

The Future of Manufacturing in Switzerland

IWF / INSPIRE

AIM 2008 Conference

Zürich, 27.09.2008

Konrad Wegener,
Lukas Weiss, Thomas Lorenzer



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Inhalt:

- 1.) Introduction – inspire for industry
- 2.) Boundary conditions
- 3.) Enable the enabler - Mechatronics
- 4.) Environmental impact
- 5.) Miniaturization
- 6.) Individualization
- 7.) Master the processes
- 8.) Manufuture and outlook



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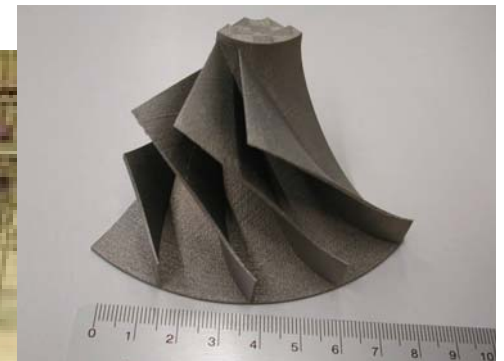
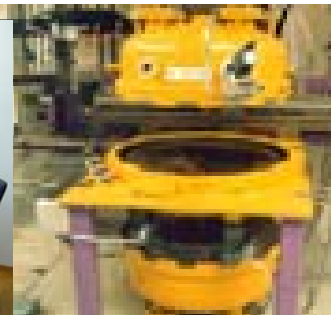
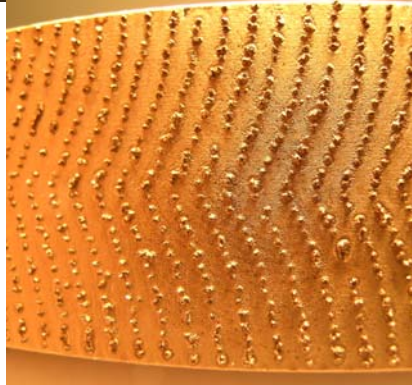
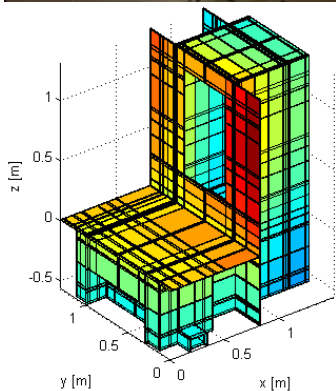
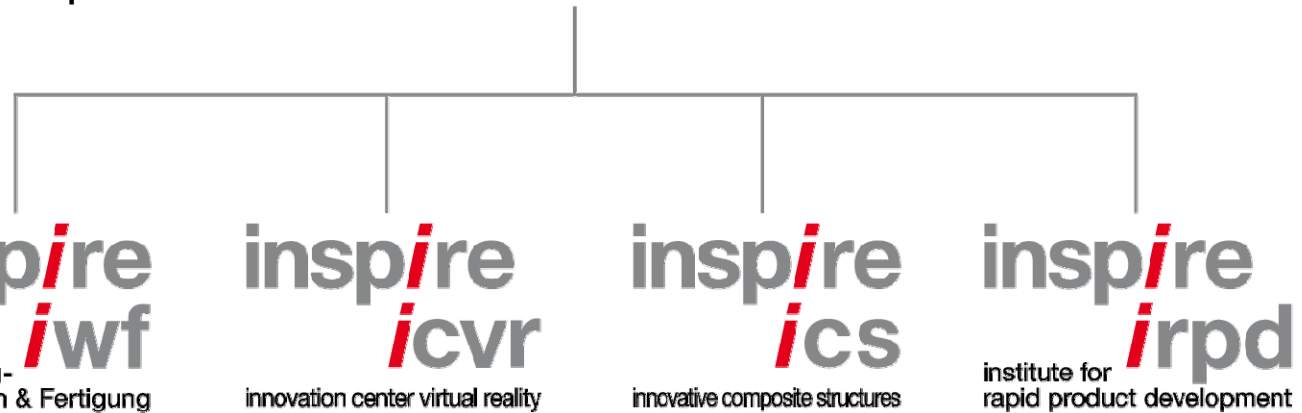
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Inspire = Initiative of Swiss MEM - Industry

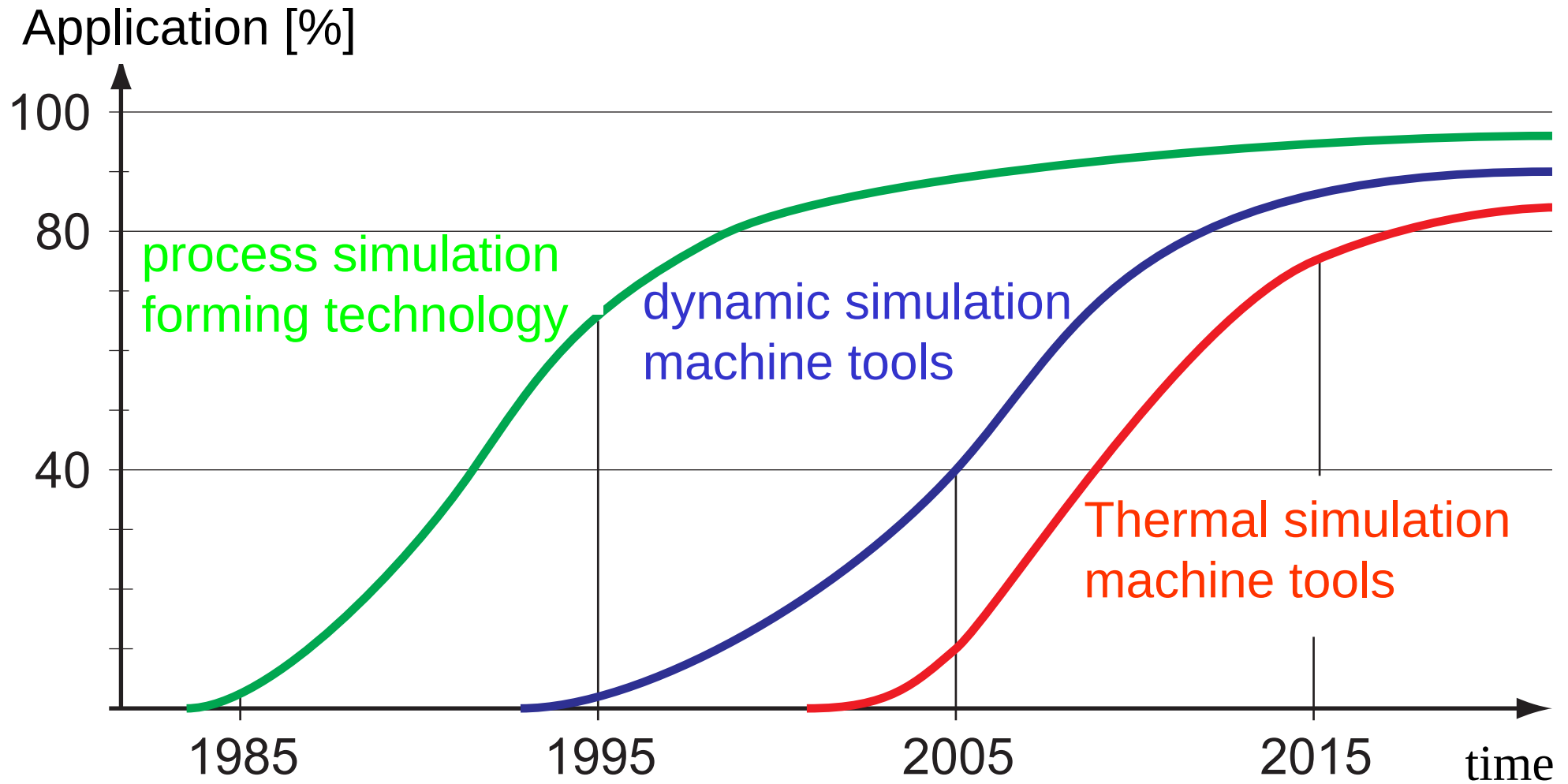
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Number of employees:
IWF / Inspire: 68
from these Inspire: 46
add. external PhD: 4



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Concept: Industrial Application of Methods



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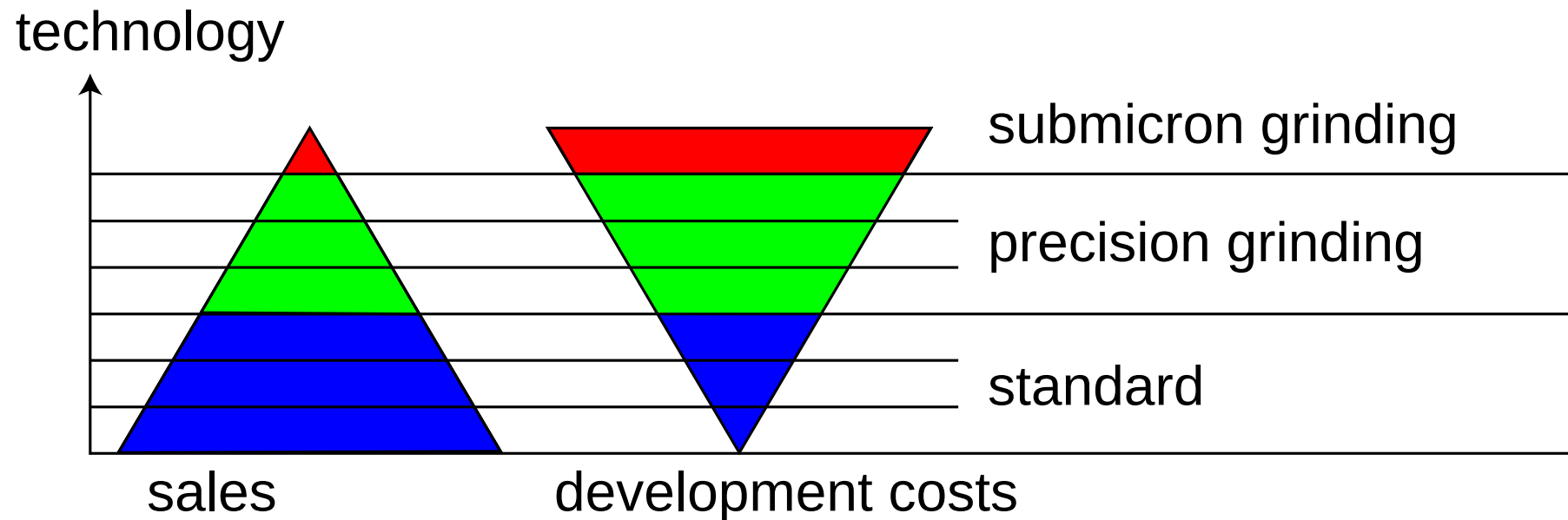
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Concept: Industrial Application of Methods

Swiss virtues: precision, quality, reliability

→ Swiss machines are judged expensive



Medium-sized machine tool industry **in development costs trap**

Niche strategy is no sustainable solution

technology only is not sufficient



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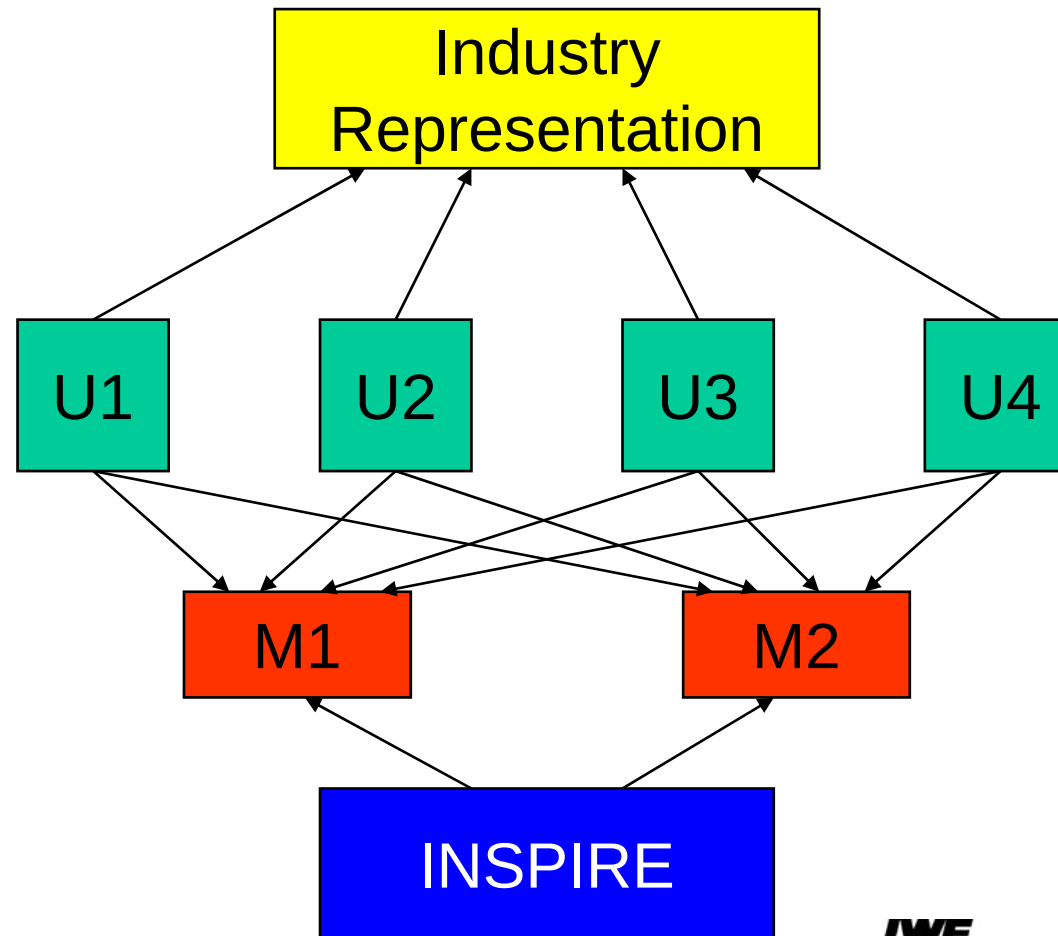
The basis for refinancing development costs must be broadened

International Market

Industry

Methods

Research



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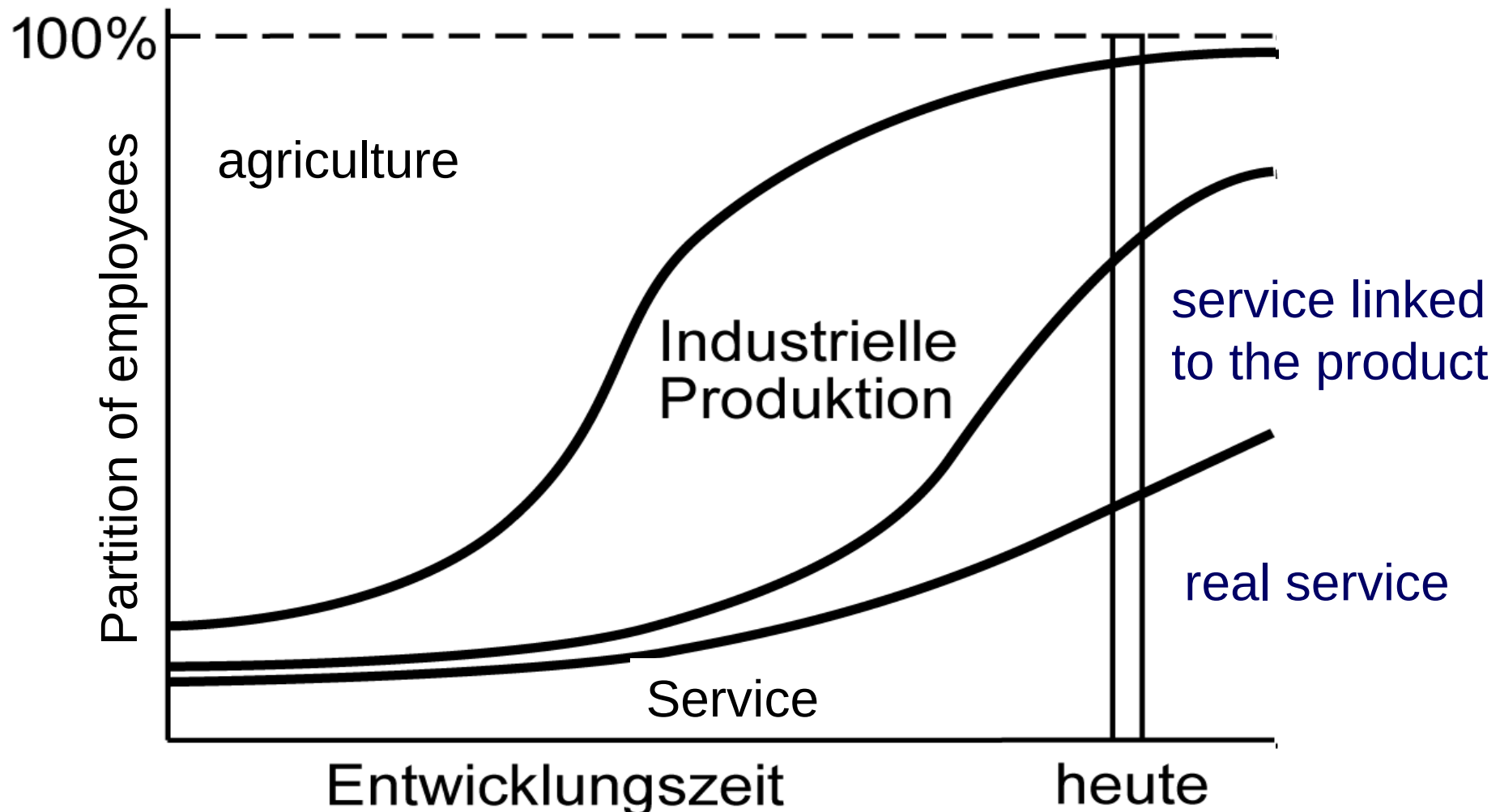
World champion of production

For no economy in the world manufacturing has a similar importance as for Switzerland

Statistic machine tools (2007, Gardner)

country	production			implementation			export		balance	
	[Mio \$]	Rang	[\$/K/a]	[Mio \$]	Rang	[\$/K/a]	[Mio \$]	Rang	[Mio \$]	[\$/K/a]
Schweiz	3323	8	445.9	1283	15	172.2	2458	5	2041	273.9
Japan	14444	1	113.4	7619	2	59.8	7610	2	6824	53.6
Deutschland	12725	2	154.4	7252	3	88.0	9168	1	5473	66.4
China	10090	3	7.8	15390	1	11.9	1600	8	- 5300	- 4.1
Italien	7273	4	125.3	5056	5	87.1	4208	3	2217	38.2
Korea	4555	5	93.8	4150	6	85.4	1800	6	400	8.2
Taiwan	4378	6	192.5	3785	7	166.4	3408	4	593	26.0
USA	3578	7	12.2	6172	4	21.1	1660	7	- 2594	- 8.9

Region of alps → European machine tool centre
18800 Mio \$, 26 % of worldwide machine tool production

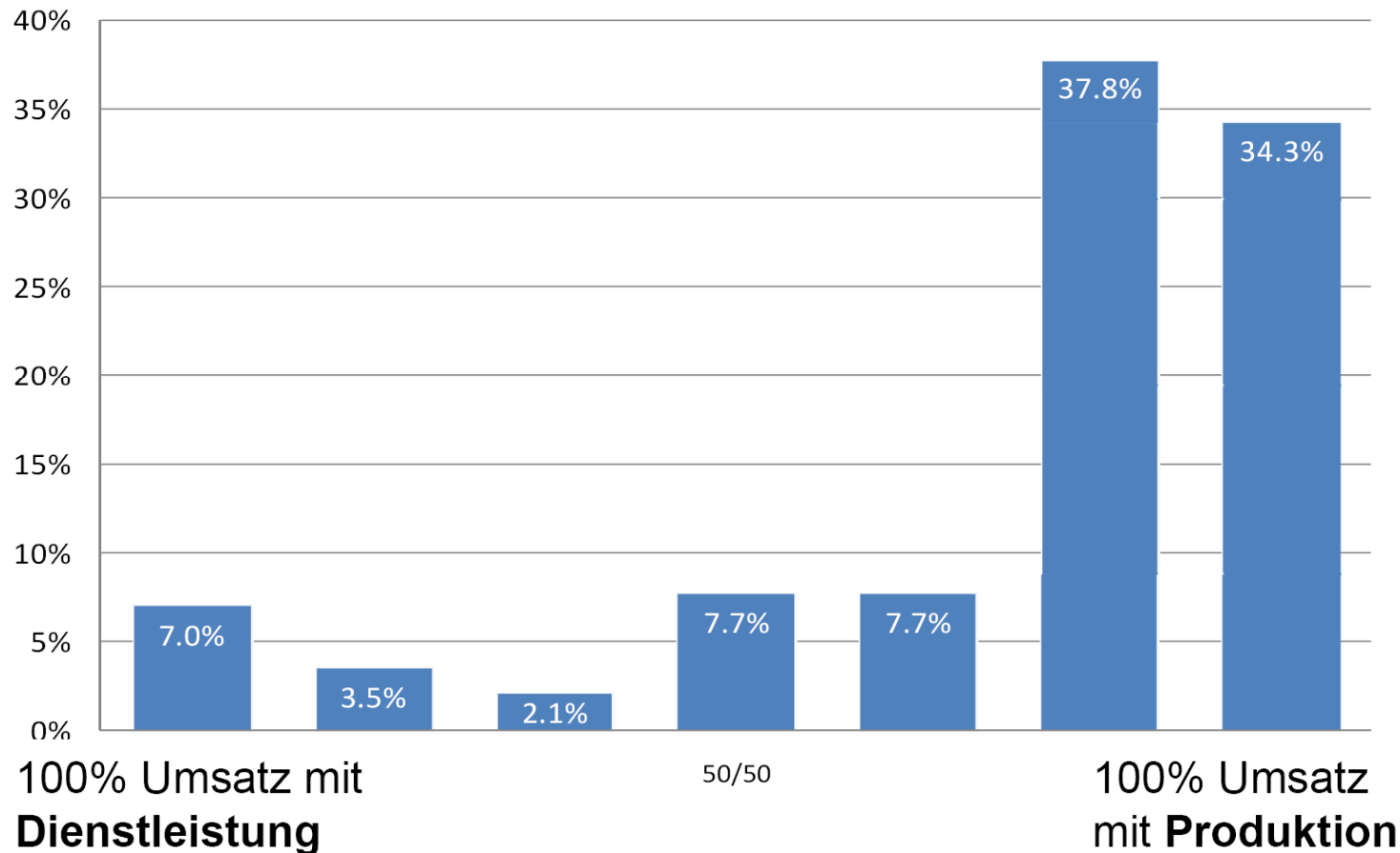


The idea without product has no market value

The way to the service society is only via the product.

Study Swiss Car (Boutellier) among 143 Swiss automotive suppliers

[% Nennungen]



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Why Production technology → competence of realization

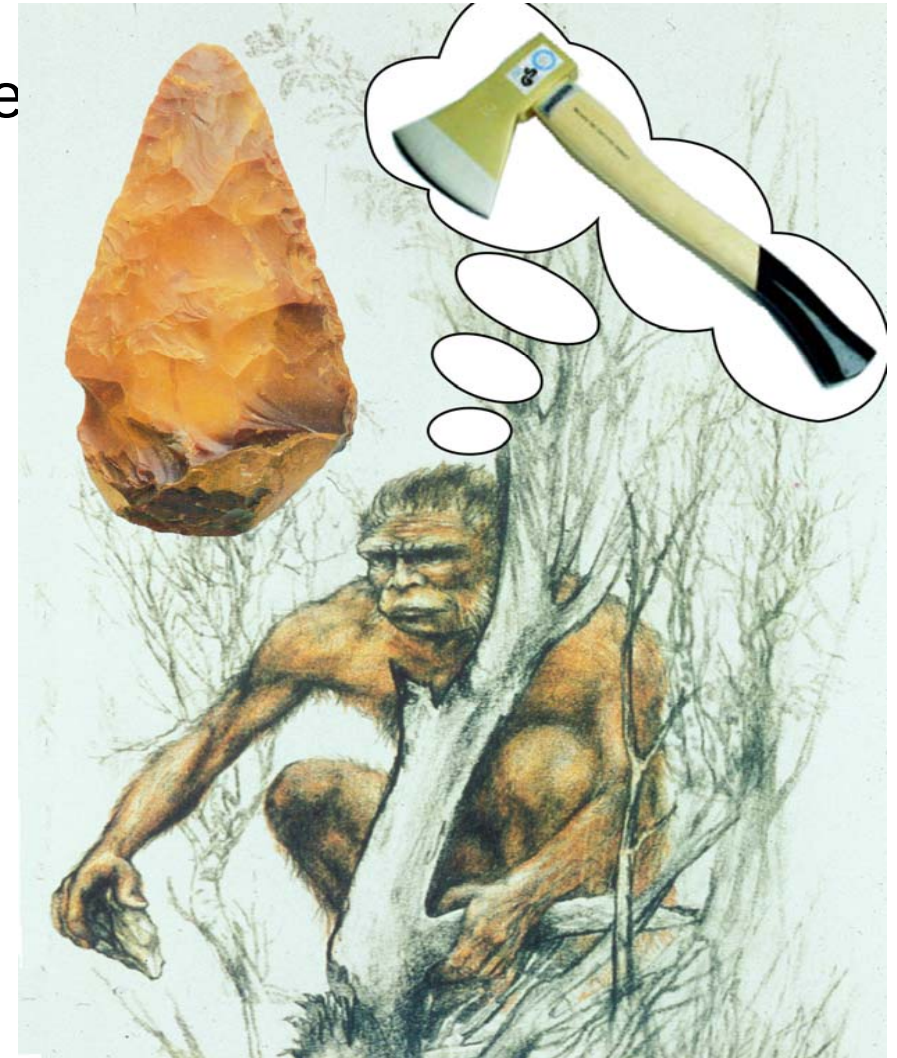
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The good idea alone without competence of realization is worthless on the world market

Manufacturing and product development proceed with the help of each other

the mastered manufacturing technology defines the competitiveness of the developed products

Without manufacturing no high tech place is feasible.



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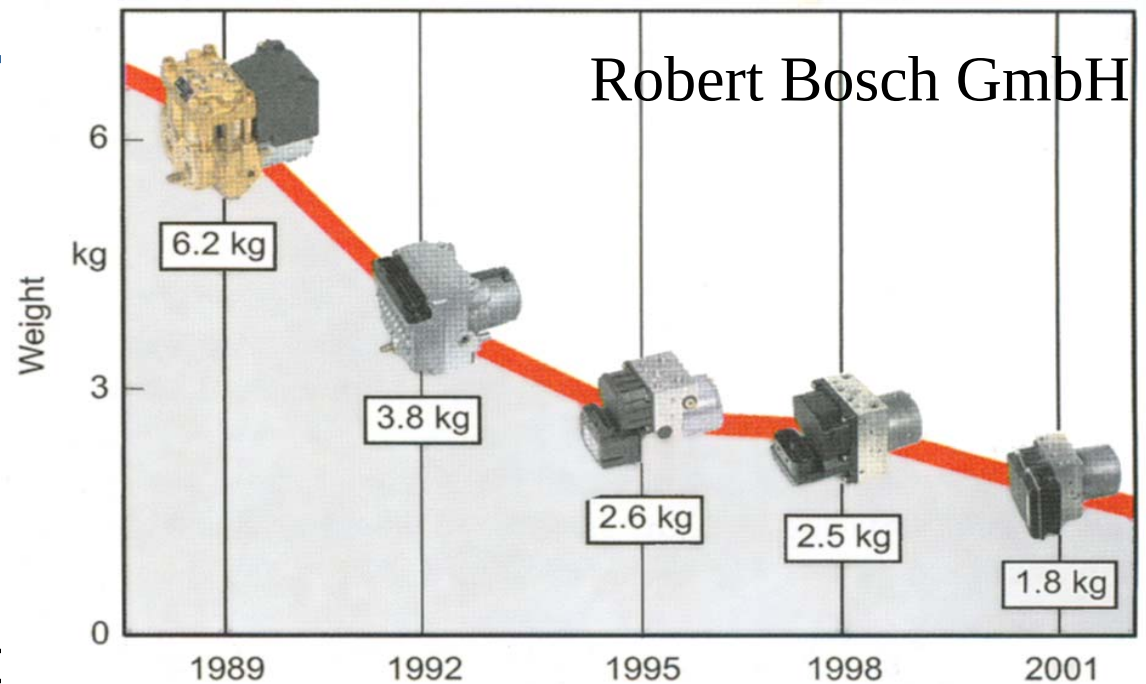
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Innovation by manufacturing

Cut costs, reduce weight,
shrink space requirements

- ➔ Multifunctional parts of highest complexity
- ➔ highly developed manufacturing technology and processes
- ➔ innovative manufacturing for innovative product development
- ➔ Education and research in manufacturing at ETH Zurich
- ➔ Production machinery enables manufacturing
- ➔ No manufacturing without knowledge of machinery

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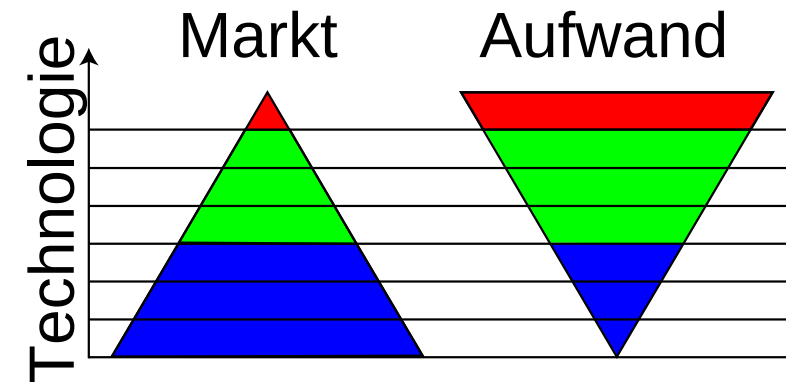
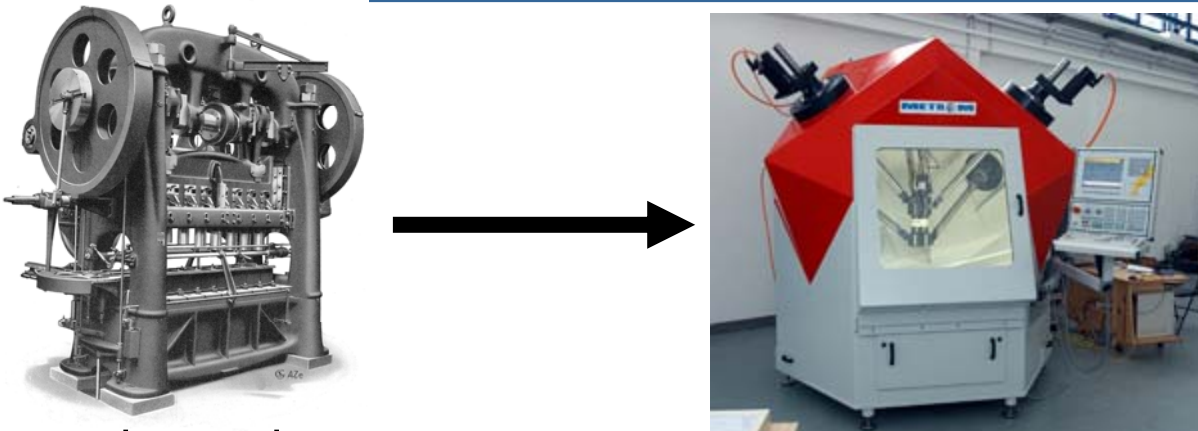
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Machine tools, the enablers: Mechatronic – driver of innovation

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Mechatronic:

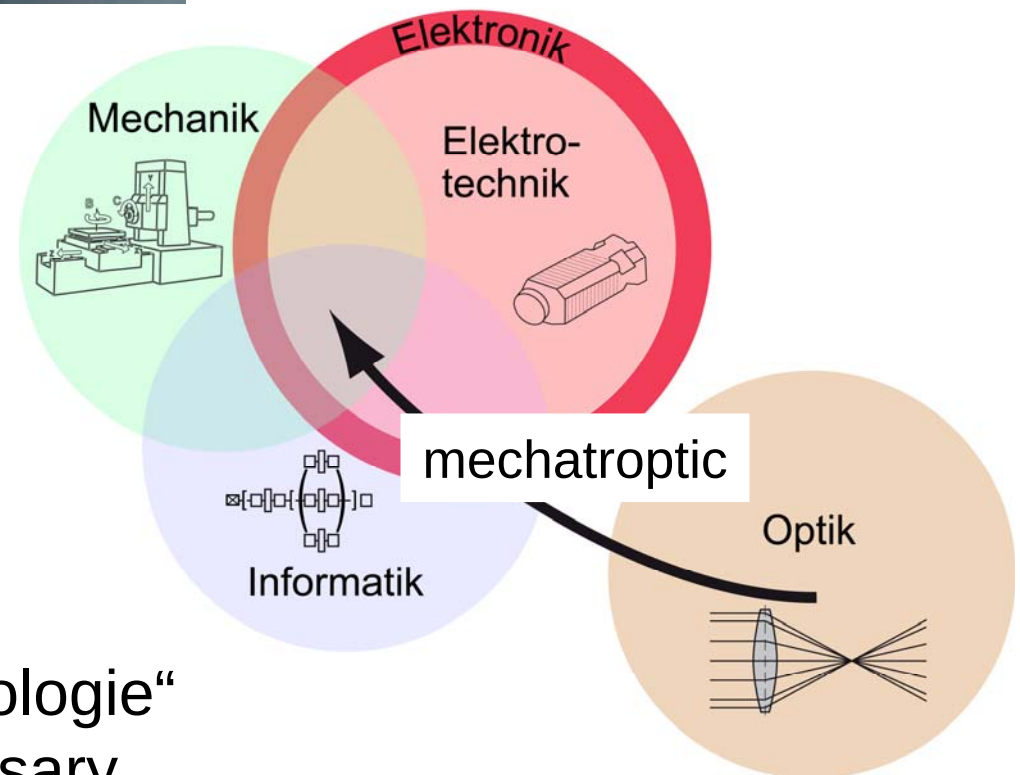
YASKAWA Electric Corporation 1969

Dreiber

- cost pressure
- increase of accuracy
- increase of performance of electronic devices
- increase power density in actuators
- flexibility
- new possibilities

➔ Mechatronic is „Enabling Technologie“

➔ research at the interfaces necessary



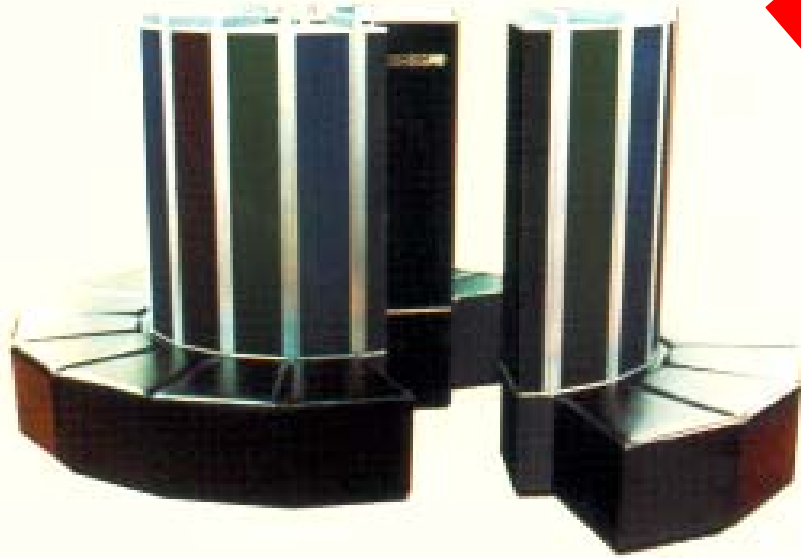
Availability of computational power

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Cray 1: 1976
100 MFlops
30 Mio. Fr



Motor control
2001: 100 MFlops
processor: 30 Fr



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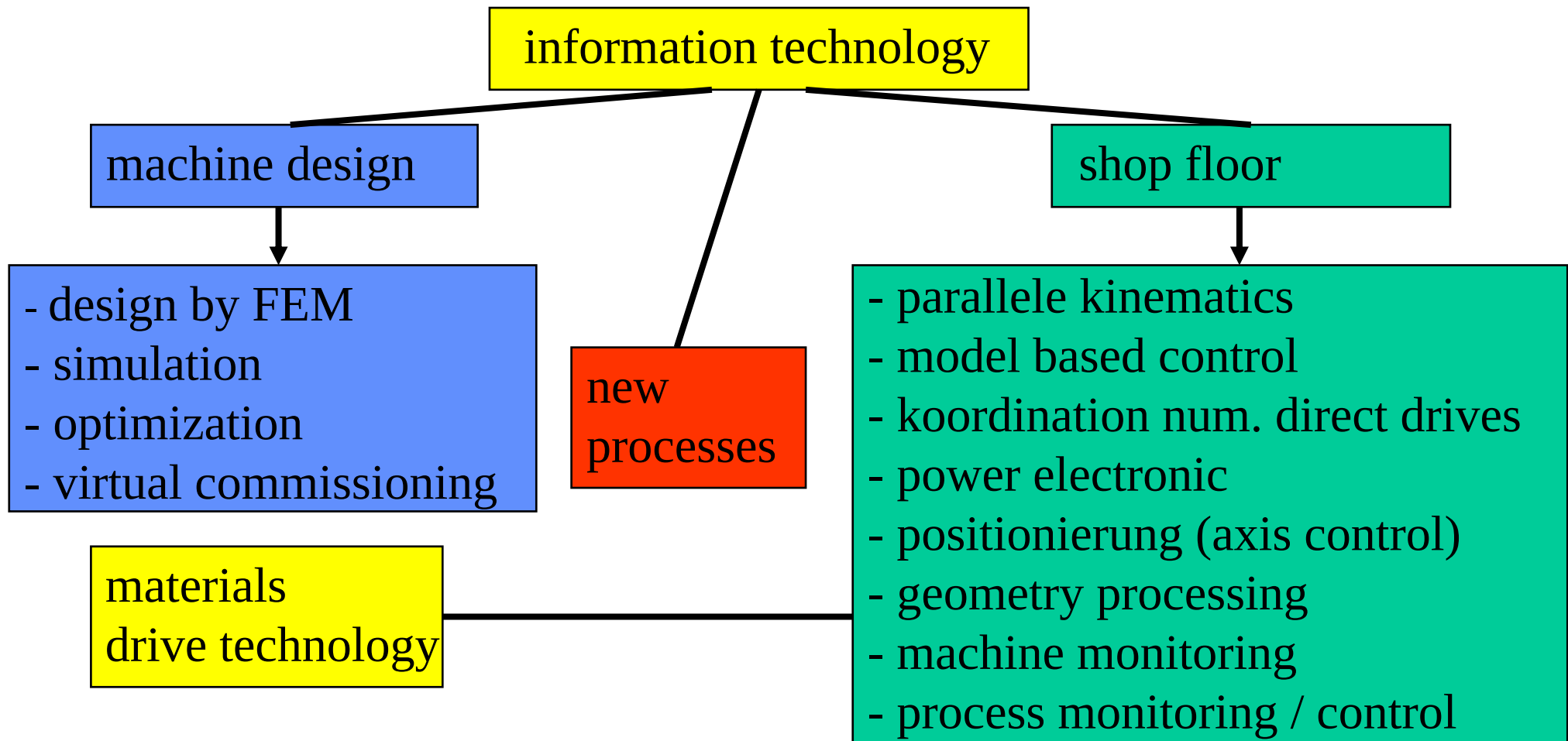
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Quelle: BMW

Der Einfluss der Elektronik und Informationstechnik steigt



Interdisciplinarity, mechatronics



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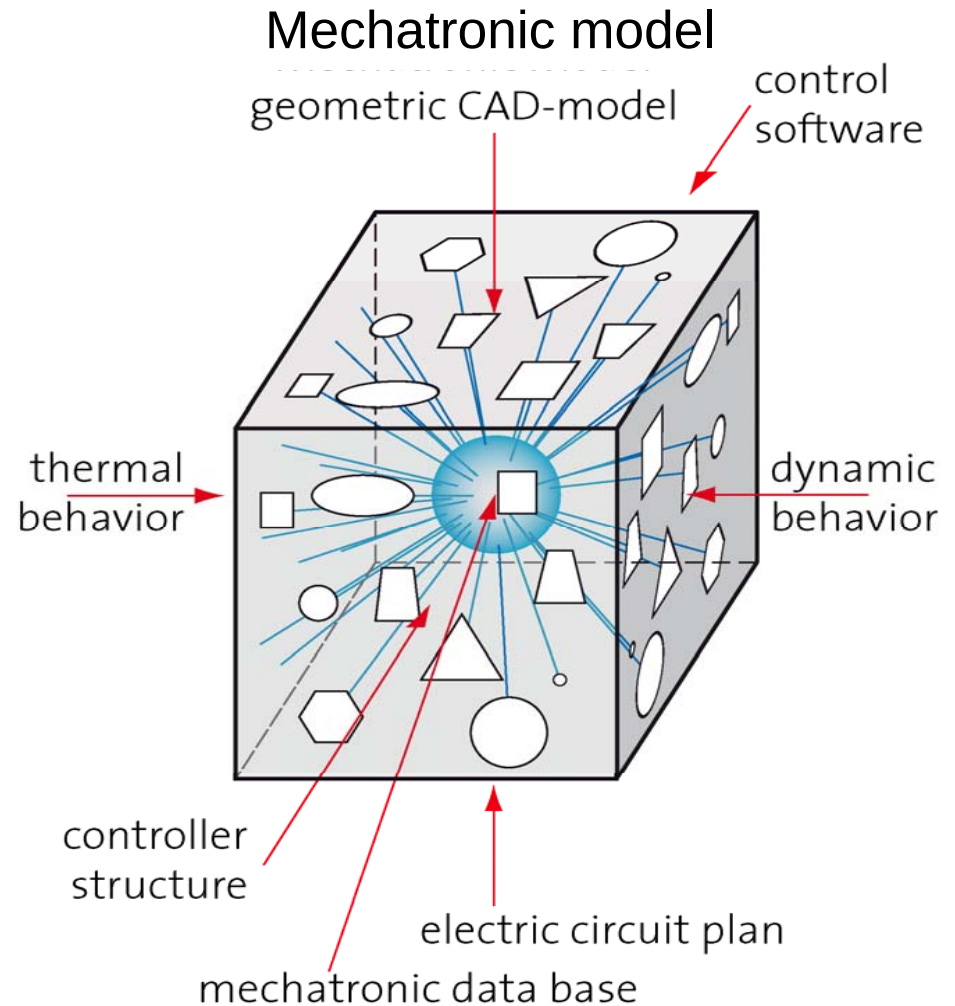
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Modelling and Analysis: Data base

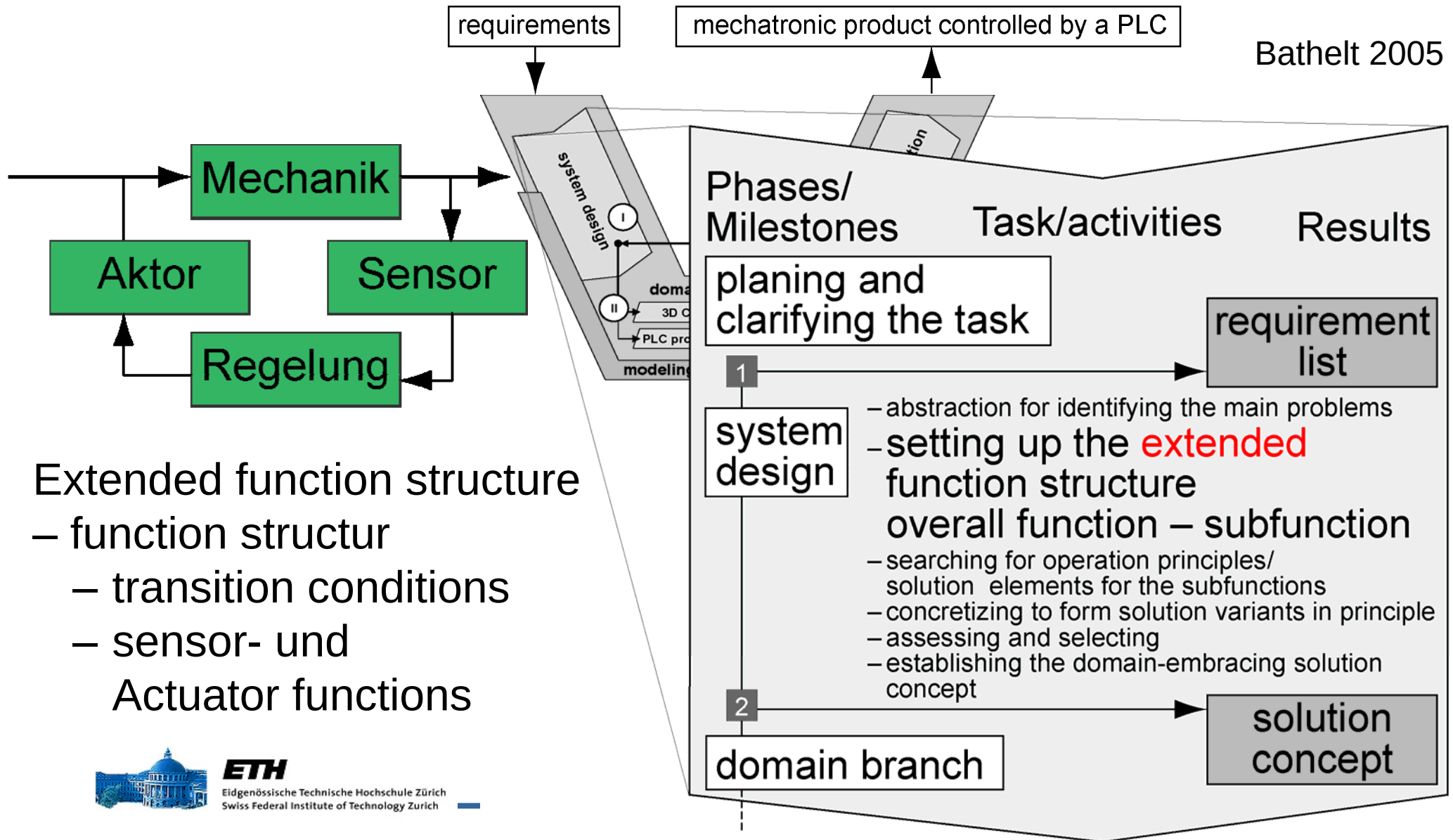
- mechatronic design needs function orientation (VDI 2206)

- mechatronic systems model as an all inclusive database, that can be treated from different sides
- interaction by input, evaluation and computation.
- different input tools to build up a homogeneous data structure need evaluation of data base for the human recognition.
- Evaluations of the homogeneous data base reveal special aspects of the virtual machine.
- Requirements: build up of data base from data necessary for the specification of the product and it's functionality
 - ➔ organisation of system data



- ➔ General: integration of design- and modelling tools

Bathelt 2005



Extended function structure

- function structur
- transition conditions
- sensor- und Actuator functions



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Electronic Support Adaption to straining

Distributed functionality:

Application of smart materials:

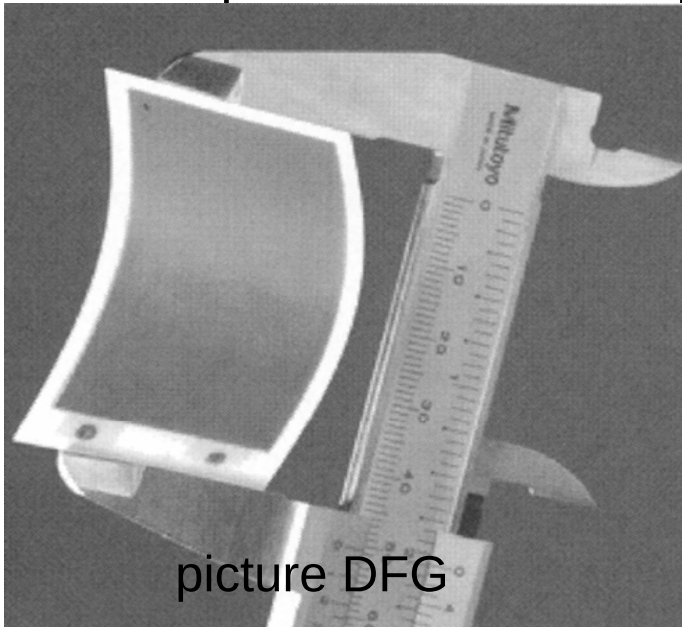
EAP, piezo, shape memory alloys

electrorheological fluids

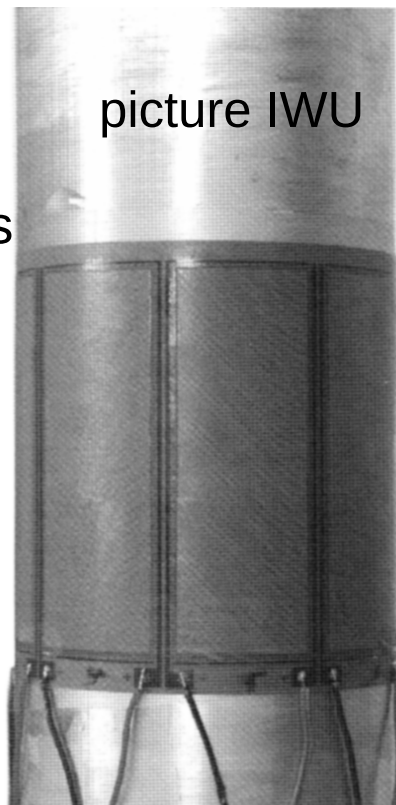
magnetorheological fluids

➔ Adaptronic

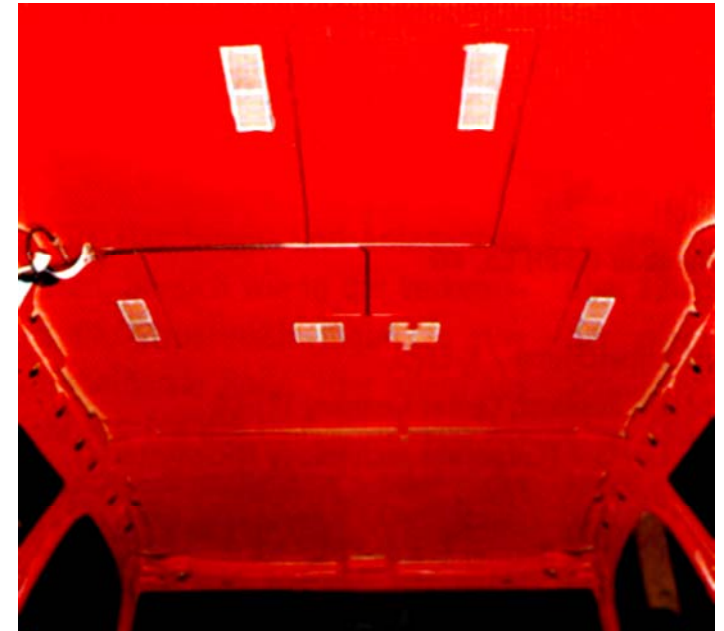
➔ Adaptation of structure properties



picture DFG



picture IWU

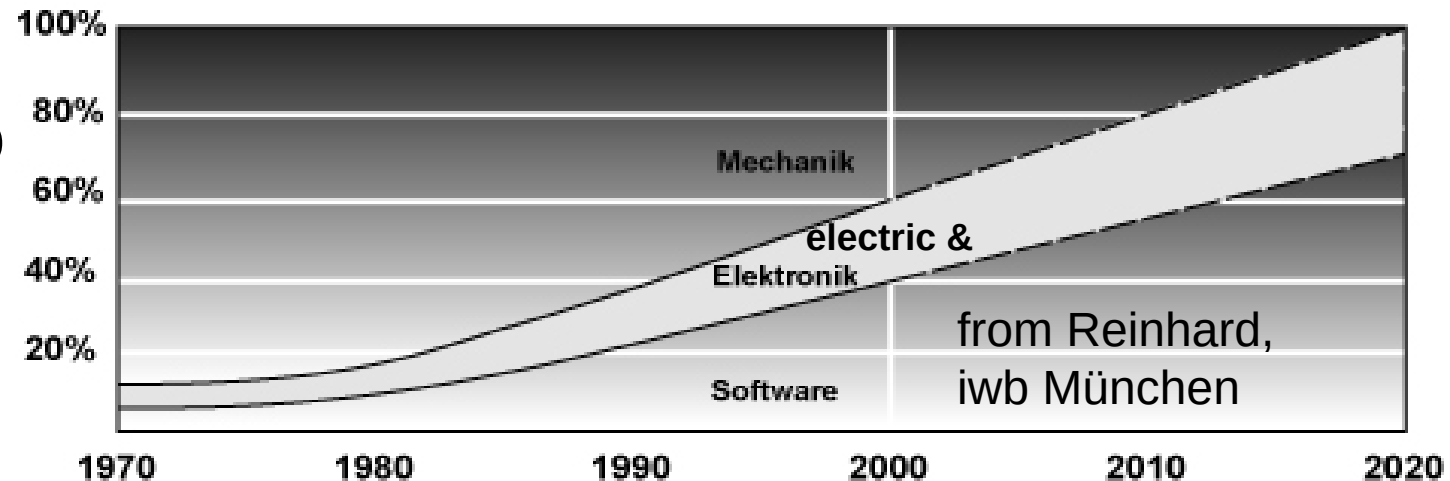


picture VW



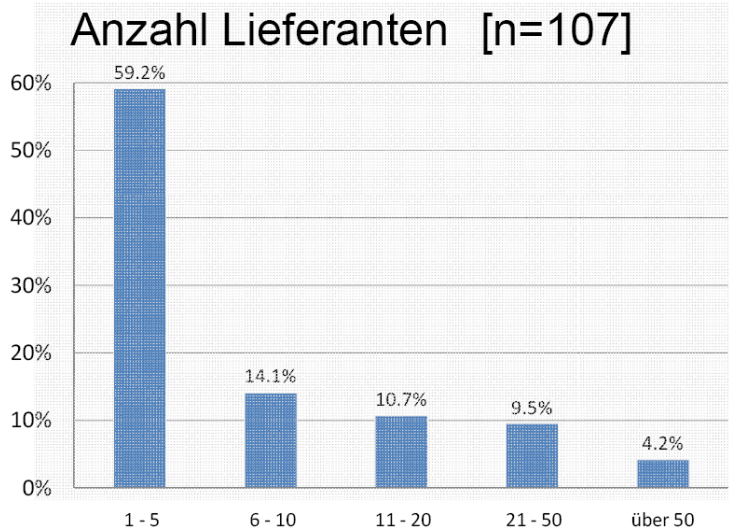
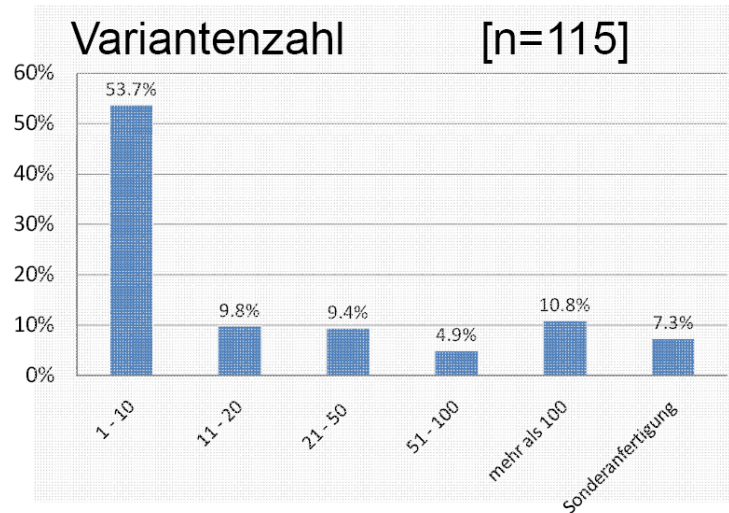
Extrapolation not allowed:

→ CECIMO
Mantys



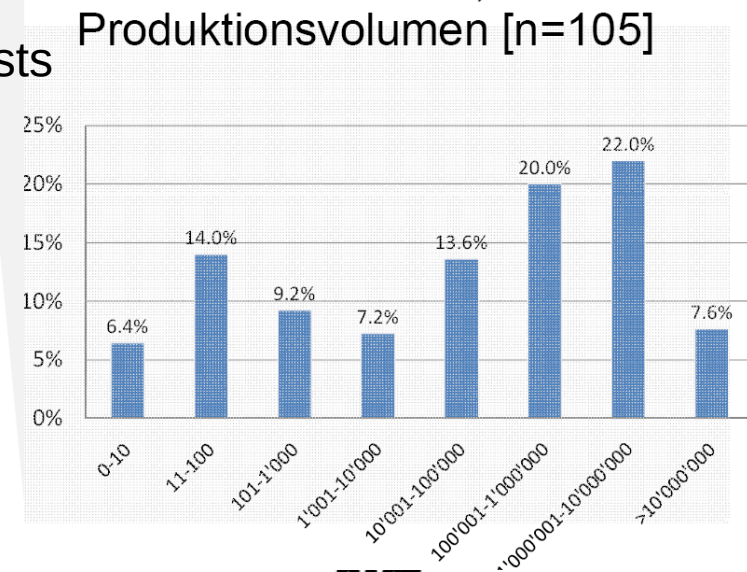
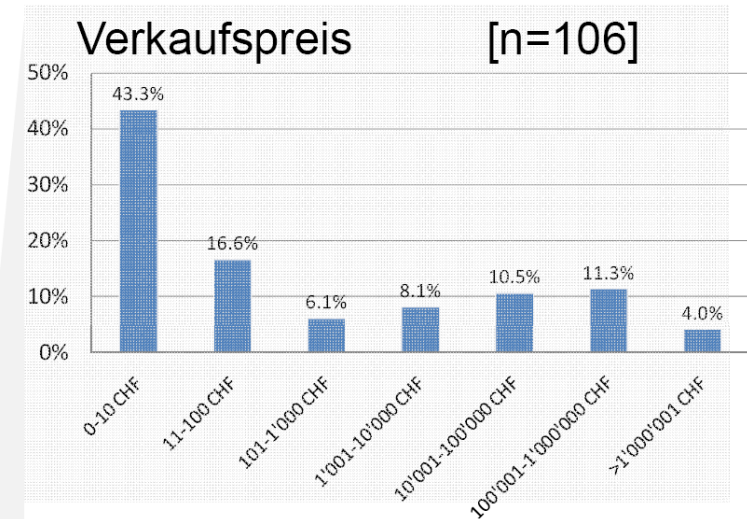
- Also in the future physics will be valid
- Mechanical functions will be electronically enhanced and supported
- Increase of reliability (competition against LWC)
- Selfdiagnosis und selfrepair (adaptation to wear / damage state)
- kognitive planning of strategy (→ 5 – minutes machine)
- automatic startup and self tuning
- reduce complexity for operators → increase complexity of systems
- task is to master complexity → precondition: process knowledge

Study swiss car:



Swiss automotive suppliers are

- successful
- mass producers
- process specialists



Quelle: ETH swiss CAR Studie „Automobilindustrie Schweiz“



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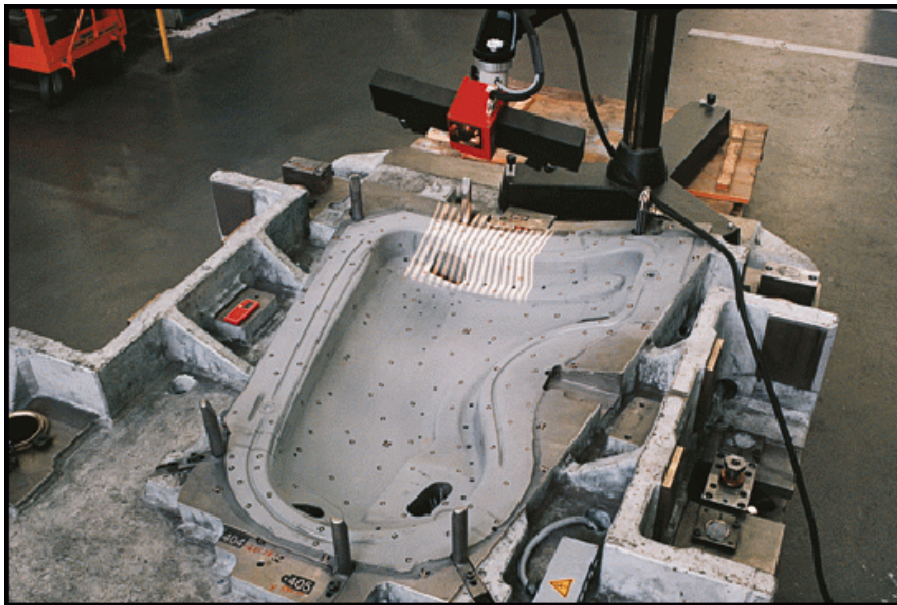
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Adaptive Manufacturing: Repair of Expensive Parts

The machine identifies the manufacturing task and develops the solution strategy

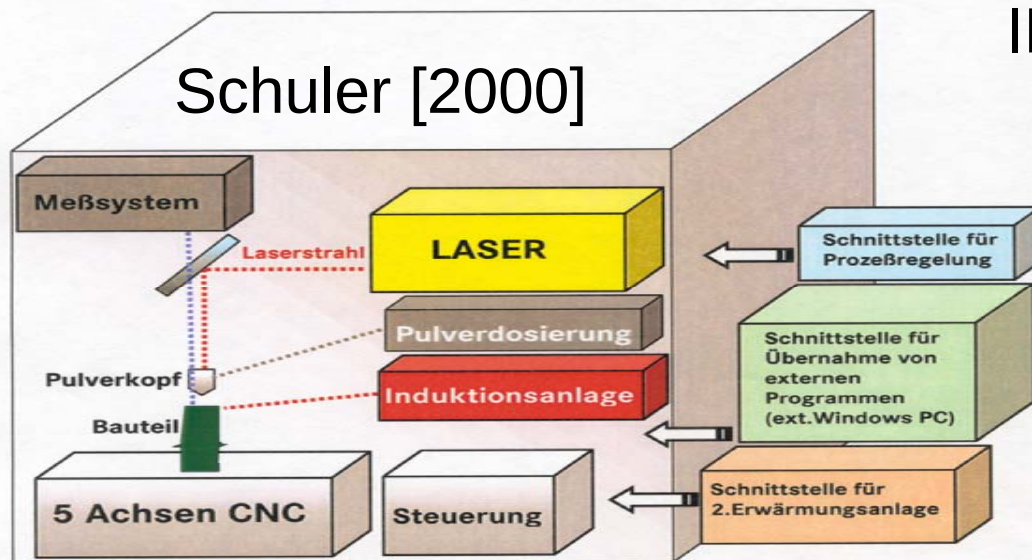


Picture: GOM

Adaptive complete manufacturing:

- i.n. inspection initial state
- digitizing initial state
- comparison with projected state (CAD)
- welding strategy
 - internal stress management
- set point generation
- welding
 - deep melting necessary → laser
- digitalizing welded state
- comparison with projected state
- milling strategy pre finish (if possible derivation from existing NC program)
- milling strategy finishing
- polishing

Schuler [2000]

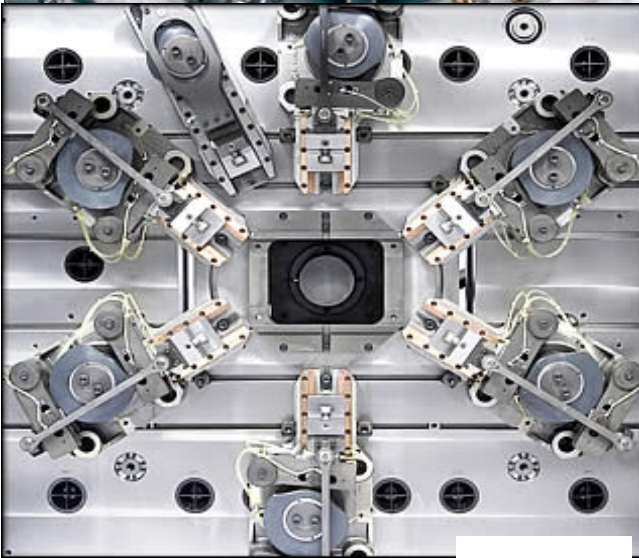
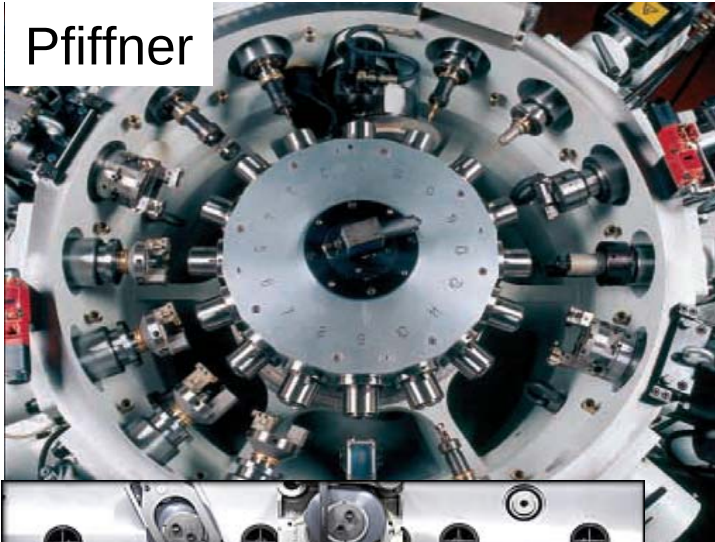


IPT Opto Rep [2004]



Hybride Concepts, completed manufacturing inspire

Pfiffner



Bihler

Each machine change needs 1 week

- completed manufacturing:
- drastic reduction of run time of the process chain
- enhance process ability
- aber: usage of individual components decreases.

- round transfer machine with turning spindle
- Milling turning centers
- Turning grinding centers
- point incremental forming on milling machines
- drilling threading on lasercutters
- Chipping on forming machines
 - transmission chains
- Laser welding in chipping manufacturing



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4. Rekonfigurierung auf zwei Ebenen: Virtuell und physisch

Rekonfiguration of a machine:

- modelling with virtual modules
- derivation of control configuration
- physical assembly
- initialization and calibration
- selfcommissioning and autotuning



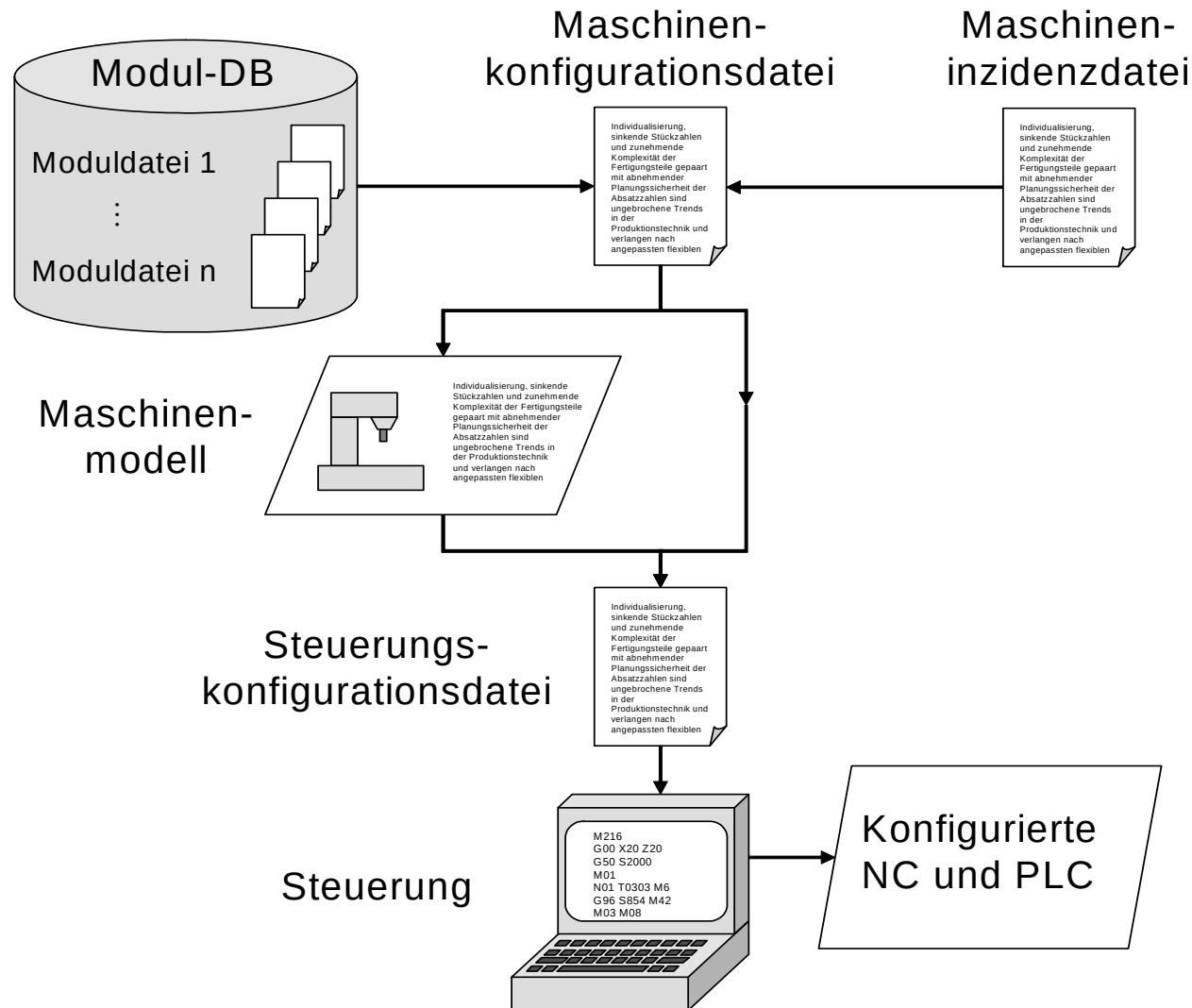
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4. Steuerungskonfiguration mit Modulinformationen



- choice of moduls
- modelling
- generation of parameters
- loading of control system

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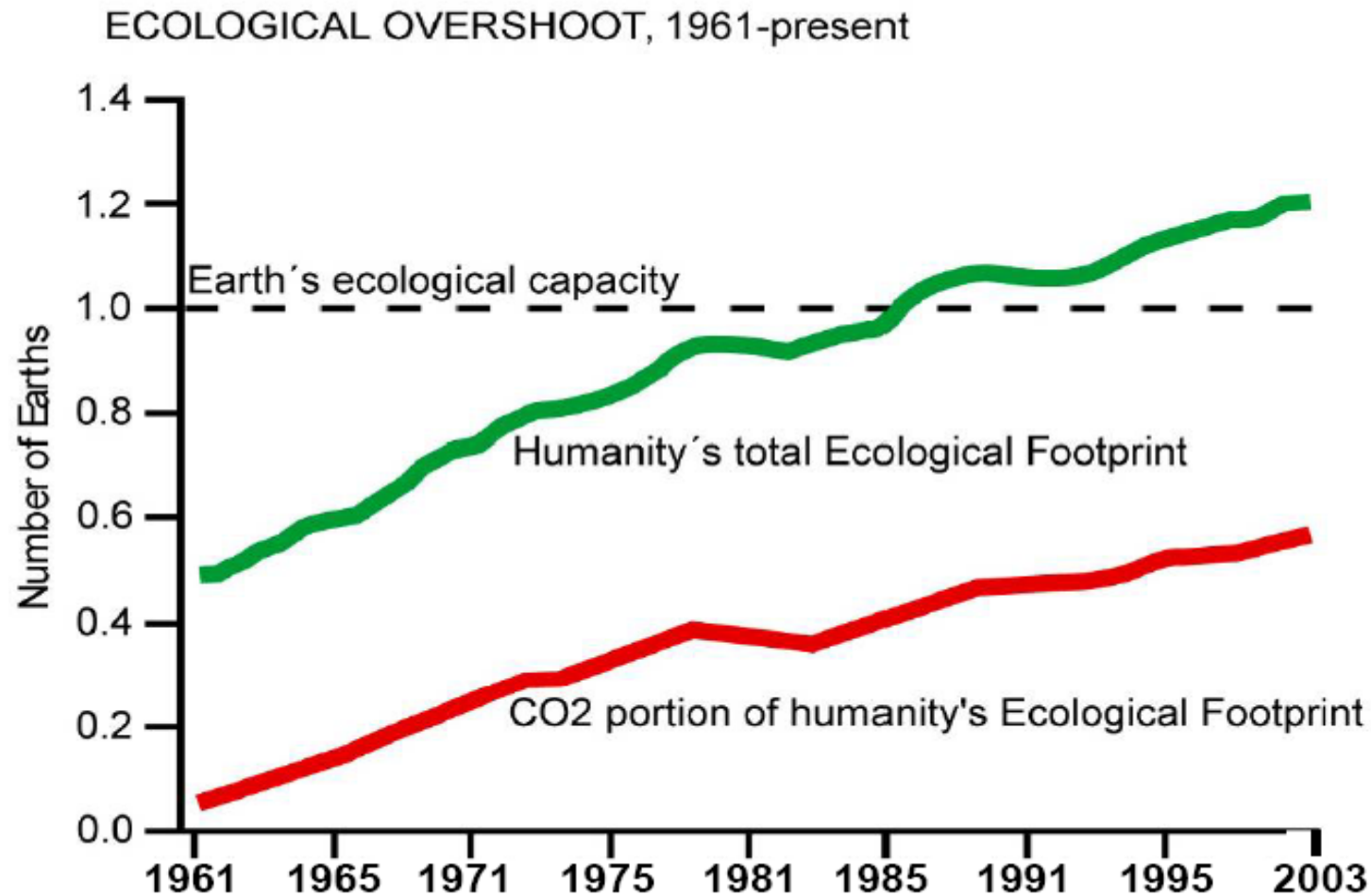
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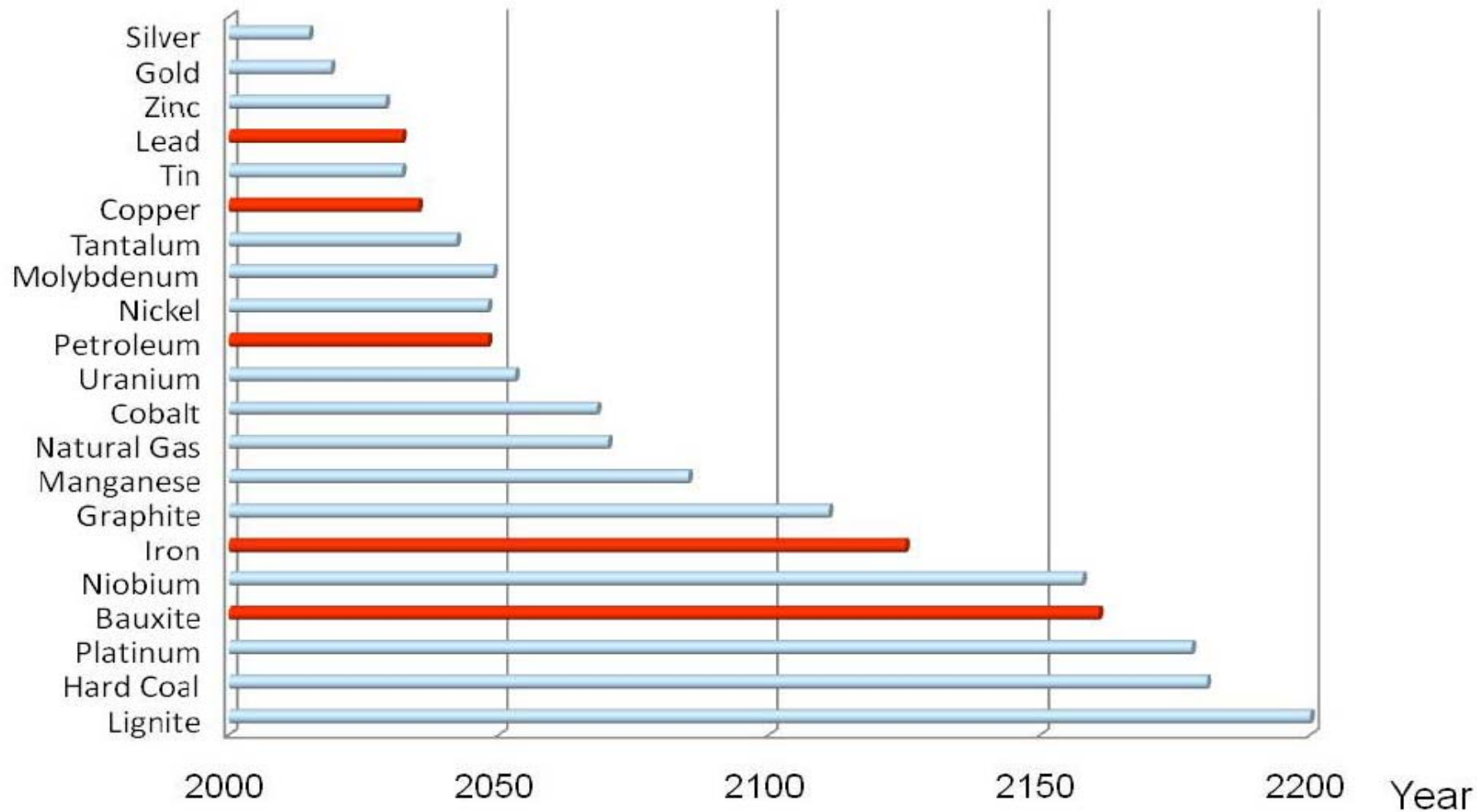
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Limitations become obvious



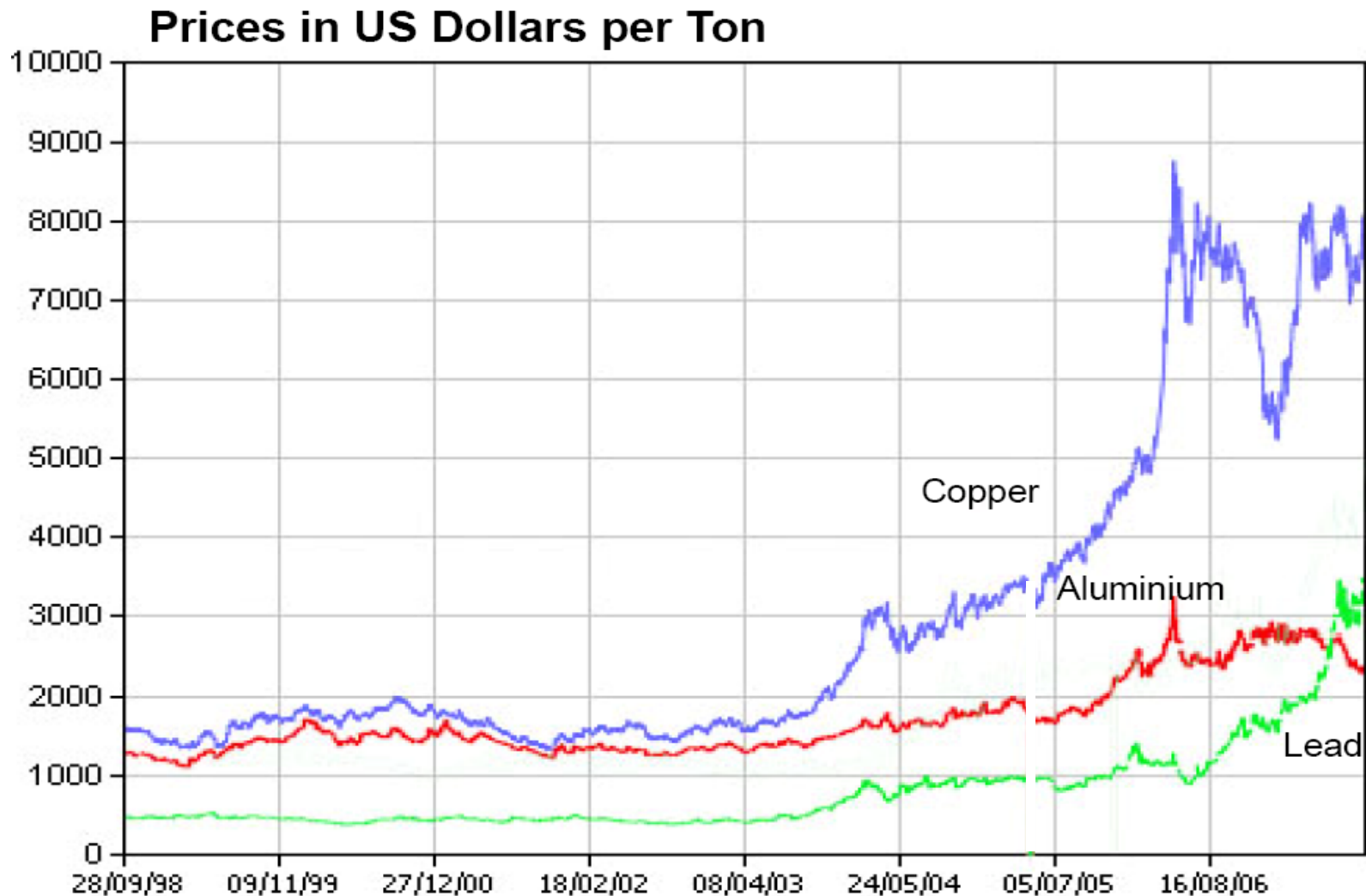
Source: Mathias Wackernagel: Ecological Footprint Accounting. In: Keiner, Marco (Ed.): The Future of Sustainability, Springer, 2006

Availability of resources



Source: Federal Institute for Geosciences and Natural Resources (BGR), 2003.

Price for Material



Source: London Metal Exchange, 2007

New opportunities for production technology

Product and process innovation ahead of others
new areas of business for

- Efficient use of energy, Total Energy Management (TEM)
- Reduction of media application
- Efficient use of material
- Increase efficiency of production (first pass yield, robustness, overall equipment effectiveness,
- Effective production methods for energy saving, energy storage, energy harvesting, energy using
- Avoidance of waste
- Design for recycling and reuse → repair machines
- Disassembly is manufacturing

Switzerland develops technologies, methods and processes to gain advance

Technologies necessary also for LWC to survive

Energie harvesting

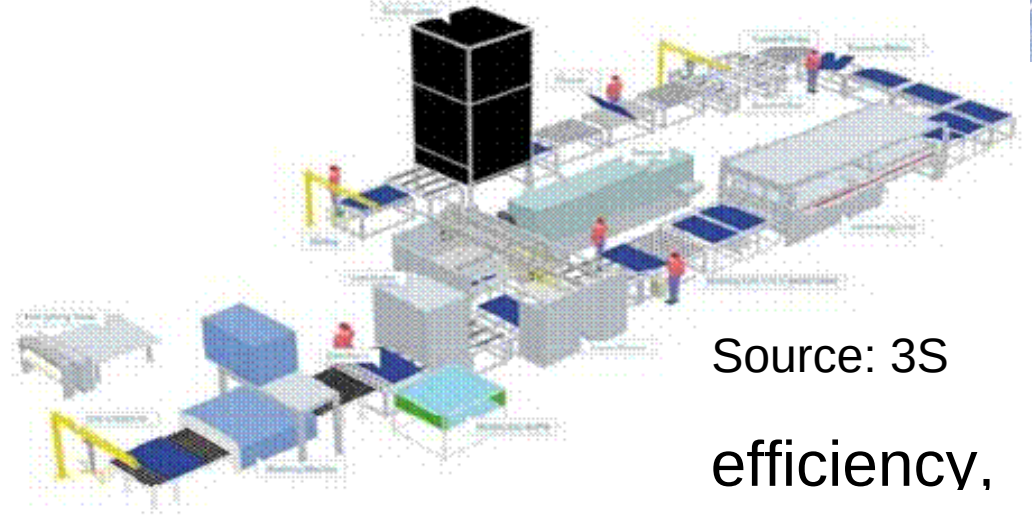
Windenergy:
Reindustrialization of a region
impact for production technology



Source: VDI
Rexroth

e Zürich
Zürich

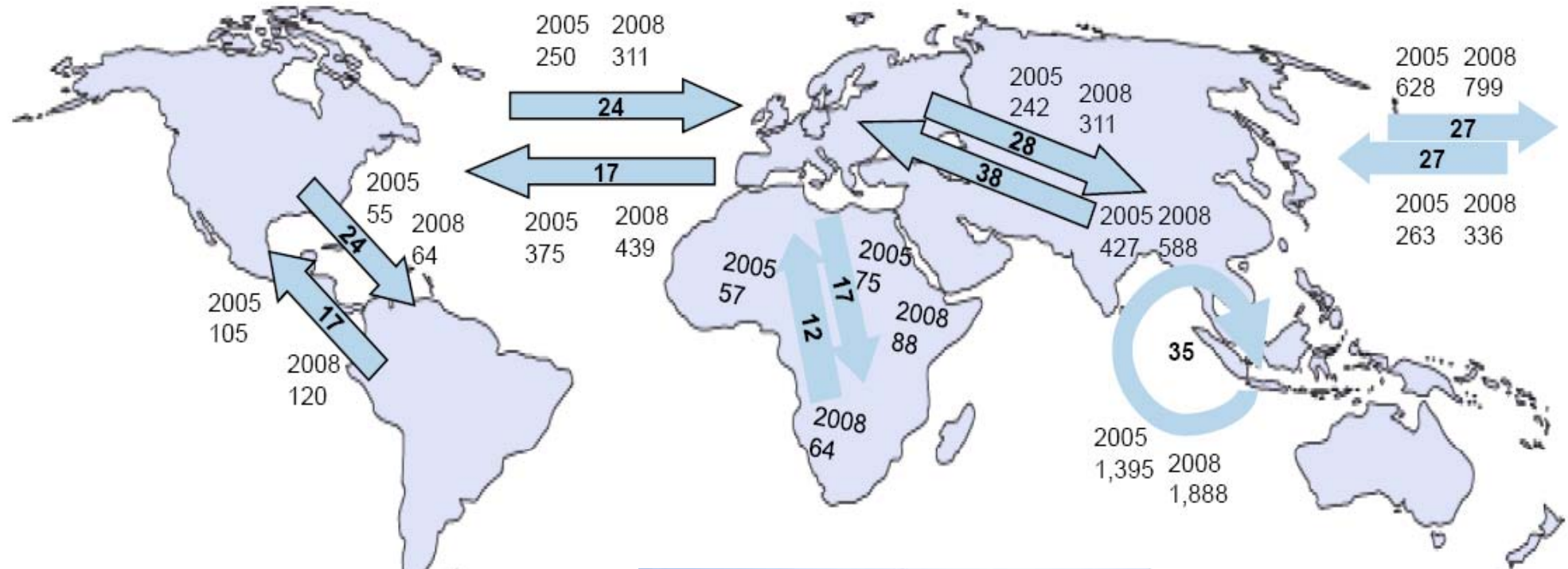
Photovoltaic:
System- and machine technology
from Switzerland



Source: 3S

efficiency,
thin film technology

Global Transport Volumes



Values in trillion US Dollars in 2005
and 2008 (% increase)



Energierequirement transportation 1 t material CH – Asien – CH:

	<i>ship</i>	<i>aeroplane</i>
2x 14'000 km ship	4'900 MJ	
2x 1'000 km lorry	1'000 MJ	
2x 12'000 km aeroplane		140'400 MJ
2x 100 km lorry		100 MJ
Total ca.	6'000 MJ	140'000 MJ
	(= grey energie of ca. 100 kg stainless steel)	(=grey energie of 3'000 kg C-steel)

Datenbasis: The Oil Point Method , ISBN 87-90855-09-4, 2000

Manufacturing on the markets

→ Global Manufacturing

Capital invest for ship freight
and conservation and seaworthy packing

Alternative: invest in highly automatic systems in HWC

Machines adapted to the local cost structure.

Complexity of highly automated systems and downtimes
limite the possible savings

→ F&E: self diagnosis and self commissioning, selfrepair

→ EU FP7 – topic for research



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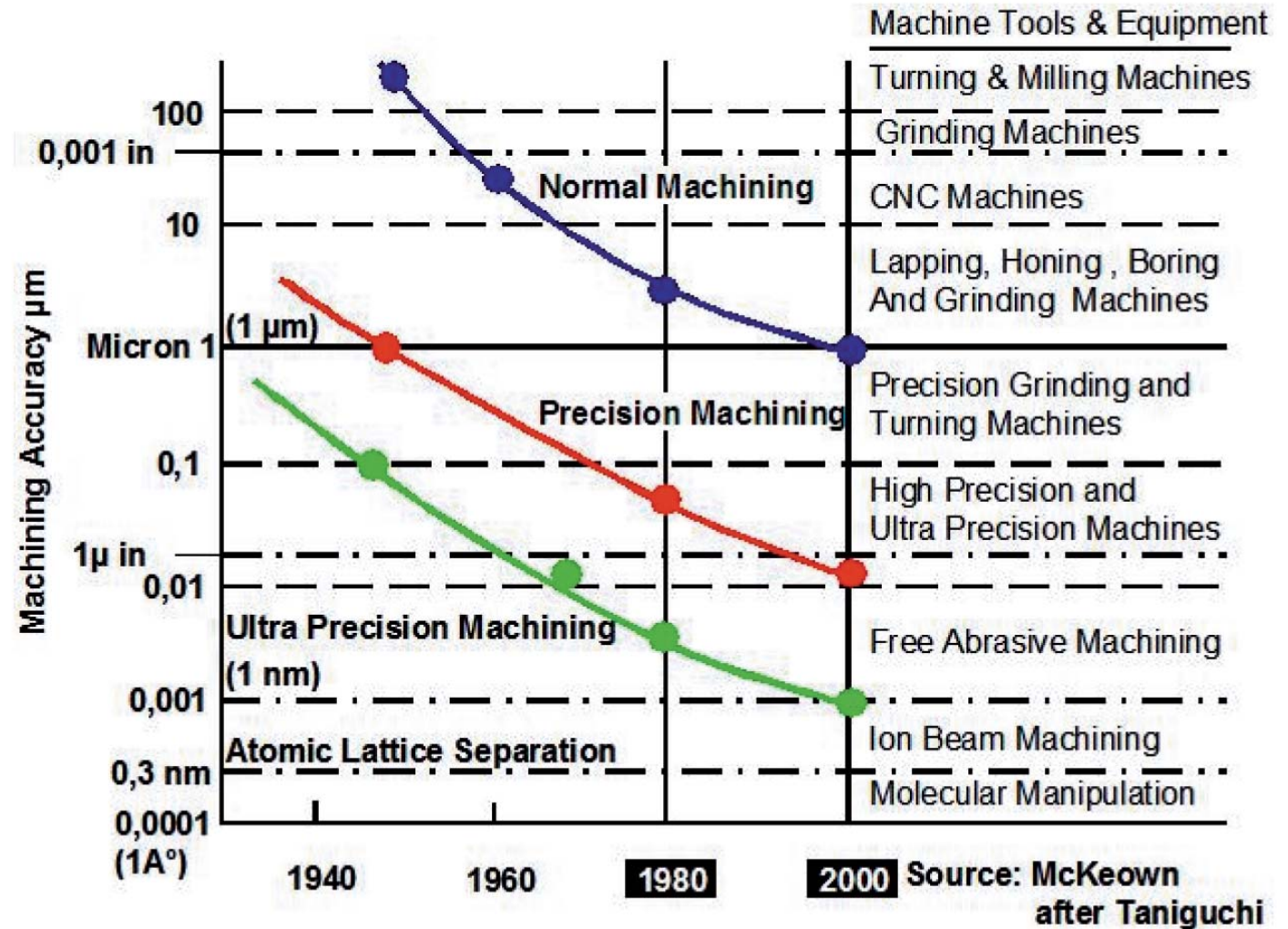
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Taniguchi's Law

- Reduction of tolerances
- Change of „precision“
- derived from Moores law



from Taniguchi 1983



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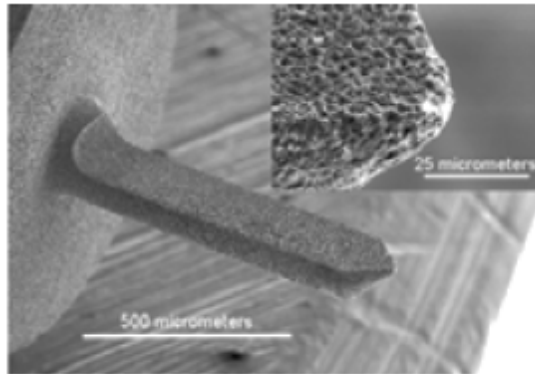
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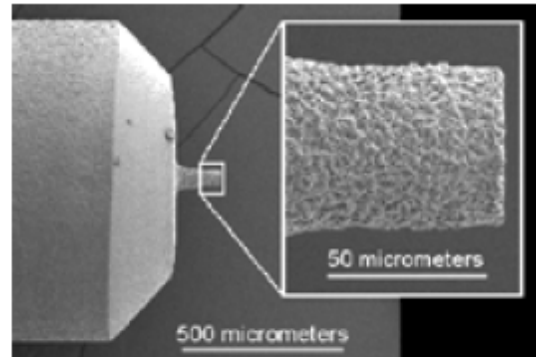
Micro manufacturing

Characterization of manufacturing processes

EDM PCD Morgan

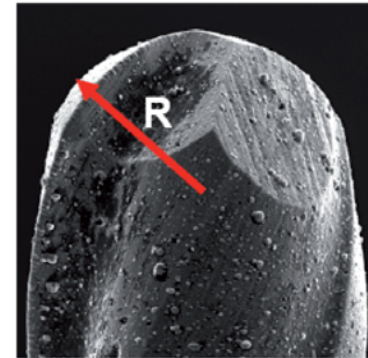


Micro drill

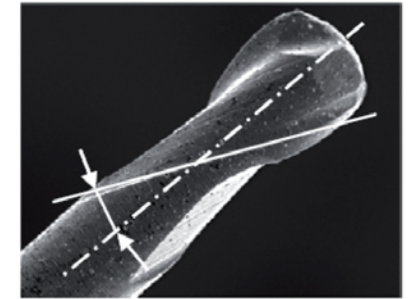


Micro mill

Tool radius on spherical end



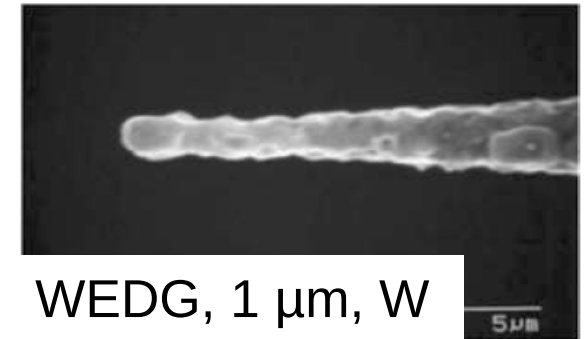
Helix angle



Rake face roughness

diam. drill
200 μm

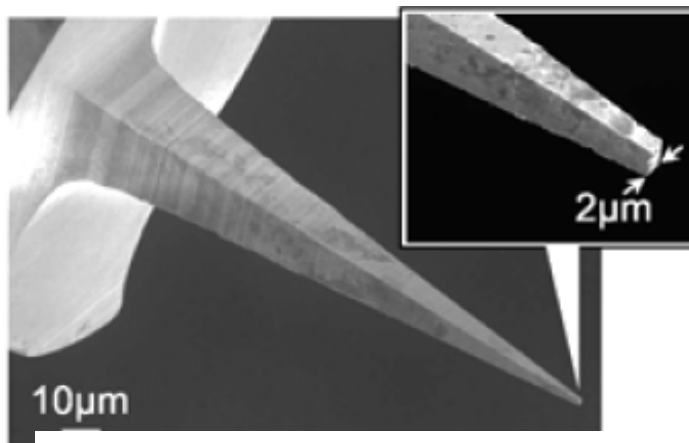
Cutting edge radius



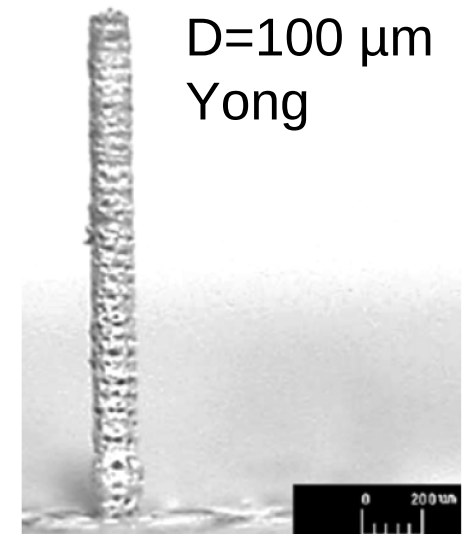
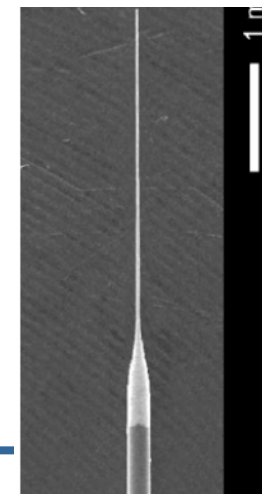
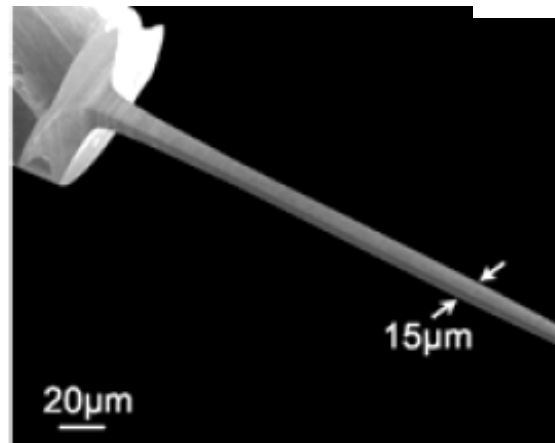
WEDG, 1 μm , W

ECM D=30 μm
Datta

ECD
D=100 μm
Yong

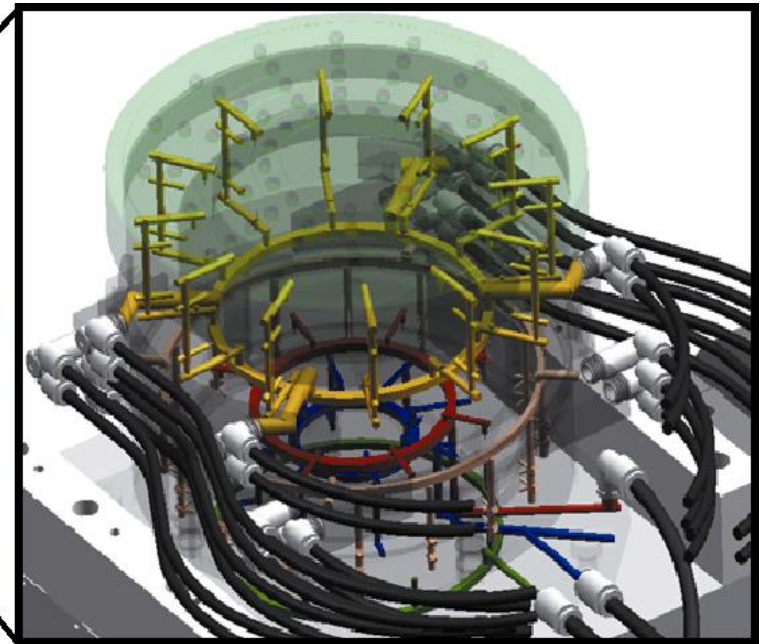
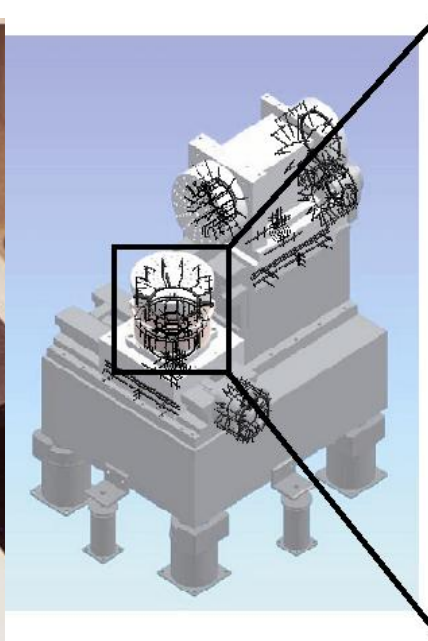
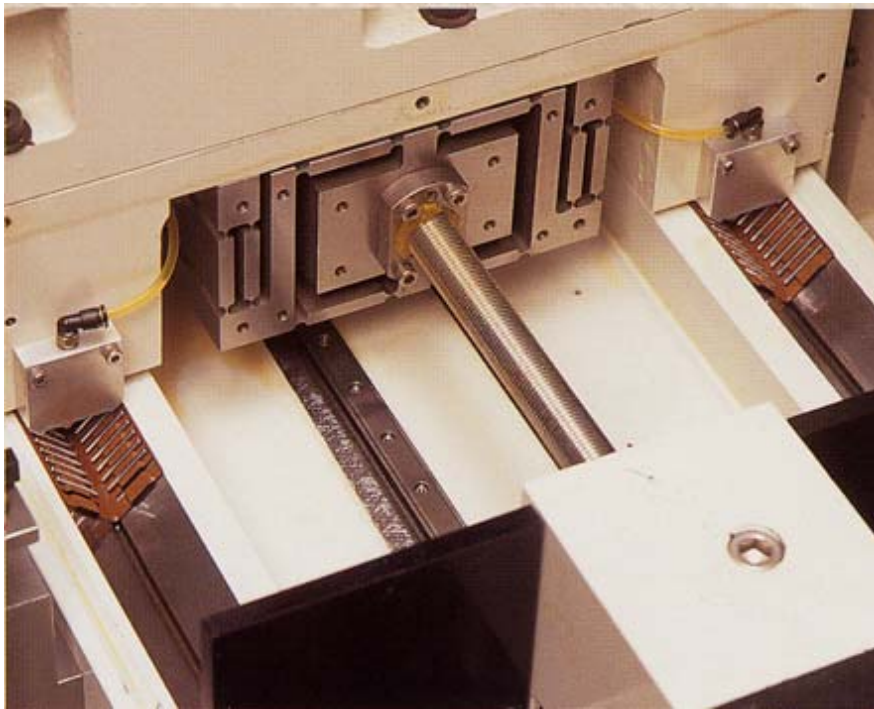


ELID – Schleifen, Ohmori



Ultraprecision machines

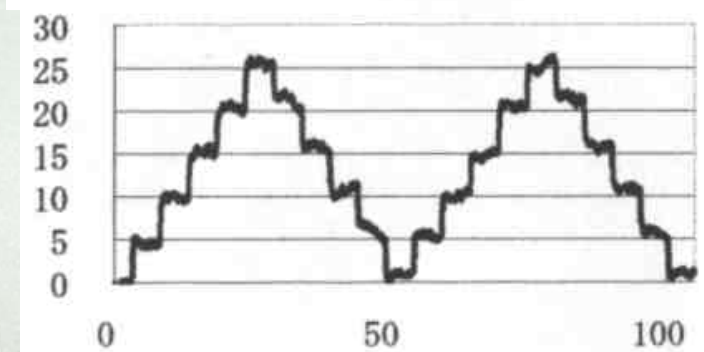
inspire



Takeuchi 2005



Position [nm]



Time s

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Today manufacturing of micro and nano parts / systems is limited by insufficient production capabilities

- develop replication methods
- manufacturing of dies and molds

Japan is far ahead

- keeping up is of ultimate interest



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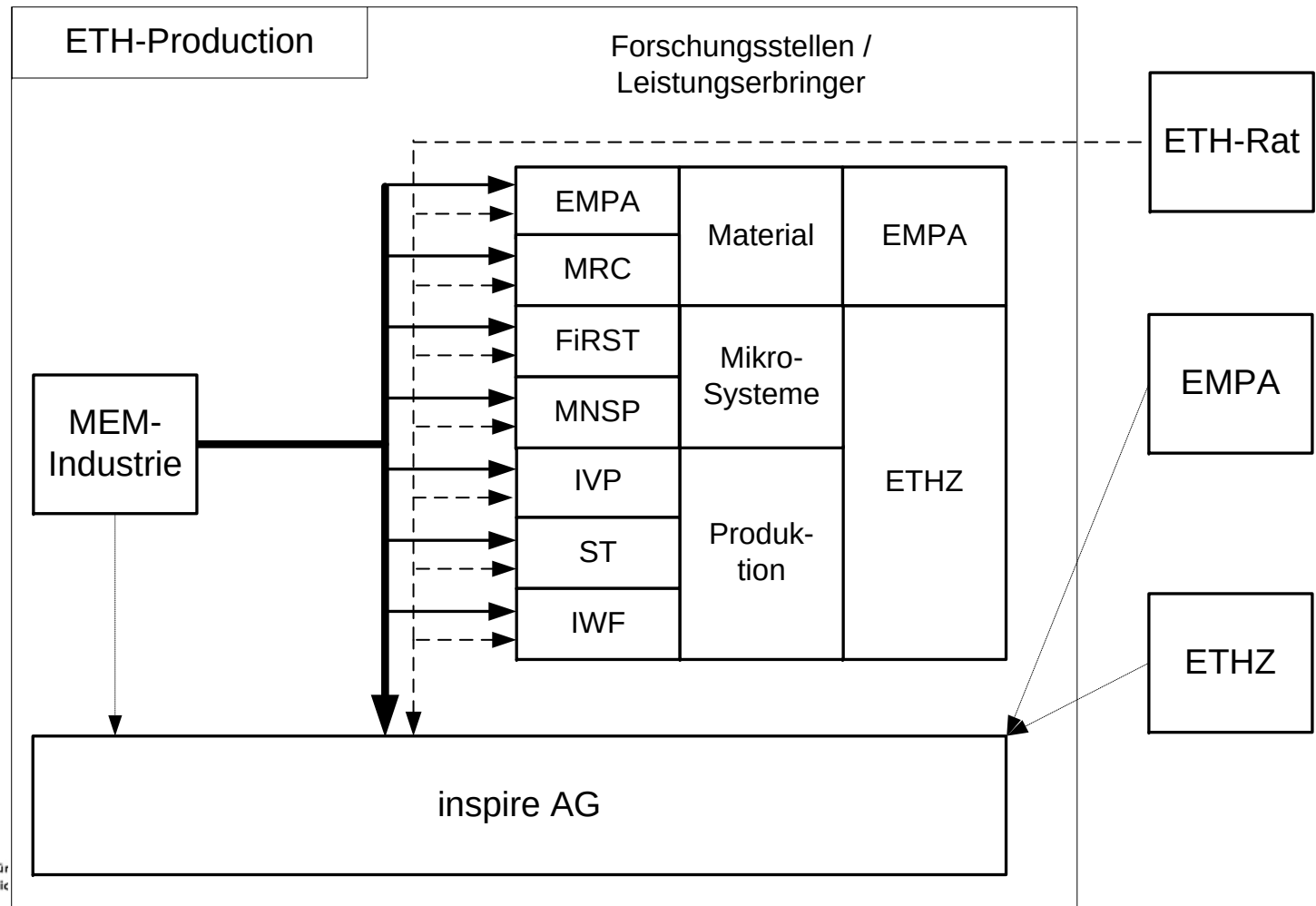
Startup of ETH - production

Abb.: Struktur und Geldflüsse "ETH-Production"

Legende:
 —————> Geldfluss Projektfinanzierung / Fördermittel / Ausrüstung
 - - - - -> Geldfluss Grundfinanzierung
 —————> Aktionäre inspire AG

Vision (micro):

- non waferbased manufacturing
- polymerelectronics
- measuring Techn.
- mikrofluidik
- bioMEMS
- intensive cooperation with industry



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Inhalt:

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- 2.) Boundary conditions
- 3.) Enable the enabler - Mechatronics
- 4.) Environmental impact
- 5.) Miniaturization
- 6.) Individualization
- 7.) Master the processes
- 8.) Manufuture and outlook



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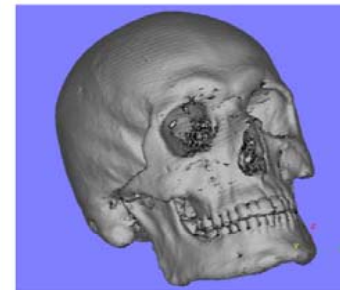
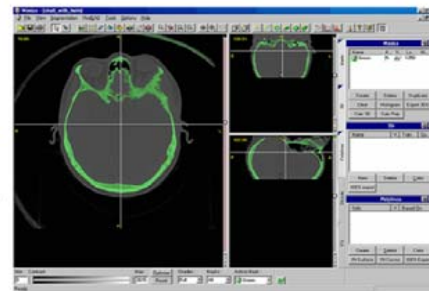
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Medical process chain

Chirurgie is manufacturing:

- individualized spare parts for humans.
- Use reverse Engineering by CT

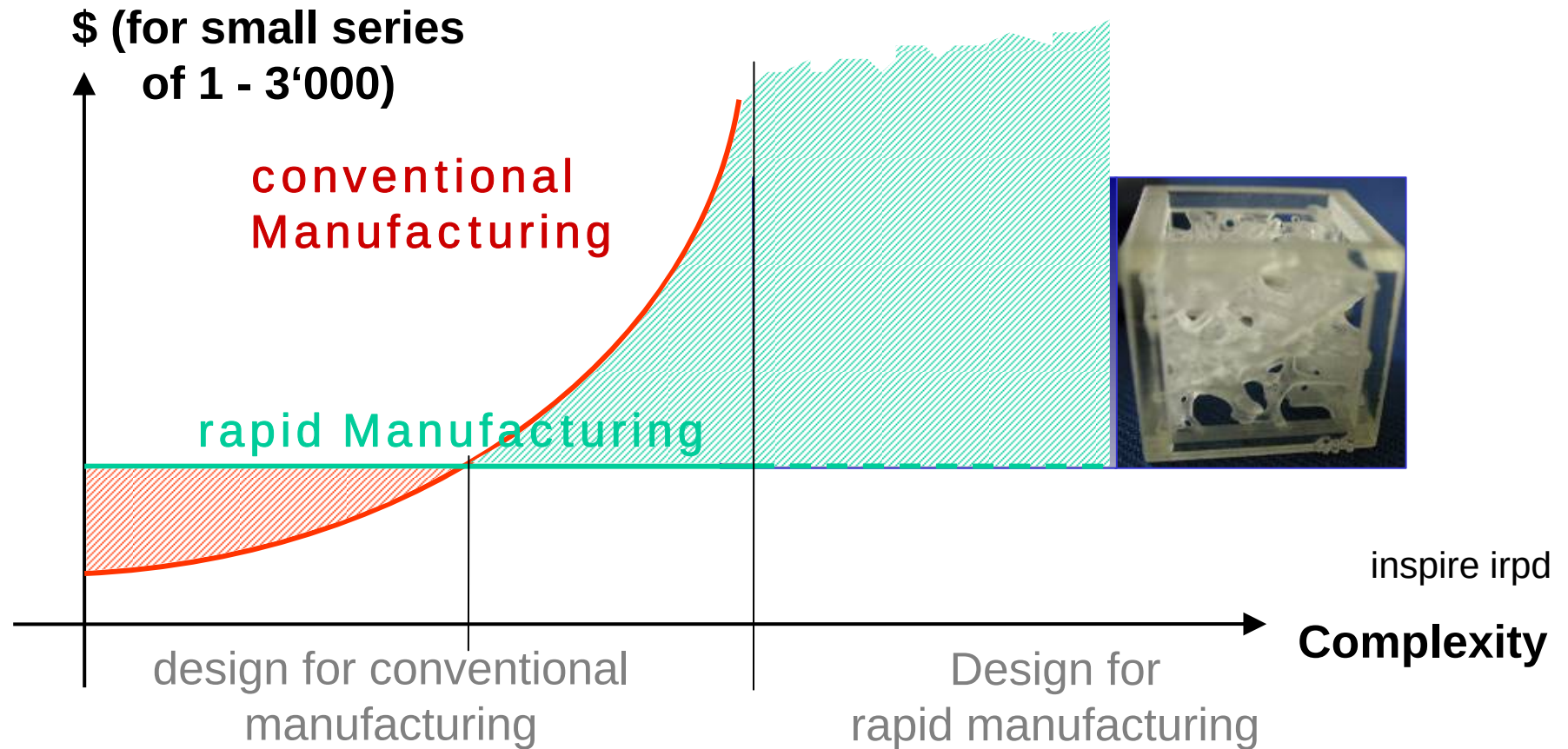
Volume Zoom
Zoom into the future.



Medizinische Prozesskette
Computer Tomographie
STL – Daten
SLS - Modelle



Complexity for free



Nearly unlimited design possibilities



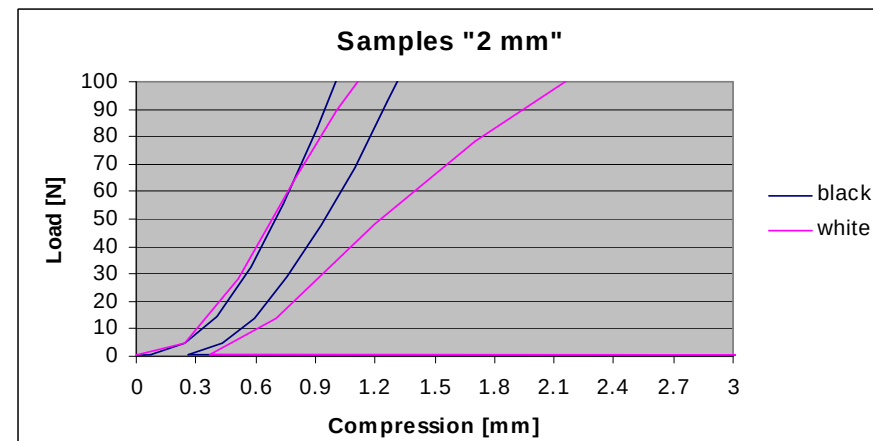
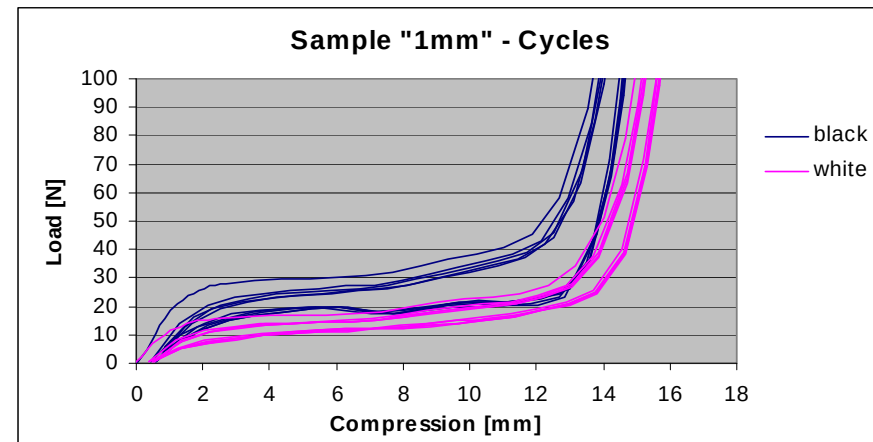
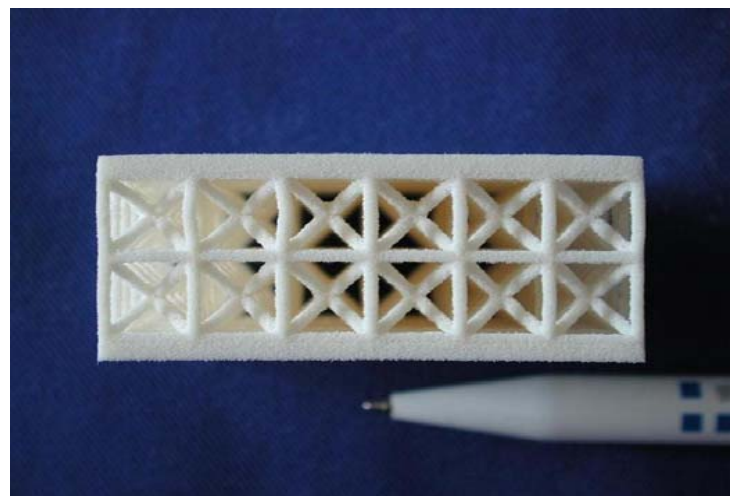
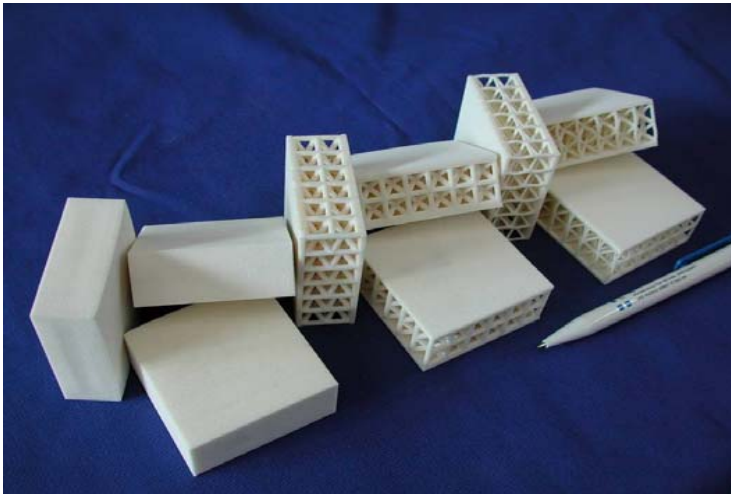
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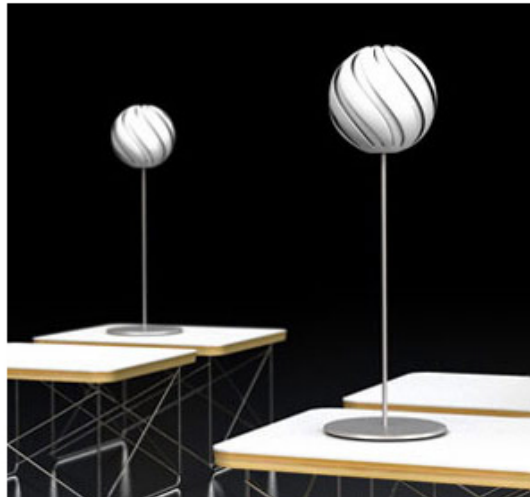
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Freedom of Design „Complexity for Free“





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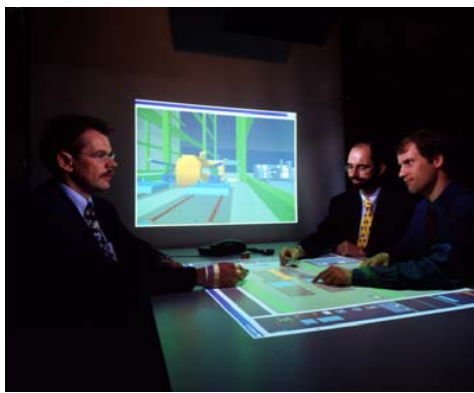
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Strategien	Kunden-orientierung	Produktions-orientierung	Markt-orientierung	Produktions- und Markt-orientierung	Individuums-orientierung
Produktions-merkmale	Einzelserie Manufaktur	Massen-fertigung	Kunden-anonyme Varianten-produktion	Varianten-reiche Serien-produktion	Serienhafte Unikat-fertigung
Technologien	manuelle Produktion	starre Prozessketten	flexible Produktions-anlagen	flexible und automatisierte Produktions.-anlagen	Produktions-anlagen zur Individual-produktion
Fabriken	lokale Kleinbetriebe	Zentrale Fabriken	Outsourcing / Kernkompetenzfokussierung globale Produktion für lokale Märkte		Dezentrale Fertigung in Abnehmer-märkten



- Integration von Produkt-, Prozess- und Ressourcendaten
- Optimiertes Planungsvorgehen mit skalierbaren vorgedachten Minifabrikmodulen
- Wissensspeicherung und Wissenstransfer
- Variantenmanagement von Minifabriken



Leitlinien der Minifabrikplanung:

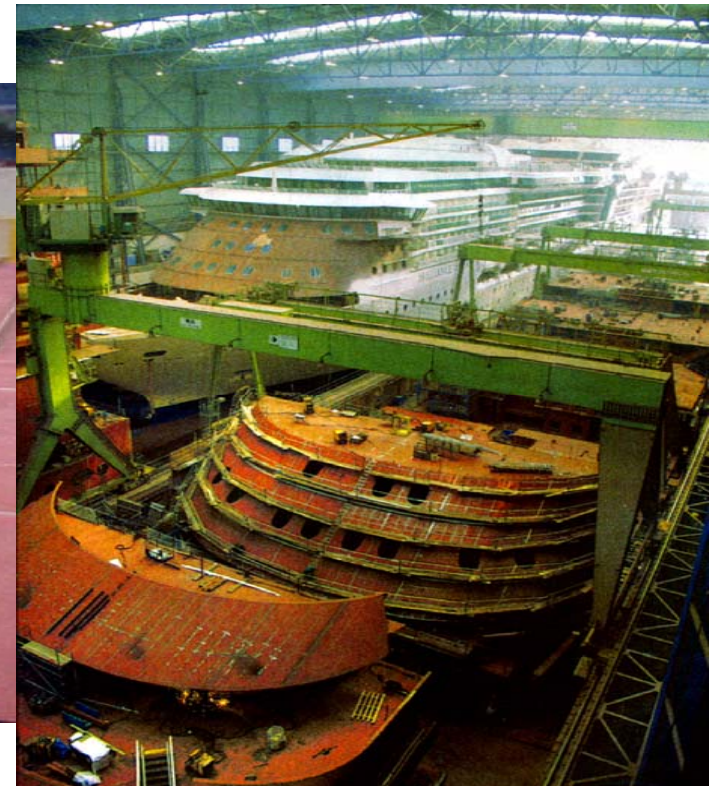
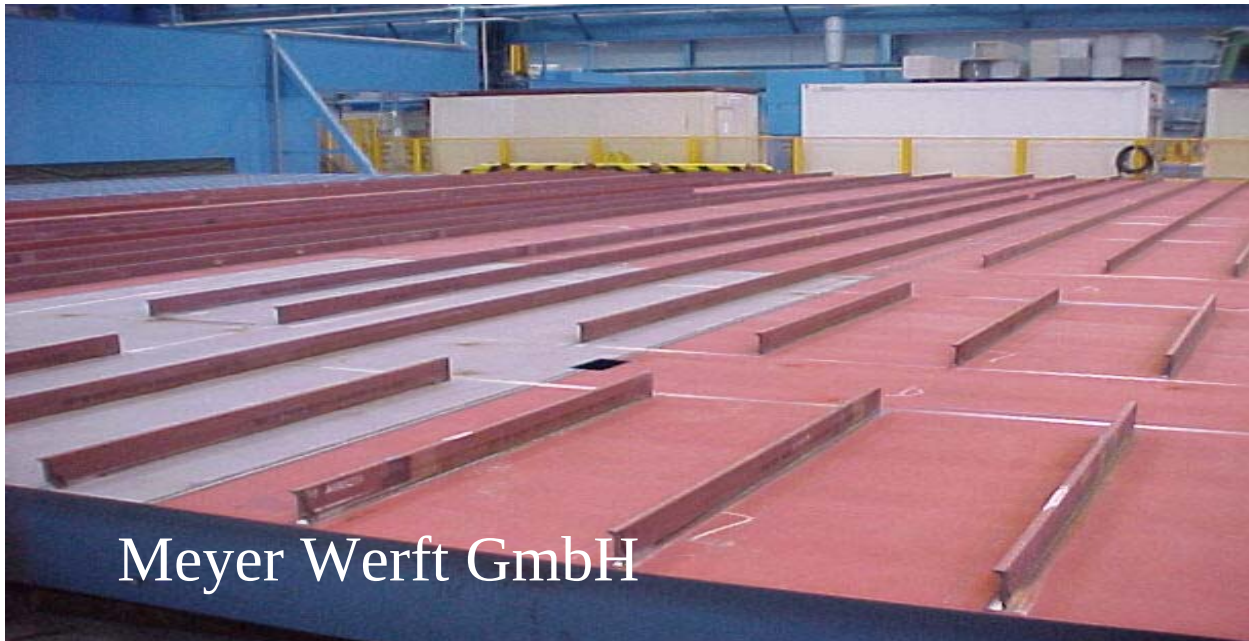
- Verkürzung der Zeit bis zum Markteintritt
- schneller und effizienter Produktionsanlauf
- schnelle und qualitativ hochwertige betriebsbegleitende Fabrikplanung
- effektive Nutzung von Ressourcen / 3D-Produktdaten

Mastering of Businessprozesses

Reengineering of Process Chains

inspire

A cruiss liner consists of 360 individual panelfields with varying thicknesses and materials, area ca. 120000 m²



hot rolled profiles and sheets, large tolerances, the right task for laser?
Contemplation of the whole process chain: Largest influences first.



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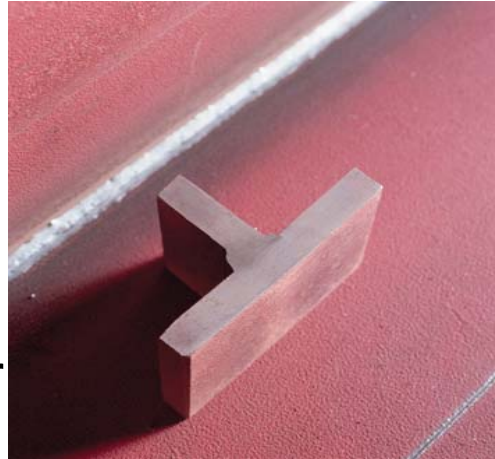
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Laser – Hybrid: Kehlnahtschweissen

Laserhybrid- welding:

- 80% less
welding wire
- 5 – times higher
welding speed

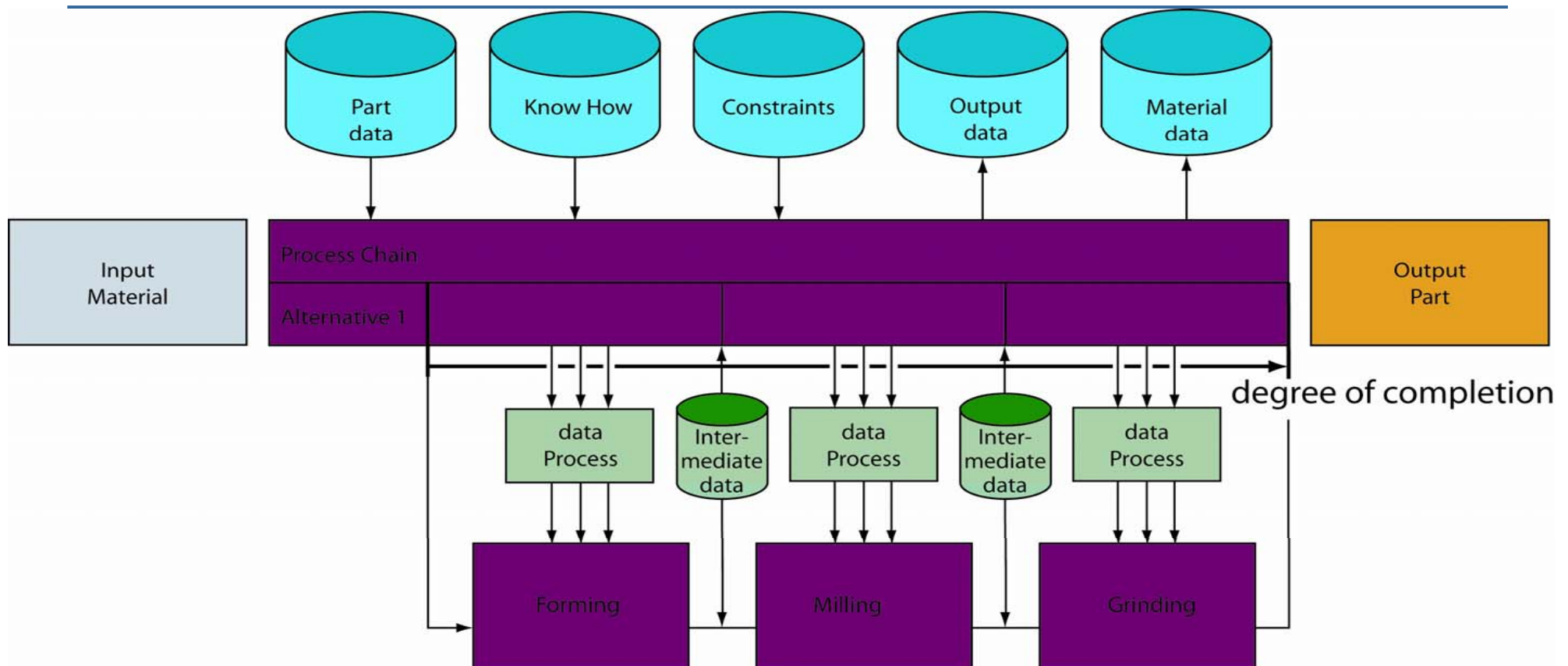


secondary effects:

- 10-times less distortion
- no turnover (root seam)
- larger prefabricated blocks
- individual automatic
- closed data processing chain



2.5 Automatische Prozessplanung



Volatile markets → increasing number of plannings and replanning

Systems for automatic process and tasks planning:

- Simulation of the process chain → robustness
- Optimization of production costs
- Cost information from rough to fine

- Lean Manufacturing
- Six Sigma
- Lean Six Sigma
- Design for LSS
- Supply Chain Integration
- Complexity reduction
- Cope with volatility of market



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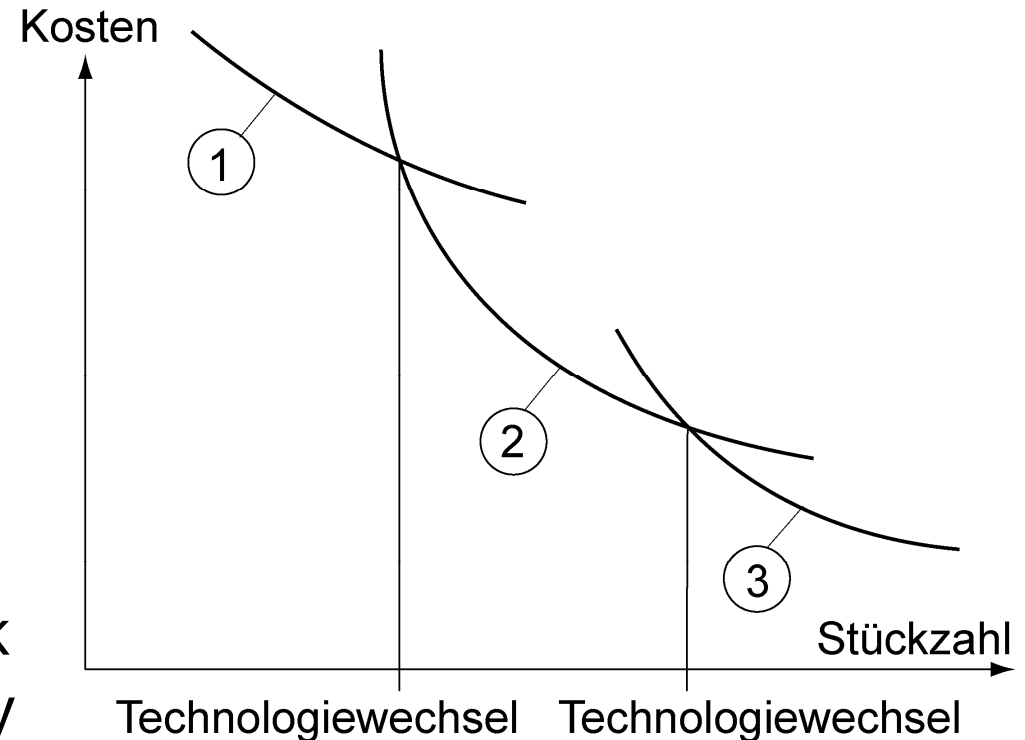
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Golden rule of special purpose machinery (25%):
With 4 machines one is for free

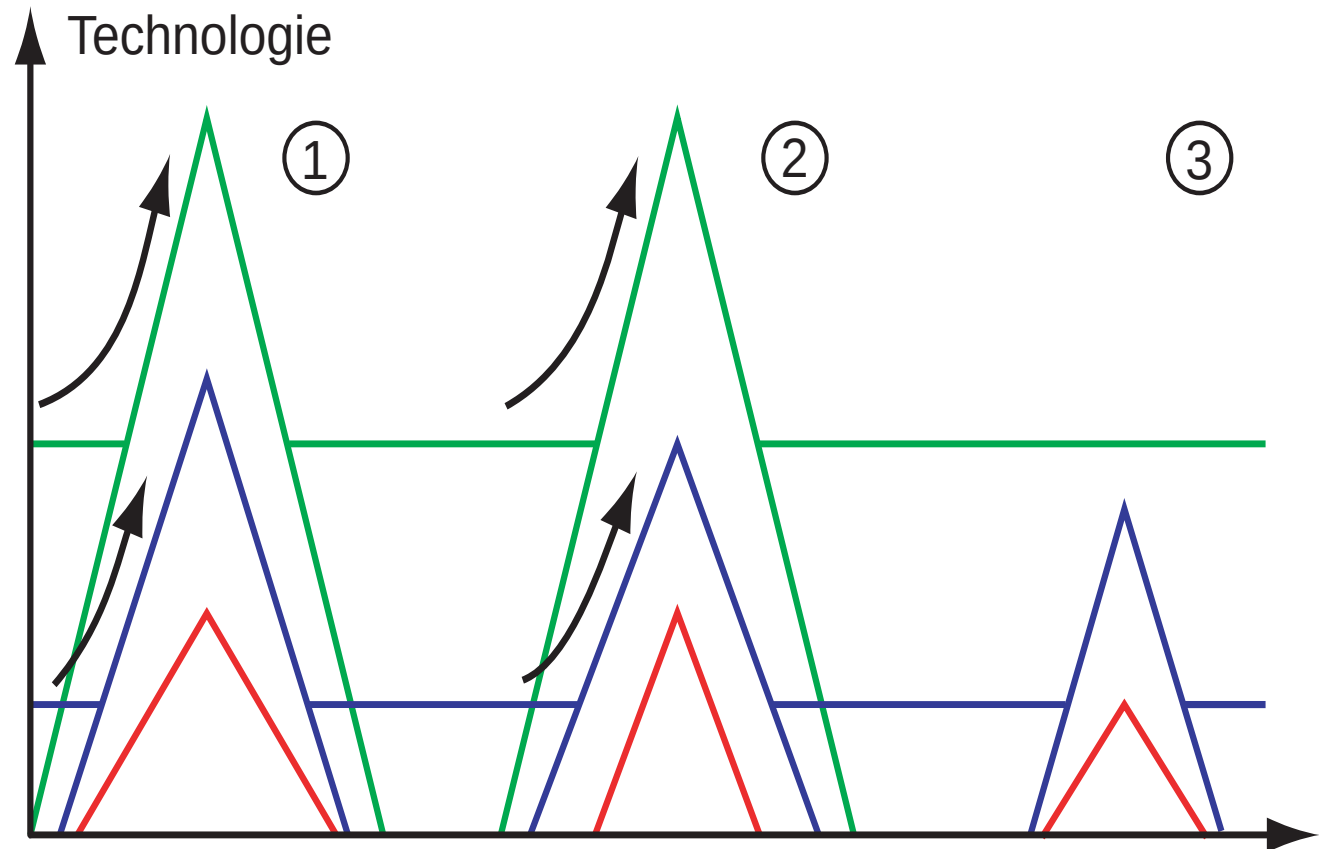
- Each serial size has its dedicated production technology
- machine tool manufacturer develop to integrators of standard components
- Machine tool manufacturers work at the limits of technical feasibility



Cutting edge of technology needs environment inspire

Environment:

- Mobility
- Platform für Information exchange
- Skilled work force
- suppliers
- research
- Application of technology



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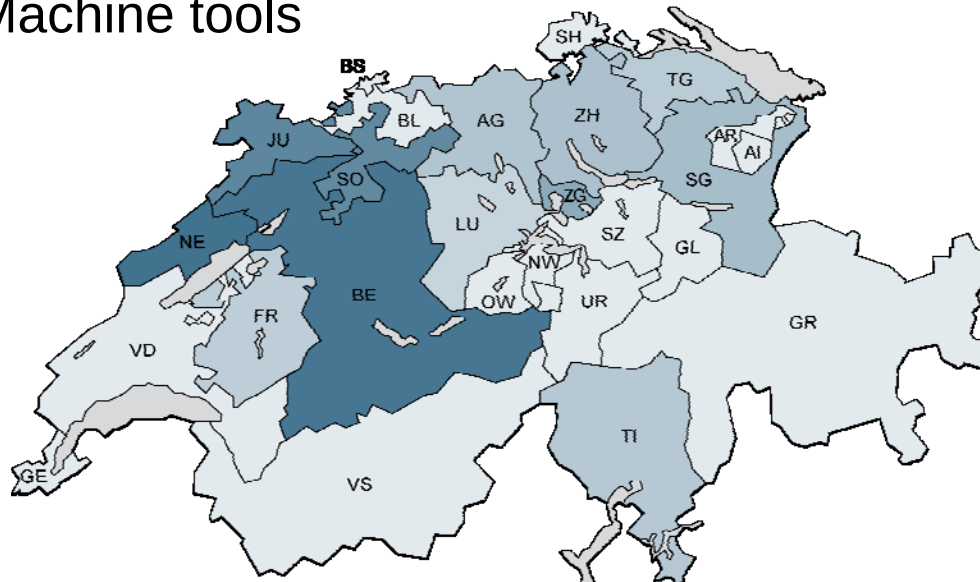
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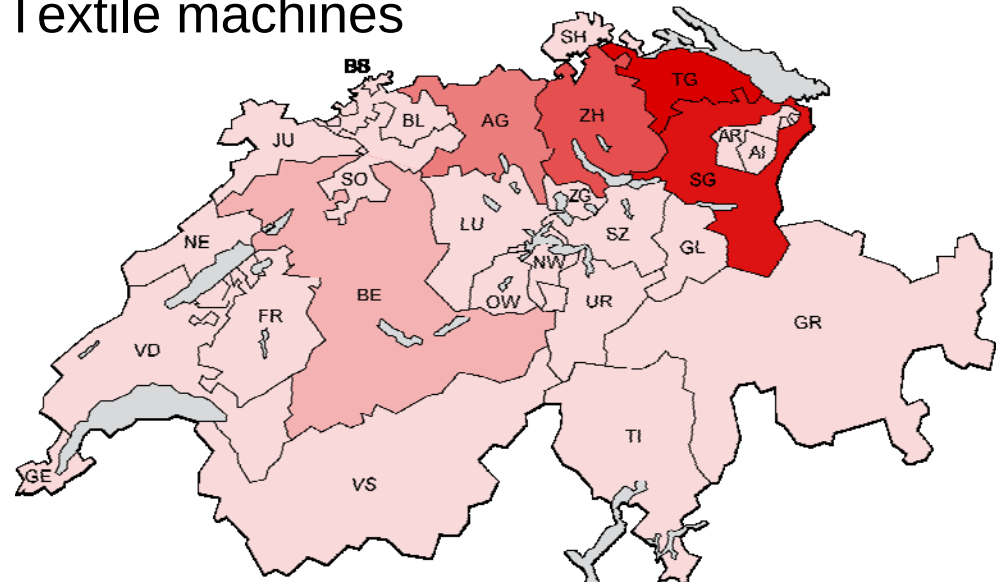
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Competence Clustering

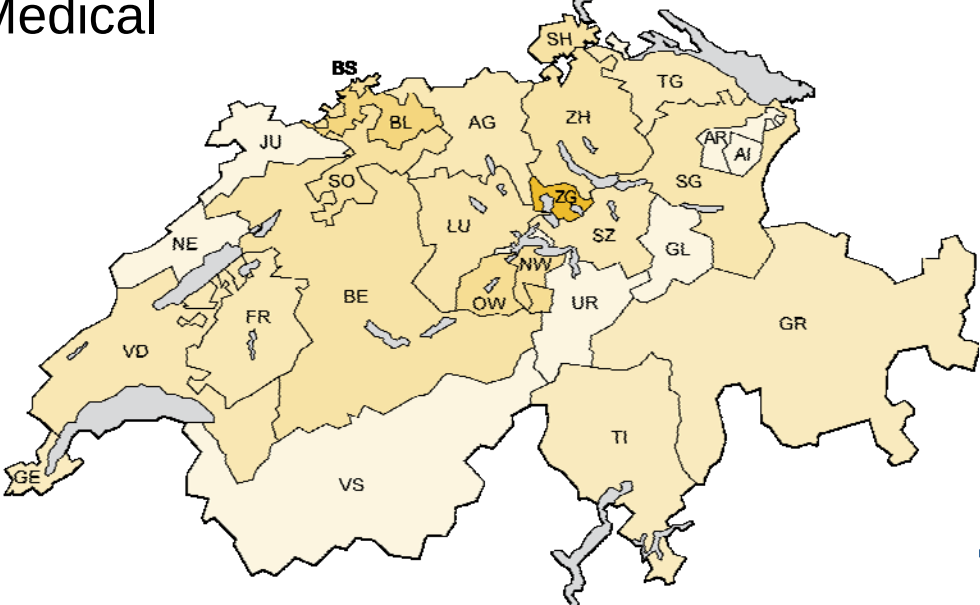
Machine tools



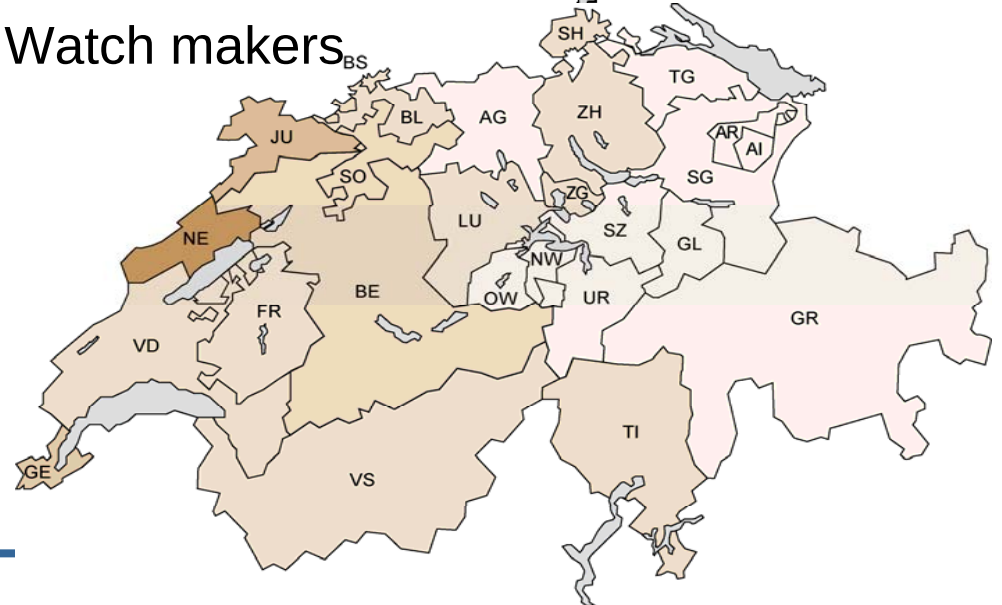
Textile machines



Medical



Watch makers



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Manufuture goals:

- knowledge based manufacturing
methodological approach instead of trial and error
➔ economical use of ressources
- from linearity to complexity
fully take into account the interdependencies in producing entities
- from individual to system competition
develop the substrates of competence and cooperation
- interdisciplinarity
- miniaturisation
- Generative technologies
rapid technologies, self assemblies



-
- increase awareness and PR for manufacturing
 - develop a climate for learning in manufacturing
 - technological research
 - develop suitable business models and organizations
 - abolish restrictions and limitations



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The Future of Manufacturing in Switzerland

inspire

- ➔ **Prognoses are difficult if they concern future**
- ➔ **Fabricare necesse est.**
- ➔ **Production is the most interesting and most exciting topic.**
you must master:
 - finance
 - the product and development
 - the equipment
 - energy and media
 - materials
 - processes
 - organisation
 - human resources
- ➔ **Not to produce means capitulation in front of that huge task**
„Keep it simple“ is not a strategy but a testimony of limitation
- ➔ **„keep it suitable“**
- ➔ **At the end: those who can, can - those who cannot will not**

Switzerland:
Industriestandort $\leftrightarrow$ Industrie stand dort
let's work for the first

Thank you for your attention
www.inspire.ethz.ch



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