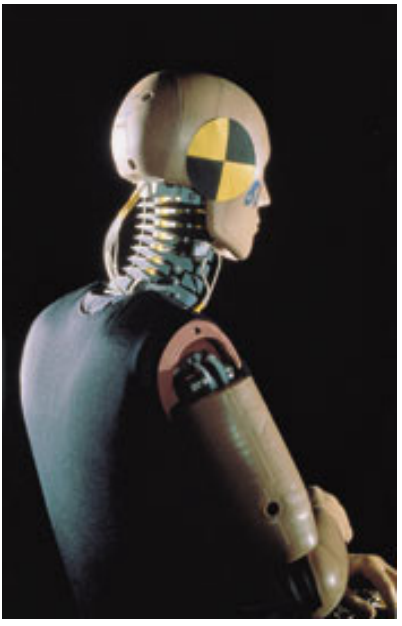
VINNOVA ANALYSIS
VA 2005:05

IMPACTS OF NECK INJURIES RESEARCH AT CHALMERS UNIVERSITY OF TECHNOLOGY

Summary



KNUT SANDBERG ERIKSEN & ARILD HERVIK ET AL

SUMMARY OF VINNOVA ANALYSIS VA 2004:07

Title/Titel: Impacts of neck injuries research at Chalmers University of Technology. Summary
Author/Författare: Knut Erik Sandberg Eriksen & Arild Hervik et al
Series/Serie: VINNOVA Analysis VA 2005:05 (summary of VINNOVA Analys VA 2004:07)
ISBN: 91-85084-33-6 **ISSN:** 1651-355X
Published/Utgiven: April 2005
Publisher/Utgivare: VINNOVA – Verket för Innovationssystem / Swedish Agency for Innovation System
VINNOVA´s Case No/Diarienr: 2004-00608

About VINNOVA

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VINNOVA´s mission is to promote sustainable growth by developing effective innovation systems and funding problem-oriented research.

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Impacts of neck injuries research at Chalmers University of Technology

Summary

(of VINNOVA Analys VA 2004:07)

Knut Sandberg Eriksen
&
Arild Hervik et al

VINNOVA´s foreword

This Summary Report presents the main results of an impact analysis on research on the understanding of how neck injuries resulting from traffic accidents actually occur. These injuries, often called whiplash injuries, account for around 65 % of all injuries that lead to medical disability.

VINNOVA, and its predecessors TFB and KFB, have funded basic research at Chalmers since 1985. The Programme Board for Automotive Research (PFF), established in 1994, made it possible for the researchers at Chalmers to co-operate more closely with those conducting development work in the automotive industry. As a result, the Swedish automotive industry, in close co-operation with researchers, has been able to develop better car seats that reduce the risk of injury by half when this kind of accident occurs.

The objective of this analysis has been to describe the impact of VINNOVA's and PFF's funding of the research on the companies and on society. The analysis also aims to describe the mechanisms that have been important to the identified impacts.

A team at the Norwegian Institute of Transport Economics was selected to perform the analysis. This team was composed of Knut Eriksen Sandberg, project leader, Rune Elvik, Rolf Hagman and Arild Steen. Professor Arild Hervik from Molde University College, who is a recognised evaluator in Norway, was also linked to the team.

We wish to extend our thanks to the investigators and also to all those who have contributed through interviews and in other ways. We also wish to mention the research on crash safety conducted by the insurance company Folksam and the Swedish Road Administration which has provided important input to the calculations on socio-economic impacts.

The full report in Norwegian, titled Effektanalys av nackskadeforskningen vid Chalmers, VINNOVA Analys VA 2004:07, is available at www.VINNOVA.se under "Publikationer".

Stockholm, November 2004.

Per Eriksson

Director General

VINNOVA

Contents

1 Introduction

Neck injuries resulting from traffic accidents pose a serious health problem to Swedish society. They account for more than 2 000 injuries per year, or 65% of all injuries that lead to medical disability.

Since 1985, VINNOVA and its predecessors, TFB and KFB, have funded basic research at the Crash Safety Division (TTS) of the Chalmers University of Technology on how whiplash injuries arise.

VINNOVA has, as a rule, provided 100% of the funds. Since it was founded in 1994, the Programme Council for Vehicle Research (PFF) has also funded research and developement in the field. PFF is a body for co-operation between the motor industry and the State, with each party providing 50 per cent of the funds. On behalf of VINNOVA, the Institute of Transport Economics in Oslo and Møre Research in Molde have analysed the effects of the research on neck injuries conducted at Chalmers after 1985. The benefits to society, the companies involved and the research field have been analysed. The aim has been, as far as possible, to quantify the effects in financial terms, or in terms of other physically measurable effects, and to highlight the contribution made by the research from the point of view of innovation systems. Three different methods were selected in order to carry out this assignment. Each of these methods covers part of the assignment but also complements the others:

1. The economic analysis has attempted to establish elements of the financial benefit for Swedes in general, for the industry and for the world at large, and to compare these benefits with the costs. This analysis shows that the historically-based economic benefits exceed the economic costs. This net present value tells us something about the value of the research in a market perspective. Such a historical cost-benefit analysis encounters many measurement problems, however, and many effects fall outside the framework of this analysis. It does, however, indicate how high the value of the established R&D unit may have been in an historical perspective.
2. The second method moves away from market-oriented valuation methods. It approaches instead a classic valuation of an R&D institute in which no direct attempt is made to value the institute concerned in market terms but rather to benchmark the institute in relation to other equivalent R&D institutes in terms of a number of dimensions. The measurement indicators include the number of scientific articles published, the number of doctorates, the quality of the research, the development of networks and collaboration with other institutes, the utilisation of the research and the methodology underlying the

development and dissemination of knowledge and know-how. We have followed a classic tradition in that we have started by conducting our own valuation in order to acquire relevant knowledge and then followed this up with a panel of key individuals who have been invited to participate in an open discussion in order to assure the quality of the evaluation. This in turn has been complemented by further interviews followed by the evaluation by the panel of experts. The problems encountered have related to evaluating the various indicators as result requirements for the institute and to creating a good basis for the benchmarking process in order to ascertain what constitutes a highly-competent R&D institute. The main problem has been to establish how high a target to set.

3. In the private sector, the value of a company is not set on the basis of historical data but on the basis of the profits expected in the future. Future profits are, however, often forecast on the basis of previous data, and in this context there are parallels with the private sector in terms of the historical economic analysis. The market value of a company, e.g. a listed R&D unit such as the Internet company FAST, must reflect the market value that can be expected in the future, as until fairly recently the company has returned only limited profits. In its simplest form, market value is then the estimated future cash flow that the market expects this R&D unit to be able to create. The parallel with our analysis is that we not only have to deal with the great degree of uncertainty regarding the value created, but that, from an economic perspective, we must also be able to establish what we expect this R&D activity to be able to create in the form of a reduction in the number of accidents, increased automobile sales and spin-offs to other projects in the future. The R&D unit must, on the basis of its strategies, be able to make clear that it can further reduce the number of whiplash injuries, with all the benefits this can provide, while also opening up new research routes. This entails not only considering what has been achieved so far, but also evaluating what can be achieved in the future. In this evaluation, it is important to assess whether the competence that has been developed has the potential to improve this type of preventive measure by means of research, so that injuries can be reduced even further.

2 Economic analysis

2.1 Methodology

The benefit to society of providing effective protection against injury can for the most part be divided into two categories. First, for the general public, the benefit is that the quality of certain cars will be improved. The second category relates to the benefit that will fall to Swedish industry in connection with increased exports of these products or cars that contain them. This category partly reflects the benefit to the world at large of these products, but has been calculated using an entirely different method.

The method for calculating the benefit to consumers is based on the method applied in the cost-benefit analysis of infrastructure investments in the transport sector. Here, an attempt is made to measure the increase in the willingness to pay in relation to the improvement in quality. This can be measured as a consumer surplus by assuming that the improvement in quality is not covered in the form of a price increase on the Swedish market.

The calculations are based in part on SIKA's recommendations concerning the costs of injuries suffered in traffic accidents, where a death is estimated to cost SEK 17.5 million, a serious injury SEK 3.1 million and a less-serious injury SEK 175 000 million. Neck injuries are difficult to fit into the usual injury pattern, but we have calculated that the costs for a neck injury that gives rise to symptoms for more than six months (serious neck injury) is in the region of SEK 2 million.

The benefit to Swedish industry is calculated in the form of the increased export value of these products on the world market.

2.2 Benefit to the consumer

Protection against neck injuries in the form of active, protective components in car seats and head restraints can be found primarily in cars produced in Sweden by Volvo and Saab. The analysis is based on calculations performed by the insurance company Folksam on the number of serious and slight neck injuries and on five analyses of the injury-mitigating effect, four Swedish and one American. Overall, these indicate a mitigating effect of 50 per cent for the serious injuries and of 20 per cent in the case of less-serious accidents.

It is calculated that the number of Swedish cars containing such protection equipment in the period from its introduction in 1997 up to 2004 amounts to 250 000. We have calculated that the benefit per car and year averages SEK 675. For the entire car fleet, this amounts to SEK 169 million. Assuming that the cars will be used for a period of 15

years, the benefit to the Swedish consumer thus totals SEK 1 900 million for the cars in which neck protection equipment was installed on the production line.

The post-installation of neck protection equipment has taken place recently. In a joint project, Folksam and Autoliv have developed new equipment for projection against whiplash injuries for post-installation in the existing vehicle fleet. It costs SEK 1 000 per car to install this equipment. In order to test the effects of this measure, Folksam installed similar neck protection equipment in 8 000 Toyota Corolla cars built between 1993 and 1997. The preliminary results indicate that the general risk for whiplash injuries is halved when the equipment is installed. This is well in line with previous calculations.

Let us assume that it is realistic to post-install neck protection equipment in 10 per cent of the Swedish car fleet of approximately 4 000 000 registered cars, i.e. in 400 000 cars. Estimates indicate that 200 serious injuries and 2 000 less-serious injuries will occur in these cars if this equipment is not installed. By installing the equipment, we could reduce the number of serious injuries by 100 and the number of less serious injuries by 400.

If we use the same cost valuations as in Eriksen et al (2004), we arrive at a cost saving for Swedish society of SEK 226 million once the installation costs have been deducted. Calculated over the cars' remaining lifetime (which is assumed to be 10 years) this amounts to SEK 2 040 million. The average per car with post-installed neck protection equipment is thus SEK 564 per year and SEK 5 105 discounted.

Equipment to protect the side of the head is available in the form of several products, including inflatable curtains. The development of these products has been closely linked to the research conducted at Chalmers. Autoliv has taken the lead in this field, and all the cars produced by Volvo and Saab are now fitted with such equipment. A recent American survey indicated that this type of side protection reduces the risk of death in connection with a car accident by 45 per cent. Our calculations indicate that the reduction regarding serious injuries is approximately half of this figure. Using accident statistics, we have calculated the number of fatal traffic accidents that have been caused by collisions from the side or by diagonal collisions. We believe that the number of cars in Sweden with various forms of side protection for the head amounts to 460 000, but this figure is uncertain and may be too high.

The calculations show that the benefit per car and per year averages SEK 305. For the entire car fleet this totals SEK 140 million per year, and calculated over the lifetime of the cars the figure is SEK 1 600 million.

2.3 Value to industry

For Swedish industry, the benefit of offering cars fitted with good neck and head protection equipment consists of the increase in the value of net sales on the export market. On the basis of information from Autoliv, we have calculated that this value is almost SEK 1 200 per car. If we assume that 350 000 Swedish cars with such equipment are exported annually, this provides a benefit of SEK 420 million per year. If we add the annual benefit to Sweden of these factory-installed products, we arrive at a total of SEK 700 million. On the other hand, it is no simple matter to total figures that have been arrived at in such different ways.

The value of the lead gained by Swedish research depends on how great we estimate this lead to be, which is highly uncertain. In the case of neck protection equipment we estimate the lead to be six years. Calculated over a 10-year period, this provides a benefit of SEK 1.3 billion. In the case of equipment to protect the side of the head, the lead is estimated to be three years. This provides a benefit of SEK 960 million after discounting. We will not go into further detail about these estimates here.

The degree of uncertainty is high. There is a lack of reliable data in most cases. Sensitivity analyses have therefore been carried out which show that the results are stable in the event of changes in the cost calculations.

2.4 Costs

We have not been able to produce a complete overview of the research and development costs for neck protection equipment and equipment to protect the side of the head. A major part of the problem lies in the difficulties associated with determining and identifying the boundaries between which costs are linked to which products. Funds from State research sponsors such as VINNOVA and PFF can be identified, but constitute only a part of the whole. The total funds allocated by PFF to TTS at Chalmers from 1994 to 2003 amounted to SEK 26.4 million. Industry contributed the same sum, so the total for these programmes is SEK 52.9 million. How large a part of the research on neck injuries has been funded by Chalmers internally is unknown.

VINNOVA and its predecessors provided funds of SEK 18.8 million between 1985 and 2003. Account must be taken here of double calculations and of the fact that TTS has also participated in other projects.

Saab's and Volvo's development costs for neck protection equipment were between SEK 1.5 and 2 million per year from 1994 to 2003. This is our valuation, which is based on discussions with representatives of the industry, and is in addition to pure research projects (cf. PFF) in which Autoliv has also participated. Autoliv is a research-

based group that invests major sums in research and development each year. The percentage relating to neck injuries is not known.

Other research concerning neck injuries has also been carried out at other research institutes in Sweden. The financial extent of this research is not known.

2.5 USA – a comparison

It is not only in Sweden that these products are of great economic importance. As an example of the effects in another western country with high accident costs, we have conducted a simple review of the importance of similar factory-installed neck protection equipment in cars sold on the American market to American consumers. We estimate that the effect in terms of reducing injuries is similar to that in Saab and Volvo cars in Sweden.

The greatest difference between the USA and Scandinavia with regard to cars is how the cars are used. With a population of 264 million, the USA has 133 million cars, i.e. approximately the same number of cars per person as in Sweden. On the other hand, annual mileage per car is assumed to be much greater in the USA, a factor which should also be reflected in the accident statistics.

The evaluation of the benefit of avoiding accidents is based on an article by Zaloshnja et al (2004). In order to make it easier to make comparisons with our earlier calculations, we have converted all the figures into Swedish Kronor (SEK) and merged the two lowest classifications of the degrees of injury used in America. This gives us a figure of approximately SEK 3.5 million for a serious neck injury and of SEK 200 000 for a less serious neck injury. This is somewhat higher than the figures we used for Sweden (approximately SEK 2.0 million and SEK 175 000).

We have no absolutely reliable figures on how many cars on the American market have factory-installed neck protection equipment, but estimate the number to be approximately 1 million. The total number of whiplash injuries in the USA is, according to various sources, in the region of 1 million per year. Some 140 000 of these are classed as serious injuries. We assume, as in the case of Sweden, that the injury mitigating effect of neck protection equipment in cars is 50 per cent for serious injuries and 20 per cent for less serious injuries. In our calculation for 1000 000 cars, the number of serious neck injuries should thus be 1 037. With neck protection equipment it should then be possible to reduce the number of these injuries by 519, and the number of less serious injuries by 1 274.

This constitutes and annual saving of SEK 2.1 billion. Calculated over an assumed lifetime of 10 years for American cars, the total benefit for these cars will thus be SEK 18.7 billion. The annual benefit per car is SEK 2 070, which over a period of 10 years totals SEK 18 700.

It can be noted that this represents a significantly higher average benefit than in Sweden. This is due to a combination of the fact that the accident rate per year is twice as high and that the cost per accident is somewhat higher. Whether the higher accident rate is realistic or not is not something that we will go into here, but it is clear that cars that are used more are more exposed to accidents. To what extent this applies in other countries is not known, but Sweden is assumed to be more like the rest of Europe than the USA.

2.6 Summary

There is a great degree of uncertainty in these calculations. Sensitivity calculations have therefore been carried out. These are not presented here but indicate that the calculations are stable with regard to cost elements and the injury mitigating effects.

The main impression, therefore, is that the systems for protection against injury described above provide **major economic benefits**. No attempt has been made to draw up cost-benefit ratios for these measures as we can only determine some of the costs. It is highly unlikely, however, that the costs approach anything like the level of the economic benefits.

The analyses do not take into account the future benefits of an increase in the use of neck and head protection equipment, or the potential that similar products in the same area may have.

3 Measurement of the results of the TTS

The TTS's objective is to conduct basic research as well as more applied research with a focus on the users of Volvo and Saab vehicles. The TTS shall also provide teaching at the basic research and further education levels and has its own budget for this. A third objective is to disseminate the knowledge acquired by participating in the general public debate.

3.1 Teaching

An indication that the objective concerning basic research has been achieved is the number of PhDs that have been awarded. Since 1985, 15 doctors have graduated from the TTS. Five of these now work at Chalmers, three are employed in the Swedish motor industry (including accessories), five work in the motor industry abroad and two are at research institutes in other countries. Almost half of the doctors are thus working abroad, which is a high figure. Although 1/3 of the doctors have remained at Chalmers, this is not a particularly high proportion. This PhD course makes an important contribution to disseminating research knowledge throughout the industry, but only 1/5 of the graduates work in the Swedish industry. The TTS has a staff of 7 researchers and awards just over one PhD per year, which is a fairly low figure. In both 2002 and 2003, however, two PhDs were awarded, while one was awarded in 2004, so the level seems to be improving. On the other hand, the TTS has acted as an examiner for 15 engineering licentiates. In addition to the PhD course, the institute provides tutoring for approximately 15 Master's theses each year and runs foundation courses for the engineering programme. In its own evaluation, the TTS points to the PhD courses as the most important activity. TFB, KFB, and VINNOVA were important sources of funding for the initial PhD courses.

3.2 Basic research

Another important indicator that the TTS engages in basic research is the number of articles published in recognised journals that require review by referees. In 2003, eight such articles were published. This is a fairly high figure considering the size of the Institute, especially as half of the articles were published in journals the set the highest quality criteria and are the most prestigious. Two articles were particularly highlighted in 2003. Ten articles were published in 2002 and 10 referee-reviewed articles in 2001, which makes an average of approximately 10 published articles per year. In 2004, three

articles have been published so far (spring 2004). The articles published represent a wide distribution of authors. From the perspective of published articles, it seems therefore that the basic research conducted at the Institute is of high quality, judging from the volume of articles and the quality of the journals they have been published in. Together with the approximately two doctoral theses per year in recent year, this indicates a good level of participation in basic research.

The basic funding for the teaching activities comes from the State, and the finances for these activities are well balanced. The group that teaches is also the group that conducts externally-funded research, and external funding increased from SEK 8.1 in 2001 to 12.4 million in 2003 (over and above funding for teaching). This major increase points to a problem for the development of basic research, as the level of basic funding has declined from 50 per cent to 14 per cent. Between 1985 and 2002, TFB/KFB/VINNOVA financed both basic research and applied research. In 2003, VINNOVA decided to extend its previous support and thus to provide funds for the planning of future projects. VINNOVA pointed out that this would entail a temporary reduction, but that this would not affect the possibility to receive funding in the future. Since the start of 2004, VINNOVA's funding has continued at the normal level.

The TTS has become more dependent on the project funds from the PFF provided by the industrial collaborators, and on EU projects. The PFF's funding has played an important part in the co-operation between the industry and the problem-oriented basic research system. The close co-operation between the industrial and research worlds, in which both parties are "forced" to collaborate with each other, is felt by both parties to be very fruitful. However, the dependence on such funding makes the research group more vulnerable to shifts in funding and also reduces the focus on basic research.

If TFB/KFB had not funded the operations of the TTS in its initial development phase, it is uncertain whether the research programme on neck injuries would ever have been started. At that time, Per Lövsund and his group did not have the academic qualifications required to obtain funding from the normal sources for university research. The co-operation between the TTS and a funder that does not primarily focus on basic research (TFB/KFB/VINNOVA) is felt by both parties to be very positive and fruitful.

In order to conduct basic research, an organisation must exceed a certain critical mass and have the funds required to participate in international conferences and to publish articles. With a level of funding of 14 per cent, the TTS is now in a more vulnerable position with regard to basic research. On the other hand, the major increase in external funding indicates that the Institute has the ability to compete for funds to secure the required funding level. It is important for the Institute to demonstrate that it can compete successfully for research funds from the EU and companies. This provides evidence of a high level of user-friendliness.

In the long term, however, there is a risk of placing too great an emphasis on acquiring funds from industrial companies, as this can take place at the expense of basic research. This would eventually undermine the benefit provided by the fact that basic research complements the research carried out at companies.

To date, the TTS seems to have been successful with regard to basic research. There is a clear view within the field that the TTS has been, and still is, the world leader. This view is strongly supported by the partners of the TTS in industry: Saab, Volvo and Autoliv. The synergy that arises between teaching and the fact that teaching is funded by the State reduces this problem somewhat, but interviews reveal that industry also invests a lot of time and energy in acquiring funds for basic research. Such funds can only be provided by the user environments to a minor extent. The list of customers that the TTS can present as a basis for external funding has, over the last three years, contained only three users: Volvo, Saab and Autoliv, and the fact that the Institute is so dependent on so few users for such a large part of its budget entails a certain risk. The fact that Volvo and SAAB are now owned by American companies can be said to increase this risk.

3.3 Research networks

Over the years, the TTS has developed an important network within the research system and in relation to user environments. The fact that representatives of the institute attend international conferences and present their own work, with referees, demonstrates that the Institute participates in network structures within the research system. In 2003, the Institute visited nine such conferences with referees and five other conferences. In 2002, the figures were eight and two respectively, while in 2001 the figures were ten and two respectively. The researchers attend an average of approximately two international conferences per year to present their own work. This is not a particularly high figure, but they attend the most important of these conferences.

Ever since this research began, the Institute has formed a close network with the motor industry, and today this network with Volvo, Saab and Autoliv is important both in terms of technological development and funding. In 2003, half of the funds came from collaboration projects paid for through these companies, with the PFF providing almost half of the funds involved. This co-operation is also being developed by providing four part-time (20 per cent) research posts for doctoral candidates from these companies. The fact that that this network is effective is also demonstrated by the list of articles published, as several of these candidates are among the authors. Chalmers is also the only university in Europe to have a co-operation agreement with GM on the development of a course for further education in safety engineering.

Folksam, a Swedish insurance company, has also been an important collaborator for many years. Other important national collaborators in the health field are Gothenburg

University, the Karolinska Institute and Lund University. There is no established collaboration with the important research projects on health-related whiplash being conducted at the Royal Institute of Technology by Hans von Holst and in Gothenburg by Olle Bunketorp and Malin Lindh at Östra Hospital. There is a certain amount of co-operation with the latter group, but these contacts could probably be intensified. Other collaborators in Sweden include Linköping University, the Swedish National Road and Transport Research Institute, the National Road Administration and the Swedish Road Traffic Inspectorate. There is a long list of international collaborators that are primarily involved in EU projects.

An important research network has been developed over a long period of time, which demonstrates that the Institute is active in terms of both the users and other research environments. The TTS' co-operation with industry and other research institutes, particularly in the Gothenburg region, appears to have been an important precondition for the success of the research on neck injuries conducted at Chalmers. The funding provided by TFB/KFB/VINNOVA and PFF has also been and important factor in this co-operation.

3.4 Product development

In the whiplash field, the TTS has developed a product called BioRID, a physical model or dummy that is used within the industry and for academic purposes and that is the result of basic research on theoretical and physical models, testing methods and injury criteria. BioRID is sold under the Institute’s own patent. The dummy has, together with mathematical models and knowledge about injury mechanisms and injury criteria, led to the development of protective systems at Volvo and Saab. SAHR and WHIPS have been installed in their cars since 1997-1998. The Institute has also contributed to the development of systems that are now sold by Autoliv for protection in the event of side collisions and the protection of pedestrians.

3.5 Summary

We can summarise this appraisal of TTS in terms of various indicators by saying that the Institute performs well as an environment for basic research with regard to the number of articles published in recognised journals. The average is well over one published article per researcher, and approximately two doctors have also graduated from the Institute in each of the last two years. These teach at the lower level and thus contribute to the dissemination of knowledge on safety research, as well as providing the synergy that arises between teaching and research. The TTS has developed a well-documented and extensive research network which can be further extended by contacts with the leading medical research projects on whiplash injuries in Sweden. To date, it appears that the Institute has maintained a good balance between basic research and

applied research, and it can demonstrate that it has contributed to the development of products for Volvo, Saab and Autoliv that have provided considerable economic benefits. The Institute's financial vulnerability has increased in recent years, from a position with 50 per cent basic funding (faculty funding) in 2001 to 14 per cent in 2003, which may be to the detriment of basic research in the long term. This vulnerability is increased by the financial dependence on only a few customers in Sweden which are mainly owned by companies in the USA, and by the fact that EU projects often provide only part of the funding, usually only 50 per cent.

4 The value of the TTS based on expectations concerning the creation of value in the future

In an internal appraisal, the TTS is challenged to review its strategic thinking about how its research activities can be strengthened in the future. The value that has been accrued in terms of research expertise relates not to what has been created in the past but to what the Institute has the potential to create in the future on the basis of its knowledge, know-how and networks. Biomechanical impact research is the area in which the Institute has developed its core competence. This is the area in which it conducts the basic research that contributes most to applied research, and that is of benefit to the users. Model development, simulation, optimisation and the use of algorithms for complex systems are important building blocks in the basic research conducted at the TTS.

The tradition has been to conduct research relating to what has been characterised as passive safety. The strategic plan now indicates a paradigm shift towards more active safety and a broader approach to the problem, especially in interdisciplinary projects in which medical research will become increasingly important. This also applies internationally. Researchers in the field of behavioural science may also become increasingly important collaborators. Another important factor is the development and modernisation of laboratories with their own simulators in order to be able to improve road safety.

4.1 Regional research collaboration

The TTS is now working actively to develop a broader application of the interdisciplinary working method in its research by developing a major centre of excellence for safety research, the GVSCC (Gothenburg Vehicle Safety Centre at Chalmers). Chalmers appears to be the main base for this centre, but the project also entails a significant broadening of the competence environment in that it forges links with all the relevant players in order to develop a more complete innovation system in the region. VINNOVA has provided financial support for this centre as part of a programme called “VINN Excellence Centres”.

The objectives are to instigate and maintain new, cutting-edge and interdisciplinary basic research, to link together the industrial, research and social systems in beneficial collaboration projects, to provide first-class teaching at all levels, to contribute to recruitment to industry and to act as a forum for all the relevant players. The idea

behind the project is, to a certain extent, to create a regional centre that can exceed the required critical mass and provide sufficient competence to ensure that Sweden remains a world leader in the field of safety research for the motor industry. This will play and important part in the effort to retain the motor industry in Sweden in the long term, and it may provide an important platform for creating new industrial operations. The aim is to establish centres of excellence in areas where we already have a comparative advantage in order to increase Sweden's competitiveness. Competition with the USA will require growth. The network can generate new ideas for industry, and we know that for high-tech industry access to competence, and preferably the leading basic research environments, is an important localisation factor. Within their international groups, both Volvo and Saab are centres of excellence in their own right with regard to R&D on safety. The new centre of excellence is also a part of the strategy to strengthen this research within these groups. The companies live with ongoing competition in terms of quality with regard to where they choose to locate their research operations.

By contributing its know-how and expertise to the development of the GVSCC, the TTS is playing its part in the creation of such a broader research forum. The core competence of the Institute will probably provide an even greater return within the framework of such a broad forum. There is always a risk, however, that it may not be possible to achieve results in the future that are as good as those we have seen from the research conducted to date. We cannot know for certain whether this research can contribute to a further reduction in the number of serious whiplash injuries, increase the profits of the motor industry or generate spin-offs of high value in new areas that we cannot conceive of today.

According to Folksam, the accident statistics give no sign that the level of whiplash injuries is beginning to flatten out. This means that a lot of work remains to be done, both in terms of research and product development.

4.2 The value of the research

Estimating the value of the research with a focus on the profits and benefits it may provide in the future is a process equivalent to that in which the stock exchange values new R&D companies. Making such estimates will always entail looking to the future and making assumptions about the income that we would like the operations concerned to generate in the future in order to cover the expenditure that the operations incur today. The present value of this future net cash flow thus represents the value of the R&D company concerned. In the analysis, it is important to evaluate whether the competence that has been developed has the potential to further increase safety by conducting additional research, so that the number and extent of injuries can in turn be further reduced. The quality of the basic research conducted will continue to be the most important criterion for the success of the TTS. However, all efforts to develop

basic research in order to provide value in the future are associated with a high level of risk. The ability of the funding institutions to take a long term approach will therefore be decisive. The fact that the TTS is also a teaching organisation will reduce the risk of having to achieve results somewhat, as this will in itself be of value.

4.3 The importance of State funding

Key personnel in various parts of the vehicle-related research system, the motor industry and research funding organisations have given their views on how State funding works.

With regard to **basic research**, the predominant view is that a large part of this research would not have been conducted without the support of VINNOVA and its predecessors. Funding basic research to a level of 100 per cent is essential in enabling the research concerned to provide results that can form the basis for applied research and product development. The importance of VINNOVA and its predecessors to both problem-oriented and basic research is emphasised.

As far as research on neck injuries is concerned, the funding provided by VINNOVA and its predecessors has been vital. The importance of this research was realised at an early stage by key personnel at VINNOVA's predecessor TFB, and most of the funding for the basic research conducted at the TTS has always been provided by TFB/KFB/VINNOVA. The applied research was originally funded by TFB/KFB, but has been funded since1994 by the "user controlled" (company controlled) PFF, in which the motor industry and the State each contribute 50 per cent.

Most of the parties concerned feel that this form of funding works extremely well. The subcontracting sector in particular, which primarily consists of small and medium-sized companies, points out that its research activities are now considerable whereas previously they were practically non-existent. It is also pointed out, however, that much remains to be done before these research activities reach a satisfactory level. Opinion is divided on whether this form of funding has also led to more effective research or whether it is only the level of research that has increased.

In the case of the small companies, most of the research has focused on product development, while the large companies have usually prioritised more basic research. The small companies feel that co-funding has been a prerequisite for their research, while the large companies claim that their research would still have been carried out, but at a later date and to a lesser extent.

Stimulating **positive interaction** at different levels was an important motive for the foundation of the PFF, but has also been an important factor for TFB/KFB/VINNOVA. User control and co-funding have clearly led to closer co-operation between the industry and the research institutes. The fact that the companies are the formal

applicants for research funding, while the institutes provide the ideas, contributes to an effective exchange of information.

The co-operation is marked by trust, and an unwilling ness to share information has not been a problem.

The mutual co-operation between the large companies is seen as a horizontal collaboration on measurement methods, standards and joint equipment, for example the BioRID dummy. Co-operation has worked very well on this level, and is something that this form of funding encourages. Co-operation between the large companies on products is limited, however, due to the competition between them.

The small companies have usually collaborated with a large company on the improvement of a product that the small company concerned supplies to the large company.

Co-operation between the funders is also important. Even though VINNOVA and PFF largely play a background role, they can make a positive contribution as catalysts, particularly for the small companies, by bringing companies together with each other and with researchers.

The interviewees stress that the interplay between basic research and applied research that borders on product development is necessary if product development is to take place. The industry identifies its needs, which also has an impact on projects that are more basic in nature.

The impression is that the co-operation between all the different players, whether they are at the same level or at different levels in the field of vehicle research, often leads to greater efficiency and synergy in that everyone works to achieve a common objective. Under more unfavourable circumstances, however, such co-operation could lead to increased bureaucracy, internal competition and co-ordination problems. It is pointed our, however, that several of the domestically-funded projects, e.g. those funded by VINNOVA and PFF, are better in this respect than international projects. Several interviewees also say that VINNOVA and PFF are unbureaucratic and flexible organisations.

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Production & layout: VINNOVA´s Communication Division
Printed by: AB Ingeniörskopia, www.ingeniörskopia.se
April 2005

VINNOVA´s mission is to promote sustainable growth
by developing effective innovation systems
and funding problem-oriented research

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