Sustainable MANUFACTURING

Shaping Global Value Creation

Sustainable manufacturing – A German perspective on shaping global value creation

11th Global Conference on Sustainable Manufacturing - Berlin, Germany on 23rd – 25th September, 2013

Prof. Dr.-Ing. Günther Seliger

CRC 1026 Sustainable Manufacturing – Shaping Global Value Creation
Funded by German Research Foundation (DFG)

Global Conference Series on Sustainable Manufacturing

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
I. GCSM Alabama, USA September	**II. GCSM** Berlin, Germany September	**III. GCSM** Shanghai, China October	**IV. GCSM** Sao Carlos, Brazil October	**V. GCSM** Rochester, USA September	**VI. GCSM** Pusan, Korea September	**VII. GCSM** Madras, India December	**VIII. GCSM** Abu Dhabi, UAE November	**IX. GCSM** St. Petersburg, Russia September	**X. GCSM** Istanbul Turkey November	**XI. GCSM** Berlin, Germany September	**XII. GCSM** Johor Bahru, Malaysia, Sep. 30th – Oct. 2nd Universiti Teknologi (UTM)

- GCSM 2013: conference contributions from 34 countries (51 German, 72 international)

Sustainable MANUFACTURING

Agenda

- Challenge
- Architecture of global value creation
- Laboratory of sustainable manufacturing
- Dissemination

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- **Challenge**
- Architecture of global value creation
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Resource challenge

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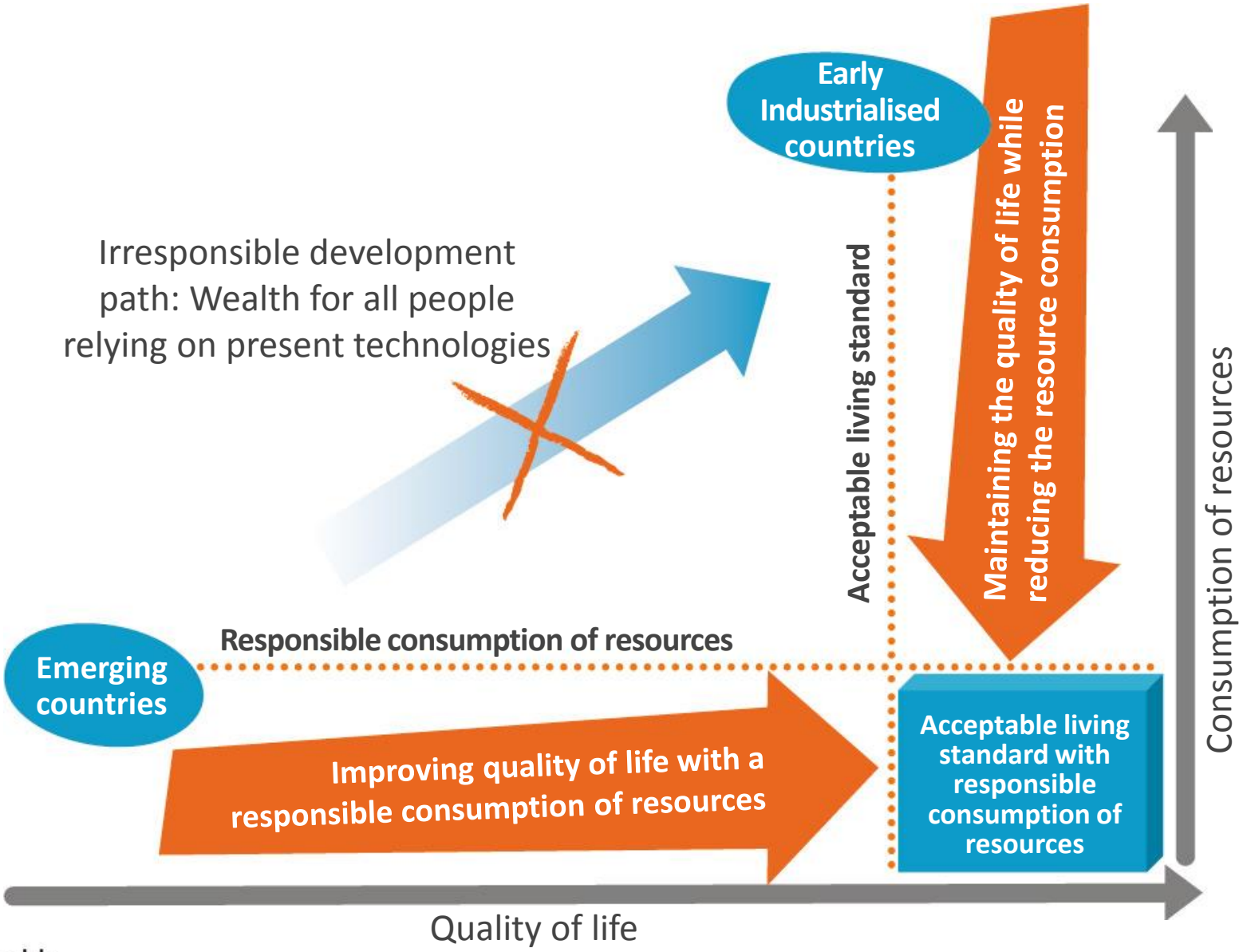
Prosperity for everybody?

- How to design and manufacture products and services
  - opening up hungry markets,
  - avoiding bad investments in saturated markets,
  - increasing human wealth on global level within conditions of environmental resource availability
- Adapt existing process paradigms
  - between economies of scale and economies of scope,
  - to create more benefit for more people with less resources.

Quality of life and consumption of resources



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- **Architecture of global value creation**
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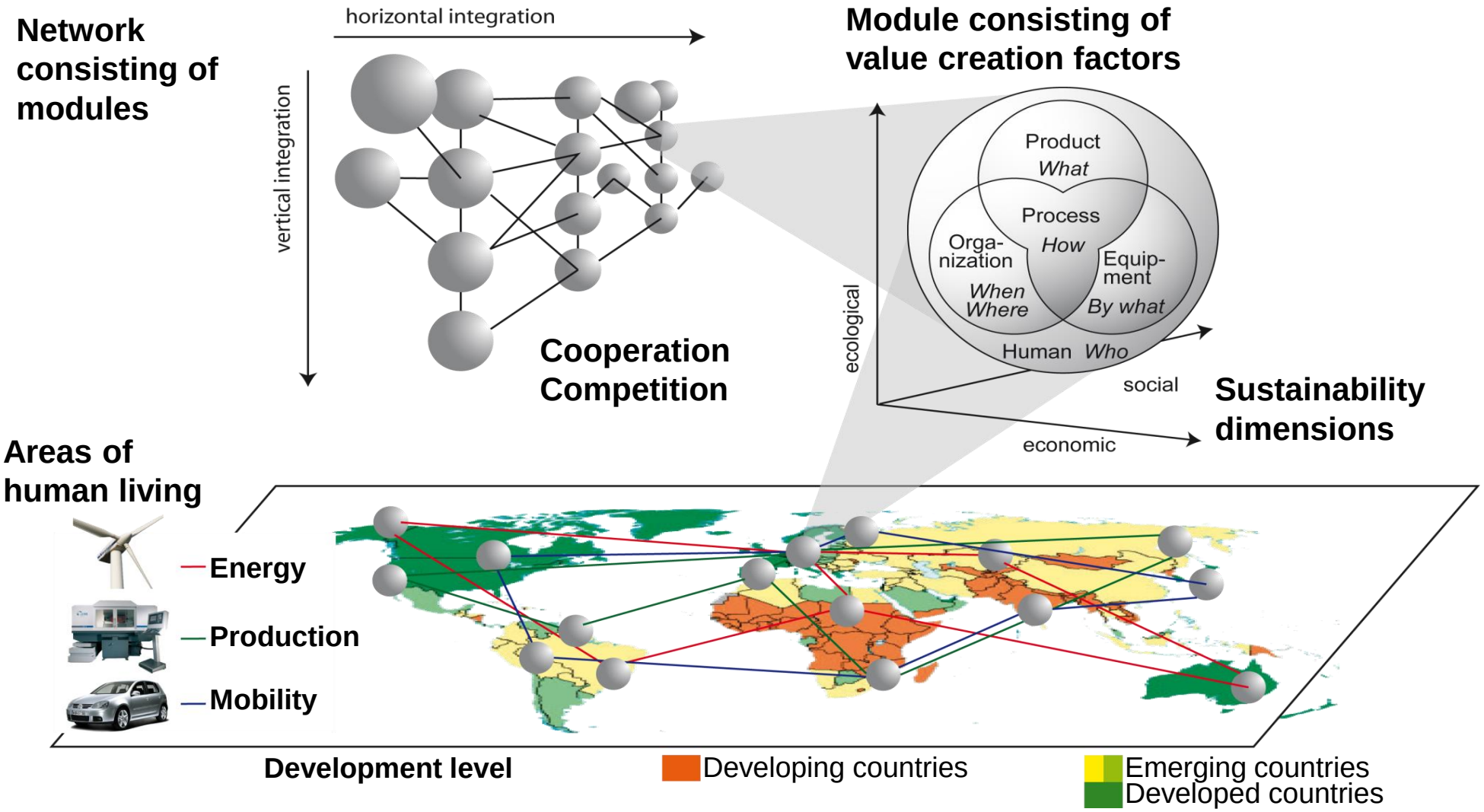
Utilizing competition and cooperation for sustainable development

The dynamics of global competition and cooperation shall be utilized for lending wings to processes of innovation and mediation towards the reasonably demanded sustainability on our globe.

Global value creation



B6 - Integration shop / laboratory of sustainable manufacturing

- Implementation of physical and virtual value creation modules (VCMs)
- Exemplarily connected to value creation networks (VCNs)

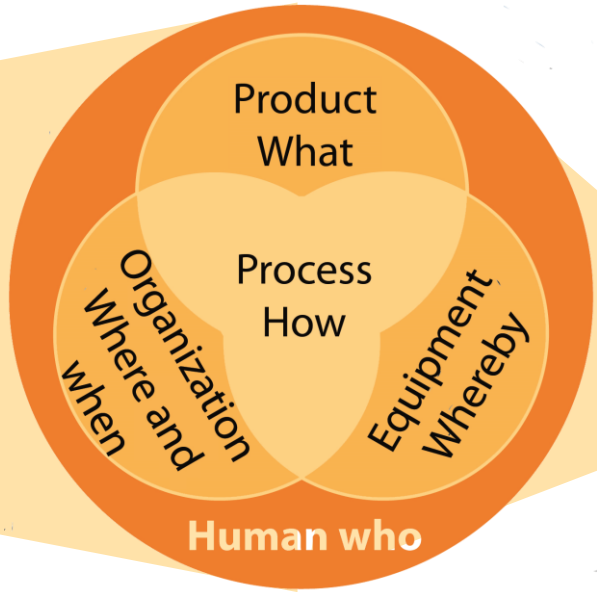
Assembly cell as VCM

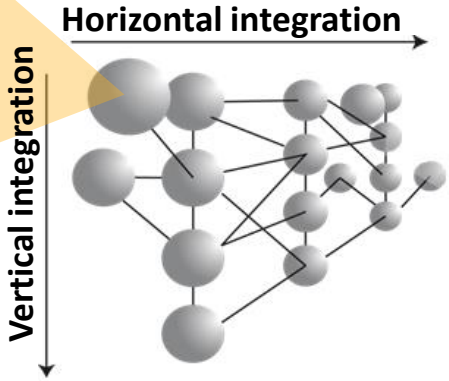
Bicycle frame as product

Workplace as equipment

Fixture as equipment

Laboratory with VCMs/VCN





VCM/VCN	Product	Process	Equipment	Organization	Human
Reconfiguration	Bicycle · frame · hub motor · wheel	Disassembly Assembly	Workplaces Tools Fixtures Learnstruments	Reducing set-up Sequence of operations Task assignment	Pupils Students

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- Challenge
- Architecture of global value creation
- **Laboratory of sustainable manufacturing**
  - Area search and valuation
  - Area implementation
- Dissemination

Laboratory of sustainable manufacturing – Day 2, 14:30 – 16:30

A1/Demonstrator: "Pathways for sustainable technology development"
Technology integration demonstration

A5: „Multicriteria optimisation"
Optimisation methods

KAP: "KAP: Knowledge, awareness, and prediction of man, machine, material, and method in manufacturing; Volvo, Nissan, Intel, Infineon"
Poster presentation

B5: "Design of accuracy increasing systems for simple machine tools"
Presentation and comparison of testing work pieces

S: "Samara – energy efficient material handling"
Robot and computer presentation

SIM: "Integrated control system simulation for PLC-controlled material flow"
Simulation and control system

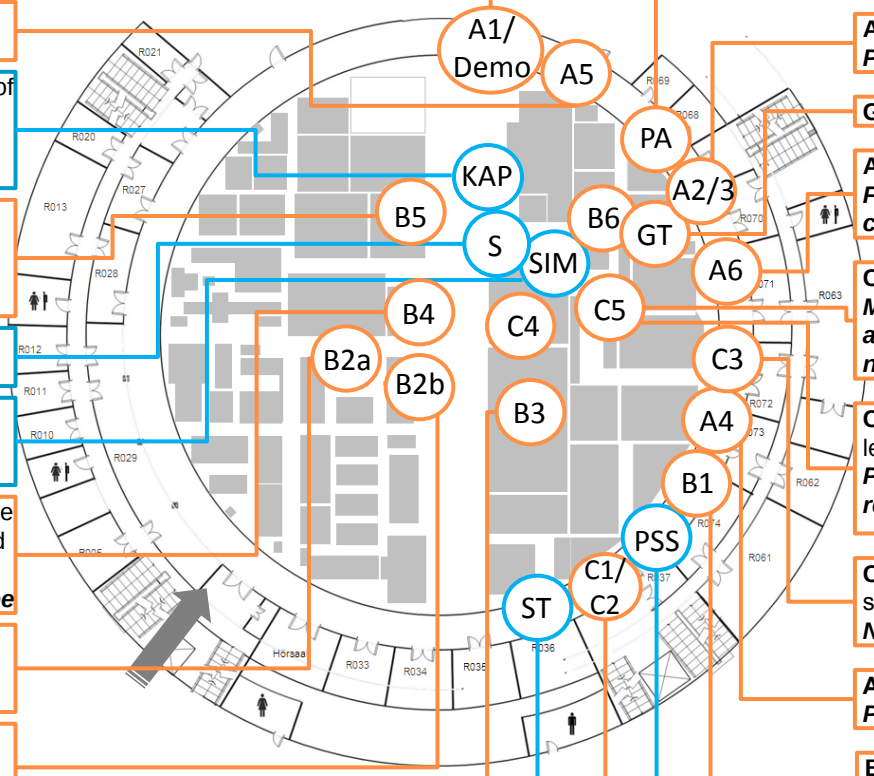
B4: "Development of microsystem enhanced machine tool structures for lightweight and accuracy optimised (LEG²O) frames"
Presentation of LEG²O and sensor node prototype

B2a: "Energy efficient dry ice cleaning"
Presentation of rotational wheel blasting, geometries of accelerating parts

B2b: "Energy efficient dry machining"
Presentation of tool prototype (turning tool and cooling system)

B3: "Sustainable welding production by combined application of numerical simulation and new process technologies"
Test butt welds (thick metal plate)

ST: "SmarTower" - System for wind turbines
Miniaturized model and poster presentation



B6/PA/C5: "Integration shop/public awareness"
Cube factory (decentralized manufacturing and recycling/ learnstruments)

A2/A3: "Sustainability indicators and assessment"
Poster presentation/IT

GT: "Power generation demonstrator – gas turbine"

A6: „System dynamics optimisation"
First draft of a real system dynamics model of a company producing goods (bicycles)

C5/B6: "Learnstruments in value-creation-modules"
Manual assembly work places for self-help repair and customization of bicycles and value creation network configuration

C4/C5: "Human oriented automation and learnstruments"
Pose recognition in manual assembly, failure recognition, automatic work plan generation

C3: „Strategic interaction and incentives for sustainable economic activity"
Nonrenewable resources, strategic behaviour

A4: "Macroeconomic Sustainability Assessment"
Poster presentation

B1: "Virtual product creation"
virtual bicycle models, poster presentation/IT

PSS: "Product service systems"
Sensor enhanced bicycles

C1/C2: "Emulation of modeling process and evaluation of the value creation"
Poster presentation/IT

CRC Project

CRC affiliated project

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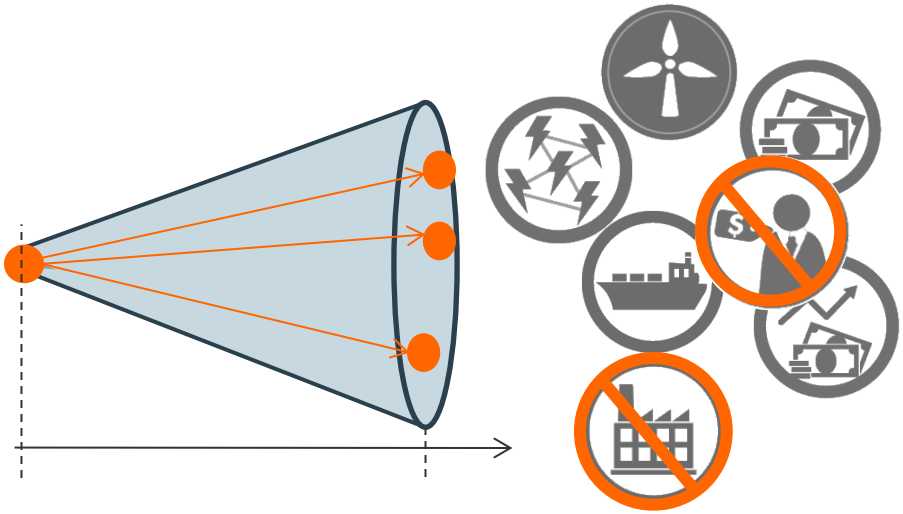
A1 - Exploiting technology for useful applications

Surrounding field scenarios



Technology scenarios

- Problems
- Tasks
- Requirements

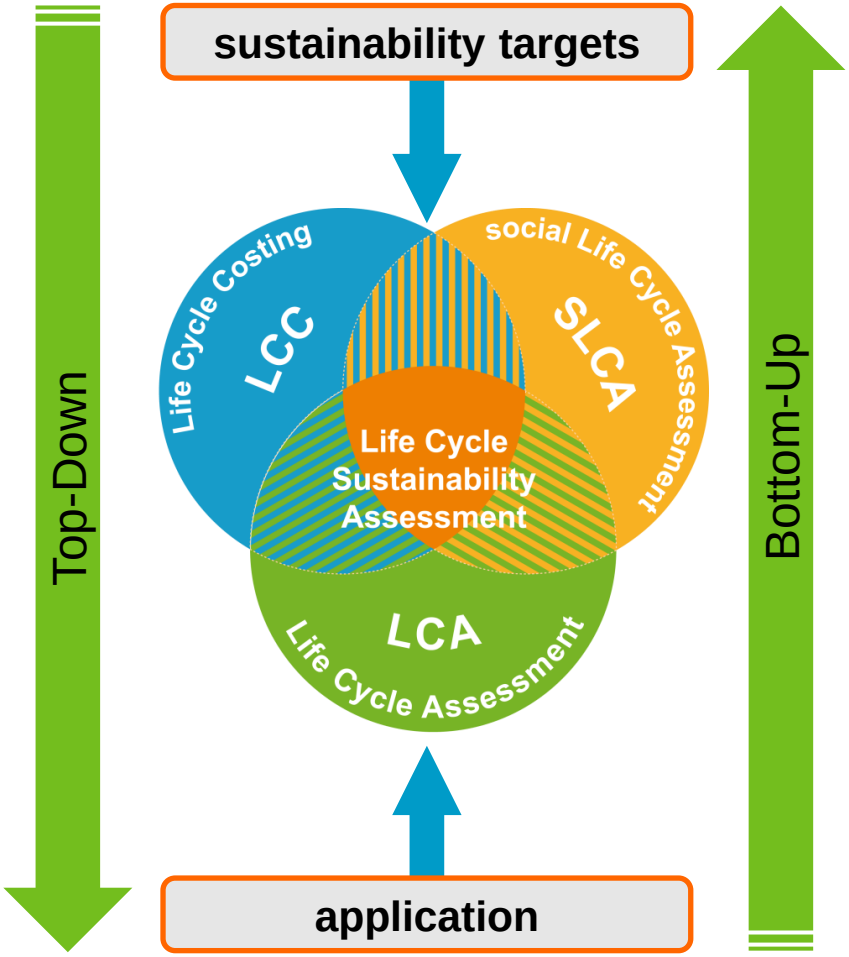
System creation

- Transfer technological potential into useful applications

- Technological potentials/solutions

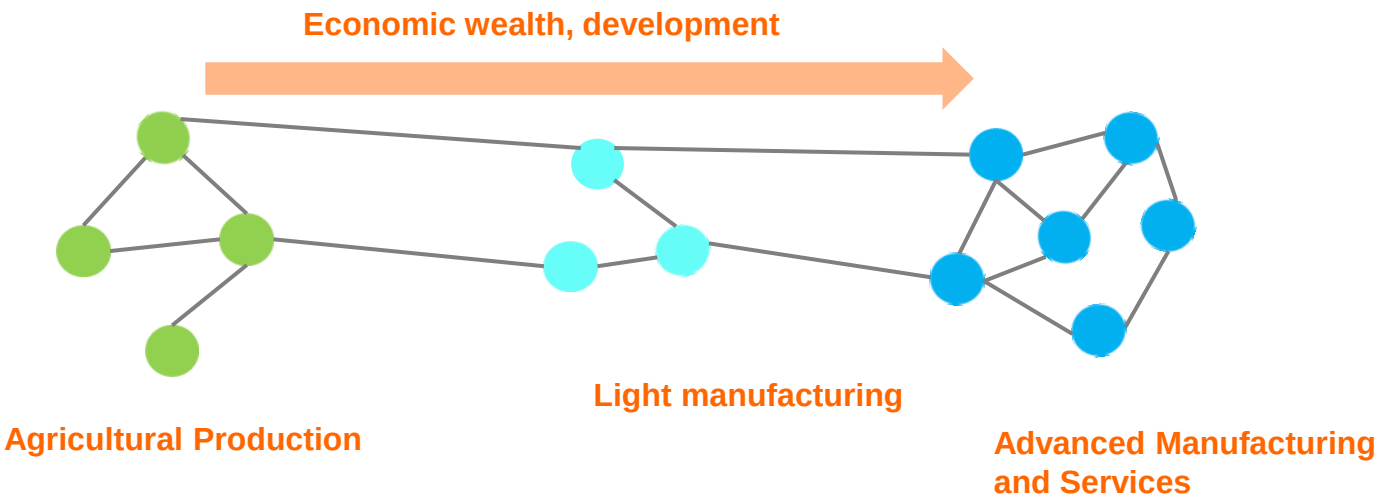
A2/A3 - Sustainability assessment & indicator development

- Development of a **new methodology and suitable indicators** for assessing **sustainability in specific value chains** within the manufacturing community
- Life Cycle Sustainability Assessment
  - environmental dimension
    - reduce environmental damage
    - identify environmental hotspots
  - social dimension
    - train & qualification of employees
    - consideration of (far) upstream supply chain
  - economic dimension
    - cost assessment and economic prosperity
- Measurement of sustainability impacts
  - practical case studies for products & processes



A4 - Manufacturing sector as key area for economic wealth

- Analysis of development paths by the use of worldwide Input-Output data
- Nodes refer to economic sectors



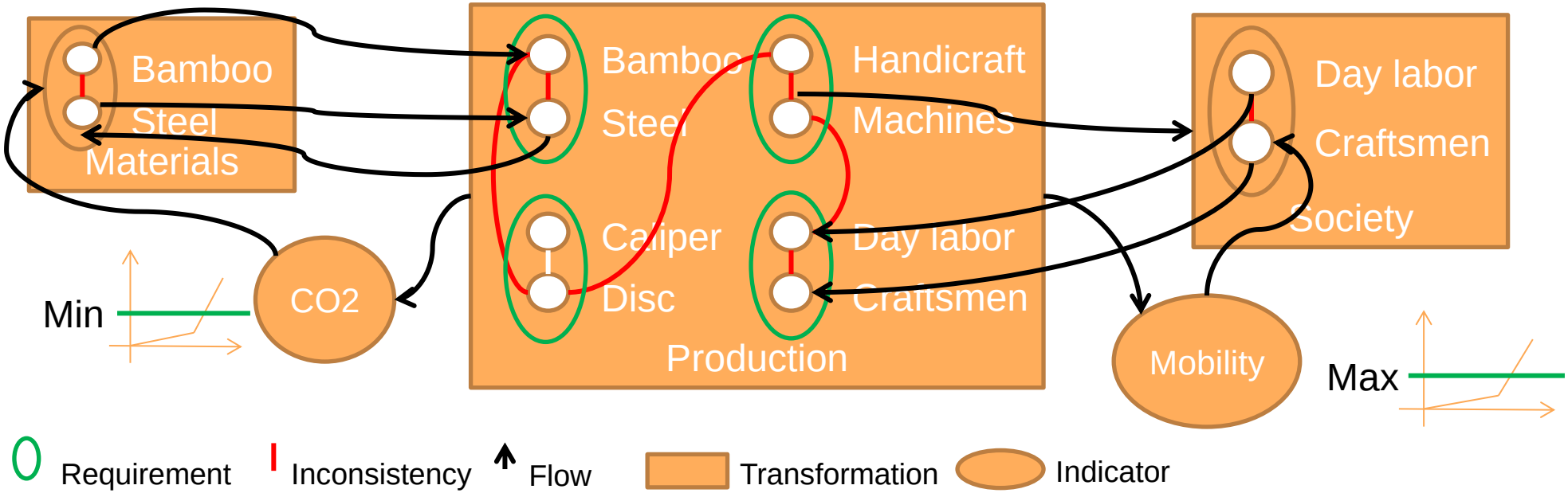
Outcomes

- There are only a few feasible development paths (links)
- The critical bottlenecks are dominated by **(light) manufacturing** sectors.

Implications

- The establishment of manufacturing industries is crucial for economic wealth
- The successful development of manufacturing sectors shapes human capital, institutions, natural stocks or society
- The access to sustainable manufacturing technology is the key for worldwide prosperity

A5/A6 - Mathematical tools for sustainable module and network design – multicriteria optimisation and system dynamics



Description in terms of mixed integer programs

$$
\begin{array}{lcccll}
\max & Cx & + & Dy & & \\
\text{(i)} & x_{\delta_v^+} & = & A_v x_{\delta_v^-} + b_v & \forall v & \text{production} \\
\text{(ii)} & x_{\delta_v^-} & \leq & \sum_{q \in Q_v^-} y_q u_{q,\delta_v^-} & \forall v & \text{config limits} \\
\text{(iii)} & 1 & = & \sum_{q \in Q_v^-} y_q & \forall v & \text{config choice} \\
\text{(iv)} & y_q & \in & \{0,1\} & \forall q & \text{config choice} \\
\text{(v)} & x & \geq & 0 & & \text{activity levels}
\end{array}
$$

- Goal: Providing decision support tools
- Requirements:
  - Quantitative description and formalisation
  - Finding algorithmic approaches to compute Pareto optimal solutions

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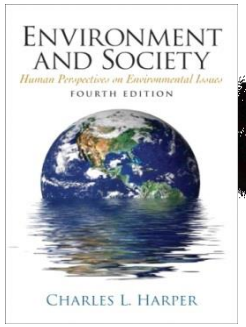
B1 - Virtual product creation in sustainable value creation networks

Enterprise and Society View

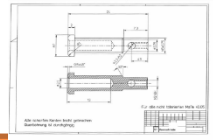


ss criteria

societal value

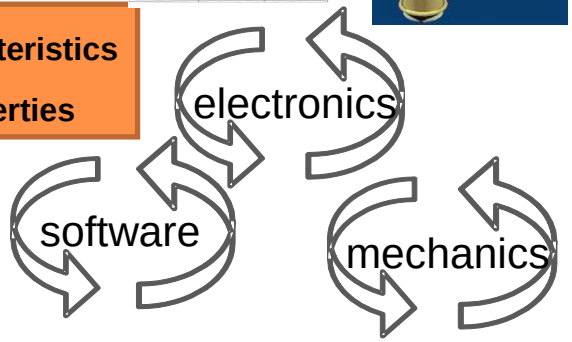
Trade-off between sustainability context areas and technical performance

Traditional Engineering View



characteristics

properties



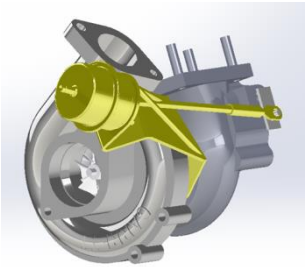
Major Goal

Enable and qualify the engineer to develop products for sustainable value creation

Approach

Development of a Design Decision Support Assistant, embedded into designer's IT environment

Turbo charger



System design is based on the development of a pedelec and a turbo charger in a bottom-up analysis

Pedelec

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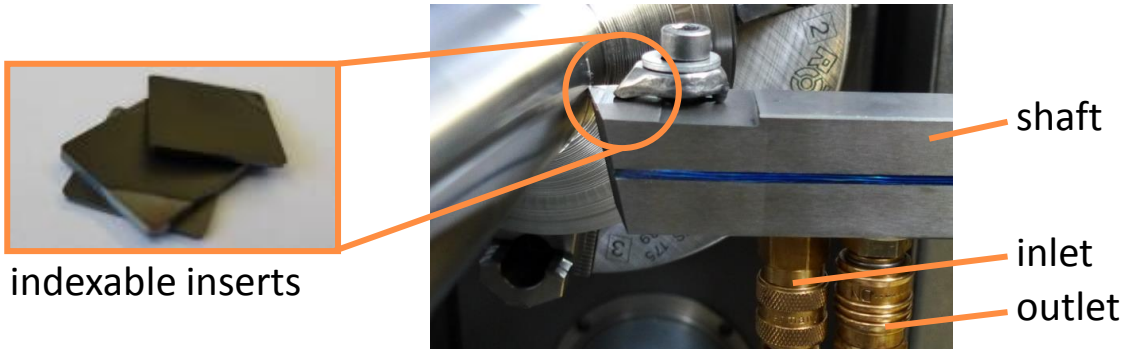
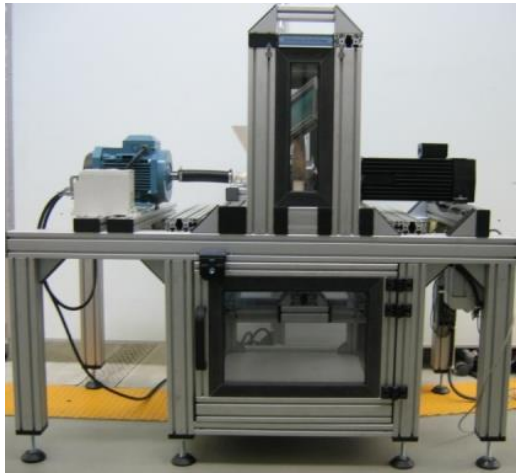
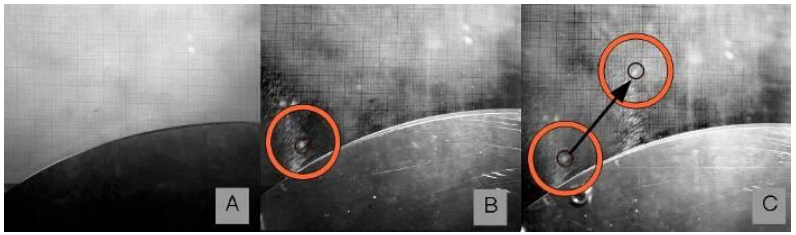
B2 - Energy efficient cleaning and dry machining

- Value creation module dry machining: Closed loop cooling
  - Design of LN2 cooling, control system and turning tool
  - Cutting trials with different cutting insert geometries (best stiffness to thickness ratio)
  - Evaluation of conventional turning tools (forces, temperatures, wear)



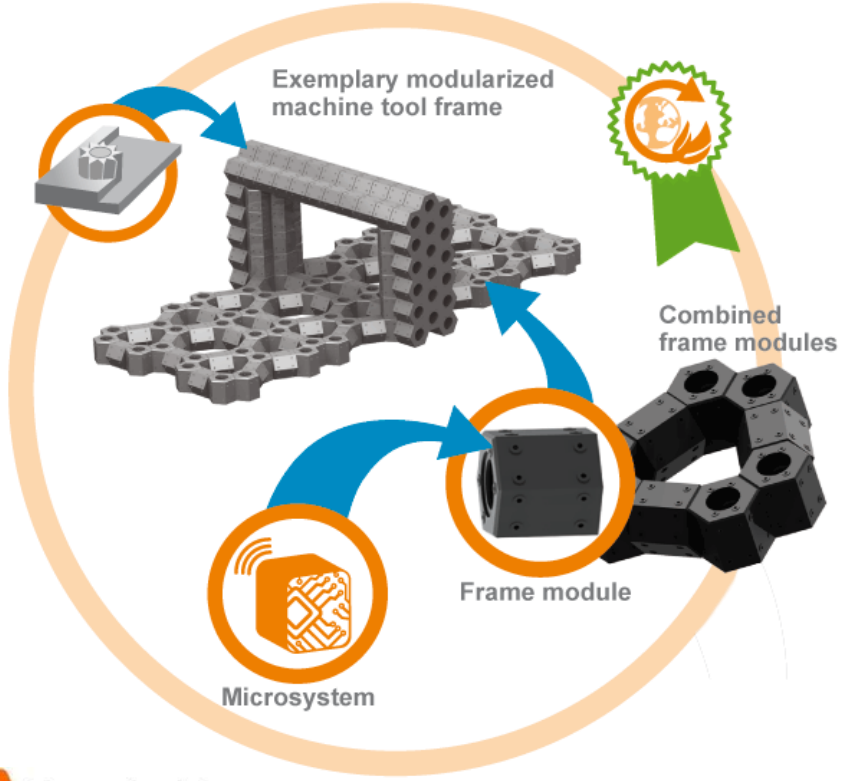


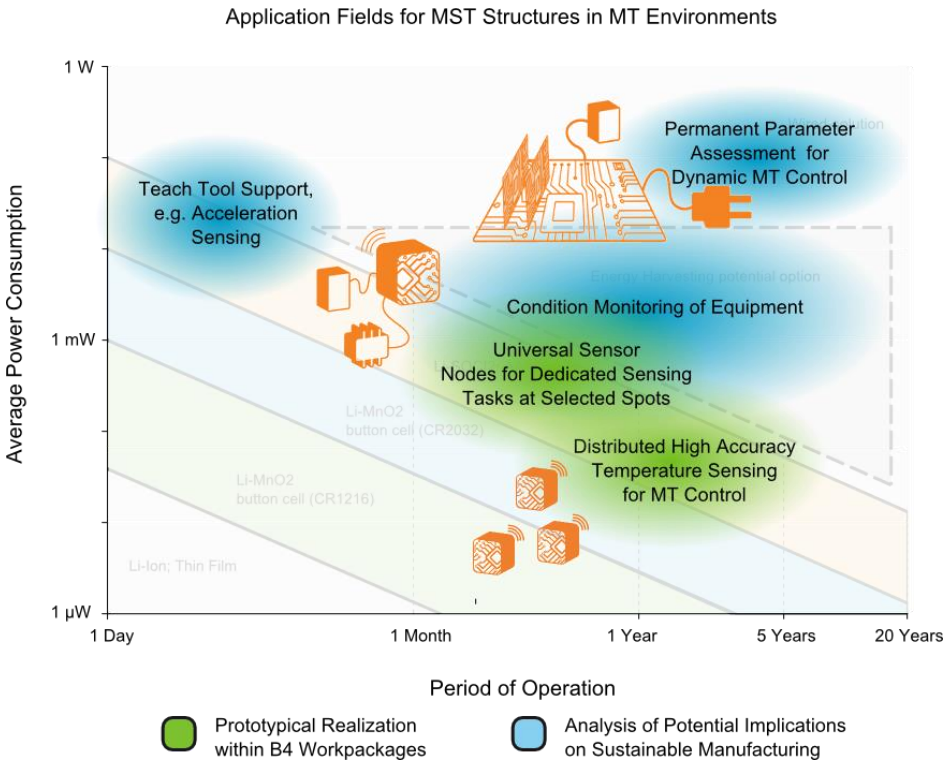
- Value creation module cleaning: Energy efficient cleaning
  - Development of a standard of comparison for cleaning capacity
  - Investigation of promising principles
  - Machining trials: High speed camera investigations
  - Fundamental investigation of principles to apply mechanical and thermal mechanism separately



B4 - Development of microsystem enhanced machine tool structures or lightweight and accuracy optimized (LEG²O) frames

- Modular machine tool structures (MT) provide the basis for higher degrees of adaptability, mobility and functionality
- Mechanical optimization of single structure, interconnects and assembly





- Microsystem technology (MST) enabling crucial functionalities in MT to foster sustainable value creation
- Wireless sensors considered on various functional and technological levels

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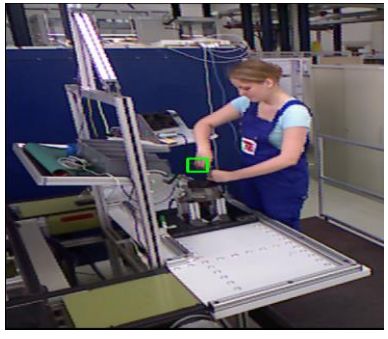
C5 - Learnstruments in value creation modules

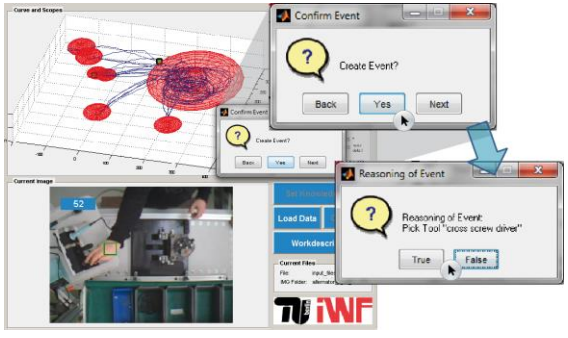
- Goal: Increase in teaching and learning productivity for sustainable manufacturing through application of learnstruments
- Leranstruments are artefacts which automatically mediate their functionality to the user
- Learnstruments are designed for use in a combined working and learning environment

Planning assistance

Physical work place teach-in



Work place optimization assistance



Assembly assistance

Audio/ visual work description generation/ use

Tele working support

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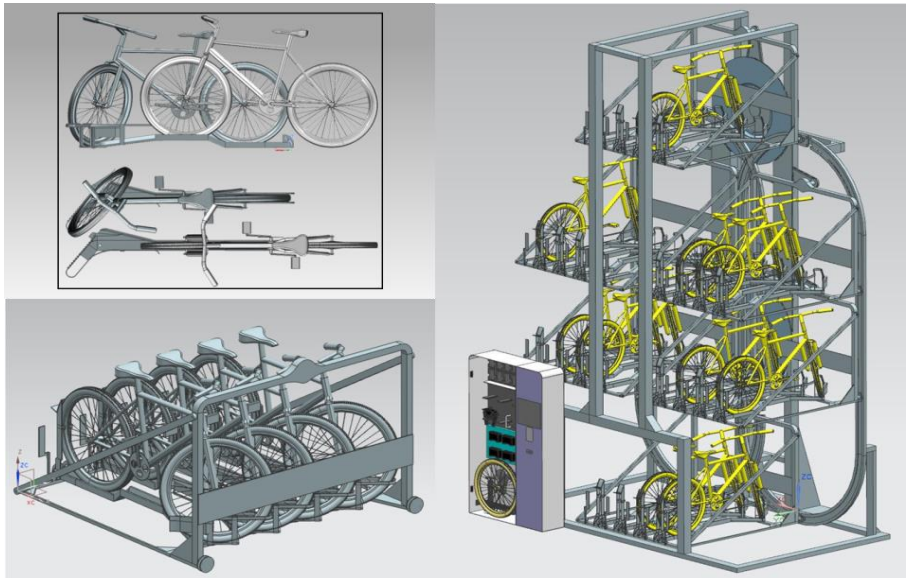
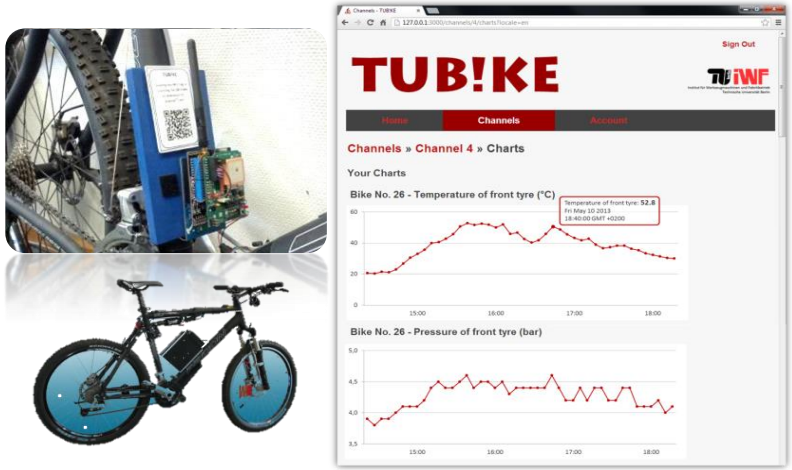
PSS: Product-Service Systems enabling for sustainable city mobility



E-Bike rental system with improved accessibility

- Bicycle for city mobility
- PSS-based maintenance, repair and overhaul (MRO)
- Win-win-win among the stakeholders customer, provider and society
- Implementation: E-Bike rental system



Web-based platform for condition monitoring and MRO planning

Interaction platform on smartphone

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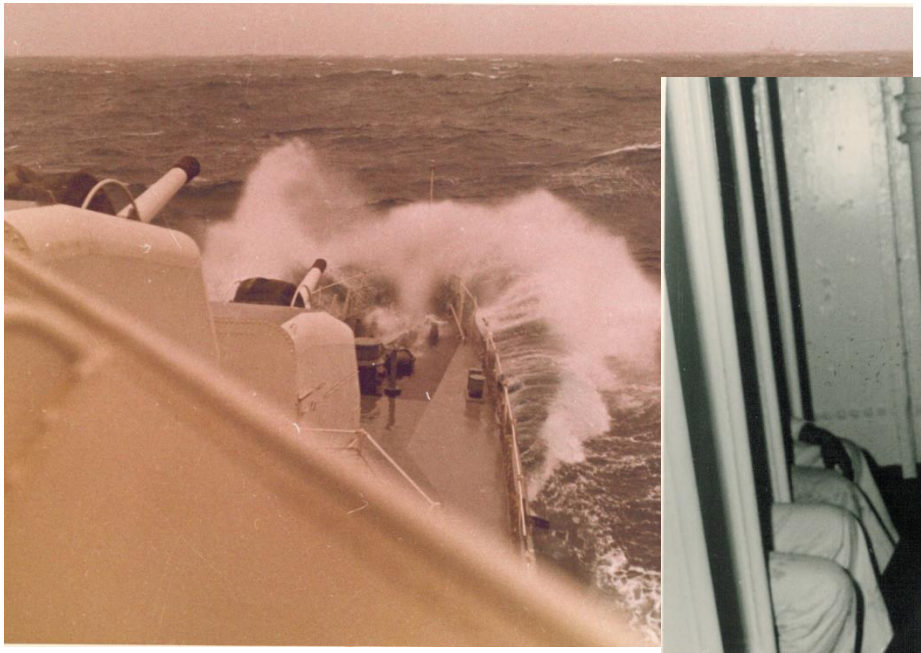
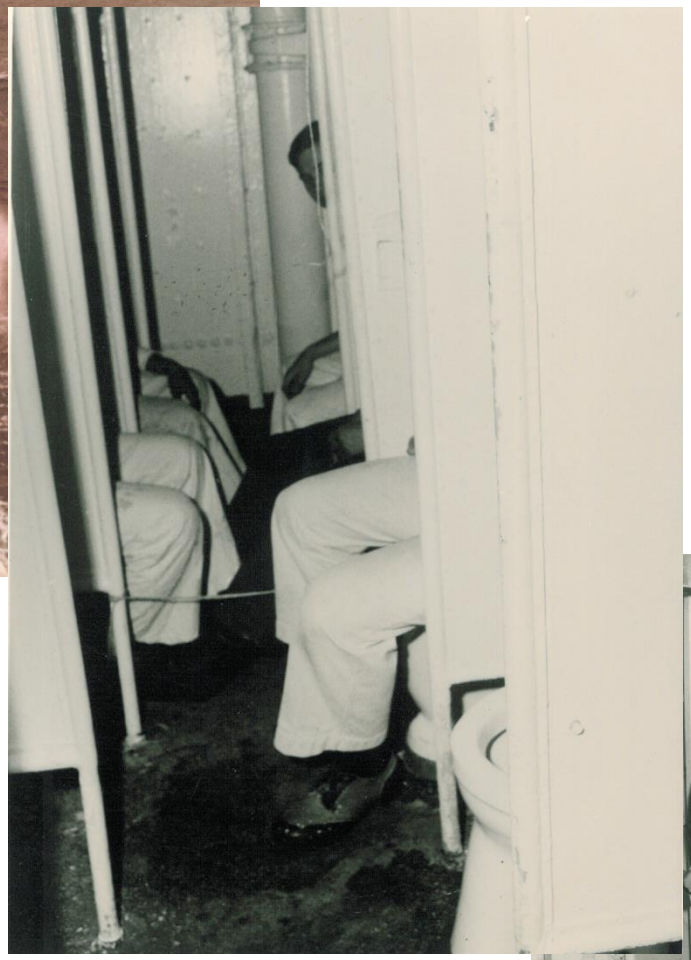
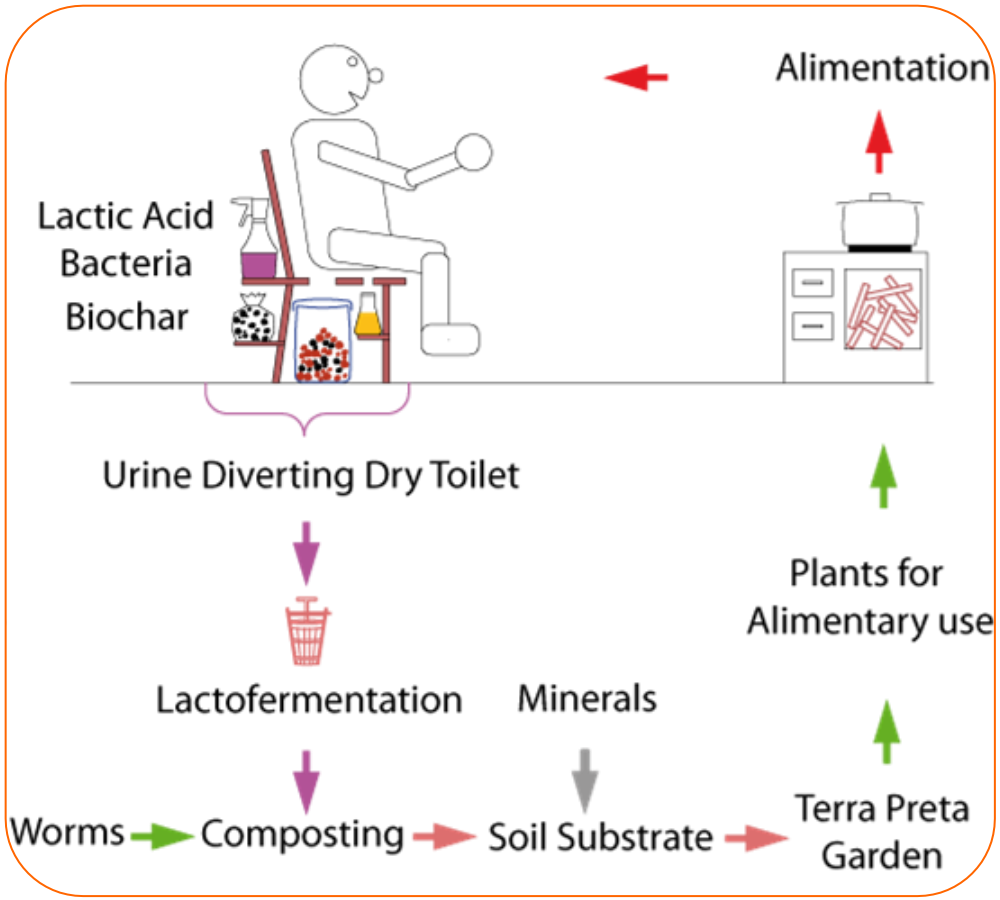
Sensitive areas

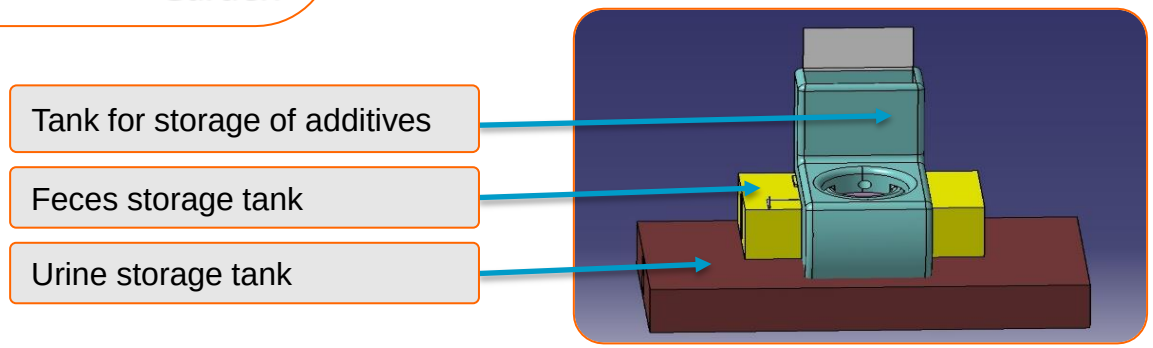




Sustainable sanitation systems



- 2.4 billion people do not have access to basic sanitation
- many deaths and disabilities are caused by improper sanitation
- on average, each middle-class person uses 60 liters of fresh water per day to flush their urine & feces down the drain



Dry toilet concept with anaerobic separation

Stone paper - a rock solid alternative

Hundreds of years of paper supply

Goldmine in Nevada, USA

80 % limestone powder
(non usable material from e.g. goldmines)

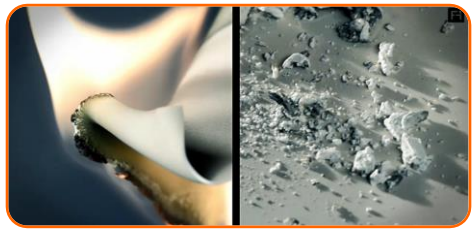
20 % polyethylene
e.g. recycled plastic bottles

NO tree cutting

NO water pollution

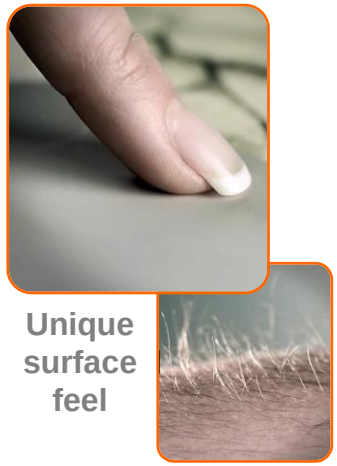
NO air pollution, bleach or strong acids

Water and grease proof



Flame retardant material

Tear resistant



Unique surface feel

Decomposes into limestone powder after

6 – 9 month under environmental influence

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Exemplary Global Research Cases

When? Day 3

Where? Oval Office

What? ICT as an enabling technology for sustainable manufacturing

How?

- 09:30 Keynote: European Vision for Horizon 2020 and ICT for Factories of the Future (Danuta Seredynska, European Research Programme Officer)
- 10:00 Keynote: Global research and new manufacturing technology projects (Thomas Messervey, Inteligent Manufacturing Systems Project Development Coach)

Capacity building for sustainable engineering – Day 3, 9:00 – 12:30, room 307

- Partner countries:
  - Jordan
  - Lebanon
  - Palestine
  - Syria
- Approaches:
  - Academic Exchange
  - New academic programs
  - Enhancing current programs
- Projects:
  - MeEng: Middle Eastern Partnership in Sustainable Engineering
  - MUREE: Modernizing Undergraduate Renewable Energy Education

European Commission
TEMPUS
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- Target industries:
  - Quarrying and Stone
  - Textiles and Garments
  - Leather and Shoes
  - Furniture
  - Handicrafts
  - Chemical Industries
  - Pharmaceuticals
  - Food Processing

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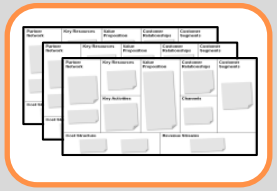
BRAGECRIM: Brazilian-German Collaborative Research Initiative in Manufacturing Technology – Day 3, 9:00 – 12:30, room 112

- **Theme: Networking for competitive remanufacturing**
  - Aim: allow the inclusion of remanufacturing in the processes of small and medium sized companies in Brazil and Germany.
  - Solution: Provide a set of business models based on remanufacturing principles to companies by the mean of an online knowledge platform.

Connect and inform companies about remanufacturing

Guidelines in interactive website

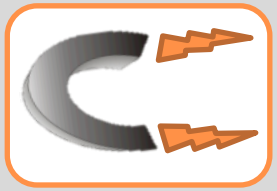
Business models



Step-by-step application

Success case studies

Attractiveness criteria



Extended storyboard

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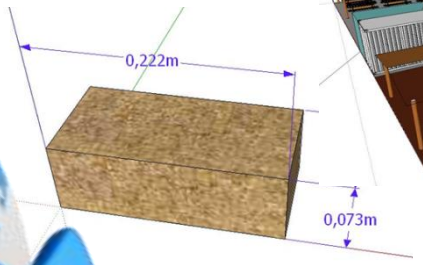
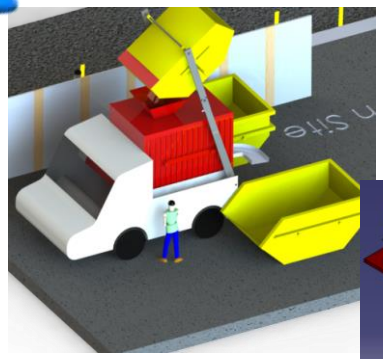
International partnership „Housing-Manufacturing-Water“ – Day 3, 9:00 – 12:30

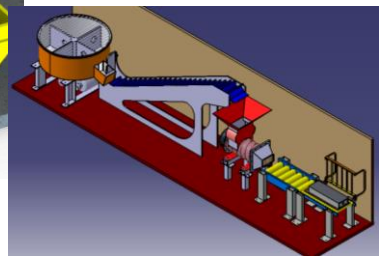
- 2010 – Concepción, Chile „Recycling of construction materials after catastrophes“

- 2011 – Cape town area, South Africa „Brick minifactories in townships“



- 2012 - Vitoria Brazil „Mobile construction material factories“





Pontificia Universidad Católica de Chile

Universidad de Concepcion

Universidade de São Paulo

Universidade Federal do Espírito Santo

Universiteit Stellenbosch University

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DAAD

International universities – Day 3, 9:00 – 12:30

Fraunhofer IPK

TU berlin iWF

New master program in „Global Production Engineering and Management" with a special focus on sustainable manufacturing

Vietnamese-German University VGU

TÜRK-ALMAN ÜNİVERSİTESİ
TÜRKISCH-DEUTSCHE UNIVERSITÄT

New Master Program in „Industrial Engineering" with a special focus on sustainable manufacturing

Fraunhofer Society founds a Turkey-based subsidiary to extend the outreach of research in promoting sustainable value creation with Turkish and Middle East partners. Fraunhofer

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Bundesministerium für Bildung und Forschung

DAAD

TÜBİTAK UEKAE

T.C. YÜKSEKÖĞRETİM KURULU

The World Bank

Vietnam Education Ministry of Education and Training