport is from Guides Network (2007). Emission factors are calculated in the same way as for flights in general, and the different aircrafts share of the total number of flights is the same as in Part I. Background information for calculating emissions for regular flights is presented in table A12.

Table A12: Shows the data for calculating the emissions for the regular flight. The emissions do not include a life cycle perspective.

Type of aircraft	**Distance** (km)	**Emission factors** (gCO_2/pkm)	**Emissions** ($kgCO_2$)	**Share of flights**
MD-81	883	131	116	20%
Boeing 737-300	883	123	109	30%
Airbus A320	883	116	103	50%

The train distances are taken from Die Bahn (2007). Energy use for German trains and emissions from electricity production in Germany are provided by DB Energie (Barth, 2007; DB Energie, 2006). The occupancy for German trains is assumed to be the same as for Swedish trains. The data for German trains are shown in table A13.

Table A13: Data for calculating emission from the train transfer in Germany. The emissions from trains include a life cycle perspective.

Part of trip	**Distance** (km)	**Energy use** (kWh/train km)	**Electricity production emissions** (gCO_2/kWh)	**Emission factors** (gCO_2/pkm)	**Emissions** ($kgCO_2$)
Frankfurt airport - Wurzburg	149	21,2	514	43,9	6,5
Wurzburg - Schweinfurt	44	11,7	514	100,4	4,4

8 Göteborg - Stockholm

The distances for buses and taxis are taken from hitta.se (2007) and for Arlanda Express from Byström (2007). Emission factors for buses are from NTM (2007). Energy use and occupancy for Arlanda Express is from Byström (2007). Data from all transfers are shown in table A14.

Table A14: Shows the data for calculating the emissions for transfer to and from airports in both cities. The emissions do not include a life cycle perspective, except for the emissions from Arlanda Express where a life cycle perspective is included.

Transfer	**Distance** (km)	**Emission factors** (gCO_2/pkm)	**Emissions** ($kgCO_2$)	**Share of transfer**
Göteborg Landvetter				
Bus	25,3	60	1,5	50 %
Taxi	27,1	179	4,9	50 %
Stockholm Bromma				
Bus	9,4	78	0,7	25 %
Taxi	9,4	179	1,7	25 %
Stockholm Arlanda				
Arlanda Express	37,5	17	0,6	25 %
Taxi	41,1	179	7,4	25 %

The flight distance between Landvetter airport and Bromma/Arlanda airport is from American Express travel agency (Zdrilic Siljedahl, 2007). Emission factors are calculated in the same way as for flights in general, and the different aircrafts share of the total number of flights is the same as in Part I. The data are shown in table A15.

Table A15: Shows the data for calculating the emissions for the regular flight. The emissions do not include a life cycle perspective.

Type of aircraft	**Distance** (km)	**Emission factors** (gCO_2/pkm)	**Emissions** ($kgCO_2$)	**Share of flights**
MD-81	415	152	63	34 %
Boeing 737-300	415	133	55	66 %

The distance for driving from Göteborg to Stockholm is from hitta.se (2007). Emission factors are from the Swedish Road Administration (2006).

Table A16: Shows the data used for calculating the emissions from cars. Emission factors for cars include a life cycle perspective.

Type of car	**Distance** (km)	**Emission factors** (gCO_2/km)	**Emissions** ($kgCO_2$)
Ave. SKF Sweden company car	472,6	167	78,9
Ave. SKF Europe rental car	472,6	214	101,1

The distance for the train ride is from SJ (2007). Energy use and occupancy are from Andersson and Lukaszewicz (2006). CO_2 emissions from electricity production of "Bra Miljöval" electricity is from Vattenfall (2005), for Nordic average electricity the emissions are from Andersson and Lukaszewicz (2006) and for Nordic marginal electricity the emissions are from the Swedish Energy Agency (2006). Information about Swedish trains is presented in table A17.

Table A17: Presents the data for calculating the emissions from a train ride. The emissions from trains include a life cycle perspective.

Type of train	**Distance** (km)	**Energy use** (kWh/train km)	**Electricity production emissions** (gCO_2/kWh)	**Emission factors** (gCO_2/pkm)	**Emissions** ($kgCO_2$)
X2000	456	13,6	5,2[1]	0,4	0,2
X2000	456	13,6	96[2]	7,4	3,4
X2000	456	13,6	969[3]	74,9	34,1

[1] ”Bra Miljöval”-electricity.
[2] Nordic average electricity.
[3] Nordic marginal electricity.

The rising threat of climate change makes it necessary for companies to work with greenhouse gas emissions in a wider perspective than only focusing on production. This report deals with the effects from business travels, which for instance is an important contributing factor to climate change. The business travels at SKF are studied with a sustainability perspective, including environmental, social and economic effects for the company.

The report summarises all SKF's global travels and their effect on the climate. It also includes the travels' effects on the travellers and their families and average costs. Two case studies are included in the report comparing a small chartered aircraft with a regular flight and three different means of transportation between Göteborg and Stockholm.