# Semantics and Graphics in Product Life Cycle Management (PLM)

## Bringing Virtual Engineering to the Real World

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# Roadmap


Vision
PLM/PLC
TECHNOLOGY
Large
Semantics
Visualization
Integration
Simulation
Knowledge
Models

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# **Virtual Engineering** (VE)

"The goal for virtual engineering is **for the engineer** to better focus on **solving the problems** at hand, without spending undue amounts of time gathering information, modeling the information, and then analyzing it. **Virtual engineering is a user-centered process** that provides a collaborative framework to integrate all of the **design** models, **simulation** results, test data, and other **decision-support tools** in a readily accessible environment."

C. Q. Jian, **D. McCorkle**, M. A. Lorra, K. M. Bryden, "**Applications of Virtual Engineering in Combustion Equipment Development and Engineering**", 2006 ASME International Mechanical Engineering Congress and Expo, IMECE2006–14362, Chicago, November 2006.

- **Virtual Engineering Applications** (VEA) and **Virtual Engineering Tools** (VET) should fit into the **environment**

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# Semantics

- Semantics is the area of knowledge that studies the meaning of things. The word comes originally from the Greek term *sēmantikos* that means “significant”.
- The word semantic in its modern form is considered to have first appeared in French as *sémantique* in Michel Bréal's 1897 book, “*Essai de sémantique*”.
- According to Feigenbaum "*Knowledge Engineering (KE) is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise*".

Feigenbaum, E., and P. McCorduck. (1983). **The Fifth Generation. Reading**, MA: Addison-Wesley.

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## Some **advantages** of using **Semantics** in **VETs**

- Improved information and knowledge management
- Enhancements in the search, knowledge and information sharing
- Use of the intrinsic knowledge embedded in the elements being described
- Empowerment of the user knowledge and embedment of such knowledge in a structured and explicit conceptualization.

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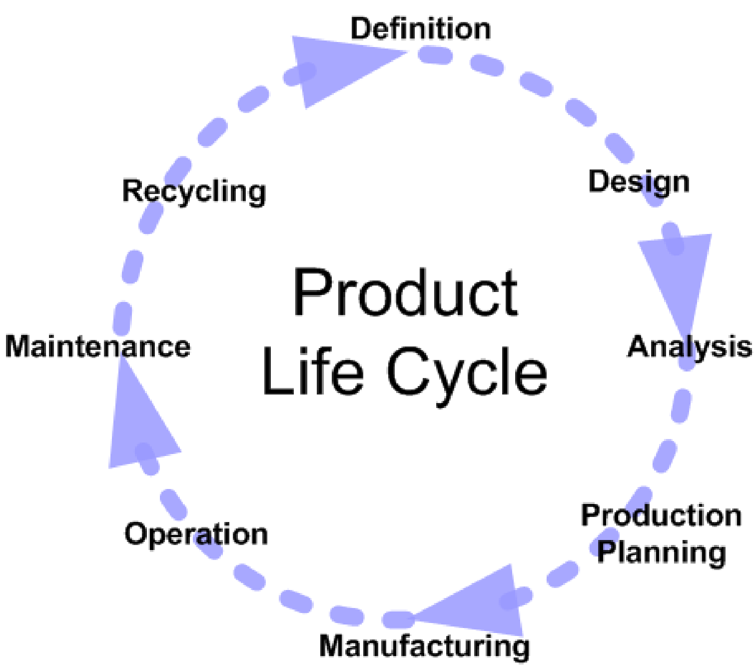
# CIMdata[1] defines PLM as:

- A strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information
- Supporting the extended enterprise (customers, design and supply partners, etc.)
- Spanning from concept to end of life of a product or plant
- Integrating people, processes, business systems, and information

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(1) CIMdata site: http://www.cimdata.com

# Introduction – PLM Technologies

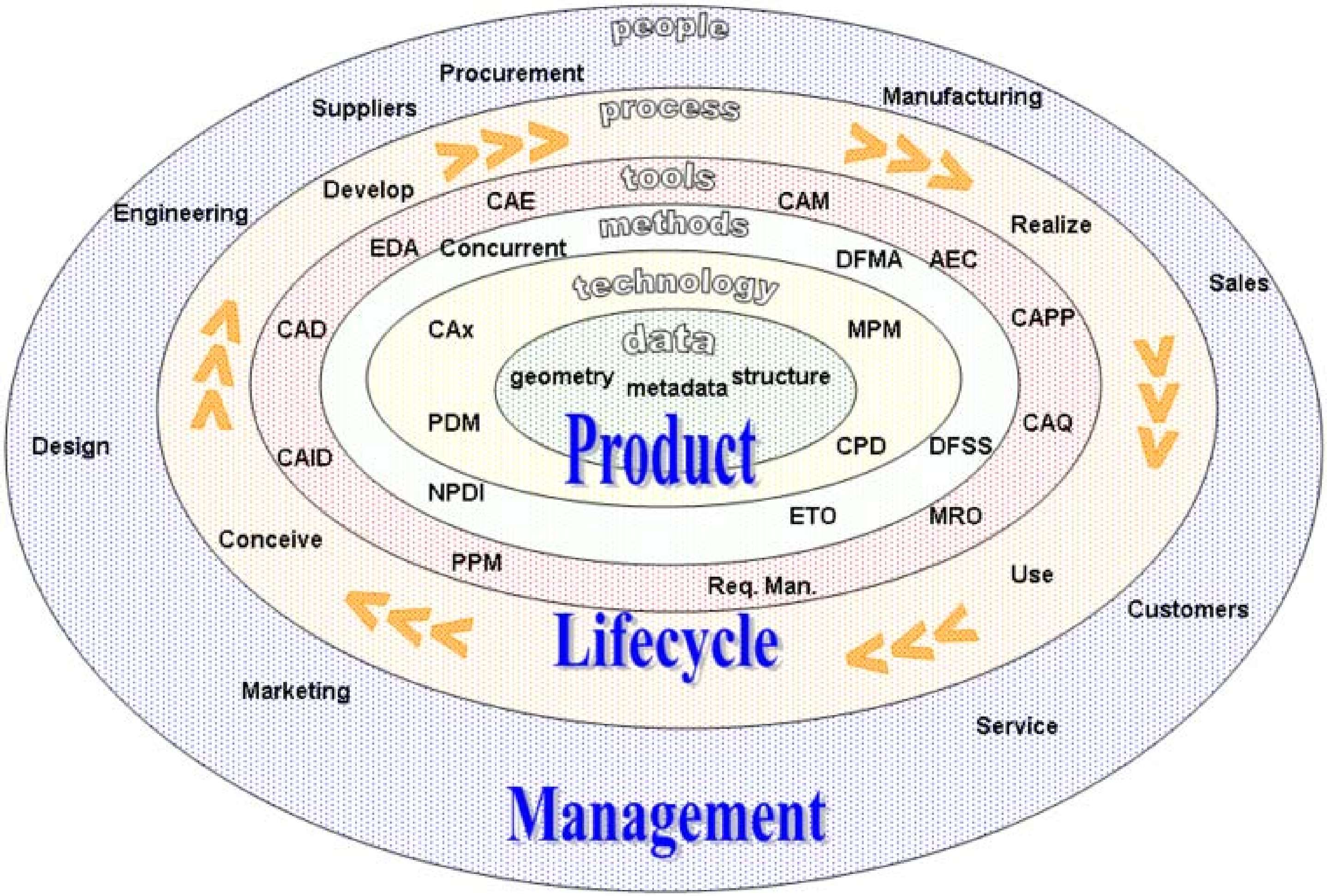


Image taken from Wikipedia:
http://en.wikipedia.org/wiki/Product_lifecycle_management

How are **Semantics and Graphics** currently used in each step of the **product life cycle**?

How have our applied research projects improved that usage in some of the PLC steps?

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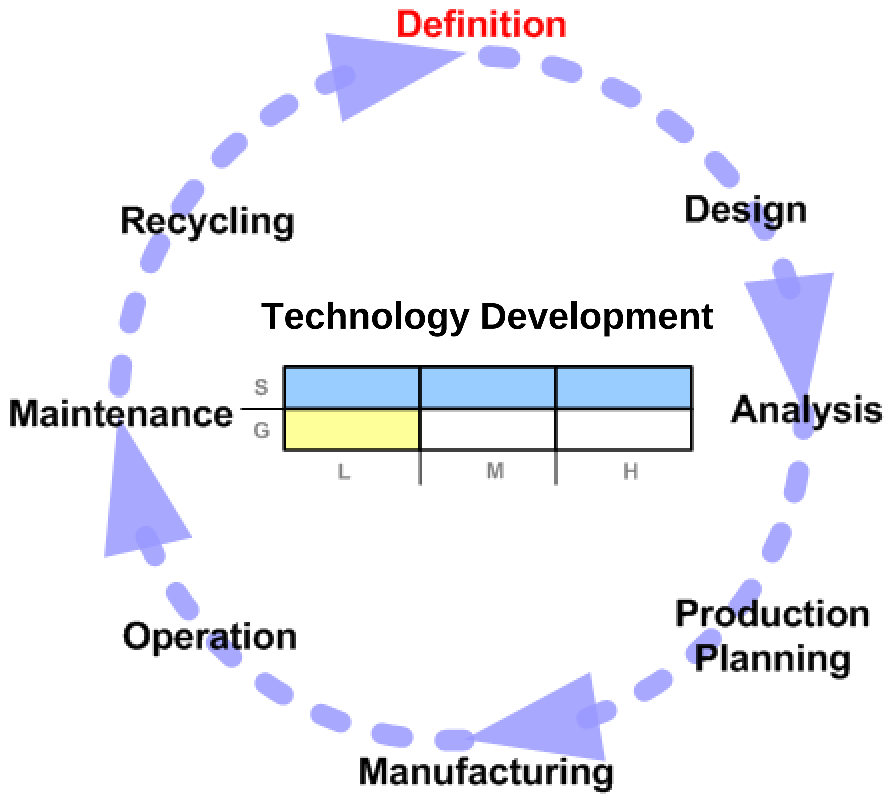


- **DEFINITION**
  - Evaluation of the needs and basic operations of new products
  - Output: Characteristics to be fulfilled and initial sketches
- Semantic Tools
  - Word Processor, email
  - Documentation management
  - Glosary and Terminology
- Graphics Tools
  - Planning Tools
  - Functional Diagrams
  - Desingn methodologies
  - Traditional sketching and 2D drawings
- R&D Projects
  - **WIDE** http://www.ist-wide.info/
  - **AIT VEPOP:** ait-vepop.oulu.fi

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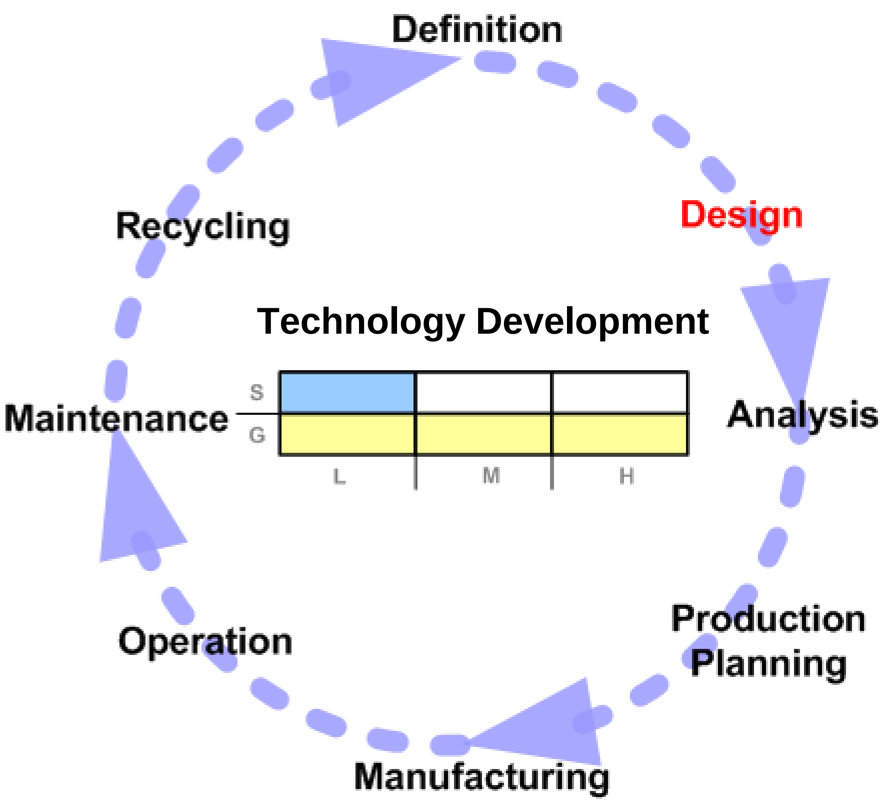



## DESIGN

- Conceptualization of the product
  - functional point of view
- How to materialize the prototype and to evaluate it
- Output: Functional Prototype

## Semantic Tools

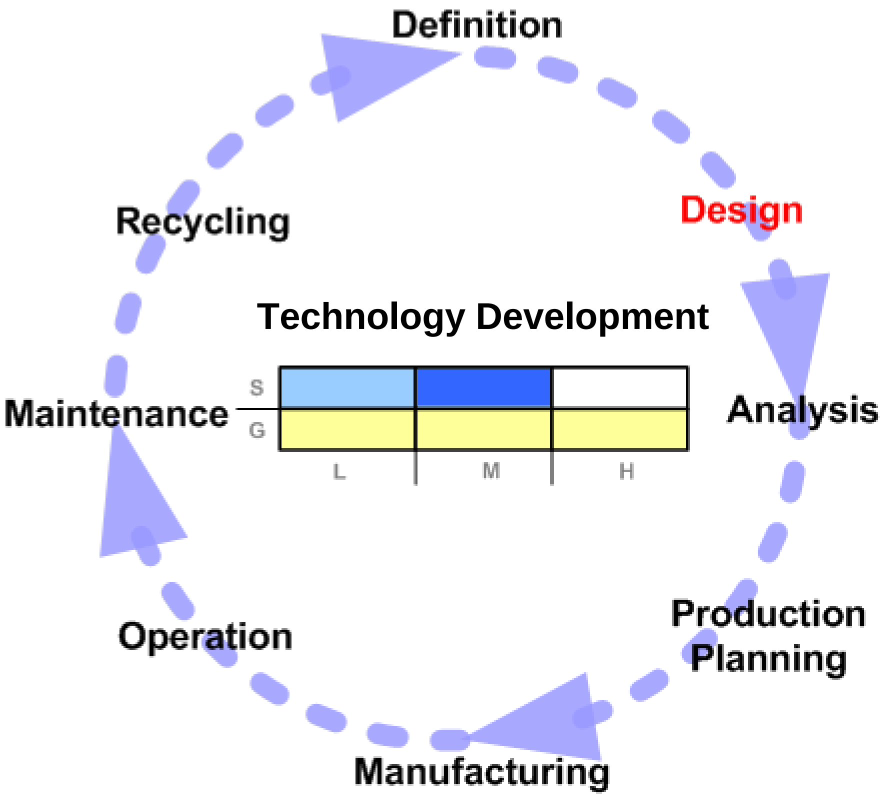
- Technological Development: **LOW**
- Design methodologies: TRIZ, Taguchi, etc

## Graphics Tools

- Technological Development: **HIGH**
- CAD/CAM Tools are widely used
  - 3D models
  - Schematics

## R&D Projects

- IMPROVE
- Aim @ Shape: www.aimatshape.net
- SMART SKETCHES




# IMPROVE

**IST-2003-004785**

## Improving Display and Rendering Technology for Virtual Environments

# IMPROVE (I)



## Introduction

- Improve the design review process within the **architecture** and **automotive** industries
- Using of augmented and virtual technologies. (**AR – VR**)


## Motivation

- **Automotive industry** and **Architecture** needs improvements in the **design review phase**
- Designers collaboration within a virtual scene and work on the same virtual 3D object
- Technologies combination to allow users, through innovative interaction techniques:
  - annotate objects,
  - create or modify geometry,
  - change lighting conditions.

## Objectives

- Develop stereoscopic lightweight transparent eyeglasses with OLED-based micro-projectors.
- Improve tiled large scale displays
- Enhance the realism of the displayed virtual objects, especially in mixed reality scenes
- Improve **user interaction** with advanced displays through new interaction metaphors and **tracking** approaches
- Improve video transmission technology for synchronized stereoscopic viewing with HMDs

# IMPROVE (II)

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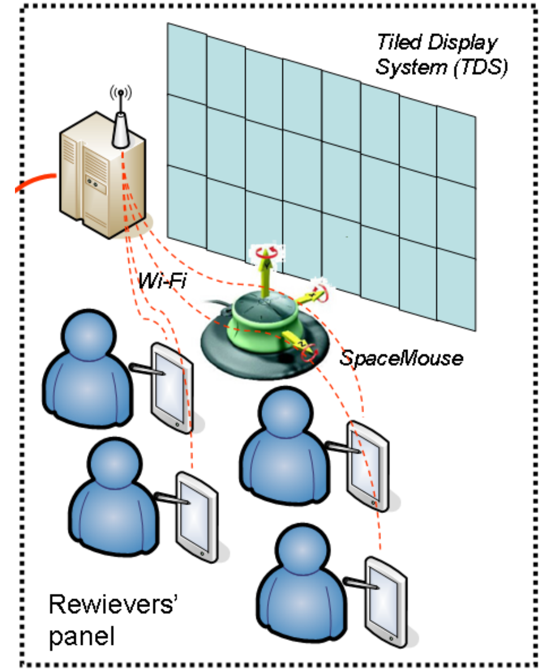
## Proposed Solution

- Photorealistic visualisation of virtual objects
  - Full HDR Rendering
- Markerless Tracking
  - In-Door – Out-Door
- Navigational User Interface
  - User oriented
  - Adapted to the design review tasks
- Components:
  - **Head Mounted Displays → Human Computer Interaction**
  - Large Screen Displays
  - Video Transmission (Rendering is performed out-the-box)




- **Product Life Cycle Management Relationship**
  - Semantics: **Medium**
    - Knowledge-based implementation of user interaction methods
  - Graphics: **High**
    - High real-time photorealistic rendering, HDR
    - Markerless tracking in-door and out-door

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# IMPROVE (III)

- **Real-time photorealistic visualisation of virtual objects**

Low Dynamic Range background and reflection

High Dynamic Range background and reflection

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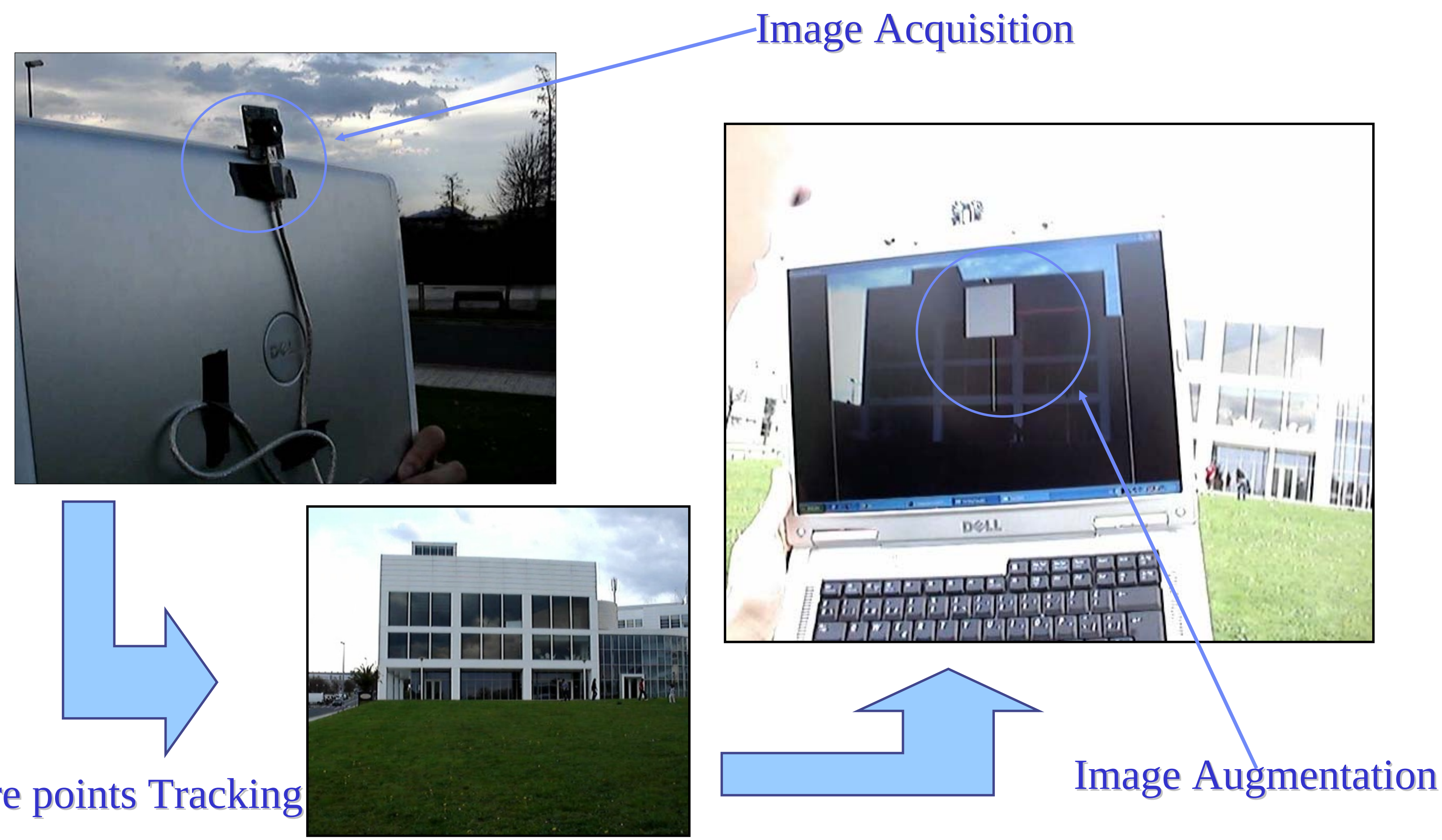
## Marker-Less tracking (OutDoor Scenario)

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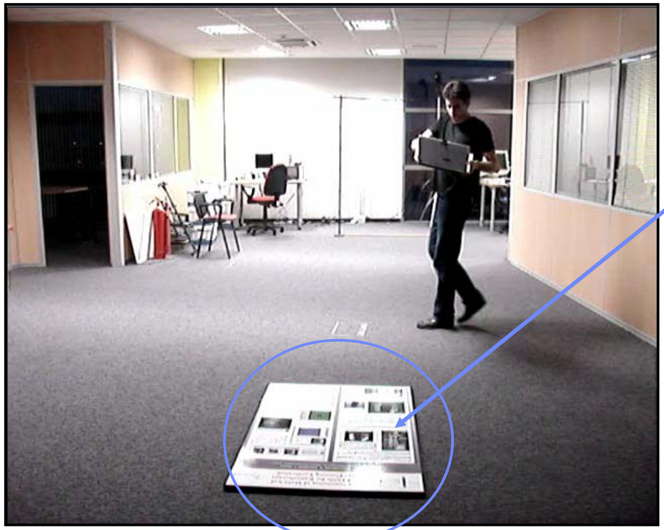
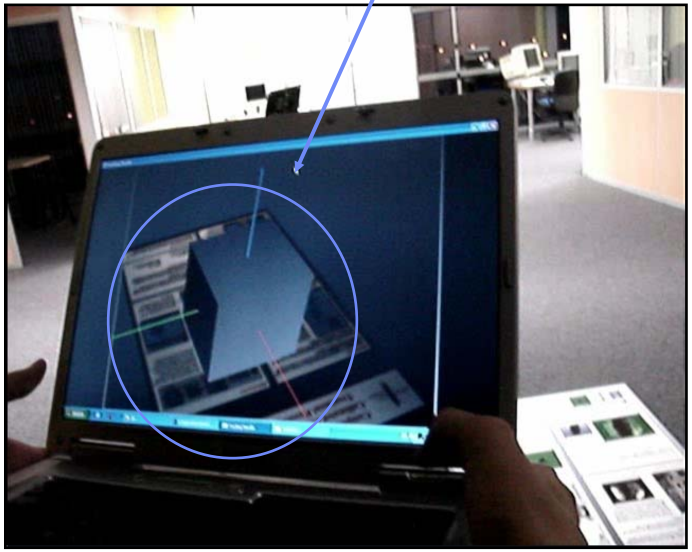
## Marker-Less tracking (InDoor Scenario)

Textured plane

Image Augmentation





Feature Points Tracking

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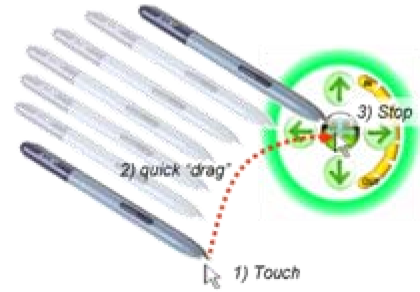
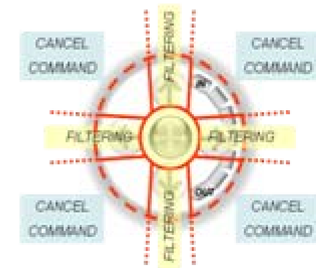
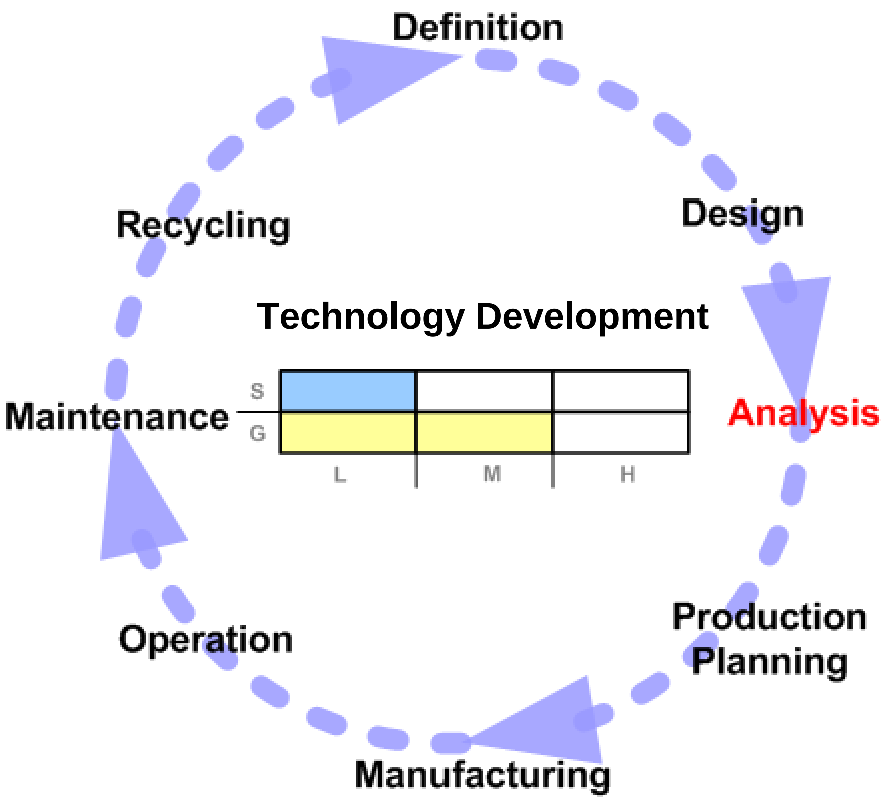
# Navigation

- The user can navigate by triggering the ring menu through a hold-and-press action.
- This menu automatically appears next to the pointer whenever the command is invoked.
- The user can switch between navigation commands by selecting the appropriate buttons.




## ANALYSIS

- Calculation of mechanical and electrical elements
- Analysis on physical characteristics
  - material stresses
  - thermal properties

## Semantic Tools

- Technological Development: **LOW**
- Massive used of CAD systems, with a semantic loss in conversion processes

## Graphics Tools

- Technological Development: **MEDIUM**
- Reviewing tools
- CAD tools (reusing same tools)
- Finite elements analysis (numerical)

## R&D Projects

- Mirowalk
- Coperion K-Messe: http://a4www.igd.fraunhofer.de/projects/48/
- ViSiCADE - www.visicade.de

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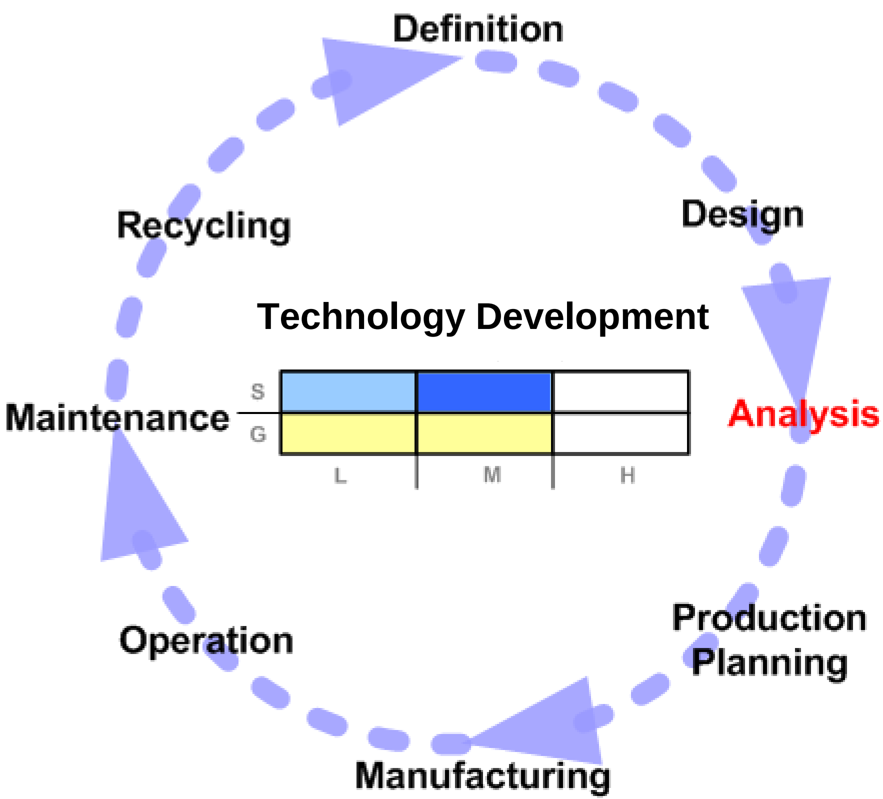


# MIROWALK

## Advanced Semantic Techniques for Interactive 3D Navigation in Large CAD Model Visualization

Institut Graphische Datenverarbeitung

Deutscher Akademischer Austauschdienst
German Academic Exchange Service

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# MIROWALK (I)



## Introduction

- Large Model Viewer for Design Review and Analysis that uses Semantic oriented tools

## Motivation

- Design Review during avoids costly corrections during the construction phase.
- Natural navigation and perception in a VR environment eases the work of the designer in the analysis stage.

## Objectives

- Explore the use of semantics in the LMV problem
- Involve the user characteristics to produce a better visualization experience in standard computers (no specialized hardware is required).

## Proposed Solution

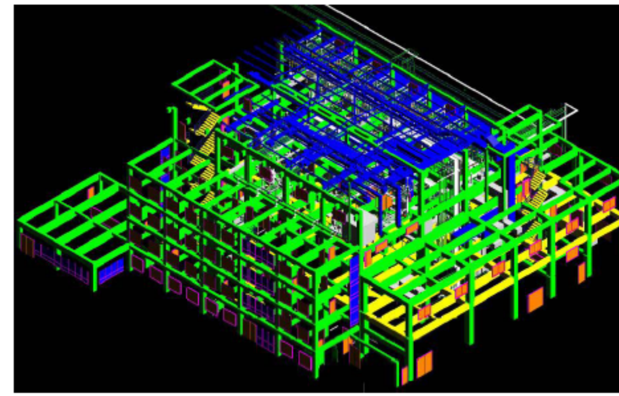
- **In order to visualize large CAD models, classical CG techniques can be used:**
  - Culling techniques (Drop, Occlusion, Visibility), Levels of Detail (LOD) and hardware acceleration.
  - Even using traditional CG techniques, some models cannot be handled by a normal PC.
  - The semantic information embedded in a CAD model is hardly used.
  - Different users have different profiles and knowledge (manager, engineer…)
  - Different models have different structures (Plant, Aircraft, Steel Detailing, Boats)
  - The elements of a CAD-drawing have meanings (valve, pipe, wall, bolt, profile, joint…)

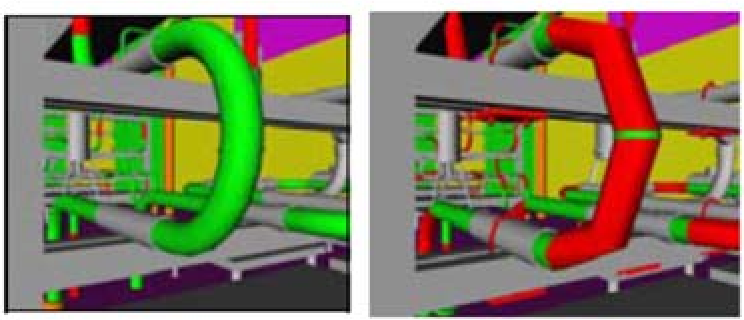
- **Product Life Cycle Management Relationship**
  - Semantics: **Medium**
    - Semantic loss is lessened, user intentions and prior knowledge is used to enhance traditional CG techniques.
  - Graphics: **Medium**
    - Different CG techniques were implemented, the VRML export fro two different well known CAD programs was developed as part of the presented approach.

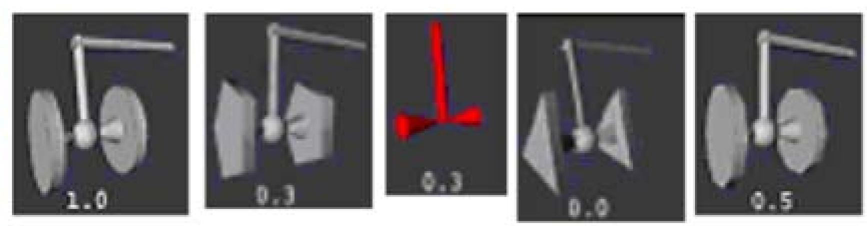
# MIROWALK (III)

- We modeled an ontology following the STEP (ISO 10303-AP227) protocol for plant space configuration

- We modeled the user and needs and as a result we produce a VR adapted model





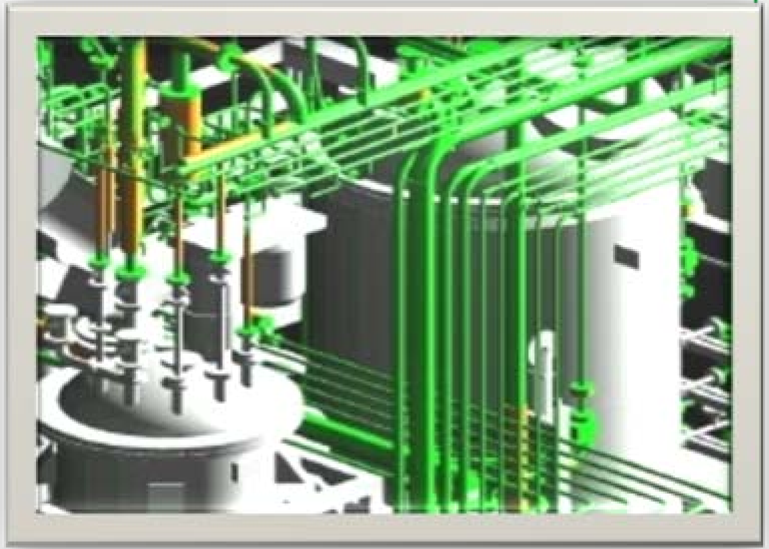


# MIROWALK (IV)



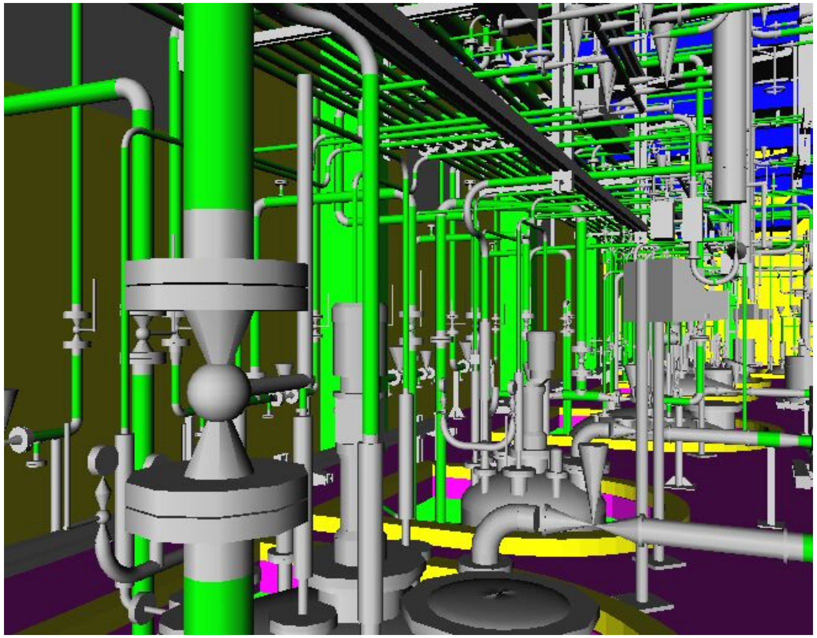
Example: pipe system of a plant, user is an engineer

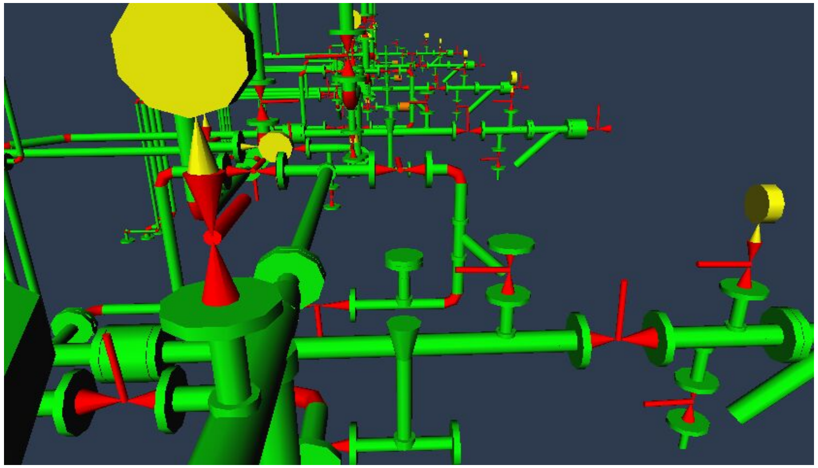
- The information was used to automatically replace the valves with simple 3D symbols
- Symbols are faster to render
- Other techniques are also controlled by semantic decision:
  - Selective LOD on a per element basis
  - Removal of elements
  - Selective rendering-complexity on a per element basis



# MIROWALK (V)

- Using these simple techniques together with semantics we get quite impressive results:
- Could not be visualized on a normal desktop PC
- Complete model can be visualized using MiroWalk at interactive frame rates on an of-the-shelf desktop PC
- Export to VRML took only 5 minutes





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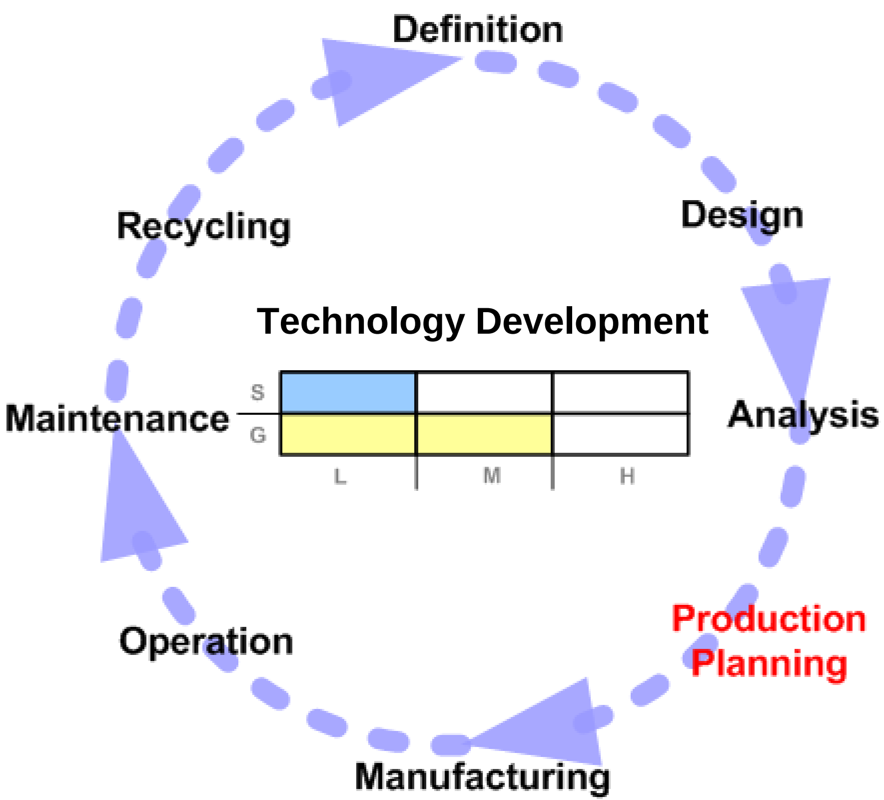



## PRODUCTION PLANNING

- Design is adapted to the facilities of the producer
  - Inside the factory?
  - Buy parts externally
  - Desired day production
  - New plant?

## Semantic Tools

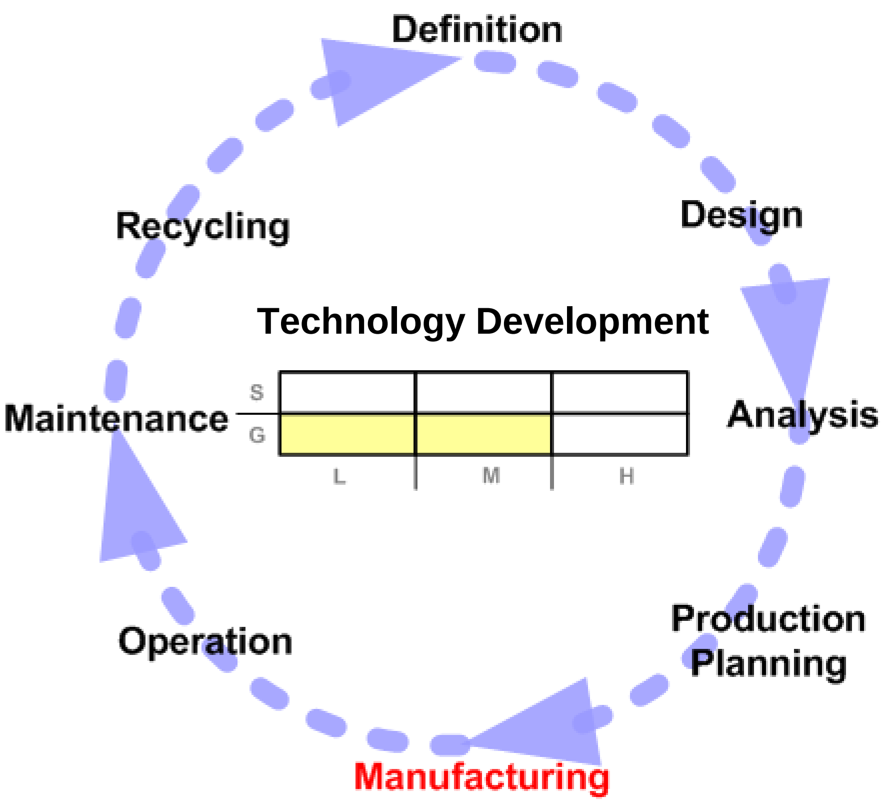
- Technological Development: **LOW**
- Production Planning Tools
- Cost Analysis Tools

## Graphics Tools

- Technological Development: **MEDIUM**
- Walkthrough visualizers
- 2D Diagrams and workflows

## R&D Projects

- Pabadis: www.pabadis.org




## MANUFACTURING

- Make of the product in the amounts needed
- Calculate materials needed and expenditures
- Store the manufactured pieces

## Semantic Tools

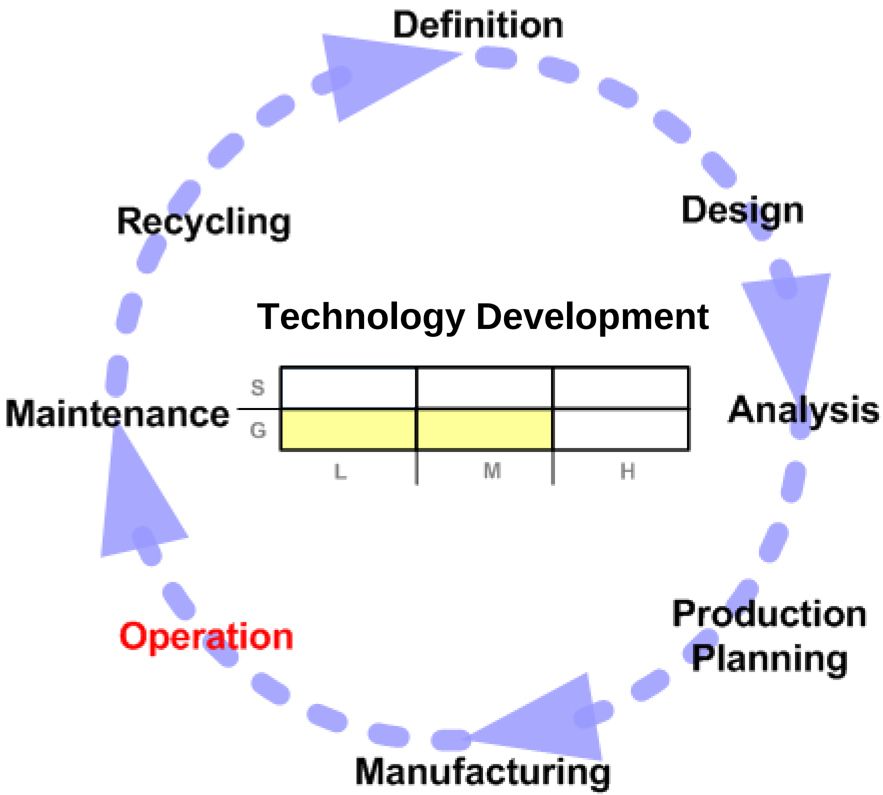
- Technological Development: **VERY LOW**

## Graphics Tools

- Technological Development: **MEDIUM**
- CAM Tools
- Economical Analysis (Diagrams)

## R&D Projects

- SIMUMEK




## OPERATION

- Products are on market
- Review Design, Productivity and market analysis
  - Selling and Competence awareness
- Final user support
  - Manuals, SW, ...

## Semantic Tools

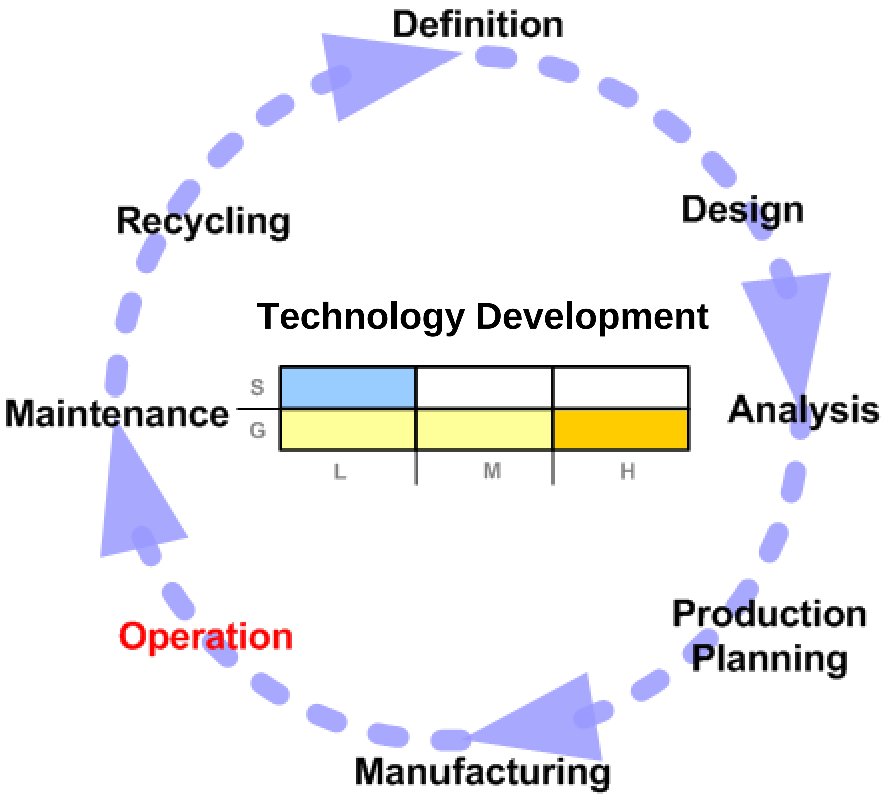
- Technological Development: **VERY LOW**

## Graphics Tools

- Technological Development: **MEDIUM**
- Interactive tools
  - virtual manuals
  - Simulation and training tools
- 2D maps to visualize selling markets, stocks, and relevant information

## R&D Projects

- VAR-Trainer
- eWindTech




# VAR-TRAINER

**COLL-CT-2003-500452**

## Versatile Augmented Reality Simulator for Training in the Safe Use of Construction Machinery

ikerlan ik4 research alliance
VICOM Tech
IGD Institut Graphische Datenverarbeitung
OKTAL l'atout simulation
Foundation Stiftung INI-GraphicsNet

# VAR-TRAINER (I)



## Introduction

- Construction sector is a high risk activity
- Every year, a lot of industrial accidents caused by non-experienced people or by dangerous situations

## Motivation

- Training: user oriented
- High quality graphics to enhance realism (immersive)
- Construction machinery simulation
  - Wheeled vehicles: Excavator, Dumper
  - Elevators: Lift (people), Platform (goods)

## Objectives

- Training people safely
  - Mobile platform with real machine cabins and HMD.
- Train risky situations virtually: Exercise edition, train and evaluation

# VAR-TRAINER (II)



## Proposed Solution

- Mix of Virtual Reality and Augmented Reality
  - Using an stereo HMD (Head Mounted Display), immersive
  - Chroma-key technique
  - User Tracking (IR Marker on the head)

- Training Simulation
  - Using a mobile platform + real cabins and controls
  - PC-Based using standard game pads

- VR elements
  - Excavation Simulation
  - Atmospheric effects Simulation

- **Product Life Cycle Management Relationship**
  - Semantics: **Low**
  - Graphics: **High**
  - Notes:
    - User is taken into account (it is essential)
    - Different roles: manager, trainee, trainer, designer…
    - Usability and ergonomic issues

# VAR-TRAINER (III)

Mobile Platform Version

PC-Based Version

# VAR-TRAINER (IV)



- Construction Machinery

Excavator

Dumper

Lift

Platform

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# VAR-TRAINER (V)

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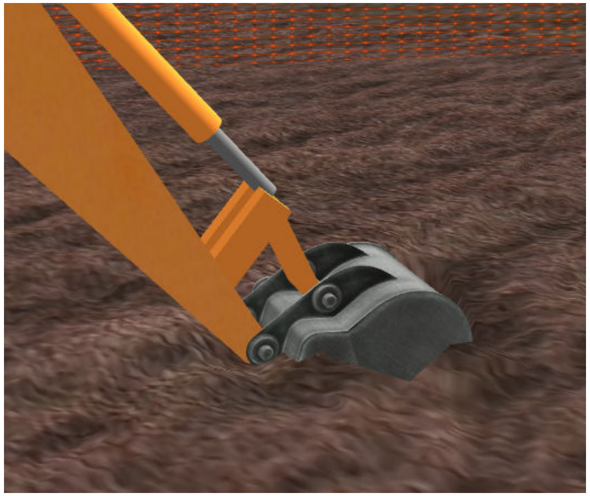

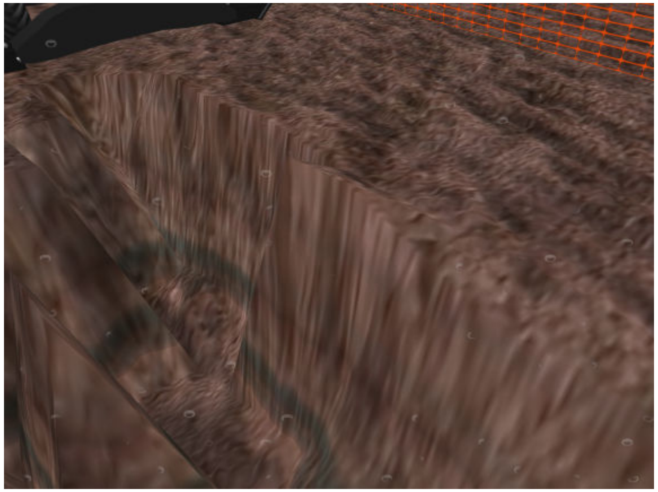


A simplified algorithm for real-time material removal

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# VAR-TRAINER (VI)

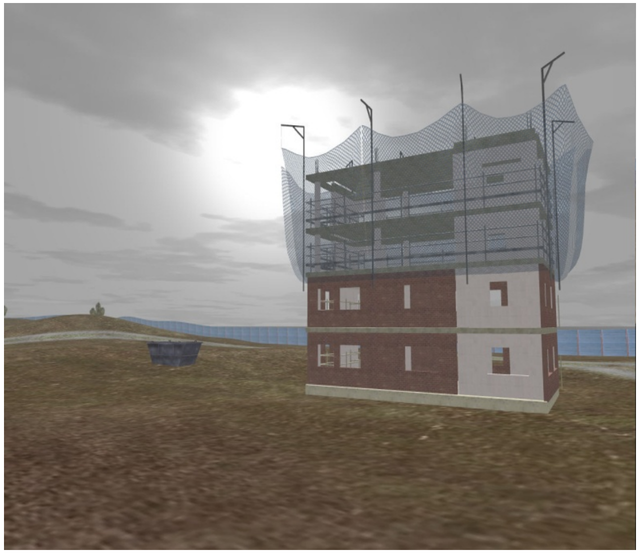


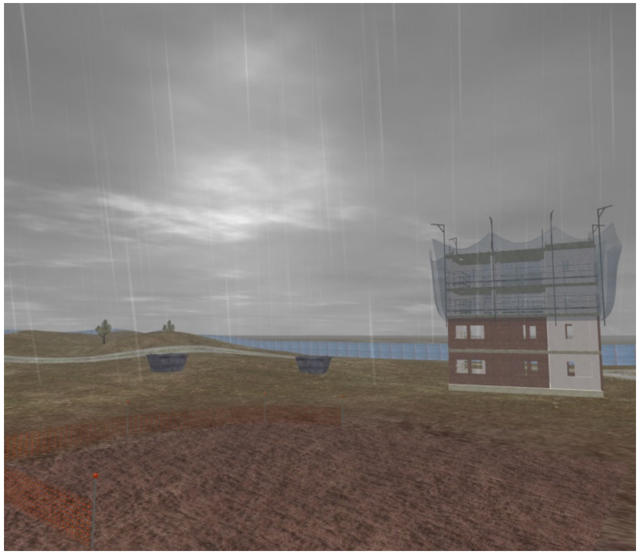
- Chroma-key based Augmented Reality solution


- See-Through HMD prototype with 2 cameras and an IR marker for tracking

# VAR-TRAINER (VII)

- Atmospheric effects simulation (clouds, fog, dawn, rain,...)





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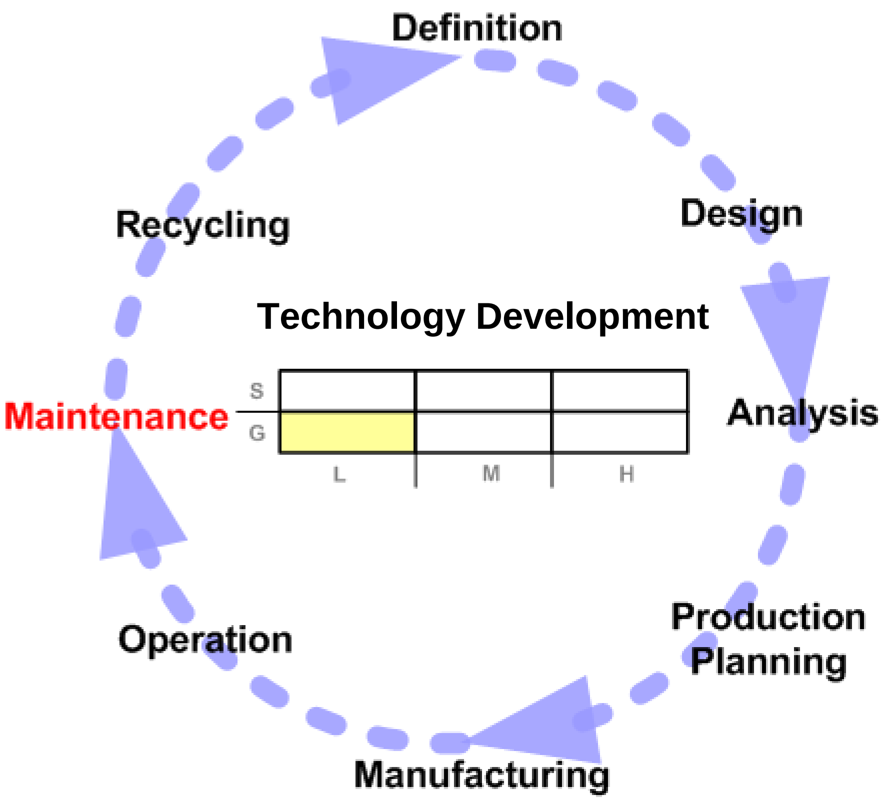



## Maintenance

- Preventive maintenance
- Replacement parts
- Warranty management

## Semantic Tools

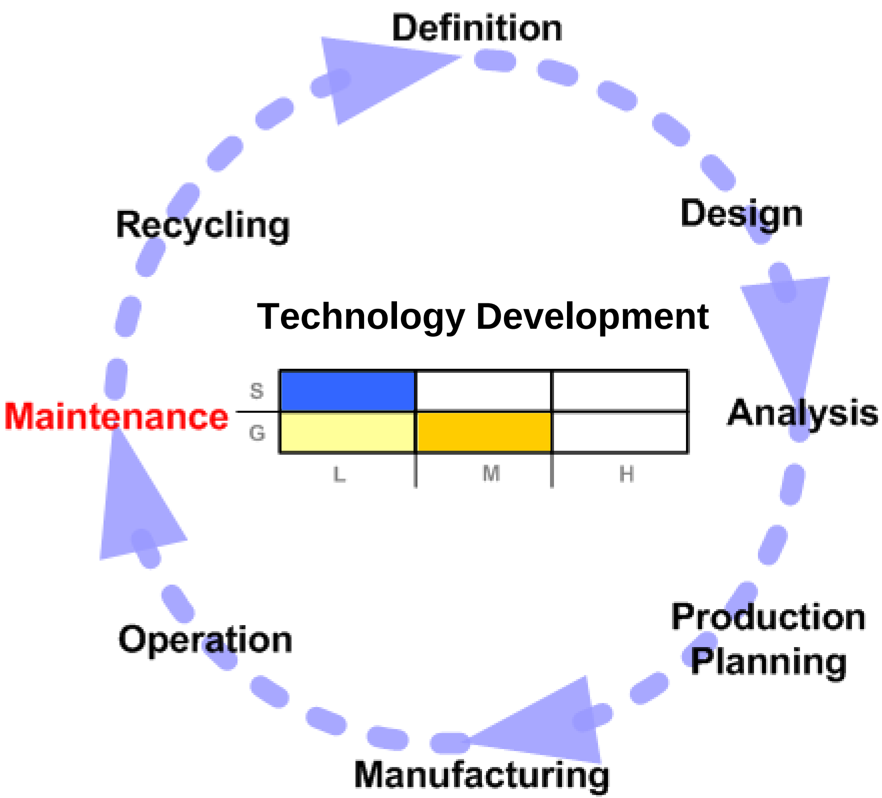
- Technological Development: **VERY LOW**
- DB: Factory Components
- DB: Clients and warranty life

## Graphics Tools

- Technological Development: **LOW**
- 2D maps (client localization)
- 2D animations (howto's)

## R&D Projects

- SEMTEK
- Arvika: www.arvika.de
- S-TEN: www.s-ten.eu




# SEMTEK

## Semantic Based Maintenance using mobile devices and Augmented Reality

# SEMTEK (I)



## Introduction

- Mobile Augmented reality steered by semantics to support Maintenance Tasks
- The application of agent theory is a key factor in this project.
- Conventional software systems are designed for static worlds from which a perfect knowledge has been already acquired.
- SEMTEK, however, deals with dynamic and uncertain contexts where the computational system has only a local vision of the world and has limited resources.

## Motivation

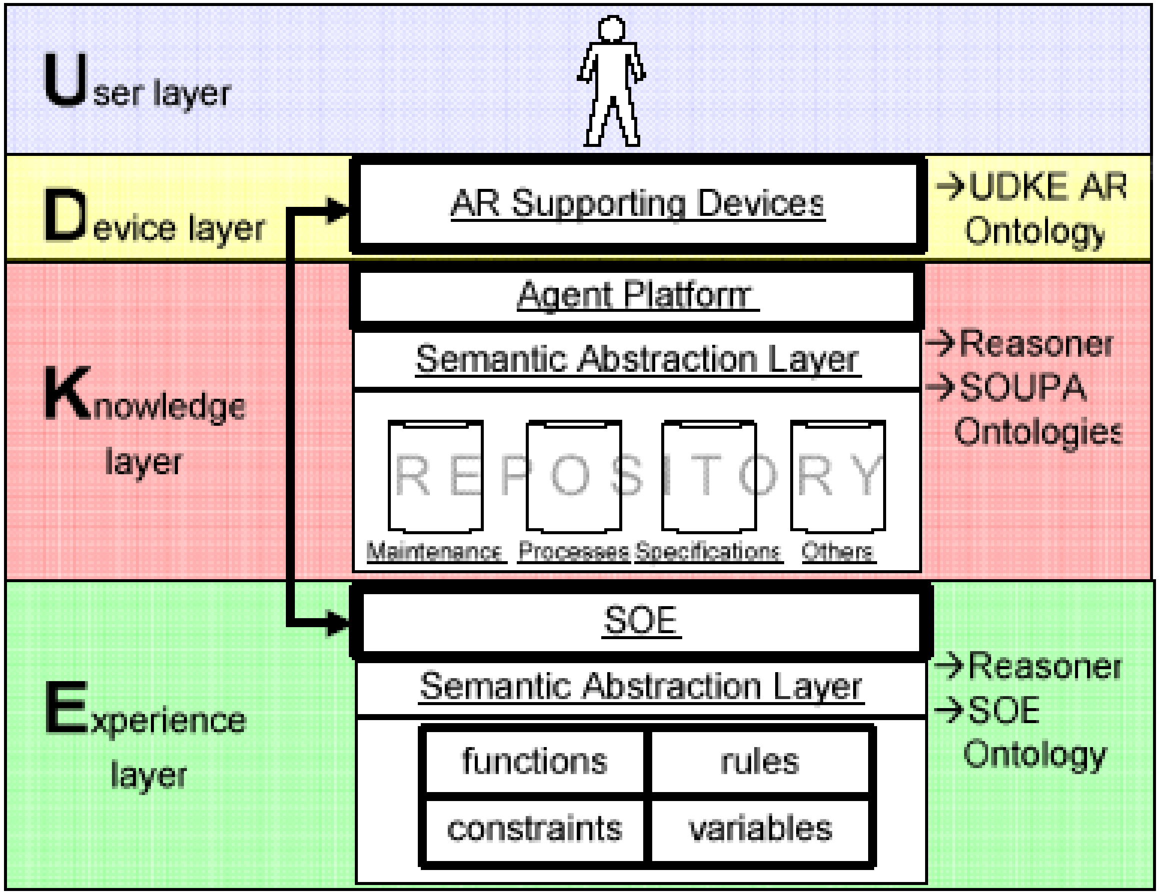
- As test case we chose the Industrial Maintenance scenario and we mixed traditional VR-AR techniques with semantic technologies (ontologies-SOEKS) embedded in portable devices (UMPC, PDA).
- The use of novel techniques like the Set Of Experience Knowledge Structure (SOEKS) allowed us to model and embed user experience in the system

## Objectives

- To enhance a maintenance task with the aid of VR-AR portable systems
- To use a Semantic approach to support the Maintainer (user) experience

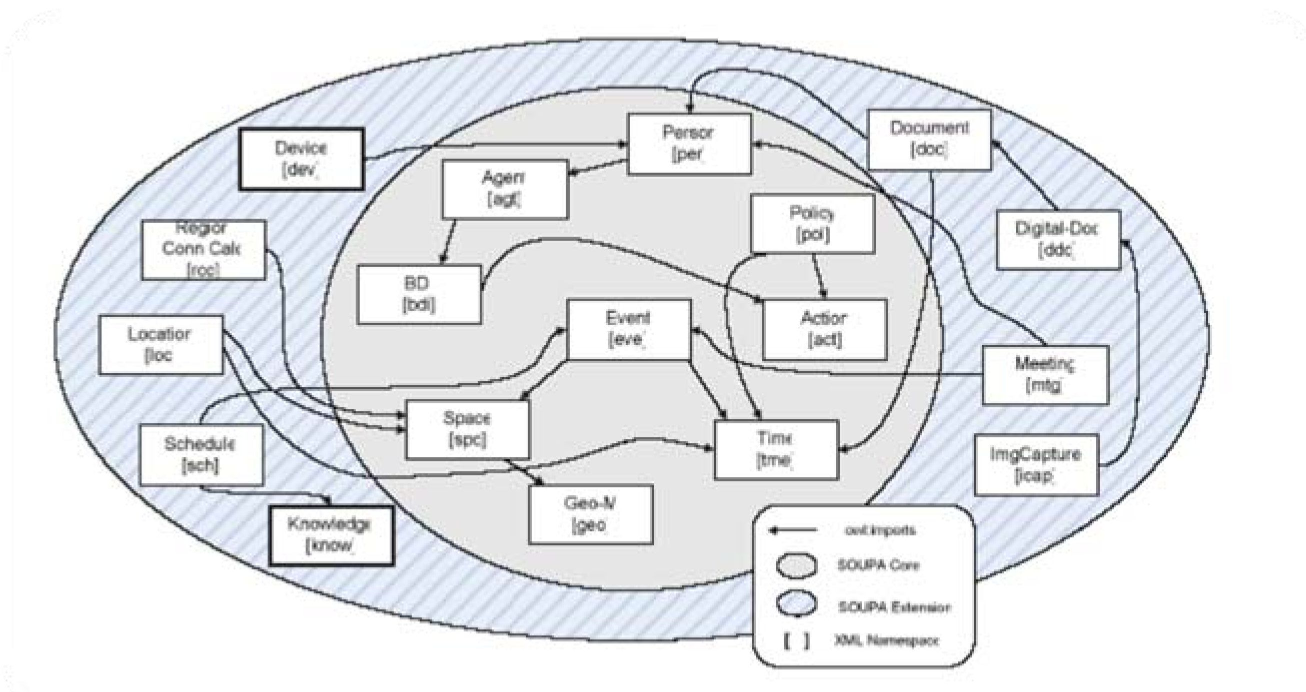
## Proposed Solution

- We propose an architecture called UDKE (User, Device, Knowledge and Experience).
- UDKE provides a possible conceptual model of a maintenance system that combines knowledge, user experience and AR techniques



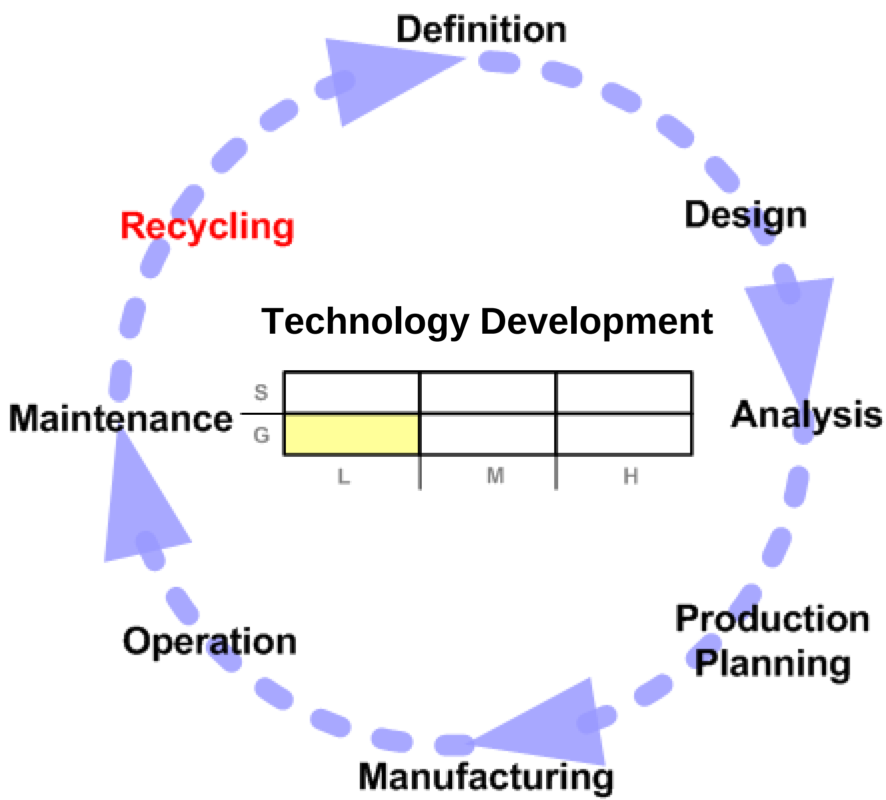
## Product Life Cycle Management Relationship

- Semantics: **Low**
- Graphics: **Medium**
- Notes:
  - User is taken into account (it is essential)
  - Different roles: manager, trainee, trainer, designer...
  - Usability and ergonomic issues



# SEMTEK (IV)


unlock nozzle
press the handler
direct the spurt to flames
type A
type B
type C
name: fire extinguisher
next_change: 1 Dec. 2007
FIRE ICE
EXTINTOR DE INCENDIOS




- **RECYCLING**
  - Product end of life
  - Recycle vs Dispose
  - Planning
    - Where, How, Who...
- Semantic Tools
  - Technological Development: **VERY LOW**
  - Databases: Components, state
- Graphics Tools
  - Technological Development: **LOW**
  - Geolocalization of dangerous disposes parts (nuclear parts) for monitorization
  - 2D statistical diagrams
- R&D Projects
  - VEGA
  - EXPIDE (www.biba.uni-bremen.de/projects/Expide)

# Conclusions

- Virtual Engineering tools benefit from advanced graphics coupled with semantic technologies:
  - Engineering data is not just geometry and numbers
  - Meaning, context and user characteristics needed
- Semantics can provide knowledge integrity throughout the Product Life Cycle.
- Graphics especially useful in design, review and testing:
  - Virtual models before any real production

# Conclusions

- Semantic technology is in an early stage in several stages of the PLC
  - An opportunity for research and improvement
- Developments and prototypes in applied research projects but **little actual use in the industry**
- Semantics and Graphics can contribute as separate elements but a good integration of both is what brings the strongest value

# Thank you

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