Information Fusion from Databases, Sensors and Simulations

SUPPORTED BY Knowledge Foundation

- a Research Program in Cooperation with Industry

Professor Sten F. Andler et al.
School of Humanities and Informatics
University of Skövde, Sweden

UNIVERSITY OF SKÖVDE

www.**infofusion**.se

Information Fusion Research Program

- Granted by Knowledge Foundation
  - Over six years (April 2005 – March 2011)
- Total budget SEK 120 million ($17 M)
  - Knowledge Foundation SEK 36 million
    - Professor, 2 post-docs, 10-12 PhD students
  - University of Skövde SEK 29 million
    - Existing faculty (including some other grants)
  - Industry etc. SEK 55 million
    - Research & development, licenses, support

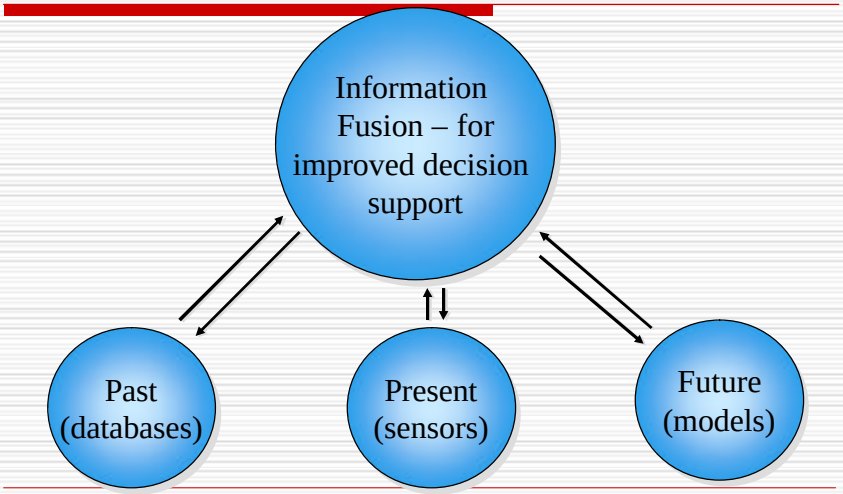
Contents

- The Knowledge Foundation grant
- The Information Fusion process
- Scenario: Ground situation awareness
- Vision: Information Fusion Framework
- Scenarios: Driving the vision
  - Bioinformatics, manufacturing, precision agriculture, systems development
- Organization and build-up phase

UNIVERSITY OF SKÖVDE

infofusion

Information Fusion Process

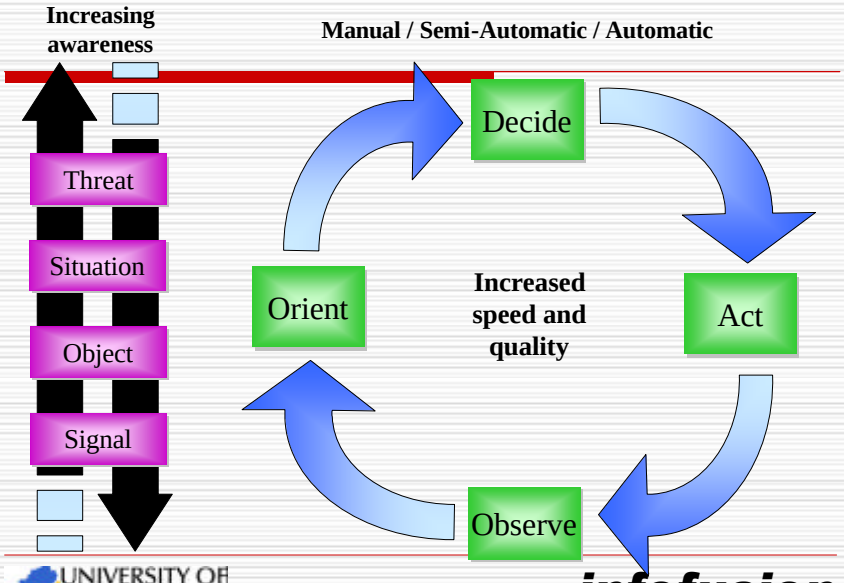


UNIVERSITY OF SKÖVDE

infofusion

(with Ericsson Microwave Systems)

Information Fusion Context

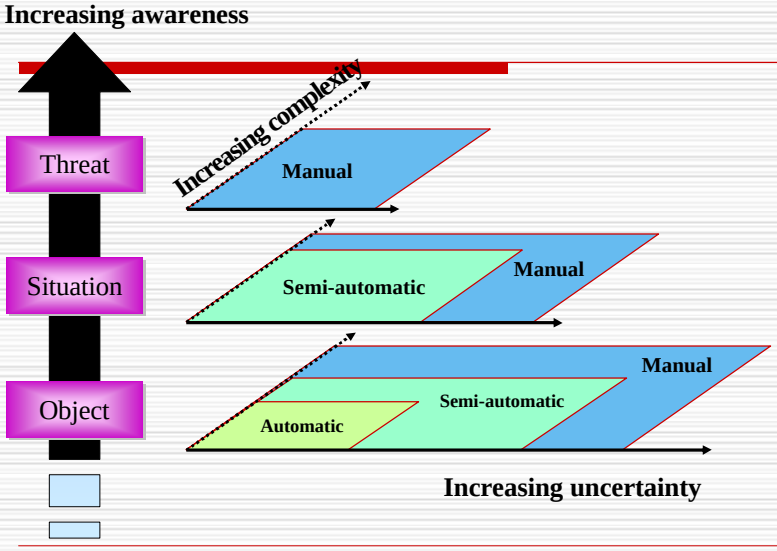


UNIVERSITY OF SKÖVDE

infofusion

(with Ericsson Microwave Systems)

Information Fusion Potential



UNIVERSITY OF SKÖVDE

infofusion

(with Ericsson Microwave Systems, Exensor)

Ground Situation Awareness Scenario: Ideal for development of information fusion methods

For situation awareness and fast decision cycles we need to:

- **Process, fuse and analyze information from many sources into Common Situation Picture**
- **Pass relevant parts of Situation Picture to everyone with need**
- **Adapt resources to situation, in planning stage and real time**

(with Ericsson Microwave Systems, Exensor)

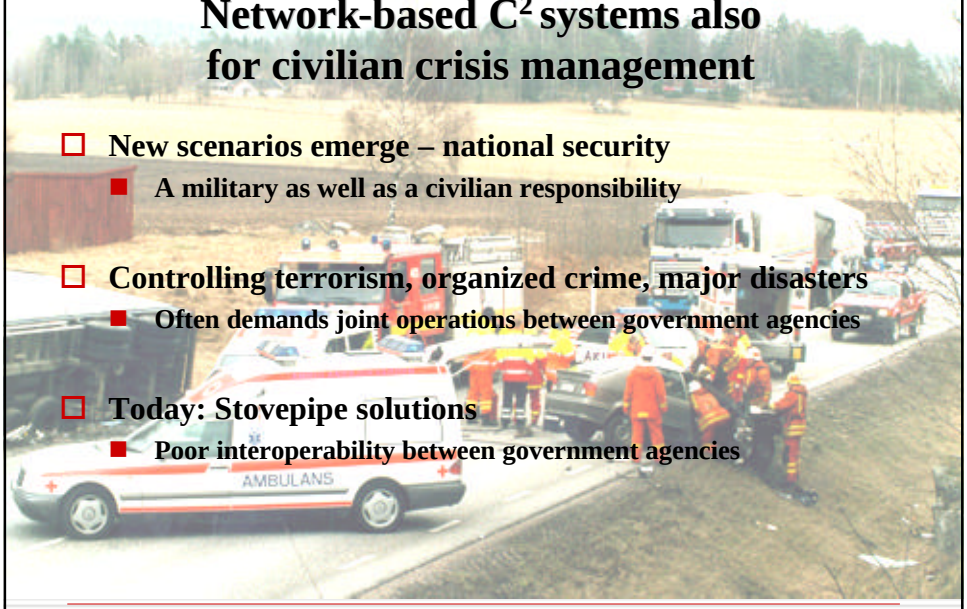
Ground Situation Awareness Scenario: Some very tough problems to solve

-complex situations
-very large numbers of detected objects/targets
-hidden or camouflaged objects
-dense target scenarios and terrain masks makes target tracking very hard
-large amounts of clutter generating false detections
-target classification/identification very important

The information environment is heterogeneous and must be interpreted at several levels

Sensor Data Fusion and Information Fusion will play important roles when combining and analyzing the information!

Network-based C^2 systems also for civilian crisis management



- **New scenarios emerge – national security**
  - **A military as well as a civilian responsibility**
- **Controlling terrorism, organized crime, major disasters**
  - **Often demands joint operations between government agencies**
- **Today: Stovepipe solutions**
  - **Poor interoperability between government agencies**

Our Information Fusion Vision

Maintaining a *holistic* perspective on IF

1. *Theoretical framework – nature of IF*
   - Terminology, information fragments, effects
2. *Algorithms and methods for IF, modeling*
   - Building blocks for IF applications
3. *Infrastructure for IF systems*
   - Domain-specific requirements
   - Toolbox / platform evaluation / demonstrator

Why a Theoretical Framework?

- To develop a holistic perspective that encompasses:
  - different types of fusion at different levels,
  - information fusion in the context of its use in the support of human decision making
- To facilitate cooperation between groups
  - e.g. terminology
- To exploit synergy between different scenarios/projects

Existing Frameworks

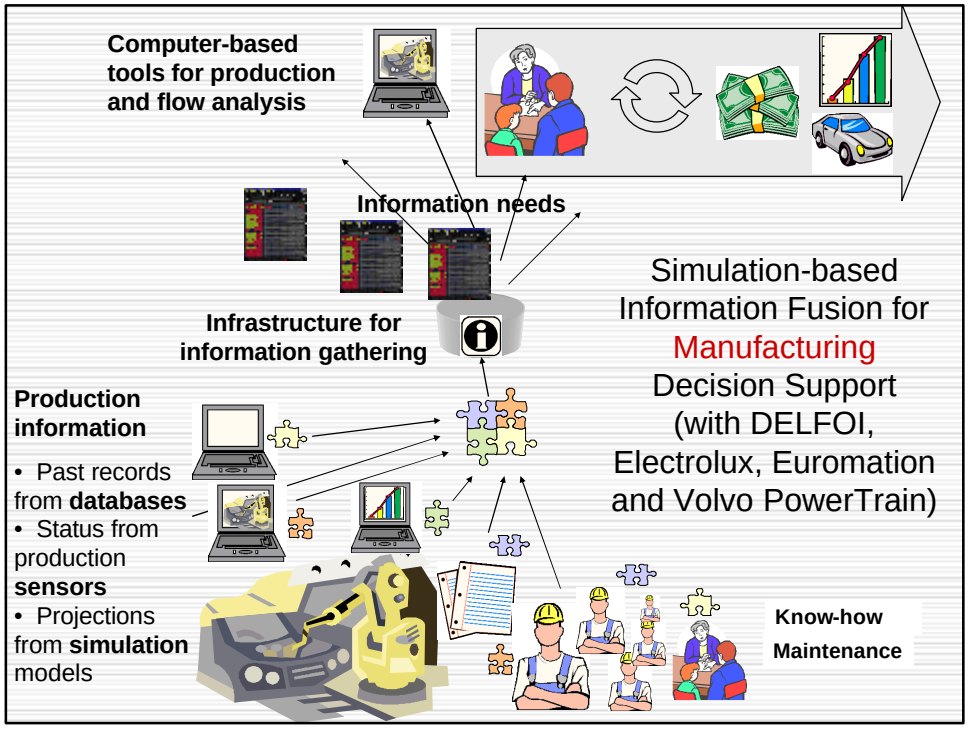
- Several fusion models exist
  - e.g. the (revised) JDL data fusion model, originally developed in the mid 1980:s
- but all of these have limitations:
  - e.g. specific to military applications
  - e.g. not incorporating
    - requirements of human decision making and support
    - system development issues

Our framework will …

- take existing models as a starting point
- develop a common terminology across projects
- identify generic elements and processes across different fusion applications and contexts
- capture the interaction of information fusion
  - with the cognitive processes and requirements of (individual) human decision making
  - with the flow of information in collective decision processes in groups and organizations
- address system development issues

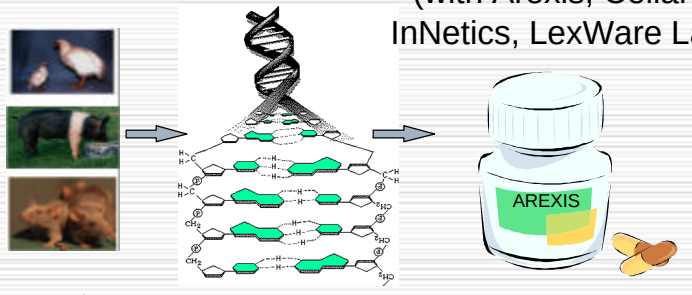
Scenarios: Driving the Vision

- Information fusion for rapid and improved decision making in network-based systems (*ground situation awareness* scenario)
- Simulation-based information fusion for *manufacturing* decision support
- Information fusion for medical informatics and *bioinformatics*
- *Precision agriculture*
- Information fusion in the *systems development* process
- *Infrastructures* for information fusion



Information fusion approach to drug discovery

(with Arexis, Cellartis, InNetics, LexWare Labs)



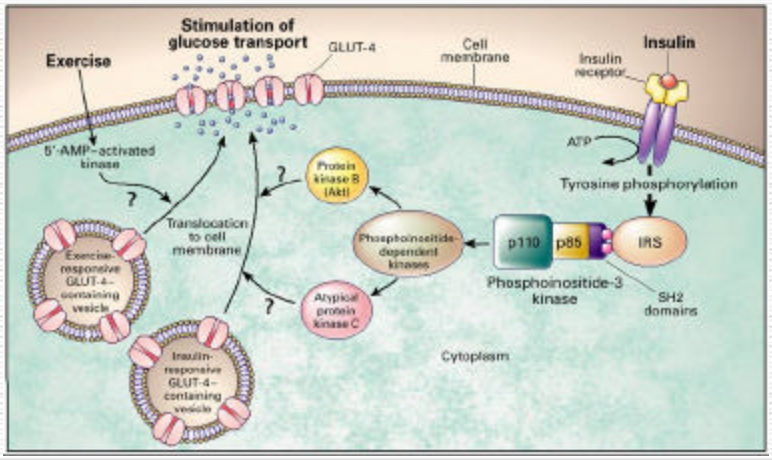
Genetics Genome Drug

- Information fusion from many different levels of data
- Observation and control of biological experiments
- Comparison to predicted behavior from models

UNIVERSITY OF SKÖVDE

infofusion

Glucose uptake - type 2 diabetes



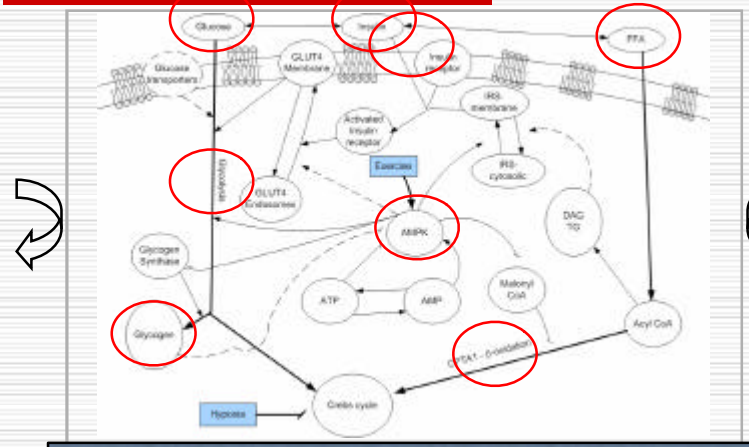
UNIVERSITY OF SKÖVDE

Modified from Shepherd et al. NEJM 1999

infofusion

Vision - short term

- Systems biology
- Software engineering
- Mathematics, etc.



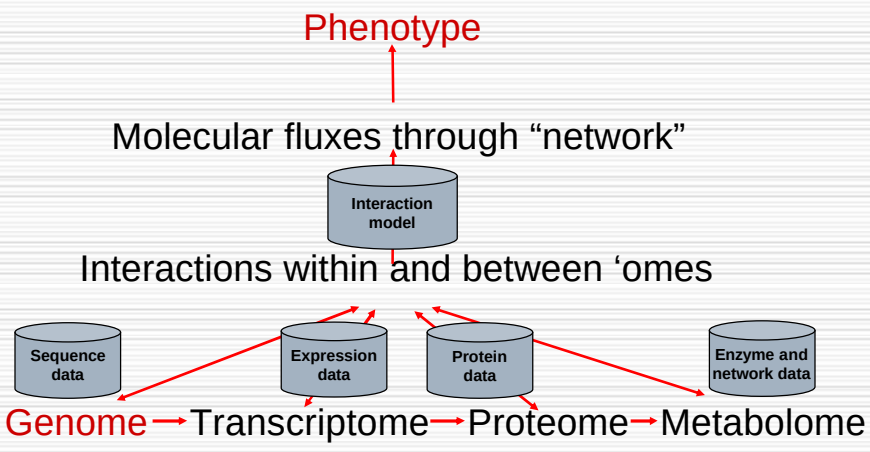
insulin resistent

insulin responsive

UNIVERSITY OF SKÖVDE

infofusion

Information fusion in bioinformatics



UNIVERSITY OF SKÖVDE

infofusion

Figure 1: 10-Year Trends in Biomedical Research Spending

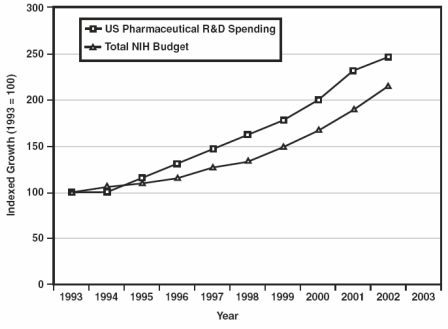
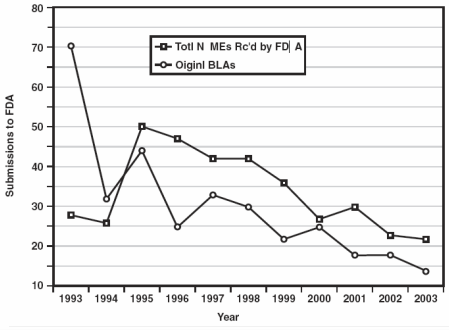


Figure 2: 10-Year Trends in Major Drug and Biological Product Submissions to FDA



UNIVERSITY OF SKÖVDE

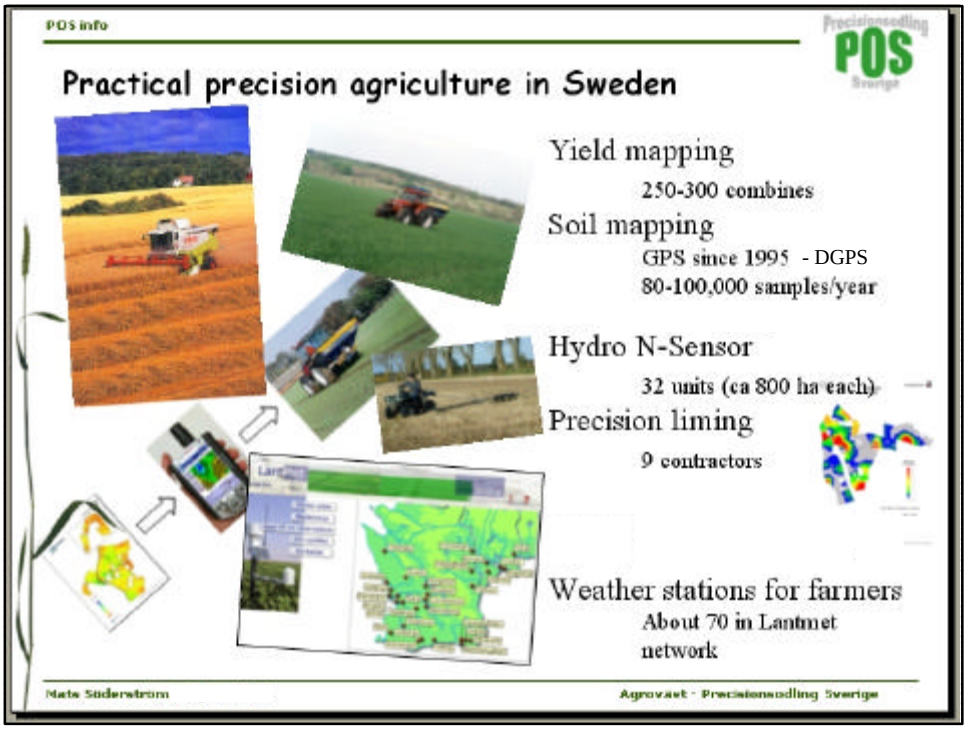
infofusion

Precision Agriculture Scenario

- Control the first link of the food production chain
  - ⇒ high/stable quality, minimal impact
- Research, development and practical application of PA techniques for
  - Optimizing the application of fertilizer and pesticides (and watering) within fields
  - Improving yield and quality towards the requirements of customers (while reducing cost)
  - Minimizing environmental impact, e.g. run-off (conventional/ecological)
- (with Agrovast foundation, Swedish Farmers' Co-operative, Yara in Sweden and Nordkalk)

UNIVERSITY OF SKÖVDE

infofusion



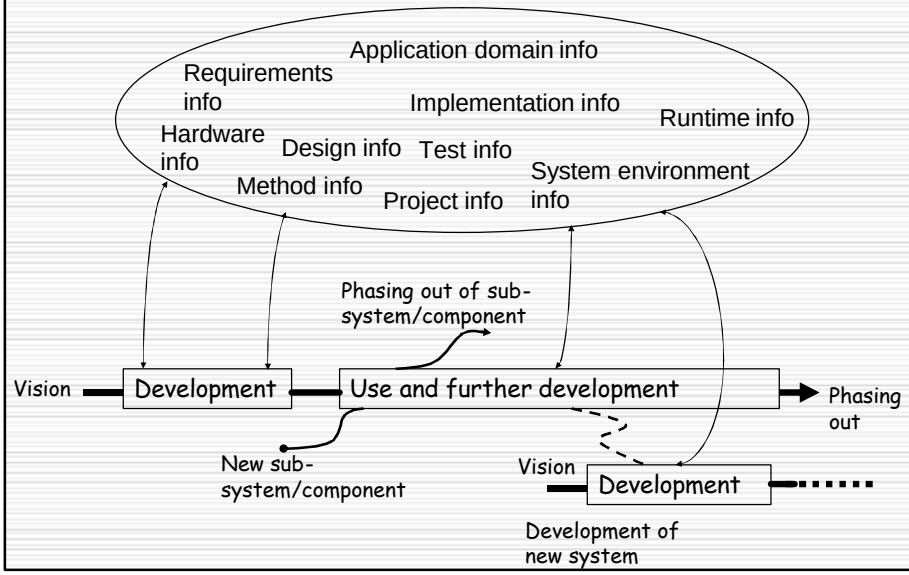
Precision Agriculture, cont.

- Soil condition (e.g. clay content)
  - Sparse samples for careful analysis in lab
  - Continuous measurements of soil conductivity
  - ⇒ Interpolation of approximate clay content
- Real-time Information Fusion of
  - Databases: soil condition, harvests, rainfall
  - Sensors: current state of crop (nitrogen take-up, water content)
  - Simulations: Models of fertilizer effect, rainfall variations, etc.

UNIVERSITY OF SKÖVDE

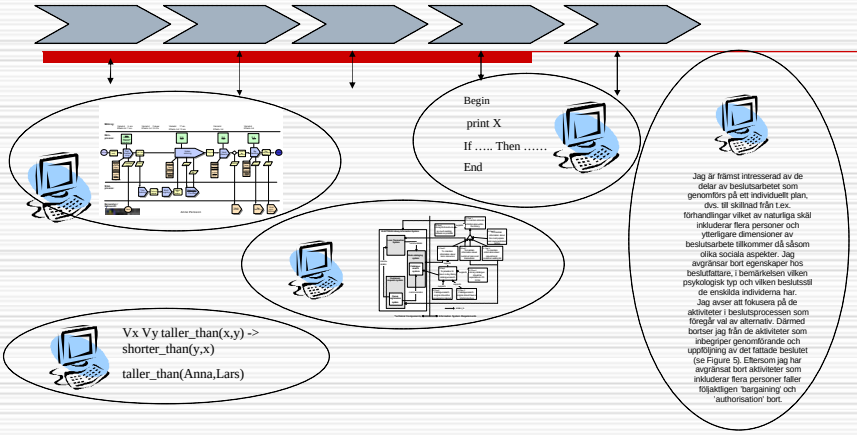
infofusion

Information fusion in the software development process



IS development
= decision driven process

Keywords: Lifecycle perspective
Information transformation
Information fragmentation



Info about the past: development information from previous life-cycles
Info about the present: runtime data, current development information
Info about the future: simulations of future system behaviour

UNIVERSITY OF SKÖVDE

infofusion

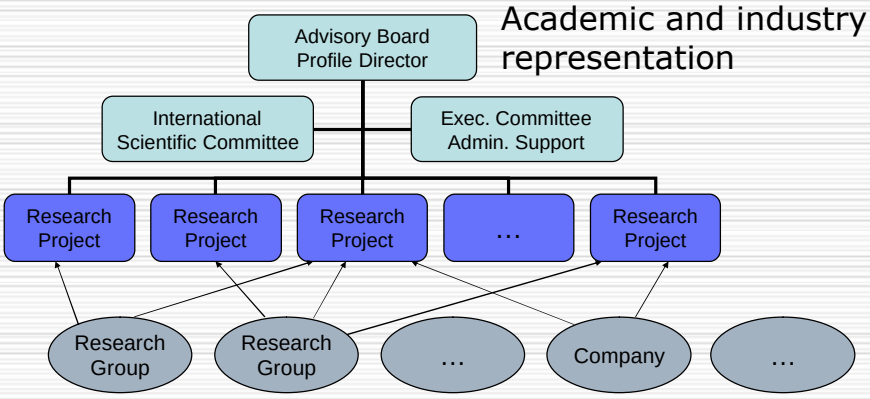
The IF vision for the software development process

- Improve precision and requirements fulfillment of developed software
- Decrease lead-time in the development process
  - increased computer supported co-use (fusion) of development information between the different development phases
  - effective and efficient integration of tool support in the development process with the intention to support synergy between the different phases
  - improved accuracy and timeliness of decision-making in the software development process

UNIVERSITY OF SKÖVDE

infofusion

Organization: Research collaboration



UNIVERSITY OF SKÖVDE

infofusion

Build-up Phase

- 15 Sep 2004 – Kick-off of build-up
  - Program director, co-director
  - Executive committee
- 1 Apr 2005 – Profile start
  - Contract with Knowledge Foundation
    - Program plan, objectives, budget
  - Contracts with companies
    - Extent, responsibilities, IPR
  - Initial project specifications
  - Advisory Board

UNIVERSITY OF SKÖVDE

infofusion

infofusion **– Information Fusion Research Program**

EUROMATION

Arexis

Inovetics

Electrolux

Lexware Labs

cellartis

DELFOI

VOLVO

Powertrain

ENEA

UNIVERSITY OF SKÖVDE

EXENSOR

Awareness Assured

ERICSSON

Atlas Copco

AGROVÄST

HÖGSKOLAN I BORÅS

ICA

Gothia Science Park

Teknikparken vid Högskolan i Skövde

ids

Sparbanksstiftelsen Alfa

SUPPORTED BY

Knowledge Foundation