IVSS
Intelligent Vehicle Safety Systems

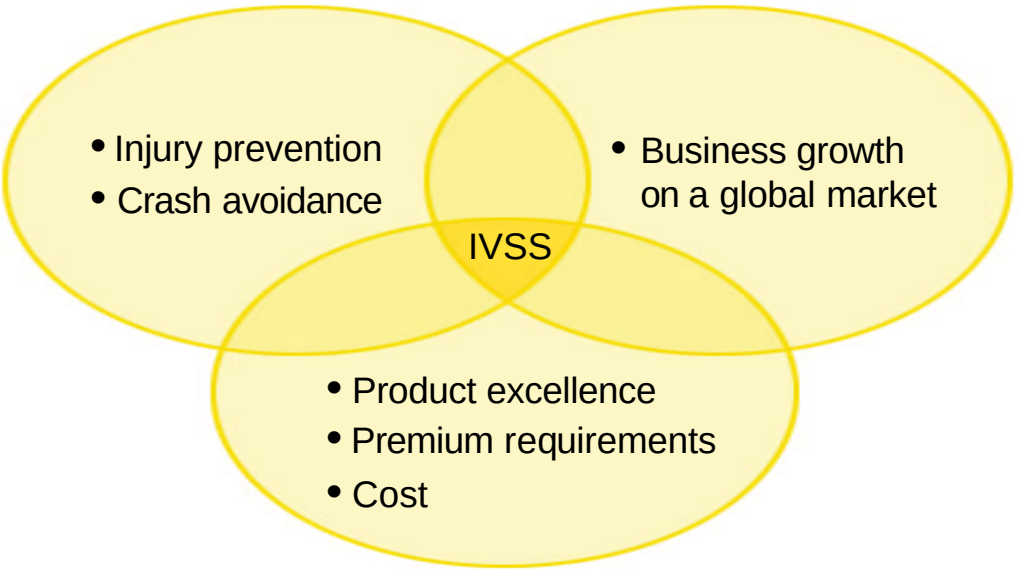
Model integration for analysis of architecture and dependability

IVSS Project Report

The IVSS Programme

The IVSS programme was set up to stimulate research and development for the road safety of the future. The end result will probably be new, smart technologies and new IT systems that will help reduce the number of traffic-related fatalities and serious injuries.

IVSS projects shall meet the following three criteria: road safety, economic growth and commercially marketable technical systems.



Three interacting components - for better safety, growth and competitiveness:

The human being

Preventive solutions based on the vehicle's most important component.

The road

Intelligent systems designed to increase security for all road users.

The vehicle

Active safety through pro-active technology.

Title of the report: : ”Model integration for analysis of architecture and dependability”

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Reference number:

Publication date: 060315

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1. Summary

This project has been a cooperation between Scania and the department of Machine Design (division for Mechatronics) at KTH.

The project has investigated and developed methodologies to improve the handling of EE-system product data, in order to increase process efficiency as well as product quality and product safety. The project has included four parts:

- PhD-student 1: Architecture design and model based development
- PhD-student 2: Model management and integration
- Case study at Scania: Information modelling
- Case study by students: Testing of concepts during development of truck scale model

The project has provided many interesting results and competent persons. The project result contributes indirectly to traffic safety since appropriate methods and tools are needed to handle the increased complexity in the EE-system:

- to avoid that dangerous faults are introduced in the already complex EE-system.
- to make the automotive companies prepared to introduce further new electronic safety functions.

This is a central area for the future, with direct effect on competiveness and growth.

2. Summary in Swedish

Detta projekt har varit ett samarbete mellan Scania och institutionen för Maskinkonstruktion (avdelningen för Mekatronik) på KTH.

Projektet har man undersökt och utvecklat metoder för hantering av produktdata för EE-system, med syfte att förbättra processeffektivitet såväl som produktkvalitet och –säkerhet. Projektet har inkluderat fyra delar:

- Doktorand Arkitekturkonstruktion och modellbaserad utveckling
- Doktorand: Modellhantering och – integration
- Fallstudie på Scania: Informationsmodellering
- Fallstudie av studenter: test av koncept vid utveckling av lastbilsskalmodell.

Projektet har levererat många intressanta resultat och kompetenta personer. Projektresultatet bidrar indirekt till trafiksäkerhet eftersom lämpliga metoder och verktyg behövs för hantera den ökade komplexiteten in EE-systemet:

- för att undvika att farliga fel införs i det redan komplexa EE-systemet
- för att göra bilföretagen beredda att introducera ytterligare nya trafiksäkerhetsfunktioner

3. Activities and results

3.1. General

This project includes the final research of two PhD-students, in cooperation, as well as a student project strongly linked to PhD-students. The project fits into the IVSS:s "dependable systems" area of research and thus the project have focused on methods for development rather then the development of new functionalities or parts for in vehicle use.

Dependability of the electronic systems in vehicles is crucial for the experience of safety and quality. The modern electronics in vehicles have become very complex and in fact the complexity itself may introduce errors and the complexity makes it difficult to find all possible errors by conventional approaches. Consequently, it is very important that the methods and tools used during development helps the engineer to view and analyse the system in various ways, so that not faulty products reach the market. By improving such methods, the project contributes to traffic safety by avoiding faults. Moreover, improved methods to handle the complexity also make the industry better prepared and inclined to introduce further functionalities that directly increase traffic safety.

The increased amount of electronics and software is a great challenge for organisations with long history of developing "mechanical" products. This challenge must be handled in order to stay competitive in the automotive industry, and this project has built competence and solutions as a contribution. It will strengthen the competiveness of Scania in a growing area of the automotive industry.

3.2. PhD-project 1: Architecture design and model based development

Ola Larses started his PhD-student project to investigate and develop methods for designing and choosing EE-system architectures. The idea was not only to look on software and electronics, but also include mechanical issues such as physical position. Various methods and tools have been developed to analyse and design the system e.g.:

1. Tool to provide keyfigures such as cable length, no. of components in bad environment, etc. for product variants and possible architectural solutions.
2. Methods to analyse the degree of modularity, and also indicate good solutions in terms of modularity.

Theses two components has also been integrated in an iterative work process as described in figure below.

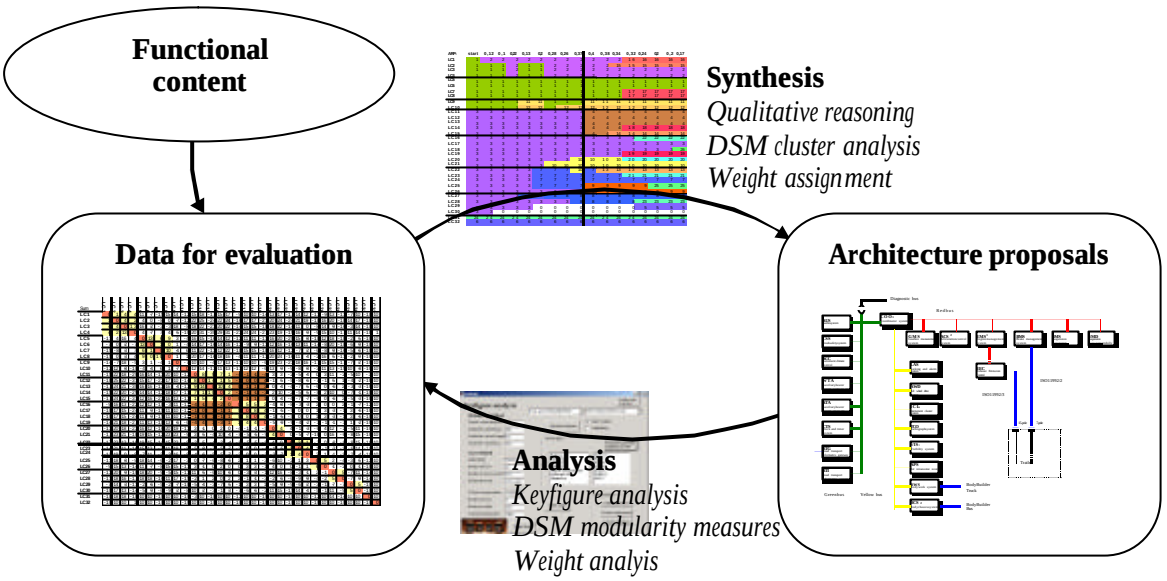


Figure: Work procedure including modularisation based on DSM-matrix, cluster analysis and keyfigure tool.

The developed methods and tools for architecture design require model based development as a basis, in order to work effectively. However, model based approaches are today not used fully in all engineering domains, and thus some of the information needed for the architecture methods was not to be found in a database format. This accentuated the need for model based representation of the EE-system, and also the need for a repository where the information could be accessed. The need to separate function and implementation, to give freedom in architecture design, was highlighted. Moreover, it became obvious that the information about the EE-system need to be accessed or linked to all the processes within the company, namely development, sales-to-delivery and customer support, as indicated in the figure below. Thus, methods for systems engineering increased in focus in the end of the project.

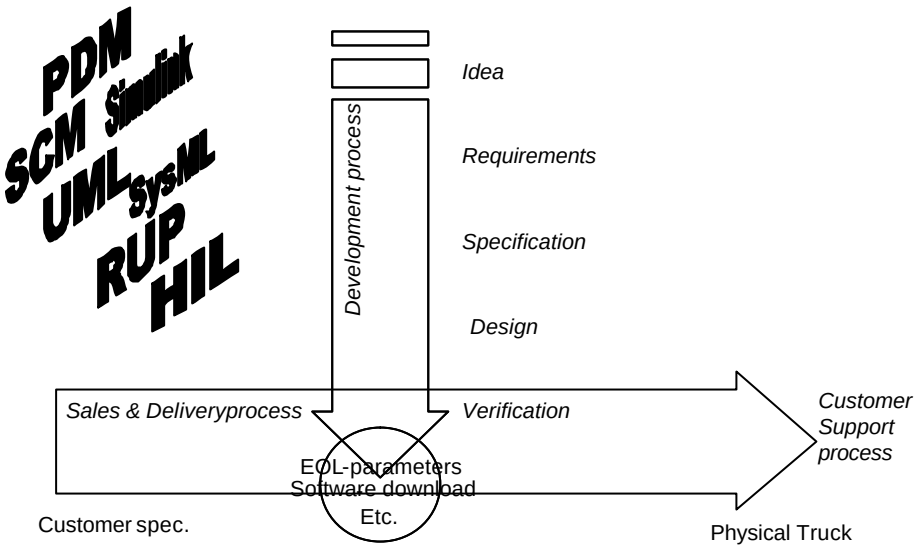


Figure: Indication of the three processes which need EE-system product data, and some of the discussed support methods.

The research is well described in the doctoral thesis, presented 051215.

3.3. PhD-project 2: Model integration and management

Jad El-khoury has worked on methods to integrate information (models) from various disciplines into one tool, in order to simply the work between the domains such as electronics, software and mechanics, as illustrated below.

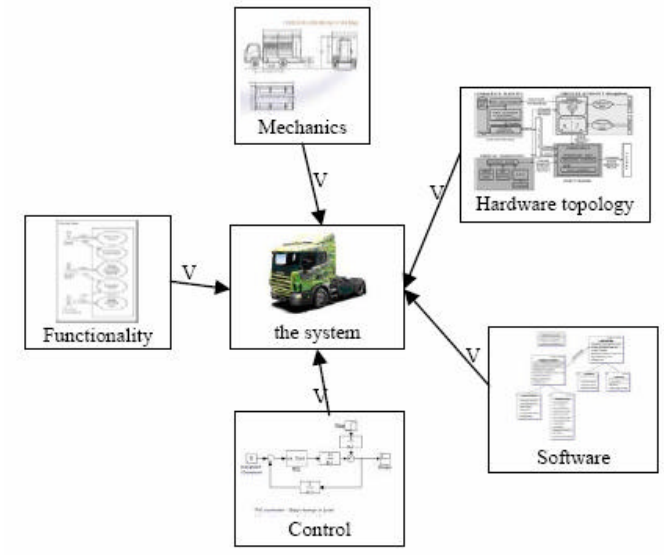


Figure: Different views of a system.

Much of the research has been devoted on how to represent the information, how to break down the information in hierarchies and how link the information between the domains. Various modelling techniques has been applied and developed as illustrated below.

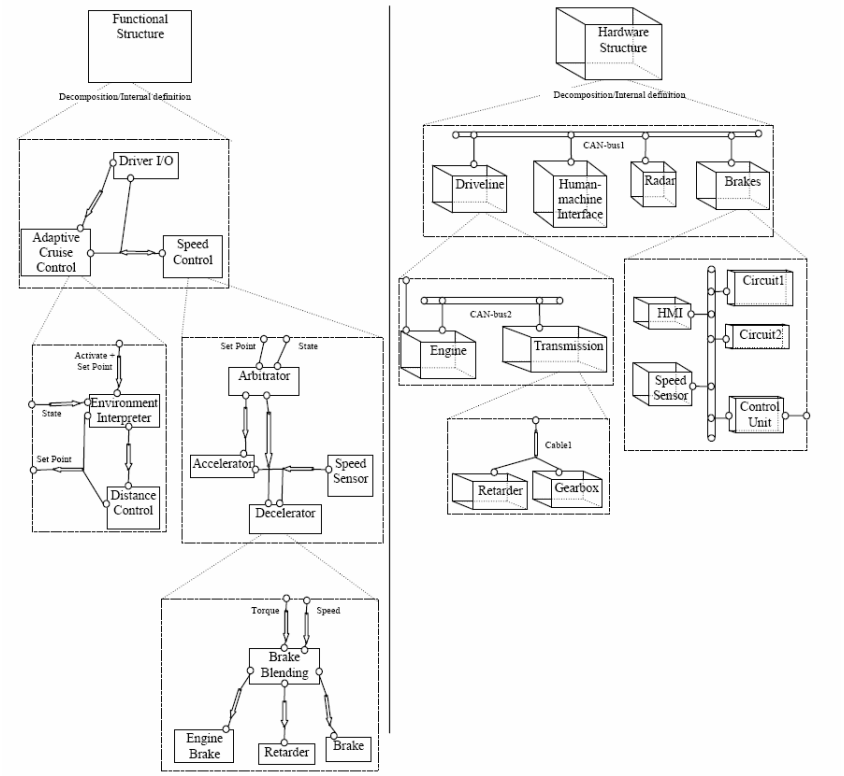


Figure: Modelling two views of a system.

The research is well described in the doctoral thesis, presented 060303.

3.4. Case study: Information model at Scania

During the end of the PhD-students research, they cooperated in a case study at Scania. The needs for EE-system product data information at various departments was surveyed and combined with the experience from previous research. The result of this activity was partly a recommendation for some changes in documentation, i.e. a better separation of function and implementation, but more importantly an information model for the EE-system.

It was highlighted that in terms of models for the EE-systems, it may be wise to use activity diagrams, not only Message Sequence Charts as conventional today, in order to separate function and implementation. Moreover, to link the function to the hardware (implementation) an activity diagram shown as swim lanes could be useful.

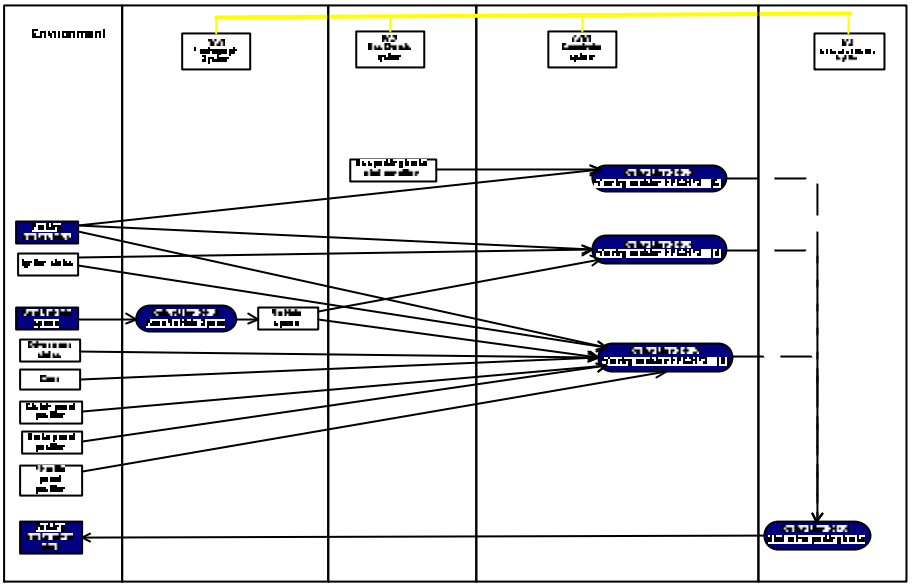


Figure: Activity diagram, with variant functions and related to hardware with swim lanes.

The information model, depicted below, may serve as basis for the development of product data management which includes EE-systems.

The result of the case study is described in the two PhD-thesis'.

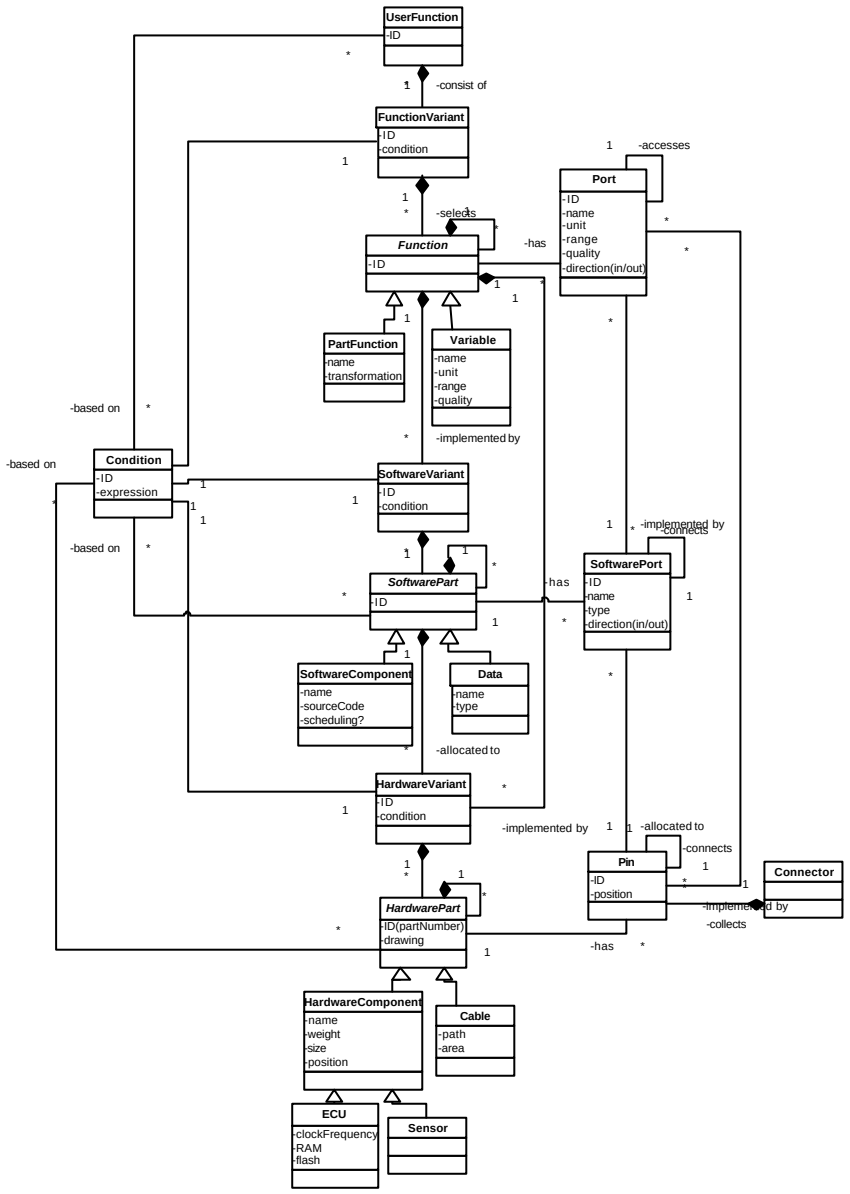


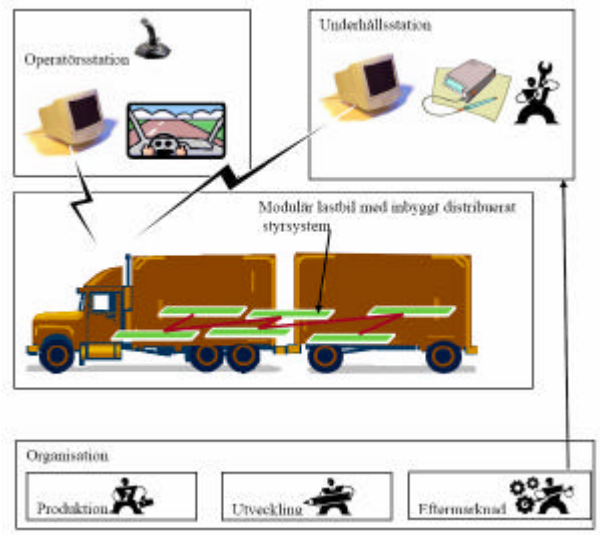
Figure: Information model for EE-systems.

3.5. Case study: The student project SAINT

During the project, first 16 MSc-students and later another 6 MSc-students, have worked on the development of a model truck (scale 1:6) with advanced functionalities. The project was named SAINT – Self Adaptive INtelligent Truck. An important part of the project has been the development and use of state-of-the-art methods. The combination of traditionally software modelling techniques such as UML (Unified Modelling Language)

and PDM (Product Data Management) has been explored, in close cooperation with the researchers.

The figure below gives an indication of technologies that has been implemented in the truck model, which includes wireless transfer of code and diagnosis. Moreover, the figure below indicate that three processes; development, sales-to-delivery and customer support has been considered by the methods and tools used.



A special effort has been done on demonstrating how a commercial PDM-system such as Matrix (today used by Scania) may be used for other product data than conventional for these systems, an effort which is described by the figure below. Automated variant configuration, and automated code download was also developed.

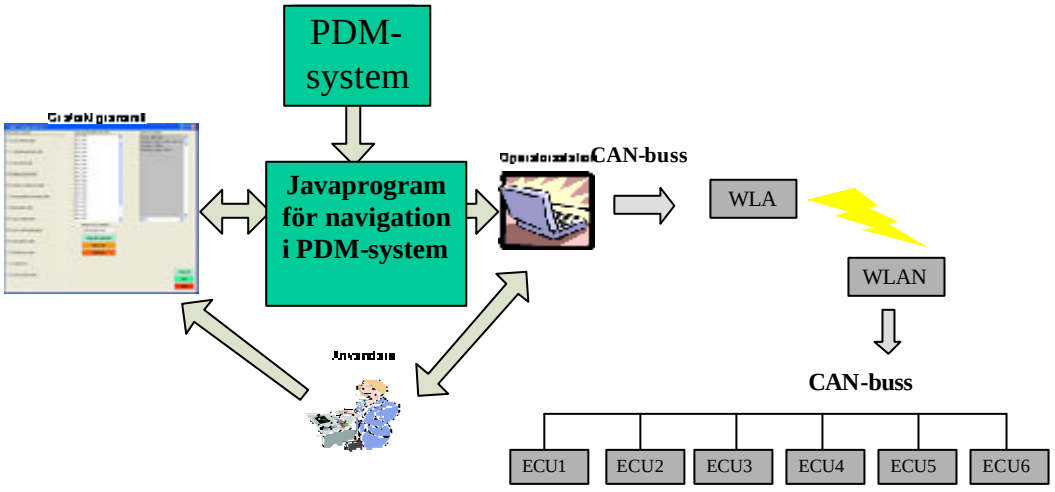


Figure: PDM-system as support.

The project is described in some detail at:
http://www.md.kth.se/download/publications/2005/damek/Trita-MMK200526.pdf

4. Conclusions and recommendations

The project objective to develop methods and tools which improves development process efficiency as well as product quality and product safety is well achieved. IVSS has only founded the last part of the project (roughly 20%), but the activities done during this period will have rapid effect on Scanias methods of work, e.g. changes in documentation (separation of function and implementation). Model based approaches for product data management of EE-systems will be the next step.

This is an important area which is reflected in how much the subject is treated at various automotive electronics conferences. Moreover, it is a difficult area because changes in methodology affect many people in large organisations. Nevertheless, a small project as this gives effects. The project has provided both results and competent persons to the industry.

Most likely it may be wise to invest in more research in the area and Scania are considering various possibilities.

5. Appendices

1. Ola Larses, ”Architecting and Modeling Automotive Embedded Systems, PhD-thesis, KTH, December 2005
2. Jad El-khoury, “A Model Management and Integration Platform for Mechatronics Product Development”, PhD-thesis, KTH, March 2006
3. Daniel Blixt, et. Al, “Project SAINT”, Technical report, KTH, 2005

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