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| Dissemination Level | | |
| PU | Public | |
| PP | Restricted to other programme participants (including the Commission Services) | |
| RE | Restricted to a group specified by the consortium (including the Commission Services) | |
| CO | Confidential, only for members of the consortium (including the Commission Services) | PU |

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1 Introduction

To enable effective management and signposting of current and future research activities and developments (at both companies and research organisations), it is necessary to make a detailed description of all the areas addressed today. This overview should not only be a technology based overview, but also indicate future items to work on. When it is clear what will be the future market needs, it is possible to plan a coordinated effort to conduct tailored research at cooperative partners to prepare technology and tools to serve industry in the near future. The possible applications and related challenges and ambitions of each of them will be documented in this brief roadmap.

Following chapters describe various research areas addressed by IDT and contain an area specific roadmap as seen by current IDT partners.

2 Roadmaps for IDT

This document is based on the previous three deliverables within the IDT cluster, namely the Taxonomy (D6.1), the State of the Art Review (D6.2) and the Key Enabling Factors (D6.3).

To define the roadmaps most effectively, it was decided to follow the approach as indicated in the Figure 1 below.

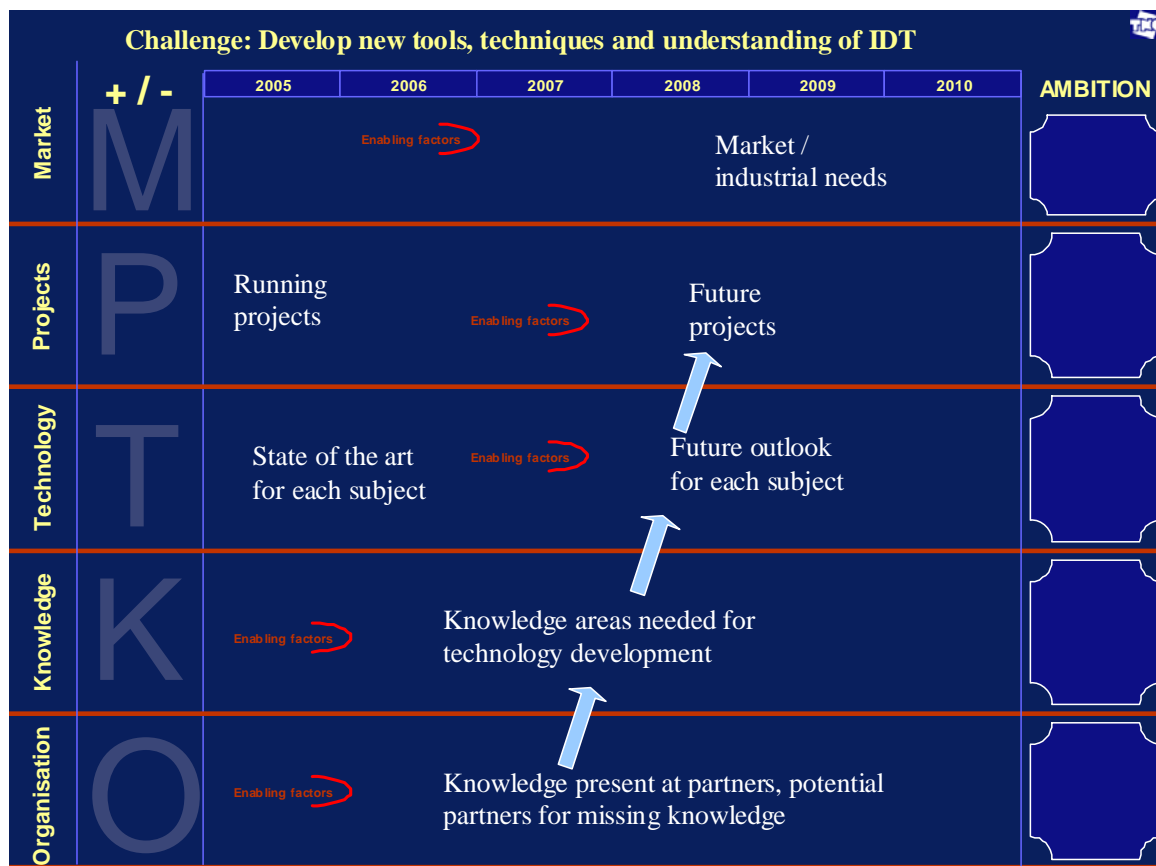


Figure 1. – Schematic of the IDT roadmap

Figure 1 gives a graphical representation of the challenge to develop new tools, techniques and an understanding of IDT. It identifies five levels of operation: starting top down, from market needs, relevant projects can be defined which need particular technology and knowledge to be able to fill that gap in ability. At the basis of it all, it requires a stable and appropriate organization to perform the job of development in an effective fashion. Vice versa (i.e. following the arrows!), knowledge among partners feeds into the area of knowledge needed which consecutively suits the future outlook for each subject. If this knowledge is used in future projects, this will automatically lead to fulfilling the market and industrial needs (which is the final goal).

For all specific area of expertise defined, a specific roadmap was made and described in following chapters. The following areas are identified:

Total Design Technology, Advanced Modelling & Simulation Technology, Advanced Computer Aided Manufacturing, Automated Design of Complex Products, Product Knowledge Management and Networked & Virtual Enterprises for Design.

2.1 Total Design Technology

| | Roadmap for Total Design Technology (lead Newcastle) | Prepared by TNO, ISRU, DCU, Minho | Ambition |
|-----------------|--|--|--|
| M Market | Market/Industrial Needs | <p>Drivers:</p> <ul style="list-style-type: none"> - Reduction time to market - First time right - Cost reduction - Flexibility in Design - Customer satisfaction - Customer feedback for product improvement <p>Trends:</p> <ul style="list-style-type: none"> - Increasing complexity in design - Larger number of varieties of a product (mass customization) - Individualized / personalized / customized products - Globalization of market and development / production sites - Extended product design (product service design) - Development of new business models - Possible unification of mass-produced products in order to reduce costs - Application of artificial intelligence in design (multi-agents, expert systems, knowledge representation, knowledge extraction) - Virtual enterprises | Achieve optimal design technologies to realize first time right developments with short time to market, low costs and flexible designs |

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| | | <ul style="list-style-type: none"> - Increased complexity of manufacturing processes and systems - Shorter lead times to customers | |
| P Projects | Future Projects | <ul style="list-style-type: none"> - Research activities <p>Development of manufacturing feature-based CAD/CAM systems</p> <p>Development of CAD/CAM systems for full-scale conceptual design</p> <p>Development of multi-agent CAD/CAM systems</p> <p>Development of a Kansei Engineering methodology for SMEs</p> <p>Development of production based feedback for design tolerances and customer appreciation</p> | <p>Achieve a working and funded consortium of business and researchers to explore the barriers around international collaborative design</p> <p>Inclusion of customer’s emotional response in the tool-box of the design stage</p> <p>An important dimension of the knowledge used to inform the design process should come from feedback from the actual performance of the production process involved in producing the designed product and in the appreciation of the product by the customer. This is particularly important with the increasing use of customised (or bespoke) design. Communication between designer, producer and customer is impaired by the lack of a common language.</p> <p>This project will identify the best methods of measuring, dissecting and summarising production variation and</p> |

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| | | | customer appreciation and develop a new language to improve communication between experts. |
| T Technology | Enabling technologies | <p>Collaborative engineering:</p> <ul style="list-style-type: none"> - PDM-system - Global communication networks - <p>Concurrent engineering</p> <ul style="list-style-type: none"> - multidisciplinary teams - multidisciplinary design <p>Design technologies (DfX)</p> <p>Customer-focused and customer-driven design</p> <ul style="list-style-type: none"> - Feedback from customers at each stage of product development. - Possible customer-driven design where customers initiate or even lead the design process by specifying their own requirements. <p>Full-scale Conceptual design</p> <p>Multi-agent design, network design</p> <p>Hierarchical Design-for-Manufacture and Assembly guidelines</p> <p>Hierarchical Manufacturing feature libraries</p> | <p>Realize optimal technologies to support collaborative and concurrent engineering</p> <p>Internet-based surveys and user interface for interactive customer product specification and feedback</p> |
| K Knowledge | Knowledge areas needed for technology | <p>Design methodologies</p> <p>Modular design</p> <p>Design for manufacturing and assembly</p> | Develop new knowledge on all related aspects of total design technology |

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|-----------------------|-------------------------------|---|--|
| | development | Life cycle design Costs of design decisions Cultural aspects in development processes Distributed database design Manufacturing Feature-based design Agent-based design Process and system design for rapid turnaround and simple scheduling | |
| O Organisation | Knowledge present at partners | Feature-based design Concurrent Engineering Design for Manufacture and Assembly guidelines Axiomatic design Integrated CAD/CAM systems Quantitative evaluation methodologies DFM/DFA evaluation software Tolerancing methodologies Design advisory systems Knowledge-based systems | |

| Driver | Enabling Technologies | Enabling Research |
|--|---|---|
| A - Reduction time to market | 1 - Collaborative engineering – A B C E | Development of manufacturing feature-based CAD/CAM systems – 3 5 7 8 |
| B - First time right | 2 - Concurrent engineering – A C | Development of CAD/CAM systems for full-scale conceptual design – 5 |
| C - Cost reduction | 3 - Design technologies (DfX) – A B C D | Development of multi-agent CAD/CAM systems - 6 |
| D - Flexibility in Design | 4 - Customer-focused and customer-driven design – A B C D E F | Development of a Kansei Engineering methodology for SMEs – 2 |
| E - Customer satisfaction | 5 - Full-scale Conceptual design - A B C | |
| F - Customer feedback for product improvement | E F | |

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| | <p>6 - Multi-agent design, network design – A C D</p> <p>7 - Hierarchical Design-for-Manufacture and Assembly guidelines – A B C</p> <p>8 - Hierarchical Manufacturing feature libraries - A C</p> | <p>Development of production based feedback for design tolerances and customer appreciation – 1 4 5</p> |
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2.2 Advanced Modeling & Simulation Technology

| | Advanced Modelling&Simulation Technology (Lead VTT) | Prepared by TNO, ISRU, Warwick, VTT, DCU, CETIM | Ambition |
|-------------------|---|--|--|
| M Market | Market/Industrial Needs | <p>Drivers:</p> <ul style="list-style-type: none"> - Fast and simple simulation tools for right first time development - Virtual prototypes for customers - Process optimization - Tools for SME sector, currently too expensive and difficult to use - Globally distributed virtual models and simulations - Evaluation Tools for Virtual Prototyping <p>Trends:</p> <ul style="list-style-type: none"> - Dedicated CAD-tools - New materials and production technologies - Custom fit products - Electronic, interactive, context-sensitive product catalogues and manuals - integrated simulation tools, simulation behind other application user interface - Generic robot language for off-line programming - Importance of standards (data, interfaces) - Model data sharing tools | <p>Eliminate need for prototype / test series Provide virtual prototype</p> <p>Elimination of simulation expert, easy to use tools</p> <p>Smooth cooperation and (modeling) data management in global networks</p> <p>Eliminate the costly, time consuming and complex processes through Virtual Product Development Techniques.</p> |
| P Projects | Future Projects | Development of Product Evaluation Tools for virtual prototyping | |

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| | | <p>Virtual reality for machine operator training</p> <p>Virtual reality for product specification and catalogues</p> <p>Intelligent, context-sensitive product manuals</p> <p>Advanced process modeling</p> <p>High-order languages for product data specification</p> <p>High-order, manufacturing-oriented programming languages</p> <p>Integrated discrete event simulation, virtual manufacturing and scheduling</p> <p>Make available to SMI numerical simulation solutions (software, ASP access) and services adapted to their technical and economical capacities</p> <p>Designed experiment approach to interrogating simulation programmes</p> <p>Simulation tools for shop floor, simulation for production planning/scheduling real-time</p> <p>Simulation integration to real machine/system/supply chain events</p> <p>Simulation/modeling to cover whole lifecycle of the product or production system</p> <p>HTI/virtual operations</p> | <p>Give access to user friendly and economical numerical simulation solutions</p> <p>Validate with maximum efficiency</p> |
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| | | Modeling of manufacturability taking into account materials processing history, modeling of new materials and new processing methods of materials | |
| T Technology | Enabling technologies | <p>Virtual prototyping:</p> <ul style="list-style-type: none"> - Linking CAD to simulations - Virtual reality simulation <p>Rapid prototyping: improving quality and performance</p> <p>Smart optimization algorithms</p> <p>Virtual environment</p> <p>XML data interface for system integration</p> <p>Development of material models</p> | Provide simulation technology that enables right first time development |
| K Knowledge | Knowledge areas needed for technology development | <p>Product Data Exchange and sharing\</p> <p>Product performance (mechanical, environmental, user, etc.)</p> <p>Manufacturability</p> <p>Maintainability</p> <p>Virtual environments</p> <p>Optimization algorithms</p> <p>Database, other system integration, XML based data transfer,</p> <p>Userinterface, graphical easy to use,</p> <p>HTI</p> <p>Materials modeling</p> | Seamless data sharing/exchange |
| O Organisation | Knowledge present at partners | <p>Virtual reality techniques</p> <p>Simulation languages</p> <p>Graphical languages</p> <p>Software development and subcontracting</p> <p>FEM simulation software, process definition and simulation (stamping forging; assembly definition)</p> | |

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| | | Discrete event simulation, robot and kinematic simulation, manufacturing .models, Integration simulation integration to ERP, other systems Parametric modeling, database driven automatic model building, e-catalogue, component based simulation HTI Simulator environments Product data management Manufacturing process and materials modeling Numerical modelling | |
|--|--|---|--|

| Driver | Enabling Technologies | Enabling Research |
|--|--|--|
| A - Fast and simple simulation tools for right first time development B - Virtual prototypes for customers C - Process optimization D - Tools for SME sector, currently too expensive and difficult to use E - Globally distributed virtual models and simulations F - Evaluation Tools for Virtual Prototyping | 1 - Virtual prototyping – A B E F 2 - Rapid prototyping: improving quality and performance – B 3 - Smart optimization algorithms - C 4 - Virtual environment – B E F 5 - XML data interface for system integration – A B D E F 6 - Development of material models – A F | Development of Product Evaluation Tools for virtual prototyping - 1 4 Virtual reality for machine operator training – 1 4 Virtual reality for product specification and catalogues – 1 2 4 5 Intelligent, context-sensitive product manuals – 4 5 Advanced process modeling - 6 High-order languages for product data specification – 1 4 5 High-order, manufacturing-oriented |

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| | | <p>programming languages - 1 4 5 6</p> <p>Integrated discrete event simulation, virtual manufacturing and scheduling - 3</p> <p>Make available to SMEs numerical simulation solutions (software, ASP access) and services adapted to their technical and economical capacities – 3</p> <p>Designed experiment approach to interrogating simulation programmes – 1 3</p> <p>Simulation tools for shop floor, simulation for production planning/scheduling real-time – 3 4</p> <p>Simulation integration to real machine/ system/ supply chain events – 3 4</p> <p>Simulation/modeling to cover whole lifecycle of the product or production system – 1 3 4 5</p> <p>HTI/virtual operations – 1 4</p> <p>Modeling of manufacturability taking into account materials processing history, modeling of new materials and new processing methods of materials - 6</p> |
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2.3 Advanced Computer Aided Manufacturing

| | Advanced CAM (Lead DCU) | Prepared by: TNO, DCU, Cetim | Ambition |
|-------------------|-----------------------------------|---|--|
| M Market | Market/Industrial Needs | Drivers: <ul style="list-style-type: none"> – Flexibility in production – Reduced time to market – Need for distance manufacturing – Reduced scrap rate – Reduced energy requirement of machine tools – Reduced environmental contamination – Improved recycling – Design for Modular manufacturing – Multi-variant inventory management Trends: <ul style="list-style-type: none"> – Increasing complexity of products and parts – Dedicated CAD/CAM-systems – New production technologies – Utilisation of new materials – Full formal product definition | Realize advanced design and production systems Design for environmentally friendly production Introduce new materials into production Self-organising machine tools with direct customer interface Dynamically re-configure systems and product designs to match emerging and developing market trends |
| P Projects | Future Projects | Rapid Manufacturing with high direct end-quality RM in metals RM of graded materials Designing for RM Development of full-scale CAD/CAM systems for | Expanding rapid manufacturing to end-quality constructional materials Full-scale commercial CAD/CAM systems with embedded DFM/DFA |

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| | | <p>collaborative, distributive product development</p> <p>High-order programming languages for product data definition</p> <p>Visual programming of machine tools</p> <p>Manufacturability definition</p> <p>Evaluation methodologies for DFM</p> <p>On going project: Usiquick:</p> <p>Evaluation of commercially available machining cycles: trochoidal cycle, plunge roughing</p> <p>Normative survey: Stepnc</p> | <p>Automation of industrialisation of machining by milling</p> <p>Preserve tool and machine, better surface quality</p> <p>Capability to integrate modifications with high level interface on the shop floor; no more post processors</p> |
| <p>T Technology</p> | <p>Enabling technologies</p> | <p>Industry-standard Rapid Tooling</p> <p>Industry standard Rapid Manufacturing</p> <p>Knowledge based CAM-systems</p> <p>Graded materials</p> <p>Integrated product models</p> <p>Self-organising machine tools</p> <p>High-order neutral (standard) machine tool programming languages</p> <p>Neutral (standard) post-processing languages</p> <p>Distributed CAD/CAM databases</p> <p>Product data exchange models for CNC machine tools, industrial robots, CMM, ...</p> <p>Parametric, variational, feature-based CAD/CAM</p> <p>Context-sensitive, intuitive CAD/CAM systems</p> | <p>Provide technology for full-scale, integrated CAD/CAM systems</p> |

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| | | Visual programming of machine tools | |
| K Knowledge | Knowledge areas needed for technology development | <p>How to design for advanced CAM</p> <p>Knowledge based systems for CAM</p> <p>Production knowledge</p> <p>Material behavior in production</p> <p>Distributed database design</p> <p>Intuitive design</p> <p>Parametric, variational, feature-based modeling</p> <p>Formal product description using neutral formats</p> | Acquire knowledge to fully understand next generation CAD/CAM systems |
| O Organisation | Knowledge present at partners | <p>Conventional CAD/CAM technologies</p> <p>Post-processor design</p> <p>General rapid prototyping techniques</p> <p>Neutral formats for product data exchange</p> <p>Manufacturing processes</p> <p>Tool path generation methodologies</p> <p>CNC programming techniques and codes and systems</p> <p>Sensor technology</p> <p>Rapid prototyping techniques for limited range of materials</p> <p>Tool design and materials</p> <p>Processing characteristics</p> <p>Process effectiveness</p> | Generalise and systemise existing knowledge of cluster partners in traditional and advanced CAM |

| Driver | Enabling Technologies | Enabling Research |
|--|---|---|
| A - Flexibility in production | 1 - Industry-standard Rapid Tooling – A B | Rapid Manufacturing with high direct end-quality: RM in metals, RM of graded materials, |
| B - Reduced time to market | 2 - Industry standard Rapid Manufacturing – A B | Designing for RM – 1 2 |
| C - Need for distance manufacturing | 3 - Knowledge based CAM-systems – A B | Development of full-scale CAD/CAM systems for collaborative, distributive product |

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|---|---|---|
| <p>D - Reduced scrap rate</p> <p>E - Reduced energy requirement of machine tools</p> <p>F - Reduced environmental contamination</p> <p>G - Improved recycling</p> <p>H - Design for Modular manufacturing</p> <p>I - Multi-variant inventory management</p> | <p>C D E F G H I</p> <p>4 - Graded materials – D F G</p> <p>5 - Integrated product models – A B C D H I</p> <p>6 - Self-organising machine tools – E F H</p> <p>7 - High-order neutral (standard) machine tool programming languages – A B H</p> <p>8 - Neutral (standard) post-processing languages – A B H</p> <p>9 - Distributed CAD/CAM databases – A C H I</p> <p>10 - Product data exchange models for CNC machine tools, industrial robots, CMM – A B H I</p> <p>11 - Parametric, variational, feature-based CAD/CAM – A B C H I</p> <p>12 - Context-sensitive, intuitive CAD/CAM systems – A B C D G H I</p> | <p>development - 5 7 8 9 10 11 12</p> <p>High-order programming languages for product data definition – 3 7 8 11 12</p> <p>Visual programming of machine tools – 3 7 8 11 12</p> <p>Manufacturability definition – 4 5 6 7 8</p> <p>Evaluation methodologies for DFM – 1 2 3 5 10 11 12</p> <p>Evaluation of commercially available machining cycles: trochoidal cycle, plunge roughing – 4 5 6</p> |
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2.4 Automated Design of Complex Products

| | Automated Design of Complex Products (Lead MEC) | Prepared by: TNO, Newcastle, MEC, Cetim, VTT | Ambition |
|---------------------|---|---|--|
| M Market | Market/Industrial Needs | Drivers: - Reducing human intervention in the design process - Improving of automation strategies of design systems - Enhancing human/machine interaction in the design process | Combine product/user knowledge with geometric product parameters. |
| P Projects | Future Projects | - Free feature modeling - Product specific CAD - Repeating features - CAD for graded materials - topology optimization - mass customization - customized products | large product variety and low cost, short lead times high quality |
| T Technology | Enabling technologies | - Adaptable and reconfigurable design processes and systems - Product and process design methods addressing a broad range of product requirements - Knowledge based assistance in design | |
| K Knowledge | Knowledge areas needed for technology development | Multi technology approaches Costs databases models and contents, and link between technical product and process models and costs product families and modularization techniques, product design process, rapid manufacturing, knowledge based | |

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| | | engineering, case-based reasoning, multi-objective-optimization, expert system, constraint satisfaction problem, machine learning, feature based modeling, adaptive search, value engineering | |
| O Organisation | Knowledge present at partners | Intelligent conceptual design, innovative design | Complete design modeling technique, automation of the process of conceptual design, Innovative design |

| Driver | Enabling Technologies | Enabling Research |
|--|---|---------------------------------------|
| A - Reducing human intervention in the design process | 1 - Adaptable and reconfigurable design processes and systems – A B | Free feature modeling – 2 3 |
| B - Improving of automation strategies of design systems | 2 - Product and process design methods addressing a broad range of product requirements – A B C | Product specific CAD – 2 3 |
| C - Enhancing human/machine interaction in the design process | 3 - Knowledge based assistance in design – A B C | Repeating features – 2 3 |
| | | CAD for graded materials – 2 3 |
| | | Topology optimization - 3 |
| | | Mass customization – 1 2 3 |
| | | Customized products – 1 2 3 |

2.5 Product Knowledge Management

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| | Product Knowledge Management Lead Clausthal | Prepared by Partners: Newcastle, Clausthal, IFW, MEC, Minho, Warwick | Ambition |
| M Market | Market/Industrial Needs | <ul style="list-style-type: none"> -Development of new methods, techniques and tools to design according to customer benefits -Classical product design theories are not applicable anymore -Design methods shall be focused on customer benefits -Existing Knowledge Management technologies have limited capabilities -Deficiencies of a conceptual foundation to link knowledge and individuals - Improved use of information collected during lifecycle for design of new products - Assistance for Concurrent Engineering and collaborative engineering - Discovering convenient, efficient, and appropriate methods, techniques, and mechanisms for capturing knowledge from various resources - Representation of knowledge in computer readable and retrievable format - Sharing among collaborative team members, for learning from past design experience, and for reuse in new concept generation - Volatile and demanding markets - Volatile products | <ul style="list-style-type: none"> -New analytic approaches, revised expert knowledge and innovative knowledge database management -Evolutionary design (products improve themselves automatically) -During the life cycle, provide the right information in the right format at the right time and the right place -A unified standard for the exchange of product data - Design by order -Total customer satisfaction - Total customization design - Total knowledge integration |

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| | | <ul style="list-style-type: none"> - Innovation based competition - Knowledge and learning as the main competitive resources | |
| P Projects | Future Projects | <ul style="list-style-type: none"> - New technologies to support design and lifecycle management - Product marketing design tools encompassing all sustainability aspects - Based on concepts, Knowledge Management puts value on individual's knowledge - Integration of Product data management (PDM) with Enterprise Resource Planning (ERP) - Management of geographically scattered product documentation - Knowledge Management applications will be oriented towards individual knowledge - Achieve a unique connection between each product and its characterizing information. - Lifecycle information directly reused to generate new product generations - Develop Product Knowledge Management Tools to support Customer Co-construction - New, distributed, virtual, distance learning techniques, and their integration with existing approaches - Integration of individual knowledge with group or organizational knowledge - Integration of "hard" knowledge management applications (e.g., PDM, STEP, Expert Systems) with "soft" knowledge management platforms and techniques (e.g., group dynamics, team management, creativity techniques and tools, communication tools, systematic innovation rules) | <ul style="list-style-type: none"> - No restrictions to certain work platforms, as well as Knowledge Management with high level semantic understanding - Clearing of the separation between product and belonging information |

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| | | <ul style="list-style-type: none"> - Research on the linkages between organisational structure, learning capabilities and innovative performance - Research on the understanding of the processes of organisational learning and knowledge creation and exploitation | |
| T Technology | Enabling technologies | <p>Factors of success are unique competencies, intelligent added value, involvement in supply-chain (knowledge management, ubiquitous computing etc.)</p> <p>Sensors, memory and processors embedded in products allow collecting information during use.</p> <ul style="list-style-type: none"> - PDM or Life Cycle Management - Knowledge Management (KM) - collaborative engineering - agent-based system - legacy system integration - Emphasis on the integration of process and social approaches to knowledge management with computational approaches to knowledge management - Shift from a systems-centred top-down approach towards an holistic, complex-driven, bottom-up approach to knowledge management - Shift from an optimization perspective towards a creative perspective in design - Emphasis on the management of tacit knowledge, i.e., knowledge that is not amenable to codification (e.g., resides either in the specific competencies of people or organizations and which is difficult to spread and communicate, and can not be done by using codified media) - Emphasis on the integration of tacit and explicit | <p>Integrated Design, Availability of use information.</p> <p>Design as innovation</p> <p>Design by/for complexity</p> <p>Chaos management</p> |

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| | | knowledge | |
| K Knowledge | Knowledge areas needed for technology development | <ul style="list-style-type: none"> – Capturing – Storing – Indexing – Searching – Retrieving – Sharing – Interpreting – Exploiting – Elaborating Data (Semantic, Ontology, Data Mining, etc.) – Document management – workflow management, project management, product structure management – classification, acquisition, process, formalization, representation, evaluation – change management, requirements management – lifecycle support – ISO, STEP, Open Source, W3C – Multi agent systems – holonic enterprises – conflict management, task management – activity scheduling – natural language processing – self-learning, knowledge discovery | <p>Apply and develop methodology of :</p> <ul style="list-style-type: none"> • Data mining - Selection, exploration & modeling of large databases to discover models and patterns that were previously unknown • Data warehousing – integrates data from all areas of a business including financial, process, customer, production and administration. |

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| <p>O Organization</p> | <p>Knowledge present at partners</p> | <ul style="list-style-type: none"> - Product Data Management (PDM) - Product Lifecycle Management (PLM) - Exchange of product data (STEP) – enabler - Product Lifecycle Support (PLCS) - enabler - Expert Systems - Interoperability (XML) - Ontology - Emphasis on computational approaches to knowledge management - Emphasis on the management of explicit knowledge, i.e., knowledge that is amenable to codification (in software, in books, manuals, blueprints, etc.) | |
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| Driver | Enabling Technologies | Enabling Research |
|---|--|---|
| <p>A - Development of new methods, techniques and tools to design according to customer benefits</p> <p>B - Design methods shall be focused on customer benefits</p> <p>C - Existing Knowledge Management technologies have limited capabilities</p> <p>D - Deficiencies of a conceptual foundation to link knowledge and individuals</p> <p>E - Improved use of information collected during lifecycle for design of new products</p> <p>F - Assistance for Concurrent Engineering and collaborative engineering</p> <p>G - Discovering convenient, efficient, and appropriate methods, techniques, and mechanisms for capturing knowledge from</p> | <p>1 - PDM or Life Cycle Management – A B</p> <p>2 - Knowledge Management (KM) – C E</p> <p>3 - collaborative engineering – B C F</p> <p>4 - agent-based system - G</p> <p>5 - legacy system integration - E</p> <p>6 - Emphasis on the integration of process and social approaches to knowledge management with computational approaches to knowledge management -E</p> <p>7 - Shift from a systems-centred top-down approach towards an holistic, complex-driven, bottom-up approach to knowledge management - D</p> <p>8 - Shift from an optimization perspective towards a creative perspective in design –</p> | <p>-New technologies to support design and lifecycle management</p> <p>-Product marketing design tools encompassing all sustainability aspects</p> <p>- Based on concepts, Knowledge Management puts value on individual’s knowledge</p> <p>- Integration of Product Data Management (PDM) with Enterprise Resource Planning (ERP)</p> <p>- Management of geographically scattered product documentation</p> <p>- Knowledge Management applications will be oriented towards individual knowledge</p> <p>- Achieve a unique connection between each product and its characterizing information.</p> <p>- Lifecycle information directly reused to</p> |

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| <p>various resources H - Representation of knowledge in computer readable and retrievable format I - Sharing among collaborative team members, for learning from past design experience, and for reuse in new concept generation J - Volatile and demanding markets K - Volatile products L - Innovation based competition M - Knowledge and learning as the main competitive resources</p> | <p>E F 9 - Emphasis on the management of tacit knowledge, i.e., knowledge that is not amenable to codification (e.g., resides either in the specific competencies of people or organizations and which is difficult to spread and communicate, and can not be done by using codified media) – C E F G H I 10 - Emphasis on the integration of tacit and explicit knowledge - M</p> | <p>generate new product generations - Develop Product Knowledge Management Tools to support Customer Co-construction - New, distributed, virtual, distance, learning techniques, and its integration with existing approaches - Integration of individual knowledge with group or organizational knowledge - Integration of “hard” knowledge management applications (e.g., PDM, STEP, Expert Systems) with “soft” knowledge management platforms and techniques (e.g., group dynamics, team management, creativity techniques and tools, communication tools, systematic innovation rules)</p> |
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2.6 Networked & Virtual Enterprises for Design

| | Networked Virtual Enterprises for design (Lead Oxford) | Partners: Newcastle, Clausthal, IFW, MEC, Minho, Oxford, CETIM | Ambition |
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| M Market | Market/Industrial Needs | <ul style="list-style-type: none"> – The complexities of modern products give rise to considerable problems in specification development and in its deployment along the supply chain and through the design network. – Integration of expertise from many organizations to provide seamless design, manufacture and distribution, focused on customers' requirements – Need for appropriate, reliable and transparent decision support tools, which must be flexible and transportable across networks and which can operate pro-actively or automatically on proposals for design modification. – Requirements for systems integration and the development of design tools. – Requirements for a real novelty products, systems, processes and organizations – Requirements for efficient design processes, implying radically shorter time-to-market – Need for tools to facilitate the cost calculation for complex products designed in a collaborative way | <ul style="list-style-type: none"> – Use of distributed design systems in networks of collaborating enterprises and the creation of a virtual product design environment – Tools and techniques to identify partners and collaborators, while providing support for fair IP and profit protection and sharing – Tools and techniques to provide ubiquitous design environments – Tools and techniques to provide Chaordic Systems Thinking (CST) – “Real-time” design – Tools to allow a transparent, collaborative calculation of life cycle costs |

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| P Projects | Future Projects | <ul style="list-style-type: none"> – CE Agile Groups as part of BM_VEARM – CE Virtual groups as part of BM_VEARM – Detailed specification of the CE processes and systems, especially considering different application domains as well as the system's variability – Application of more formal specification languages – Demonstrator projects of integration – Provision of international standards on software, hardware and data sharing – Development of contracts and obligations to protect and enable data and IP sharing – Design, or New Product Development, in Ubiquitous design systems – Chaordic systems Thinking (CST) tools and techniques for Design, or New Product Development – Formal design theory and supporting computer based tools – Provide tools for distributed design (multiple locations / suppliers work on different components to be integrated) – Define methods for integrated product, technology and enterprise roadmapping | <ul style="list-style-type: none"> – Increase the efficacy of the group in the development of new tasks arising from the increased competence of the individuals – Maintain productivity, quality, agility of the group by means of broker action – Identify and overcome (where possible) obstacles to seamless integration – Enable rapid and effective sharing of data; lower barriers for entry to Virtual Extended Enterprises – Lower entry risks for collaborating companies – Ubiquitous environments for design processes – Computer based tools for supporting automation of design processes based on formal theories – Develop together with products the correspondent optimal configuration for technology and virtual enterprise |
| T Technology | Enabling technologies | <ul style="list-style-type: none"> – Knowledge management and knowledge engineering and organizational learning for innovation and product development | <ul style="list-style-type: none"> – New products that will enable flexible integration amongst NVED participants |

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| | | <ul style="list-style-type: none"> – Learning organization for innovation and product – Agile virtual enterprises organizational concept for design team or enterprise organization and management – Meta-enterprise organizational structures for agile virtual enterprises based design team or enterprise organization and management – Inter- and Intra-design team or enterprise interoperability – Semiotics framework, or perspective, for innovation and product development information systems and management models – Chaordic system thinking and chaordic enterprise for innovation and product development – Design theory and formal design theories – Collaboration technology, teleconferencing, tele-control, tele-presence – Intelligent collaboration systems – Extended manufacturing enterprise paradigm – Inter-organisational structures based on flexible, transient cooperation models – Software standards and packages – Requirements for internet-enabled manufacturing – Ontologies and semantic web to support interoperability – Standards for the calculation of total costs of ownerships of developed products | |
| <p>K Knowledge</p> | <p>Knowledge areas needed for technology development</p> | <ul style="list-style-type: none"> – CE, Collaborative design, distributed systems, agent-based design, web-based design, conflict management, task management, activity | <ul style="list-style-type: none"> – Recommendations on appropriate rules for NVED to achieve desirable global |

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| | | <p>scheduling, dynamic knowledge management</p> <ul style="list-style-type: none"> – Better understanding of consequences for supply networks and NVED of changes to rules of behaviour; knowledge acquired through simulations and analyses based on techniques from agent-based dynamic networks | <p>and local properties of robustness and fairness</p> |
| <p>O Organisation</p> | <p>Knowledge present at partners</p> | <ul style="list-style-type: none"> – Technology evaluation of collaborative work approaches and tools – Knowledge capitalisation by profession (forge, machining...) – Strategy and stakes by sector (automotive, aeronautics) – Business models for collaborative platforms access – Assessment methodology to measure readiness to enter NVED – Virtual Enterprise Architectures oriented to dynamic reconfiguration of design teams as agile architectures and agile/virtual or virtual architectures. Specification of the BM_Virtual Enterprise Architecture Reference Model (BM_VEARM) – Brokerage function informal functional specification and time and cost functions for brokerage function validation – First experiments of agile management of design teams in direct and virtual environments oriented to dynamic reconfiguration of design teams as agile architectures and agile/virtual or virtual architectures in accordance with BM_VEARM reference model – Chaordic System Thinking (CST) principles for | <ul style="list-style-type: none"> – Integrate and share to identify and assess alternative approaches – Adjustment of each profession and skill to accommodate NVED approach – Identify methods to reduce risks and barriers to entry for SMEs – Identify and assess business models with case studies and recommendations – Conduct pilot projects over a range of sectors to produce innovative, customized products – Ubiquitous environments for performing design processes as individual or network organizations – A real novelty products, systems, processes and organizations – Total, flexible, efficient, |

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| | | providing emergency of a real novelty of products, systems, processes and organizations, etc. – Organizational Semiotics framework principles for Inter- and Intra-design team or enterprise Interoperability | seamless and generative integration of design processes and tools and designers |
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| Driver | Enabling Technologies | Enabling Research |
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| <p>A - The complexities of modern products give rise to considerable problems in specification development and in its deployment along the supply chain and through the design network.</p> <p>B - Integration of expertise from many organizations to provide seamless design, manufacture and distribution, focused on customers' requirements</p> <p>C - Need for appropriate, reliable and transparent decision support tools, which must be flexible and transportable across networks and which can operate pro-actively or automatically on proposals for design modification.</p> <p>D - Requirements for systems integration and the development of design tools.</p> <p>E - Requirements for a real novelty products, systems, processes and organizations</p> <p>F - Requirements for efficient design processes,</p> | <p>1 - Knowledge management and knowledge engineering and organizational learning for innovation and product development – A B C D</p> <p>2 - Learning organization for innovation and product – A B C</p> <p>3 - Agile virtual enterprises organizational concept for design team or enterprise organization and management – F</p> <p>4 - Meta-enterprise organizational structures for agile virtual enterprises based design team or enterprise organization and management – A B C D</p> <p>5 - Inter- and Intra-design team or enterprise interoperability – B C F</p> <p>6 - Semiotics framework, or perspective,</p> | <p>CE Agile Groups according to BM_VEARM – 1 3 4 5 9 10 11 12 13 14</p> <p>CE Virtual groups according to BM_VEARM – 1 3 4 5 9 10 11 12 13 14</p> <p>Detailed specification of the CE processes and systems, especially considering different application domains as well as the system's variability - 1 2 3 4 5 9 10 11 12 13 14</p> <p>Application of more formal specification languages</p> <p>Demonstrator projects of integration</p> <p>Provision of international standards on software, hardware and data sharing – 10 11 12 13</p> <p>Development of contracts and obligations to protect and enable data and IP sharing – 1 3 11</p> <p>Design, or New Product Development, in</p> |

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| <p>implying radically shorter time-to-market</p> <p>G - Need for tools to facilitate the cost calculation for complex products designed in a collaborative way</p> | <p>for innovation and product development information systems and management models – A B C D F</p> <p>7 - Chaordic system thinking and chaordic enterprise for innovation and product development – E</p> <p>8 - Design theory and formal design theories - F</p> <p>9 - Collaboration technology, teleconferencing, tele-control, tele-presence – A B C D F</p> <p>10 - Intelligent collaboration systems - – A B C D F G</p> <p>11 - Extended manufacturing enterprise paradigm – A B C D F G</p> <p>12 - Inter-organisational structures based on flexible, transient cooperation models – A B C</p> <p>13 - Software standards and packages - A B C D F G</p> <p>14 - Requirements for internet-enabled manufacturing - A B C D F G</p> | <p>Ubiquitous design systems – 5 6</p> <p>Chaordic systems Thinking (CST) tools and techniques for Design, or New Product Development - 7</p> <p>Formal design theory and supporting computer based tools – 8 13</p> <p>Provide tools for distributed design (multiple locations / suppliers work on different components to be integrated) – 9 10 11 13 14</p> <p>Define methods for integrated product, technology and enterprise roadmapping - 9 10 14</p> |
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| | <p>15 - Ontologies and semantic web to support interoperability</p> <p>16 - Standards for the calculation of total costs of ownerships of developed products</p> | |
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