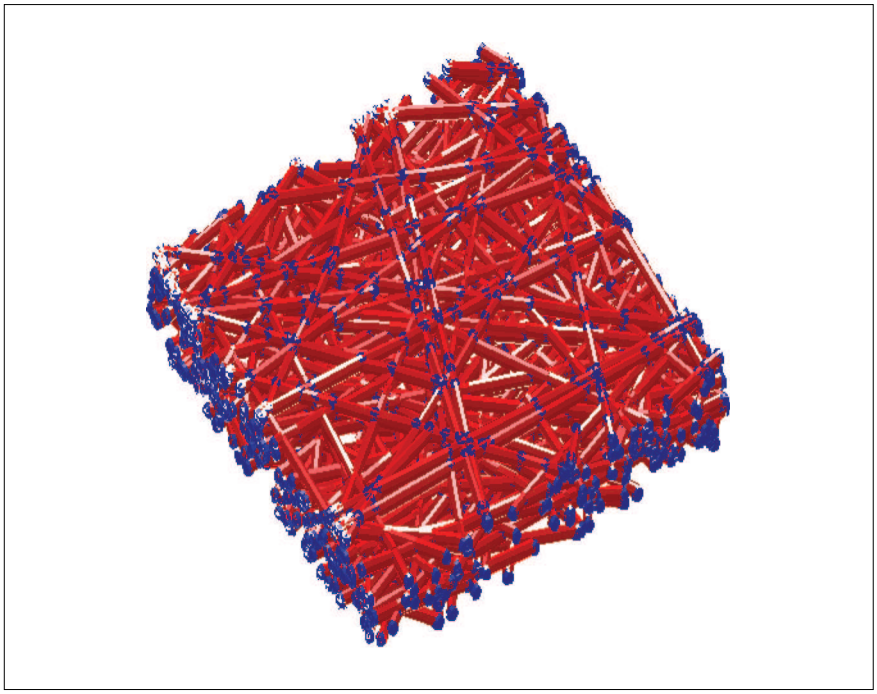
Fraunhofer ITWM

CHALMERS
Research Centre
Industrial Mathematics

Annual Report 2001-2002



FCC

Fraunhofer-Chalmers Research Centre for Industrial Mathematics

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Annual Report 2001 - 2002

Fraunhofer-Chalmers Research Centre
for Industrial Mathematics, FCC

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Preface

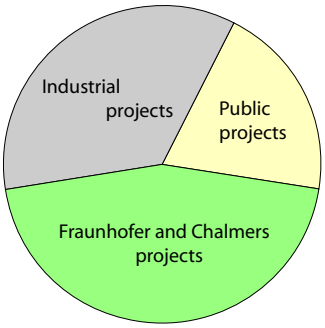
Mr Leif Pagrotsky, now Minister for Industry and Trade, inaugurated the Fraunhofer-Chalmers Research Centre for Industrial Mathematics on September 4, 2002.

In his speech Mr Pagrotsky said: "We all know that mathematics is a key technology for industrial renewal. Not just in some sectors of industry, but almost all sectors of society. With the help of computer simulation, mathematics has become a central tool, opening the door to immense possibilities when the knowledge developed in academic mathematics is applied in industry."

This power of mathematics is indeed underlined by the fact that the Fraunhofer Society, when going European, has selected mathematics for one of its first initiatives.

The creation of FCC has been a very dynamic process. The Fraunhofer Society initiated the discussion in May 2000. Fifteen months later, in September 2001, the Center started its operations.

In line with the Fraunhofer model, the profile of the Center is controlled by its income structure.



Income structure 2001 - 2002, total income 1700 kEUR.

The result of the first fiscal year July 2001 - December 2002 is most encouraging. It is well in line with the business plan of March 2001, scientifically as well as commercially. In particular, the income from industrial projects has been above expectations.

Before ending this preface, I take the opportunity to express my great appreciation of Professor Helmut Neunzert at Fraunhofer-ITWM. It is a privilege and an honour to take part in his vision for an industrial mathematics institution operating on a European scale.

Göteborg in June 2003

Uno Nävert
Director

Mr Leif Pagrotsky, Swedish Minister for Industry and Trade, and Professor Dieter Pratzel-Wolters, Director of Fraunhofer-ITWM, at the inauguration of FCC.

Uno Navert, Director of FCC.

Profile

Mathematics has become a key technology for industrial innovation since mathematics is behind all work in the virtual world.

The Fraunhofer Society and Chalmers have founded FCC to promote the application of mathematical methods in industry. To do so the Centre undertakes scientific research and marketing projects financed by the founders and works on projects defined by companies and public institutes on a commercial basis.

FCC is an example of a bottom-up strategy to build the European research space. First we define a small network of closely (daily) co-operating research institutes. To solve concrete problems from companies from all over Europe, we then create optimal teams built out of this network. We do this in the field of mathematics, which is a key technology for industrial innovation, lying behind all work in the virtual world, e g, simulation for prediction, control, optimization, and risk assessment.

FCC works on projects defined by companies and public institutes on a commercial basis.

Entrepreneurial competence

Experiences from Fraunhofer show that small and medium size companies constitute an important market for an industrial mathematics institute. The Centre has arranged a first SME day, cf page 7, which has resulted in several projects.

The Swedish Society of Applied Mathematics, STM, is a consortium of big companies with business in Sweden, cf page 5. This consortium is the largest individual industrial client of FCC and represents almost half of the total industrial income.

During its first financial year, the Center has served three international industrial clients, from France, Germany and Norway.

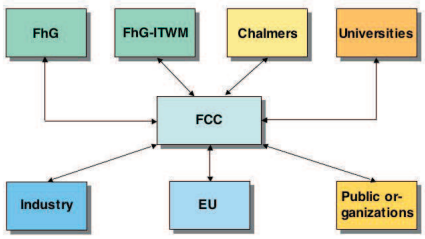
Professional networking

The Centre has a very close relation to its founders Chalmers and Fraunhofer-ITWM, cf pages 6 - 9, by exchanging staff members, co-operating in projects, by joint participation in European projects, by connecting Swedish clients with ITWM and vice versa, and by stimulating the co-operation between Swedish industry and other Fraunhofer institutes.

In order to fulfil its tasks optimally, the Center co-operates with competent scientific groups at universities and elsewhere, cf page 15.

It also promotes research and education in industrial mathematics at institutions outside the Center, cf pages 8 and 15.

FCC in close co-operation with Chalmers and Fraunhofer shall be a leading international partner in industrial mathematics.

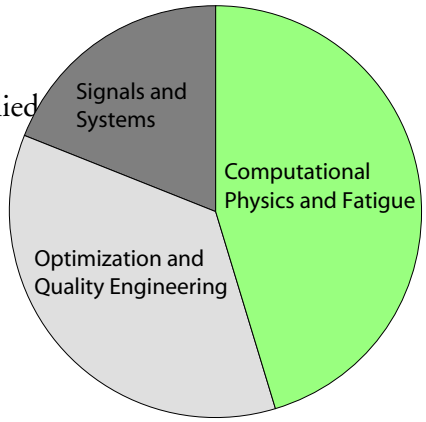


Scientific competence

The Centre undertakes scientific research projects and marketing of scientific results financed by its founders and by public institutes. Respecting the confidentiality of data from customers, the Center encourages the publication of results. FCC supports efforts to use its research for educational purposes at all levels at Chalmers as well as at other educational institutions in Sweden and Europe. FCC sponsors PhD work, if the subjects are of basic interest for the research in the Centre. FCC keeps contact with the worldwide community of applied mathematicians by active participation in conferences and by inviting guest scientists.

The Centre has organized six research programmes within three technology areas. By the end of 2002 the staff was to count four full-time equivalents, including one scientist contracted from Fraunhofer-ITWM and six scientific advisers from Chalmers, each one working 10% - 20% of full time at FCC.

FCC undertakes scientific research financed by its founders and by public institutes.



Relative cost 2001 - 2002.

Financial mix

The financial model distinguishes between three income sources: project financing from the founders, industrial project income, and public project income. These three should be in reasonable balance.

According to the business plan of March 2001, the annual turnover of the Center shall increase from 1700 kEUR in 2001 - 2002 (18 months) to 2000 kEUR in 2004. The outcome of the first fiscal year has been slightly above expectations. In particular, the industrial income has been higher than expected, cf pages 22 - 23.

After three years FCC shall earn approximately 40% from its founders, 40% industrial income, and 20% public income.

Acknowledgements

The Centre is a Swedish foundation established by Chalmers and Fraunhofer-Gesellschaft. The decision has been based on a business plan prepared by the Swedish Institute for Applied Mathematics (ITM) and Fraunhofer-Institut für Techno- und Wirtschaftsmathematik (ITWM).

The Swedish Association for Applied Mathematics (STM) and the former Swedish National Board for Technical and Industrial Development (NUTEK) have supported FCC taking over ITM operations.

The Swedish Foundation for Strategic Research (SSF) has played an essential role by announcing support of one million euro for a public project where a future scientific leader is recruited to establish a research team at the Centre.

Clients and partners

FCC has successfully co-operated with enterprises of different sizes and from many branches. In the following, those clients and project partners of the fiscal year 2001 - 2002 are listed who have accepted to be cited.

- ABB
- ABB Power Technologies
- Aerotech Telub
- AstraZeneca Molndal
- AstraZeneca Sodertalje
- Atlas Copco Rock Drills
- Bombardier Transportation
- Chalmers Industriteknik
- Chalmers Finite Element Centre
- Chalmers University of Technology
- Chalmers Wingquist Laboratory
- Elforsk
- Ericsson
- Ericsson Microwave Systems
- EU IST Consortium ViSiCADE*
- Fortum Power and Heat OY
- Fraunhofer-ITWM
- Front Capital Systems
- ITM
- IVF Industriforskning
- Jernkontoret
- Kungliga Tekniska Hogskolan/ PSCI
- Lund University, Mathematical Statistics
- NMCT
- Optimization Partner Stockholm
- PSA Peugeot Citroen (F)
- Saab
- Saab Automobile
- Safe Technology
- Saint-Gobain Sekurit Scandinavia
- Sandvik Steel
- Scania
- Simula Research Laboratory AS (N)
- SKF
- STM Forskningsservice
- Swedish Insurance Federation
- SP Swedish National Testing and Research Institute
- StoraEnso Corporate Research
- Sydkraft
- Volvo Aero Corporation
- Volvo Car Corporation
- Volvo Trucks

* EU IST Consortium ViSiCADE
Fraunhofer IGD (co-ordinator)
Airbus
CS Systemes d´Information
CLRC Daresbury Laboratory
Centre Scientific et Technique du Batiment
Chalmers University of Technology
TranscenData Ltd
ZF Friedrichshafen AG
Queens University of Belfast
ProSTEP GmbH

STM

The Swedish Society for Applied Mathematics (STM) has signed a letter of intent to finance projects at FCC with 700 kEUR in the period 2001 - 2004.

Members and shares 2001 - 2002:

Engineering and transport

Volvo	(5)
SKF	(5)
ABB	(3)
Saab	(3)
Scania	(1)
Sveriges Provnings- och Forskningsinstitut SP	(1)

Pharmaceuticals

AstraZeneca Molndal	(5)
AstraZeneca Sodertalje	(2)

Telecommunications

SaabTech Systems	(1)
Ericsson Microwave Systems	(1)
Ericsson Radio Systems	(1)
Ericsson Utveckling	(1)
FMV	(1)
Telia Sonera	(1)

Energy

Elforsk	(5)

Insurance and finance

Swedish Insurance Federation	(5)
Front Capital Systems	(1)

Wood, pulp, paper

StoraEnso Corporate Research	(1)

Authorities

Statistics Sweden SCB	(1)

www.itm.se/stm.html

Fraunhofer-Gesellschaft

Professor Helmut Neunzert, ITWM, Vice Chairman of FCC.

The Fraunhofer-Gesellschaft is Germany's leading organization of institutes of applied research. It undertakes contract research on behalf of industry, the service sector and government.

The FhG works within the framework of the European Union's technology programs, striving to improve the competitiveness of European industry through the enhancement of technical systems and processes. Commissioned and funded by the Federal and State governments, the FhG undertakes strategical research projects which contribute to the development of innovations in key technologies and spheres of major public concern, such as energy, transport and the environment.

The Fraunhofer-Gesellschaft was founded in 1949 and is a recognized non-profit organization. It currently maintains 58 research institutes throughout Germany. A staff of 12500, the majority of whom are scientists and engineers, generate the annual research budget of more than 1000 million EUR. Work focuses on specific tasks across a wide spectrum of research fields. Where systematic solutions are required, several institutes collaborate on an interdisciplinary basis.

The Institut für Techno- und Wirtschaftsmathematik (ITWM) in Kaiserslautern became a Fraunhofer institute on January 1, 2001, after an exceptional development. The budget increased from 1500 kEUR in 1996 to 5000 kEUR in 2000 and the staff size rose from 34 to 81 in the same period. Its Director is Professor Dieter Prätzel-Wolters.

The ITWM is organized into six departments, which also reflect key competence fields: Transport Processes, Models and Algorithms in Image Processing, Flow in Complex Structures, Adaptive Systems, Optimization, and Mathematical Finance.

Professor Helmut Neunzert is responsible for international affairs at ITWM. FCC originates from his vision of a European institution operating in the Fraunhofer spirit.

Co-operation

A key element in the operation of FCC is to establish a close co-operation with Fraunhofer-ITWM. This co-operation is growing, but has not yet reached the expected volume.

Project acquisitions

Five of the six department heads of ITWM have visited FCC for joint project acquisitions during the first year. Professor Neunzert, who is senior adviser at FCC, has visited several Swedish companies together with the FCC management.

www.itwm.fhg.de

Projects have been secured in the areas transport processes (start 2003), flow in complex structures, image processing (start 2003), adaptive systems, and finance mathematics (start 2003). The names of the areas refer to the department structure of ITWM.

SME day

Together with the West Sweden Chamber of Commerce and Industry, FCC arranged a day on mathematics as a technology for small and medium size enterprises in October 2002. FCC and ITWM together presented the potential of industrial mathematics, in particular in the areas surface inspection, filling processes, and logistics.

The meeting resulted in several projects in spite of a low number of participants. It also generated ideas for additional future initiatives and suggested suitable formats for further campaigns.

Exchange of staff

Dr Marco Günther from ITWM has spent thirteen months at FCC. One staff member from FCC has spent a month in Kaiserslautern to work on a project in finance mathematics.

Dr Günther mainly worked on the project described below. He also participated in projects within the computational physics field.

Dr Marco Gunther.

Parameter estimation in power networks

State estimation of a power system network is important for network control by Electrical Management Systems. The estimation makes it possible to calculate information required for state stability and power economy.

The state estimation is based on telemetered values collected from the power network. In periodic intervals the values are sent to the central control. Measurable quantities are voltage magnitude, real and reactive power flow, tap ratios at transformers and breaker settings.

The performance of the state estimation procedure strongly depends on the knowledge of the network parameters. One problem in that direction is that some of the model parameters can only be initialized by rough estimates. A second problem arises from time-varying effects in some of these network parameters.

The project has addressed different aspects of combining state estimation with parameter estimation. Different models and algorithms have been tested on a reference network consisting of 27 stations and 40 lines including 15 transformers.

Chalmers

Professor Peter Jagers, Chalmers, Chairman of FCC.

The Chalmers University of Technology (Chalmers Tekniska Högskola) was founded in 1829. It is a non-profit, non-governmental university. With its more than 7000 students for engineering and architecture degrees, and more than 1100 PhD students it is one of Sweden's two leading technology universities.

Most of Chalmer's resources come from contracts with the state of Sweden (63%), but Chalmers also has strong support from non-governmental research organizations (29%) and industry (8%). The annual (2000) turnover is 210 Million Euro. More than two thirds of the budget are allotted to research and to graduate studies. With its staff of 2500 full time equivalents, including 130 full professors, the University has strong and well-known departments in most fields of science and engineering.

Chalmers has made special efforts to integrate mathematics into a broader scientific and technological perspective. Strong activities in stochastics and numerical and modelling mathematics have emerged. Thus, besides activities in the various mathematical fields, Chalmers Applied Mathematics comprises these more specialized centres.

Professor Peter Jagers was the President of the Chalmers Faculty Senate 1993 - 2002. He brought up the idea of engaging Chalmers in a joint venture, when the Fraunhofer Society started to look for Swedish partners. He also represented Chalmers in the subsequent negotiations.

Co-operation

A key element in the operation of FCC is its close co-operation with Chalmers.

This co-operation is mainly organized through six scientific advisers. Each adviser typically spends between 10 and 20 percent of full time at the Center. Four advisers are senior scientists at the School of Mathematical Sciences and two advisers are senior scientists at the School of Mechanical Engineering.

In several cases FCC staff members act as co-advisers for PhD students at Chalmers. FCC also finances PhD projects at Chalmers.

The co-operation has been particularly strong in four areas: Computational Physics, Fatigue Life, Optimization, and Quality Engineering. In different settings, Chalmers and FCC have worked together in externally financed projects, as described below by the scientific advisers.

www.math.chalmers.se

Computational Physics

FCC interacts with activities in the Chalmers Finite Element Centre Phi, a centre focusing on the interdisciplinary development and application of finite element based computational technology. Examples of joint activities include the EU-project ViSiCADE, co-ordinated by Fraunhofer IGD, and a PhD project carried out by Rickard Bergström on finite element methods for electromagnetics, cf pages 10 - 11.

Statistical Fatigue of Materials

The establishment of FCC has made it possible for the fatigue group to host competence for solving particular industrial problems as well as for doing purely academic work.

The strategy has been to consider the fatigue group as one unit jointly supported by Chalmers and FCC. In that way, problems from industry are imported into the academic work and research results are exported to industry. This two-way communication has proved fruitful for the students at Chalmers, as well as for the industrial partners, cf pages 12 - 13.

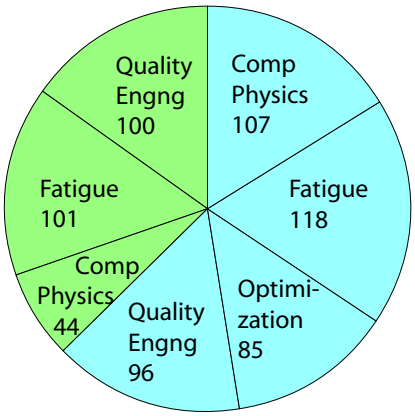
Optimization

Dr Ann-Brith Strömberg at FCC is the co-adviser of two PhD students in optimization at Chalmers. She also shares the responsibility for the course on optimization under uncertainty, given at the Department of Mathematics. The course incorporates a current project at FCC on the topic of optimization under uncertainty, thus bringing knowledge of the state-of-the-art use of applied mathematics in practice to the students, cf pages 14 - 15.

Quality Engineering

Wingquist Laboratory was started in October 2001 as an important part of a major renewal and reorganization of the School of Mechanical and Vehicular Engineering at Chalmers. The motivation was to increase the collaboration with Swedish industry and to concentrate research in strategic areas.

The laboratory conducts interdisciplinary research within the field of virtual product realization, focused on modelling, simulation, evaluation and verification of product and production concepts. Research efforts are carried out in three closely related areas; 1) product- and production system modelling, 2) robust design and variation simulation, and 3) flexible production and automation systems, cf pages 16 - 17.



Income 2001 - 2002 from projects where Chalmers (blue) and FCC (green) work together, in total 654 (kEUR).

"Together, FCC and Wingquist Laboratory possess a unique set of competence that enables industrial projects with extraordinary requirements in the field of simulation and analysis to be carried out successfully."

Professor Rikard Soderberg,
Director Wingquist Laboratory,
Scientific adviser FCC

Computational Physics

General

The FCC reasearch in Computational Physics focuses on computer simulation of physical phenomena, including fluids, solids, and electromagnetics.

Geometry and Mesh Generation

The starting point of many industrial computations is the creation of a mesh with desired properties and quality. Often this task is difficult and time consuming due to bad quality of CAD data and lack of robust 3D mesh generators. Furthermore, special meshes, for instance boundary fitted or hybrid meshes are often desired in applications.

Adaptive Methods

Computer simulations enable rapid design and optimization of products. Design optimization may, for instance, involve choice of suitable materials, geometrical shape, and even topology. Typically these problems require rapid solvers and efficient optimization algorithms.

Modern finite element techniques for solution of differential equations are based on a multi-resolution approximation of the solution, where the local resolution is determined in an adaptive fashion. To obtain desired accuracy we employ techniques for estimation of the errors in the computations. Such computational error estimation techniques have developed rapidly during the last decade and it is now possible to control the global error measured in a norm or the error in particular quantities of interest. An illustrating example of such quantities of interest is the lift and drag coefficients of an airfoil.

Inverse Problems and Optimization

Inverse problems typically involves determination of quantities or objects from measured data, for instance detection of defects in a material using ultrasound measurements. Inverse problems are closely related to shape/topology and design optimization problems in engineering where we seek to determine an optimal design (in a suitable sense).

Multiscale Computations

Often physical problems exhibit multiscale behavior. For instance, a composite material may be described by fibers in a matrix on the microscale and perhaps linear elasticity on the macroscale. Multiscale computational methods are techniques used to handle such problems. Typically, these techniques involve solution at the microscale and computation of macroscopic quantities or the effect of the microscale on the macroscale.

Computational Electromagnetics

In computational electromagnetics, FCC is sub-contracted by Scientific Computing Institute, PSCI, project 24082-6100, for code development, cf the projects below.

Some projects

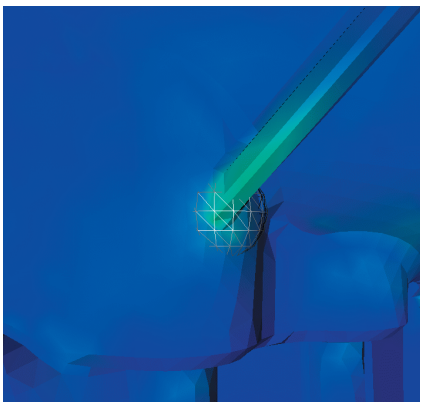
Development of Finite Element Software

High order finite elements, p-elements, are used to efficiently compute approximations to differential equations with high accuracy. Such elements have been implemented in the finite element software package Diffpack (registred trademark of Numerical Objects AS) during a project with Simula Research Laboratory AS Norway. In additions to the elements, high order quadrature rules as well as the necessary mesh and assembly infrastructure were implemented. The large systems of equations manufactured by the high order finite element method can be solved rapidly using iterative techniques including a recently developed multigrid technique.

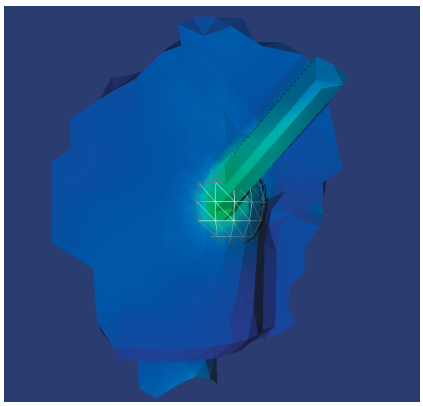
ViSiCADE

In the EU project ViSiCADE in the IST program, IST2000-28123, FCC takes part as a large subcontractor to Chalmers. The objective of the ViSiCADE project is to develop an intuitive simulation framework based on virtual reality.

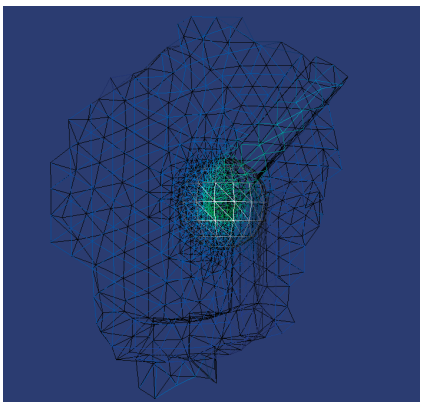
The role of FCC is to develop fast finite element solvers enabling the user of the developed system to make interactive simulation. A technique for making interactive simulations is submodeling where the accuracy of the solution in a subdomain is enhanced by



The von Mises stress on a global model. As a tool for local refinement, the sphere selects the region where increased accuracy is wanted.



Elements inside the sphere and its neighborhood are cut out and a submodel problem with increased accuracy is solved.

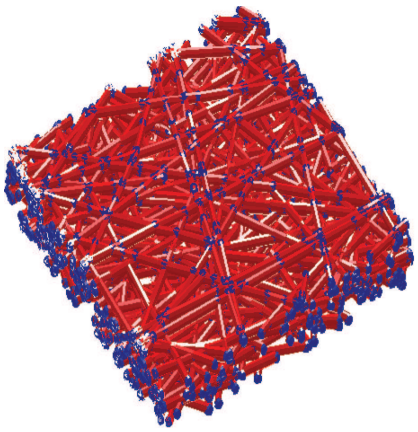


The surface triangulation of the refined submodel.

solving a local problem on the subdomain with data obtained from a coarse solution. Further the geometry or material properties in the subdomain may be changed providing the possibility to study the effect of design changes in real time.

Computational Modeling of Paper

Based on, for instance, pictures of microstructure of a material a mathematical model of the microstructure can be constructed and simulations of its properties can be done. Examples of simulations include fluid flow in a filter or the mechanical response of a small piece of a composite or foam material under load. Based on these computations estimates of parameters in macroscopic equations may be obtained. A natural next step is virtual design and optimization of materials where we instead seek to construct micro structures which gives desired macroscopic properties.



A network model of fibres for finite element simulation of the properties of paper.

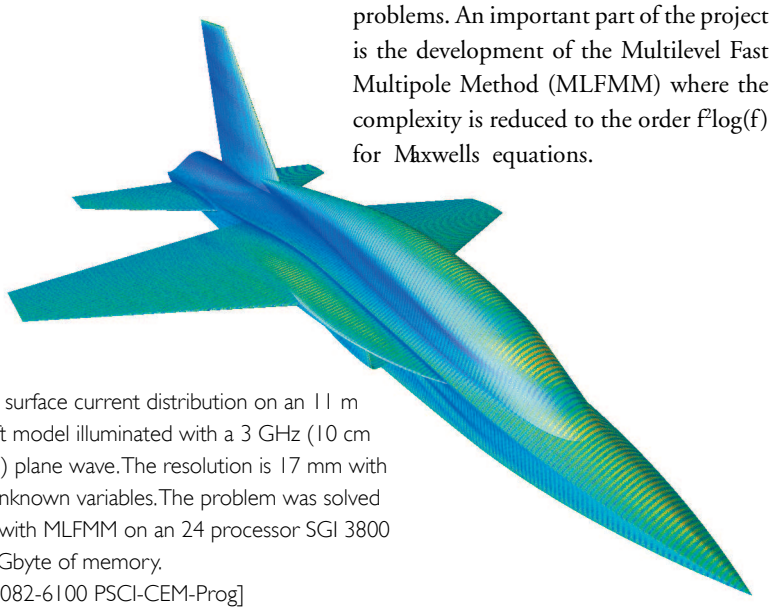
In a project supported by STM Research and StoraEnso we have developed such computer models of paper. The models focus on simulation of the mechanical properties of paper and are implemented in a demonstration software.

SMART

The objective of the SMART project is to develop a state-of-the-art software suite for Radar Cross Section (RCS) applications in order to compute and optimise the RCS performance of future low observable vehicles. The vehicles of interest are operational aircraft, unmanned aerial vehicles (UAV) and helicopters. The size of the objects range 2-15m and the relevant frequency range is 1-20 GHz. The monostatic RCS is optimised for a given system within selected intervals for the frequency and angle of incidence with respect to material parameters, one or more layers, and geometry.

Multipole Method

We solve scattering problems with a boundary element method in frequency domain. The computational complexity of classical solution methods is proportional to the fourth to sixth power of the frequency and this prohibits us from solving really large problems. An important part of the project is the development of the Multilevel Fast Multipole Method (MLFMM) where the complexity is reduced to the order $f^2\log(f)$ for Maxwells equations.



Computed surface current distribution on an 11 m long aircraft model illuminated with a 3 GHz (10 cm wavelength) plane wave. The resolution is 17 mm with 1042644 unknown variables. The problem was solved in 3 hours with MLFMM on an 24 processor SGI 3800 using 14.7 Gbyte of memory.
[Project 24082-6100 PSCI-CEM-Prog]

The Computational Physics Research Group

- Klas Samuelsson, PhD, mainly working on finite element technology
- Anders Ålund, Lic, mainly working on numerical methods and high speed computing
- Mats Larson, Docent in mathematics at Chalmers, scientific adviser at FCC

Klas Samuelsson

Anders Alund

Mats Larson

Fatigue

General: Fatigue from a Statistical Point of View

Statistical methods can help to build a complete picture of the reliability of mechanical constructions with respect to fatigue resistance, and hence show where it is most efficient to take steps to improve the quality of a product.

The reliability is a combination of strength and loading. The strength is determined through fatigue tests, while the loadings are obtained through measuring loads in service or on proving grounds. The relation between loading, strength, and fatigue life is modelled using simple physical models. The determination of the strength as well as the loading is a difficult task, hence the two quantities are attached with a certain amount of uncertainty. A statistical perspective makes it possible to combine all uncertainties and variations in a total reliability analysis, and update the models with reports on failures in service. Especially the following areas can be identified:

- *Planning and evaluation of fatigue tests.* We apply well established statistical methods, like statistical design of experiments, regression analysis, prediction and confidence intervals, which we adopt to the particular engineering application.
- *Analysis of real service loads.* We use the theory of stochastic processes, RainFlow Count analysis, and work on questions concerning the relation between laboratory tests and service loads.
- *Uncertainties of empirical models.* A statistical methodology makes it possible to compare uncertainties of models with random variations in the loading and the material, in order to find an optimal complexity in the modelling. An important issue is to distinguish between systematic and random sources of variation.
- *Feedback of failure reports.* The use of Bayesian updating techniques makes it possible to improve future modelling of the phenomena.

Some Projects

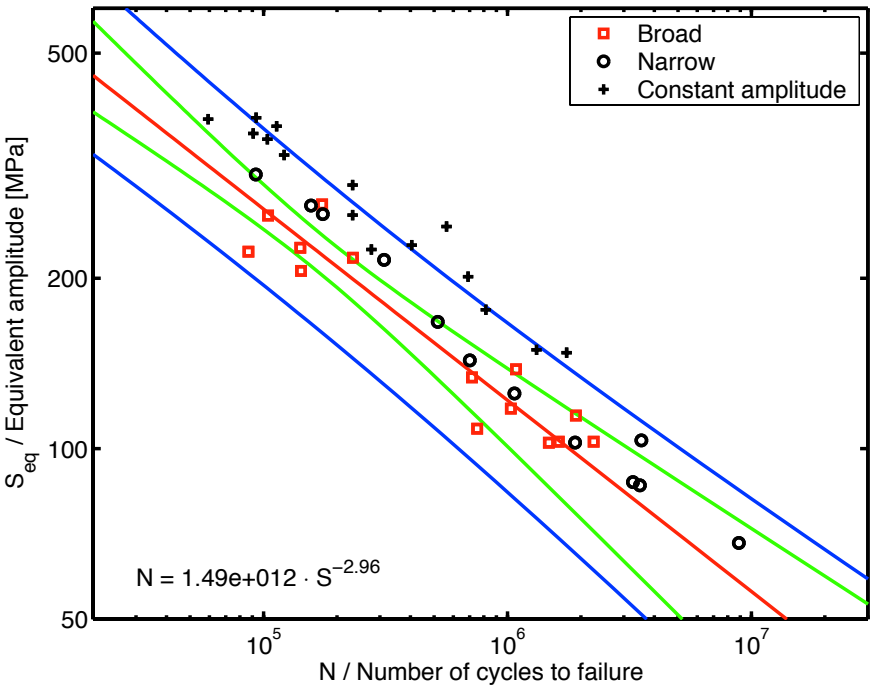
Fatigue Prediction at Variable amplitude without Constant Amplitude Tests

In a cooperation project with five companies, a method for prediction of fatigue life for service loads is developed. Traditional methodology is based on testing in laboratory using load sequences with a constant amplitude. However, in service products are often exposed to loadings of a more stochastic nature, with variable amplitudes. By performing laboratory tests at variable amplitude the life predictions can be improved, but a difficulty is that service loads are not identical from one occasion to the other. In this project a methodology is developed for predicting the fatigue life based on tests at variable amplitude, which also includes a characterization of different kinds of load sequences by an equivalent amplitude.

This project is financed by Atlas Copco Rock Drills, Bombardier Transportation, Sandvik Steel, Volvo Cars, SP, and by STM (Swedish Society for Applied Mathematics).

Extrapolation of Rainflow Matrices

Within the automotive industry an important task is to determine the load profile of different customers. Such investigations give knowledge on the variation within different customer populations, and give the opportunity to adapt the constructions to different markets or usage. To find the fatigue life of a vehicle for a specific customer, one would need to measure during the full life of the vehicle, which is not possible. One is limited to quite short measurements compared to the full life. Hence, one question is how to



SN-curve based on variable amplitude. The SN-curve (red line) is estimated from variable amplitude tests with broad band spectrum. The circles and squares show the observed lives for the narrow band and the broad band loads, respectively. The blue lines represent a 95% prediction interval for the life, and the green lines a 95% confidence interval for the estimated red line. For tests at constant amplitude, marked with plus signs, a systematic error in the life predictions is clearly observed.

extrapolate the measurement to represent a full design life of the vehicle.

For fatigue analysis the information on the load process is often condensed to a distribution of load cycles, the rainflow matrix. Within this project we have developed a method for extrapolating such matrices, with a technique based on statistical extreme value theory (Johannesson and Thomas, 2001). Of special interest is to quantify the uncertainties in the load measurements. With this technique we have studied the variation between drivers on a test track, see (Johannesson et al, 2002), and also made comparison between test tracks and real road measurements.

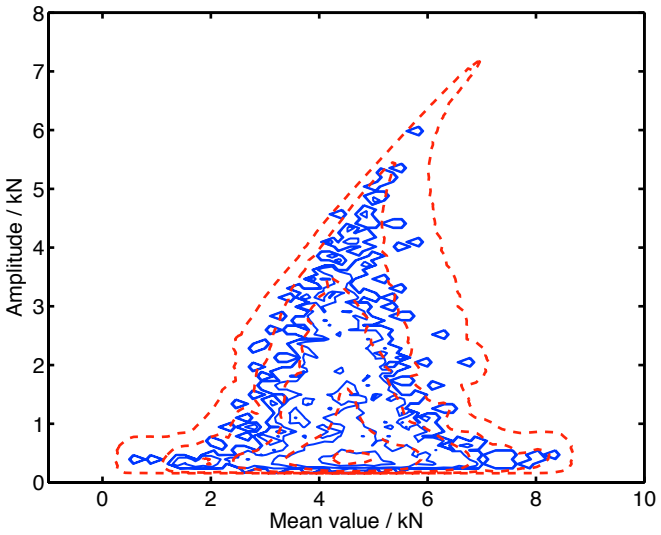
Within the area of reliability, statistical analysis and extrapolation of fatigue loads we have a long term collaboration with the Division of Automotive Research and Innovations at PSA Peugeot Citroën in Paris.

PhD projects

All the graduate students in the group (Sara Lorén, Chalmers, Jenny Andersson, Chalmers, Johan Svensson, Chalmers, Magnus Karlsson, FCC and Volvo Trucks, and Gwenaëlle Genet, Chalmers and PSA) are jointly supervised by FCC and Chalmers. Thomas Svensson has the main responsibility for Magnus Karlsson and Pär Johannesson for Gwenaëlle Genet. Both recruitments and the support by Volvo Trucks and PSA are results of the joint strength of FCC and Chalmers.

Visitors

Professor Igor Rychlik, Lund works part time in the group and Dr Ulla Machado has had a post doc position jointly supported by FCC and Chalmers. Furthermore, Bettie Joossens from the Catholic University in Leuven does part of her PhD project here.



Extrapolation of a rainflow matrix. Vertical forces on the front wheel of a prototype car from PSA Peugeot Citroen. The loads from one lap on the test track is summarised in the rainflow matrix (blue lines). The load properties of the intended design life are estimated, giving the limiting rainflow matrix (red lines). The iso-lines enclose 10%, 50%, 90%, 99%, 99.99%, respectively, of the load cycles. The picture is taken from (Johannesson et al, 2002).

The Statistical Fatigue Research Group

The statistical fatigue research group do consulting and perform research tasks, especially for the engineering industry. The group consists of

- Thomas Svensson, PhD, mainly working on variable amplitude fatigue, measurement uncertainty, and statistical methods in engineering
- Pär Johannesson, PhD, mainly working on modelling of fatigue loads, rainflow count analysis, and reliability in engineering
- Magnus Karlsson, PhD student, virtual description of road environment of trucks, independent of vehicle and driver
- Jacques de Maré, Professor in mathematical statistics at Chalmers, scientific adviser at FCC

Thomas Svensson

Par Johannesson

Jacques de Mare

Optimization

General

The area of industrial applications of optimization is very broad. Optimization problems arise as stand-alone problems in many contexts, and optimization is used in a large variety of fields in applied mathematics and natural, economical and technical sciences in order to model, solve and analyze (sub)systems. Twenty years ago, it has been said, linear programming was the scientific problem that ate the most computing power; optimization continues to have a large appetite.

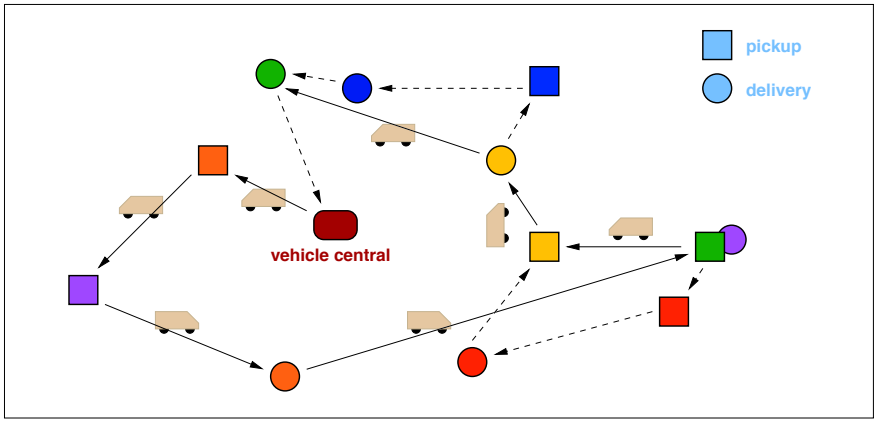
The optimization group at FCC is small but is anticipated to grow, both because of more industrial contracts and, not the least important, because more and more applied projects at FCC will need efficient large-scale optimization.

Engineering Optimization

In engineering optimization, it is quite often the case that the objective value is a measure of the performance of a system which is described in terms of a simulation. The variables in the optimization problem correspond to design parameters that are used as input to the simulation, which may be in the form of a PDE/ODE system. For some simple such models, explicit (or numerical) derivatives of the "responses" (that is, the result of the simulation as a function of the parameter values) are possible to obtain, but they are usually not explicitly given as output from the simulation. Since derivative information is beneficial for a successful optimization, a long term goal of the research at Chalmers and FCC is the development of a toolbox in engineering optimization, which will integrate the simulation and optimization through the calculation of derivative information.

Logistics

The potential for optimization of resources in the area of logistics is huge. Through the West Sweden Chamber of Commerce and Industry we have received an indication of several branches where the introduction of planning tools utilizing optimization would lead to a potentially large increase in efficiency and profitability. Examples are peoples' transportation, refuse collection and transportation of fragile products.



Logistics: Illustration of a transportation route with pickups and deliveries.

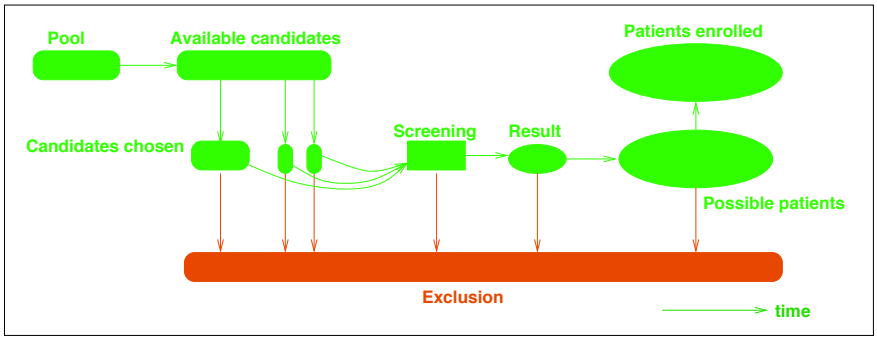
Some projects

Efficient Recruitment and Supervision of Subjects for Large Clinical Trials

From a pool of candidates one wishes to extract a sufficiently large patient population fulfilling prespecified properties, such as distribution of sex, (non)hypertension, etc. Each candidate undergoes a series of screenings where it is decided whether or not he/she may be enrolled in the patient population. The costs generated by the recruitment process consist of direct personal and material costs, the time between the first and last enrolment of patients and also ethical aspects; the aim is to minimize a weighted sum of costs. A mathematical network flow model simulates the flow of subjects in the recruitment process and compares the costs for different strategies for achieving desired properties of the population of patients enrolled.

Optimization of Power Systems under Uncertainty

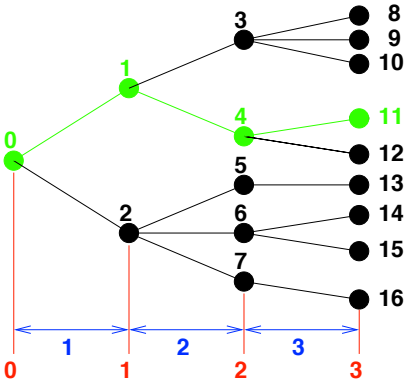
The recent deregulation of the power market has led to a new situation for the power producers which necessitates the development of new planning and decision tools, incorporating management of portfolios of energy contracts, among others. This project focusses on seasonal planning of a power system with hydro and thermal power generation, and sales and purchase of power. It considers a time horizon of 1 - 1.5 years, with a time resolution of one week. The stochasticity of the reservoir inflows, the spot price of electricity, and the demand for electric power all have a large impact on the decision model at this time scale, and is therefore explicitly modelled.



A network model of a patient recruitment process.

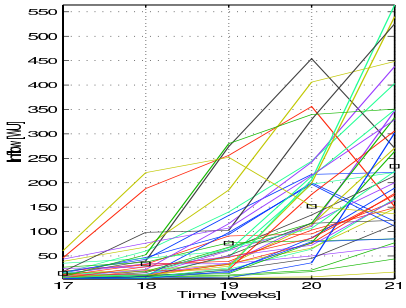
The purpose of the project is to develop a tool for decision-making in power systems planning under uncertainty; this tool will yield an increased understanding of the effects of uncertainty in the inflows on the water release policies, and of connections to power prices and the pricing of energy contracts.

The optimization model that results from the problem definition is a multi-stage stochastic program defined on a scenario tree, which represents an approximation of the possible outcomes of the uncertain parameters during each week of the planning period.

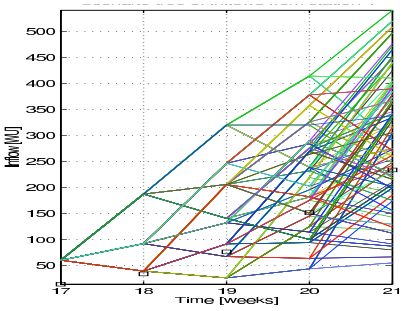


A schematic scenario tree over three time periods and the particular scenario 0-1-4-11 marked in green.

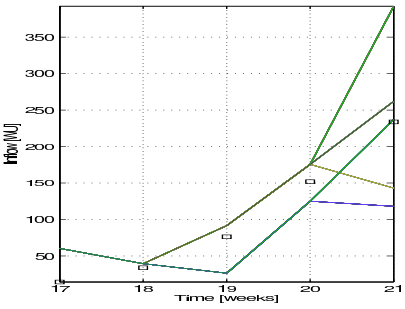
A stochastic model adapted to the simulation of the reservoir inflow and based on historical, weekly data is developed; the model separates the timing of the onset of the spring flood from the size of its flow.



Observed water inflows during the spring flood.



The scenario tree representing the observed water inflows.



A substantially reduced scenario tree.

The resulting large-scale optimization problem calls for advanced decomposition methods and high-performance computing. The optimization techniques employed are based on nested Benders decomposition, which attempts to partition the model into one planning problem for each week and scenario. These problems are, however, linked through balance constraints for the water and energy systems and for the contract portfolios. In order to receive a model that is computationally manageable the scenario tree is reduced using probability metrics.

The project runs from May 2002 until April 2004 and is a joint project between Optimization Partner Stockholm AB, the Department of Mathematical Statistics at Lund Institute of Technology, and FCC. The project is financed by STEM (the Swedish Energy Agency), and the industrial partners Elforsk, Fortum Power and Heat OY, STM Research, and Sydkraft.

PhD projects

Two PhD students have received co-advisement from FCC: Niclas Andréasson (Cost effective motor maintenance) and Fredrik Altenstedt (Asset liability management).

The Optimization Research Group

- Ann-Brith Strömberg, PhD, mainly working on combinatorial optimization and optimization under uncertainty
- Michael Patriksson, Professor of applied mathematics at Chalmers, scientific adviser at FCC

Ann-Brith Stromberg

Michael Patriksson

Quality Engineering

General

Sensitive product and production concepts often result in quality problems with delays in market introductions and lost revenue as a consequence. The opportunity to simulate and visualize variation and tolerance results, combined with tools for diagnosis are important success factors to improve quality. Less variation in products and processes gives a substantial return on investments in form of lower costs for adjustment, rejects and claims. Furthermore, since quality is one of the most important customer decision factors, employing quality as a part of the business strategy is highly motivated. This challenge, to produce high-quality products to low cost and with short lead-times, has increased the focus on quality engineering over the last decade.

Most organizations find it difficult to provide products without quality flaws, since manufacturing imperfections cause variability between different units of the same product. Additionally, during the expected life span of the product, deterioration and variability in environmental variables will cause variability in the product performance. A modern quality program aimed towards reducing variability provides tools for robust design and statistical process control combined with methods for diagnosis.

Quality engineering encapsulates all activities striving towards improved quality, including a number of areas and disciplines. Since mathematics is the most versatile of all sciences, it is uniquely well placed to contribute in all individual areas of quality engineering. Also, since a number of design tasks today are multidisciplinary in its character, including a large number of parameters, mathematics plays a critical role in the area of multidisciplinary optimization.

FCC operates to support a systematic reduction of variability in processes and products in the following key areas:

- Robust design
- Inspection planning optimization
- Process control and diagnosis
- Root cause analysis

Some projects

3D Tolerance Management

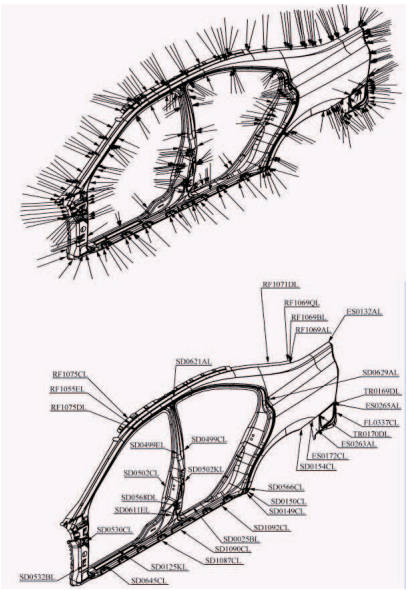
The project 3D TM within the Nutek's program "IT i verkstadsindustrin" started in 1997. The project is run by Wingquist Laboratory at Chalmers, IVF Industrial Research and Development Corporation, FCC, and Volvo Car Corporation.

The aim of the project is to reduce geometrical variation in assembled product in the automotive industry and others. In particular, geometrical variation in the structural frame of an auto body, body in white, causes quality problems in the final products such as wind noise, water leakage, door closing effort, gap and flush variation. The three focus areas, illustrated in the figure below, are; (I) robust design and variation simulation, (II) inspection planning and analysis, and (III) assembly diagnosis. The project combines advanced research with implementations in industrial environments.

The research group comprises the project manager Professor R Söderberg and Dr L Lindkvist from the Product and production development department at Chalmers, Dr J S Carlson from FCC, MSc F Wandebäck and MSc P-J Wahlborg from IVF

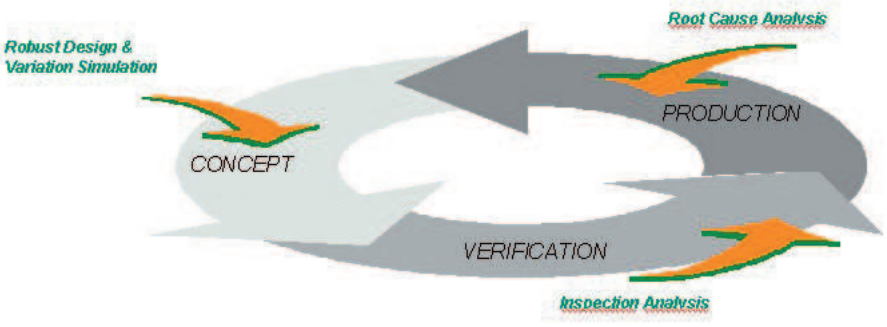
Robust design and variation simulation: We use statistical Monte Carlo simulation, sensitivity analysis and contribution analysis from our partner RD&T Technology to make the product insensitive to manufacturing and assembly tool variation. This reduces the need for costly physical prototypes and test series.

Inspection planning and analysis: We develop methods and support tools for intelligent inspection preparation. The motive is to gather as much information about the product and the process as possible with minimum number of inspection points.



Inspection point reduction in action on S60 car body side.

SPC and assembly root cause analysis: We develop statistical methods to make root cause analyses on the product to find and correct problems in the manufacturing and assembly process. The motive is fast identification and correction of problems and increased knowledge about product/process correlation.

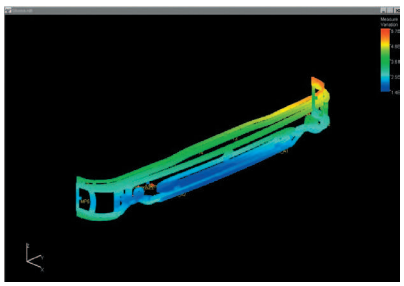


The geometry assurance process.

Evaluation: The project has earned the highest rating by the British evaluation institute Technopolis. The Technopolis states that: "The 3D TM project is one of the most impressive, successful and well-managed in the whole program. The project has worked with scientific rigor and producing very applicable results at the difficult boundary between university and industrial research, making an important contribution both to engineering science and to industrial practice"

Measurement System Analysis

Today, all subcontractors of the automotive industry are assumed to have implemented the quality management system QS 9000. An important part of QS 9000 is the Measurement system analysis which quantifies the capability of a measurement system. The aim of this project is to adopt and develop the analysis manual to CADCAM based measurement systems and its equipment, when using coordinate measurement machines.



Areas of low measurement capability indicated by color-coding.

Path Planning for Rigid Bodies and Industrial Robots

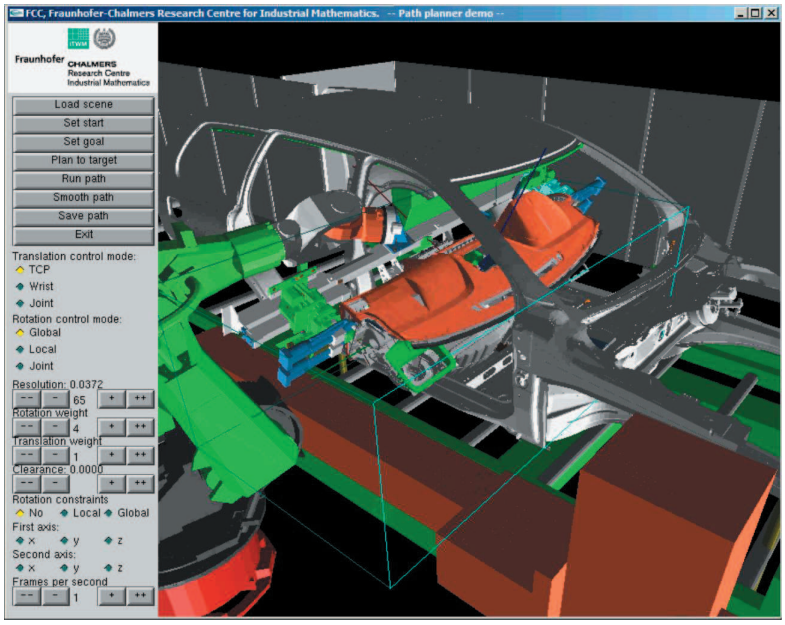
Path planning for industrial robots aims at automatically finding collision-free paths for robots, from the initial to the final configuration, minimizing cycle time, path length and joint wear. Visualization and simulation of assembly processes is also an area were the needs for automatic path planning is increasing with higher demands on reduced start-up times. Especially, path planning under non-nominal conditions is a future challenge where mathematics is considered to play a keyole.

This project has resulted in a simulation software demonstrator for automatic path planning. The goal is to obtain less planning variation and increased efficiency by supporting the following activities:

Design: Automatic assembly verification integrated in the design loop reduces mistakes and promotes standardized design methods.

Simulation: Rapid and objective assembly simulations results in unbiased estimates for assembly sequencing and simplifies visualization.

Off-line programming: Automatic via-point generation and optimization eliminates tedious off-line programming and updates caused by design changes.



Automatic path planning of driving unit (model by courtesy of Volvo).

The Quality Engineering Research Group

- Johan Carlson, PhD, Vice Director FCC
- Robert Bohlin, PhD
- Rikard Söderberg, Professor, Director Wingquist Laboratory, scientific adviser FCC

Johan Carlson

Robert Bohlin

Rikard Soderberg

Signals and Systems

General

The FCC research in this area focuses on the development of mathematical methods and algorithms in the following fields

- Signal and image analysis
- Finance and insurance mathematics
- Bioinformatics and biostatistics

Signal and Image Analysis

Focus is on the modelling and analysis of signals and images, e g,

- Detecting the presence of an object or phenomenon in the signal
- Classification of a signal or objects in an image
- Enhancement, i e, supressing unwanted features in the signal while keeping others intact or even strengthening them
- Compression, i e, reducing the data size of the signal, usually to the price of losing some information
- Systems parameter identification

Finance and Insurance Mathematics

Focus has been on the pricing of financial derivatives.

Bioinformatics and Biostatistics

Bioinformatics is a brand new discipline striving towards the seamless integration of genetics, mathematics, statistics and computer science. From the sequencing of the DNA to the development of a new drug or therapeutic method there is a long way, and efficient bioinformatics is crucial in each step. It involves research, development and application of computational tools and approaches to expand the use of biological, medical, behavioral and health data, including retrieving, storing, organizing, analyzing and visualizing such data.

Some projects

DNA Microarray Images

Microarray techniques have become increasingly important to analyze the expression of genes in cells, to measure which genes are active in a certain tissue, and to what extent. This information could give new insight into the underlying mechanisms of a disease, and propose new ways of treatment.

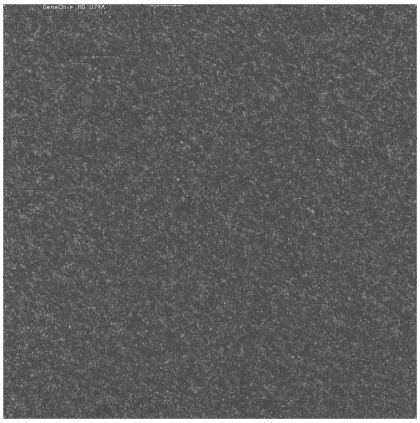
On a microarray chip, thousands of genes are tested simultaneously, each test occupying a small rectangular area. The activity of each gene is measured using fluorescent technique and a CCD camera, resulting in an image where active genes will appear as bright rectangles and inactive genes as dark.

The genes are spread out in a random (but known) manor. A non-defect image will then appear as white noise.

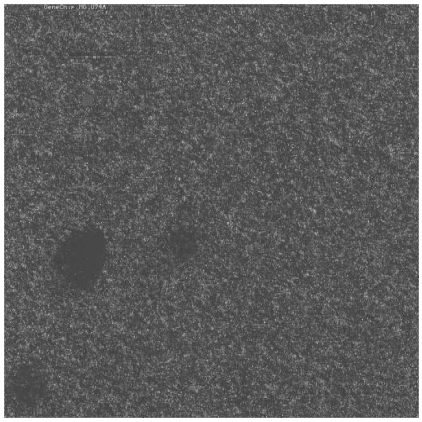
Sometimes regions of increased or decreased intensity appear, probably artifacts generated by the experiment. These may cover several test elements, and may therefore, if not accounted for, obscure the true outcome of the experiment. It is therefore of vital importance to be able to recognize, and exclude, such areas in the image.

Today, detection of artifacts is done by visual inspection, which is both time-consuming and subjective.

In this project with AstraZeneca, FCC has developed an automatic algorithm to detect artifacts and has successfully evaluated it on a number of test images.



A microarray image without artifacts.



Three dark spots, one in the lower left corner, and two in the left middle part.

The Signal and Image Research Group

- Fredrik Ekstedt, Lic
- Tomas Gustavsson, Professor, scientific adviser FCC

Fredrik Ekstedt

Tomas Gustavsson

Option Pricing

FCC, financed by Front Capital Systems and STM Research, coordinates a PhD project in option pricing at Chalmers. The project is carried out by MSc Eng Per Hörfelt under the supervision of Professor Christer Borell.

SSF project in Bioinformatics

The Swedish Foundation for Strategic Research finances a project at FCC along the same lines as in the programme "Future Scientific Leader". Project leader is Dr Marina Alexandersson. She joined FCC in September 2002 to build a group in bioinformatics.

A great interest is anticipated from the biotech industry for both direct aid in analysing their data as well as in developing software products. Important research areas include:

Computational sequence analysis: The sequencing of a genome provides the foundation for genetics and bioinformatics, but a far more difficult phase is to understand cellular biochemistry and mechanisms of disease. The first step is to organize, classify and parse the immense amount of sequence data. Computational sequence analysis methods include sequence alignment and profile searches, analysis and coordination of EST libraries, identification of functional elements such as genes and regulatory regions, identification of analysis of mutational processes, homology searches and phylogenetic inference.

Functional genomics: Although the most reliable way of determining the function of a gene is by direct experiments, this is often very difficult. An enticing approach would therefore be to computationally infer biological function from sequence alone. Functional genomics is characterized by experimental methodologies combined with statistical and computational analysis, and involves assessing structure and function from the primary sequence structure of the genes.

Proteomics: To create a drug for a disease a target has to be identified. For this we need to know what forms a protein can take, what other proteins it concurs with, and what pathways it is involved in. Proteomics and functional genomics involves the identification, characterization and quantification of proteins involved in certain pathways, cells, tissues or organs, and will have a major impact on the future development of clinical diagnostics and pharmaceutical therapeutics.

Biostatistics and statistical genetics: At this point bioinformatics adjoins the fields of biostatistics and statistical genetics. Both areas study individuals with respect to their disease status and genotypic status, and aim at inferring which genes are involved in the development of a disease, and in other interesting features such as for instance in the severeness of the disease, in the age of onset for the disease or in the survival of the affected individual.

Statistical genetics treat both quantitative and qualitative phenotypic measurements in individuals, and aim at pinpointing the position in the human (or other species) genome where there are genes affecting the disease. Interaction of genetic effects with environmental factors is of a particular interest.

Biostatistics and in particular survival analysis is involved with discovering genetic and environmental effects on the lifelength of individuals or in the age at onset for diseases.

The Bioinformatics Research Group

- Marina Alexandersson, PhD, research leader
- Dragi Anevski, PhD, from January 2003
- Sofia Andersson, PhD, from February 2003
- Sture Holm, Professor em, scientific adviser FCC


Marina Alexandersson


Dragi Anevski


Sofia Andersson


Sture Holm

Årsredovisning

för tiden 1 juli 2001 - 31 december 2002

Resultatrakning (kSEK)	2001-2002
Intäkter	
Erhållen basfinansiering	7 230
Fsg tjänster - ind proj	5 657
Fsg tjänster - publ proj	2 738
Fsg tjänster - EU proj	386
Övriga intäkter	216
Summa intäkter	**16 227**
Kostnader	
Personalkostnader	-9 197
Konsulter	-3 000
Lokaler	-1 757
Kontorskostnader	-1 037
Resor och representation	-744
Avskrivningar enligt plan inventarier	-492
Summa kostnader	**-16 227**
Rörelseresultat	
Resultat från finansiella investeringar	
Ränteintäkter och liknande	134
Räntekostnader och liknande	-61
Resultat efter finansiella poster	**73**
ÅRETS RESULTAT	**73**

Balansräkning (kSEK)	010701-021231
Anläggningstillgångar	
Inventarier	253
Datorer	384
Summa anläggningstillgångar	**636**
Omsättningstillgångar	
Likvida medel	2 214
Kundfordringar	2 168
Övriga fordringar	10
Förutbetalda kostnader och upplupna intäkter	653
Summa omsättningstillgångar	**5 045**
Summa tillgångar	**5 681**
Eget kapital och skulder	
Balanserat resultat	0
Årets resultat	73
Summa eget kapital	**73**
Långfristiga skulder	917
Summa långfristiga skulder	**917**
Kortfristiga skulder	
Leverantörsskulder	1 661
Övriga skulder	393
Upplupna kostnader	2 637
Summa kortfristiga skulder	**4 691**
SUMMA SKULDER OCH EGET KAPITAL	**5 681**

Styrelsen för Stiftelsen Fraunhofer-Chalmers centrum för industrimatematik, FCC, får härmed avge följande årsredovisning över verksamheten under tiden 1 juli 2001 - 31 december 2002, stiftelsens första verksamhetsår.

Stiftelsen bildades av Chalmers och Fraunhofersällskapet i juni 2001. Stiftelsen registrerades av Länsstyrelsen i Västra Götalands län i oktober 2001 som enskilt näringsdrivande stiftelse. Stiftelsens styrelse höll sitt konstituerande möte den 28 augusti 2001. Styrelsen år 2001 - 2004 utgörs av två ledamöter från vardera Chalmers och Fraunhofersällskapet och tre adjungerade ledamöter från industrin.

Stiftelsen tog den 1 september 2001 över delar av verksamheten, inklusive all personal, från Institutet för Tillämpad Matematik - en stiftelse. Antalet anställda har ökat från fyra till tolv personer den 31 december 2002. Stiftelsen har tecknat hyresavtal med Fastighets KB Forskarbyn omfattande 540 kvm i Chalmers Teknikpark för perioden 1 augusti 2002 - 31 mars 2005.

Uppbyggnaden av verksamheten har i stort följt den affärsplan från mars 2001 som låg till grund för Chalmers och Fraunhofersällskapets beslut att bilda stiftelsen.

Styrelse och ledning den 16 maj 2002; Staende: Joran Bergh, Peter Jagers (ordforande), Tomas Morsing (ersatt av Gunnar Andersson fr o m november 2002), Helmut Neunzert (vice ordforande), Johan Carlson (bitradande forestandare), Tomas Lefvert och Uno Navert (forestandare). Sittande: Dieter Pratzel-Wolters och Lars-Goran Lowenadler.

FORVALTNINGSBERATTELSE

Stiftelsen Fraunhofer-Chalmers centrum för industrimatematik skall utveckla och anpassa matematiska metoder för industriell tillämpning. Stiftelsen bedriver konkurrensneutral forskning med basfinansiering från ägarna och genomför projekt definierade av företag och offentliga finansiärer på kommersiell grund.

Rörelsens intäkter har uppgått till 16 226 kSEK. Detta utgör 45% basfinansiering, 35% industriprojekt, 17% offentliga projekt, 2% EU-projekt och 1% övrigt.

Årets resultat är 73 kSEK. Basfinansieringen har periodiserats så att utbetalad men ej upparbetad basfinansiering på 175 kSEK förs till nästa år. Eget kapital uppgick den 31 december 2002 till 73 kSEK. Enligt stiftelseurkunden har grundarna tillskjutit ett kapital på 50 kEUR vardera. Detta skall återbetalas senast den 31 december 2004.

Stiftelsens styrelse har under verksamhetsåret sammanträtt fem gånger. Ersättning har utgått till ordföranden med 4500 kronor per möte och till övriga ledamöter med 2250 kronor per möte vardera.

Stiftelsens ställning och resultatet av dess verksamhet framgår av efterföljande resultat- och balansräkningar vilka utgör en integrerad del av årsredovisningen.

Göteborg den 7 mars 2003

Peter Jagers, ordforande
Joran Bergh
Helmut Neunzert, vice ordforande
Dieter Pratzel-Wolters
Gunnar Andersson, adjungerad
Tomas Lefvert, adjungerad
Lars-Goran Lowenadler, adjungerad

Rakenskaperna har granskats av Deloitte & Touche.

Result (kEUR)	2001-2002
Income	
Basic funding	789
Projects - industry	617
Projects - public	299
Projects - EU	42
Others	24
Total income	**1 771**
Cost	
Staff	-1 004
Consultants	-327
Premises	-192
Office	-113
Travel and entertainment	-81
Depreciations	-54
Total cost	**-1 771**
Result of business	
Result of financial investments	
Interest and similar income	15
Interest and similar cost	-7
Result including financial investments	**8**
TOTAL RESULT	8

Balance (kEUR)	010701-021231
Fixed assets	
Furniture	28
Computers	42
Sum of fixed assets	**69**
Current assets	
Cash	242
Customer claims	237
Other claims	1
Prepaid costs and due income	71
Sum of current assets	**551**
Total assets	**620**
Equity capital and debts	
Balanced result	0
Result of the year	8
Total equity capital	**8**
Long-time debts	100
Sum of long-time debts	**100**
Short-time debts	
Debts to supplies	181
Other debts	43
Due costs	288
Sum of short-time debts	**512**
SUM OF DEBTS AND EQUITY CAPITAL	620

Appendix

Presentations / Conferences

M Alexandersson:
Bioinformatics, Chalmers, FCC inauguration September 4, 2002.

M Alexandersson:
Dynamic Programming Applied to Gene Finding and Alignment, Algorithms seminar, Datalogi, Chalmers, September 30, 2002.

M Alexandersson:
Picking Alignments from Steiner Trees, Matematisk Statistik, Chalmers, October 10, 2002.

M Alexandersson:
Genletning och Dolda Markov-modeller, Statistik inst, Orebro universitet, Orebro, October 17, 2002.

M Alexandersson:
Cross-species Gene Fiding and Alignment with Generalized Pair Hidden Markov Models, AstraZeneca, Molndal, November 18, 2002.

M Alexandersson:
Cross-species Gene Fiding and Alignment with Generalized Pair Hidden Markov Models, AstraZeneca, Sodertalje, December 16, 2002.

J S Carlson:
Kvalitetsteknik-Geometrisakring, kvalitetsgradering och Robotik, STM Annual meeting, May 15, 2003.

J S Carlson:
Mindre variation i sammansatta produkter, Invited speaker to seminar on "Variation kostar", Swedish Statistical Association, Stockholm, May 28, 2002.

J S Carlson:
Matematik som Teknologi, Vastsvenska Industri- och Handelskammaren, Goteborg, October 18, 2002.

J S Carlson:
3D-Tolerance Management
Invited speaker to A Stochastic Network Seminar, Goteborg, November 12, 2001.

J S Carlson:
Diagnosis of Sources of Variation,
Invited lecture to Workshop on Reduced Geometrical Variation in all Stages arranged by Chalmers and Michigan Engineering, Goteborg, October 4, 2001.

J S Carlson:
Visit Engineering department at University of Michigan, Ann Harbour, USA, April, 2002.

J S Carlson:
Visit Ford Motor Company, Dear Born, USA, April, 2002.

J S Carlson:
Visit GM, Detroit, USA, April, 2002.

J S Carlson:
ASME International Design Engineering Technical Conferences, Montreal, September 29, 2002.

P Johannesson:
Extrapolation and Scatter of Test Track Measurements, Presentation of paper at the Eight International Fatigue Congress, Stockholm, June 2 - 6, 2002.

P Johannesson, T Svensson, J de Mare, M Karlsson:
Four presentations at the Fraunhofer institute LBF, Darmstadt, Germany, November 29, 2002.

P Johannesson, J de Mare:
Utmattning, belastning och tillforlitlighet, Problemdriven statistikkurs (a course in statistics for Swedish industry), 4 half-days in November 2002.

J de Mare, T Svensson:
Presentation of a glossary on the statistics of extremes and its application to inclusion ratings. Meeting of the ESIS technical committee TC20, Milan, Italy, September 6, 2002.

M Patriksson:
Sensitivity of optimal solutions to optimization problems, FCC seminar, June 3, 2002.

A-B Stromberg:
Optimization of power systems under uncertainty for the board of STM, Goteborg, May 15, 2002 and for the FCC board, Goteborg, May 16, 2002.

A-B Stromberg:
Optimization in logistics at the day of SME, West Sweden Chamber of Commerce and Industry, October 18, 2002.

T Svensson:
Crack closure dynamics for random load processes - a key issue for engineering fatigue, Invited lecture at the Sture Holm seminar, September, 2001.

T Svensson, P Johannesson, J de Mare:
Participating in Course Fatigue Design by Keith Miller, Sheffield, UK.
Trollhattan, October 22 - 24, 2001.

T Svensson, P Johannesson, J de Mare:
Cumulative fatigue damage taking the threshold into account, participating in conference UTMIS livslangddag 2001. Trollhattan, October 25, 2001.

T Svensson:
Crack closure at variable amplitude fatigue - a simplified approach, presentation of paper at the Eight International Fatigue Congress, Stockholm, June 2 - 6, 2002.

T Svensson, P Johannesson:
Participating in Workshop on the fatigue limit and inclusions, Smogen, August 19 - 23, 2002.

T Svensson:
Invited lecture on fatigue limit estimation procedures at AB Volvo Trucks, , Goteborg, September 17, 2002.

T Svensson, J de Mare:
Participating in Course Material Science for fatigue and fatigue life prediction by Reinhard Pippan, University of Leoben, Austria.
Trollhattan, October 21 - 23, 2002.

T Svensson, J de Mare:
Participating in conference UTMIS livslangddag 2002. Trollhattan, October 24, 2002.

T Svensson:
One lecture on measurement uncertainy and two lectures on measurement system analysis at a course about measurement systems for Swedish industry arranged by SP, Boras, November 19 - 20, 2002.

T Svensson:
Invited lecture on quality engineering at AB Sandvik Steel, Sandviken, November 27, 2002.

Publications

M Alexandersson:
Waterston R.H. et al. Initial sequencing and comparative analysis of the mouse genome. Nature 420, pp 520-562, 2002.

R Bergstrom:
Adaptive Finite Element Methods for Div-Curl Problems. Doctoral dissertation, Chalmers, August 2002.

R Bergstrom, MG Larson:
Discontinuous/continuous least squares finite element methods for elliptic problems,Chalmers Finite Element Center, Preprint 2002-11.

R Bergstrom, MG Larson:
Discontinuous least squares finite element methods for the div-curl problem, Chalmers Finite Element Center, Preprint 2002-12.

J S Carlson and R Soderberg:
Assembly Root Cause Analysis: A Way to Reduce Dimensional Variation in Assembled Products. Accepted for publication in IJFMS Special Issue on Quality and Reliability: Modeling and Analysis for Complex Production Systems.

J S Carlson, R Soderberg and L Lindkvist:
Geometrical Inspection Point Reduction Based on Combined Cluster and Sensitivity Analysis. Accepted for publication in 2003 ASME International Mechanical Engineering Congress and Exposition November 16-21, 2002 Washington, DC.

L Lindkvist, R Soderberg and J S Carlson:
Early Evaluation of Geometrical Interactions, a Survey of Methods, Submitted to ASME Journal of Manufacturing Science and Engineering

F Ekstedt:
Artifact detection in microarray images, FCC report 601-020919-105.

M Gunther:
Parameter estimation in power network, FCC report 606-020625-102.

M Gunther, K Samuelsson, MG Larson:
Macroscopic properties of paper by microstructural simulations, FCC report 203-020919-104.

P Johannesson, J-J Thomas:
Extrapolation of Rainflow Matrices. Extremes 4, pp 241-262, 2001.

P Johannesson:
On rainflow cycles and the distribution of the number of interval crossings by a Markov chain. Probabilistic Engineering Mechanics 17, pp 123-130, 2002.

P Johannesson, J-J Thomas, J de Mare:
Extrapolation and Scatter of Test Track Measurements. Proceedings of the Eight International Fatigue Congress, Stockholm, Sweden. Editor A F Blom, Engineering Materials Advisory Services Ltd, UK, 2002.

L Beilina, K Samuelsson, K Ahlander:
A hybrid method for the wave equation. Gakuto International Series Mathematical Sciences and Applications, Proceedings of International Conference on Finite Element Methods, Three-dimensional problems, Volume 15, 2001.

P Ingelstrom, T Rylander, K Samuelsson, A Bondeson:
Adaptive mesh techniques for the FEM-FDTD hybrid solver. Conference Proceedings, EMB 01 - Electromagnetic Computations, Methods and Applications, Uppsala, November 14 - 15, 2001.

YQ Liu, A Bondeson, R Bergstrom, C Johnson, MG Larson, K Samuelsson:
Eddy current computations using adaptive grids and edge elements, IEEE Trans Mag, vol 38, pp 449-452, 2002.

YQ Liu, A Bondeson, R Bergstrom, MG Larson, K Samuelsson:
Edge element computations of Eddy currents in laminated materials, accepted for publication by IEEE Trans Mag in 2003.

P Heintz and K Samuelsson:
On adaptive strategies and error control in fracture mechanics, Chalmers Finite Element Center Preprint 2002-14.

T Svensson:
Matosakerhet, FCC report 302-020816-103.

T Svensson:
Variability in proof stress experimental results, FCC report 354-021101-108.

T Svensson:
Cumulative fatigue damage taking the threshold into account, Fatigue Fracture of Engineering Materials Structures 25, pp. 871-876, 2002.

T Svensson:
Crack closure at variable amplitude fatigue - a simplified approach. Proceedings of the Eight International Fatigue Congress, Stockholm, Sweden. Editor AF Blom, Engineering Materials Advisory Services Ltd, UK, 2002.

PhD students advisement

J S Carlson adviser of Kristina Warmefjord:
Inspection Data Feedback and Analysis, Saab Automobile AB.

T Svensson adviser, and P Johannesson co-adviser of Magnus Karlsson:
Parametrisation of Vehicle Operating Environment, Chalmers.

T Svensson co-adviser of Johan Svensson:
Optimal planning of maintenance on air engines, Chalmers.

T Svensson co-adviser of Sara Loren:
Statistical aspects on fatigue limit, Chalmers.

T Svensson co-adviser of Jenny Andersson:
Crack growth in random grain structures, Chalmers.

A-B Stromberg co-adviser of
Niclas Andreasson:
Optimization of aircraft engine maintenance, Chalmers.

A-B Stromberg co-adviser of Fredrik Altenstedt:
Asset-liability management via stochastic programming for a Swedish life insurance company (supported by Nordea Liv), Chalmers.

A-B Stromberg co-adviser of Roger Halldin:
Scenario trees for inflow modelling in stochastic optimisation for energy planning, Lund University.

Masters thesis advisement

M Alexandersson co-adviser of Erik Hemberg and Joel Eriksson:
On optimal evolutionary distance for comparative gene finding, Chalmers.

J S Carlson superviser of Ulrika Larsson:
Calibration based on Statistical Control, Saab Automobile AB, December 6, 2001.

J S Carlson superviser of Martin Lorentsson:
Reducering av geometrimatpunkter samt kartlaggning av processparametrar i tillverkning av karosskomponenter, Volvo Components AB, December 11, 2001.

J S Carlson superviser of Johan Svensson:
Kvalitetsstyrning och diagnos av geometriska variation i sammansattningssystem Saab Automobile AB, November 2001.

P Johannesson adviser of Carl-Eric Strengell:
A Survey of Experimental Design with Applications, Chalmers.

K Samuelsson adviser of Henrik Sandstrom and Mattias Shamlo:
Development of ADRIAN Joint Analysis Software, Chalmers and Volvo Cars.

T Svensson co-adviser of Per Kalling and Anders Karlstrom:
Statistical Approach to Fatigue Life Prediction of Spot Welds, Chalmers and Volvo Cars.

A-B Stromberg adviser of Cecilia Hansryd:
Integrated solution of two crew scheduling problems, Chalmers.

A-B Stromberg adviser of Anna Svagan:
Improving lower bounds for winter road maintenance problems, Chalmers.

Other assignments

J S Carlson:
Reviewer for IEEE Transactions on Robotics & Automation.

J S Carlson:
Reviewer for ASME Journal of Manufacturing Engineering.

J S Carlson:
Reviewer for IIE Transactions.

PhD students Kristina Warmefjord (advised by J Carlson and partly financed by FCC), Niclas Andreasson (co-advised by A-B Stromberg, FCC), Johan Svensson (co-advised by T Svensson, FCC), Magnus Karlsson (advised by T Svensson, FCC), and Per Horfelt (partly financed by FCC).

Annika Eriksson and Uno Navert, editors.

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The purpose of FCC is to promote the application of mathematical methods in industry. To do so the Centre will undertake pre-competitive scientific research in the field of applied mathematics and work on projects defined by companies or public institutes.

The Centre, in close co-operation with Chalmers in Goteborg and Fraunhofer-ITWM in Kaiserslautern, shall be a leading partner for international industry and academia to mathematically model, analyse, simulate, optimize, and visualize phenomena and complex systems in industry and science, to make development of products and processes more efficient and secure their technological and financial quality.