Constructing a Sustainably Competitive Europe
MANUFUTURE'2007 CONFERENCE

WORKSHOP 6:
Research and Training for Innovation

Conclusions and recommendations

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MANUFUTURE-EU

EU MARKET

MANUFACTURING IN EUROPE

EMIRA

Relevance of European Manufacturing
(Source: OECD 2005)

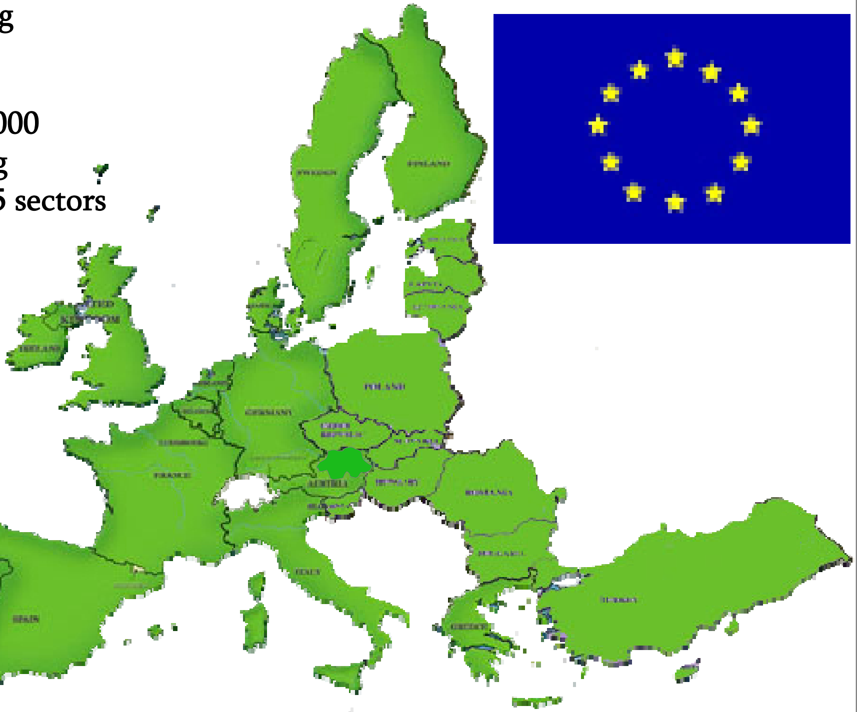
Manufacturing enterprises: over 230.000
Jobs: 30 Ml directly by Manufacturing
and 60 Ml through related Services 25 sectors

Turnover 6.553 BEURO
Value Added 1.760 BEURO

70% from six main areas:
Automotive Engineering
Electrical and Optical Equipment
Foodstuffs
Chemicals
Basic and Fabricated Metal Products
Mechanical Engineering

Total global Manufacturing trade:
EU 18%
USA 12%
JAPAN 8%

European key sectors accounting for highly competitive EU companies and 42% of total Manufacturing exports:
Automotive, Mechanical Engineering, Agricultural Engineering, some categories of Telecommunications Equipment.
Mechanical Engineering and Chemicals alone account for 31%



Export-import
Industry specialisation

SECTORS	EU	IT
Traditional Industry	+ +	+ +
Scale Intensive Ind.	-	-
Special Supplier Ind.	+	+
Science Based Ind.	-	-

More than 500000 researchers of 25 EU countries- work on manufacturing RTD&I (Eurostat 2003).

PhD students, 2004 - EU 25- 65.737

Students in Manufacturing – at all level (including PhD) – account for around 16% of the total.

The EU dominates in the production of PhD graduates overall as well as in the supply of PhDs in science and engineering.

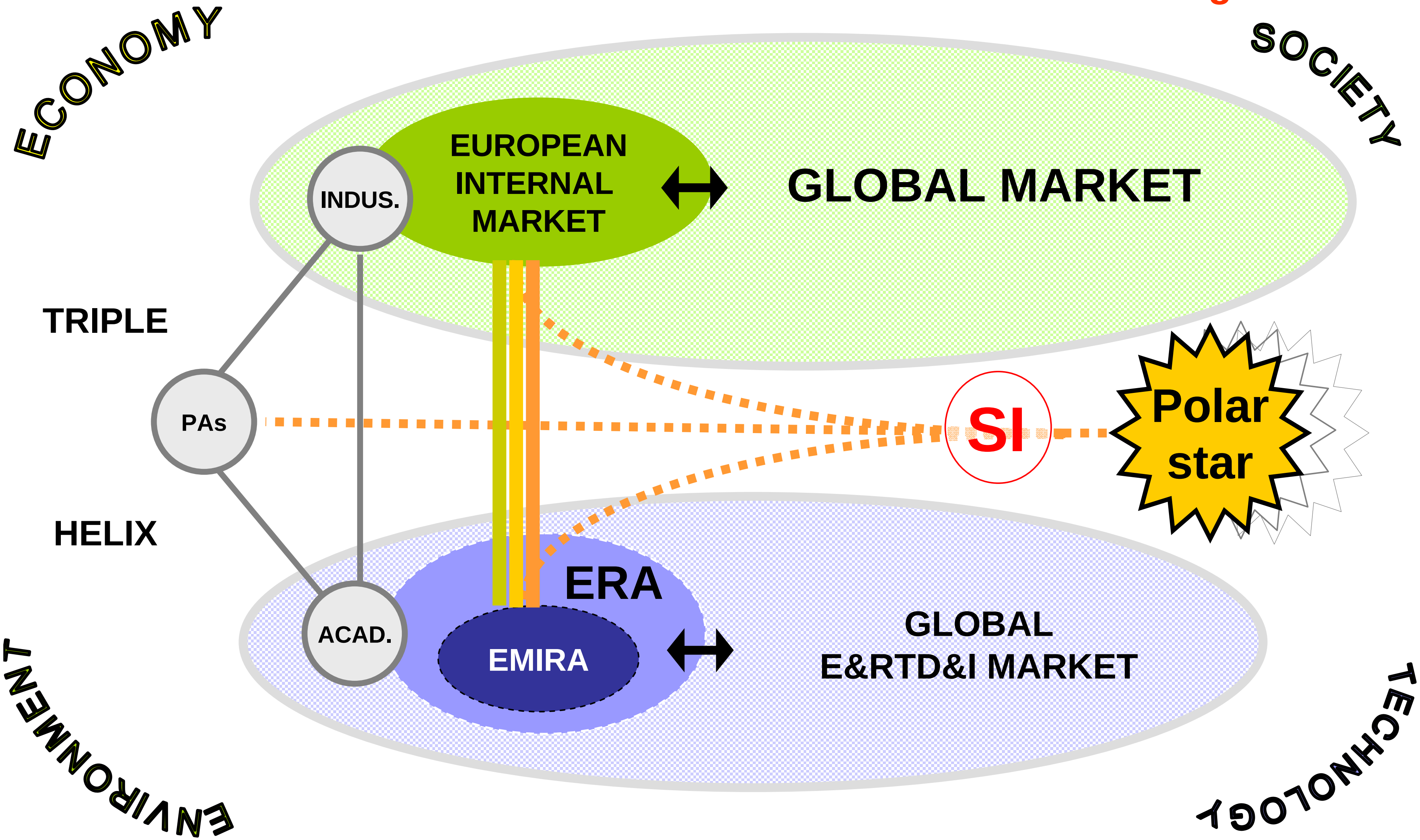
Students participating in tertiary education, aged 20-29 - 2003 - EU 25 – 2.036.957

Doctorate students (aged 20-29) - 2003 - EU 25 – 57.834

Graduates from tertiary edu (20-29 - 2003 - EU25) 313.750

Doctorate graduates (25-29)- 2003 - EU 25 – 9.433

ManuFuture Road towards the CS Manufacturing



Summary

Premise: An integrated education, research and innovation are fundamental to pursue High Value Added Knowledge-based CSM.

Current Scenarios:

(1) On-going quick transformation of industry need to be supported by the parallel transformation of Education, RTD and Innovation.
(2) European universities are being transformed following the Bologna agenda.

Challenges: A challenges were identified in the areas of the ManuFUTURE interests which need to be addressed to pursue effectively HVA K-based CSM.

Needs: The synergies and interactions between research, education and innovation need to be developed, thus requiring an alignment between policies, programmes and actions.

(1) **Industry agenda:** An agenda showing industry present and future needs in education and research to be developed. This will involve public authorities at regional, national, and European level as well as universities/research institutes and industry.
(2) **University agenda:** Universities/research institutes should describe and advertise their present and emerging competencies in research and education in similar fashion as tier-1 suppliers.

The Workshop #6 explores various options and experiments to address the need for synergies and interactions between research, education and innovation.

Education

Challenges in Manufacturing Education

- Internationalisation of manufacturing education and research
- Dynamic collaborative e-learning environment in industrial engineering
  - Working in a multicultural environment
  - Working in interdisciplinary, multi-skill teams
  - Working in an virtual environment
  - Sharing of work tasks on a global and around the clock basis
- Creating virtual classrooms or virtual centers for students
- Digital tools and simulators able to be used anywhere and anytime,
- E-training environment context-aware
- Entrepreneurship and innovation in manufacturing.
- Value creation status and job positions
- Future manufacturing curricula

Manu*Future* Workshop recomendations for Education

We are aiming to pursue HAV K-based CSM. The following recommendations are proposed to address the challenges related to education:

(1) **ManuFUTURE Educational Agenda:** to be developed in co-ownership and close collaboration with industry and respond to Lisbon agenda in the area of manufacturing. The following various innovative educational paradigms will explore the opportunities in the life-long learning paridigm:

- **(i)** **Teaching/Learning Factory** Educational Program– similar concept as used in teaching hospitals and in the "Serious games" (flight simulators, …).
- **(ii)** **European Engineering Curriculum**:- Integrate all manufacturing qualifications of EU Member States into European engineering curricula. European Universities should launch common degrees.
- **(iii)** **Global Education in Manufacturing**. (i) A world standard curriculum in manufacturing strategy; (ii) Training courses for industry aiming at updating the human capital employed in industry; (iii) Education for a Masters degree in manufacturing strategy to be delivered by universities to students either on-campus or off-campus
- (iv) **Capture best practices** in education of manufacturing engineers
  - Fundamental education (university-driven)
  - Practice-oriented education (industry-driven)
  - Research-oriented education (university/research institutes+industry; as ManuFUTURE best practice represented by SINTESI)
- **(v)** **ManuFUTURE International School -** leading to Masters and PhD qualification in industrial research.

Manu*Future* Workshop recomendations for Education

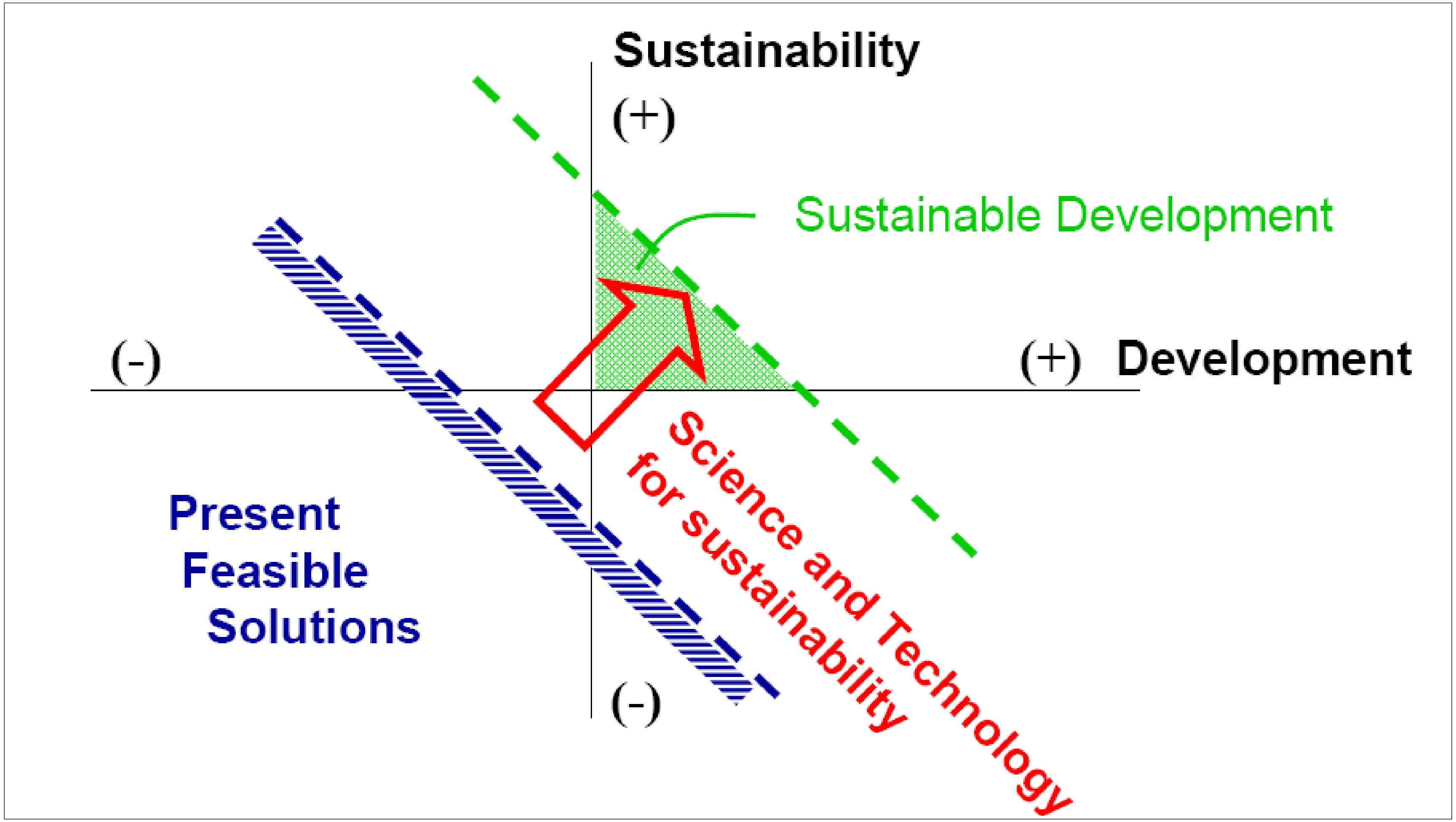
(2) **Develop rewarding system at Universities,** which will promote: not only fundamental research, academic teaching, service but also innovativeness in research and teaching: **Teaching**, **Research**, **Service** and **Innovation**. This will require development of a performance evaluation matrix and resolve a number of other issues.

(3) **Need for EU-wide Funding Program focus on education** – funding supporting both universities and industry.

Research

Example 1

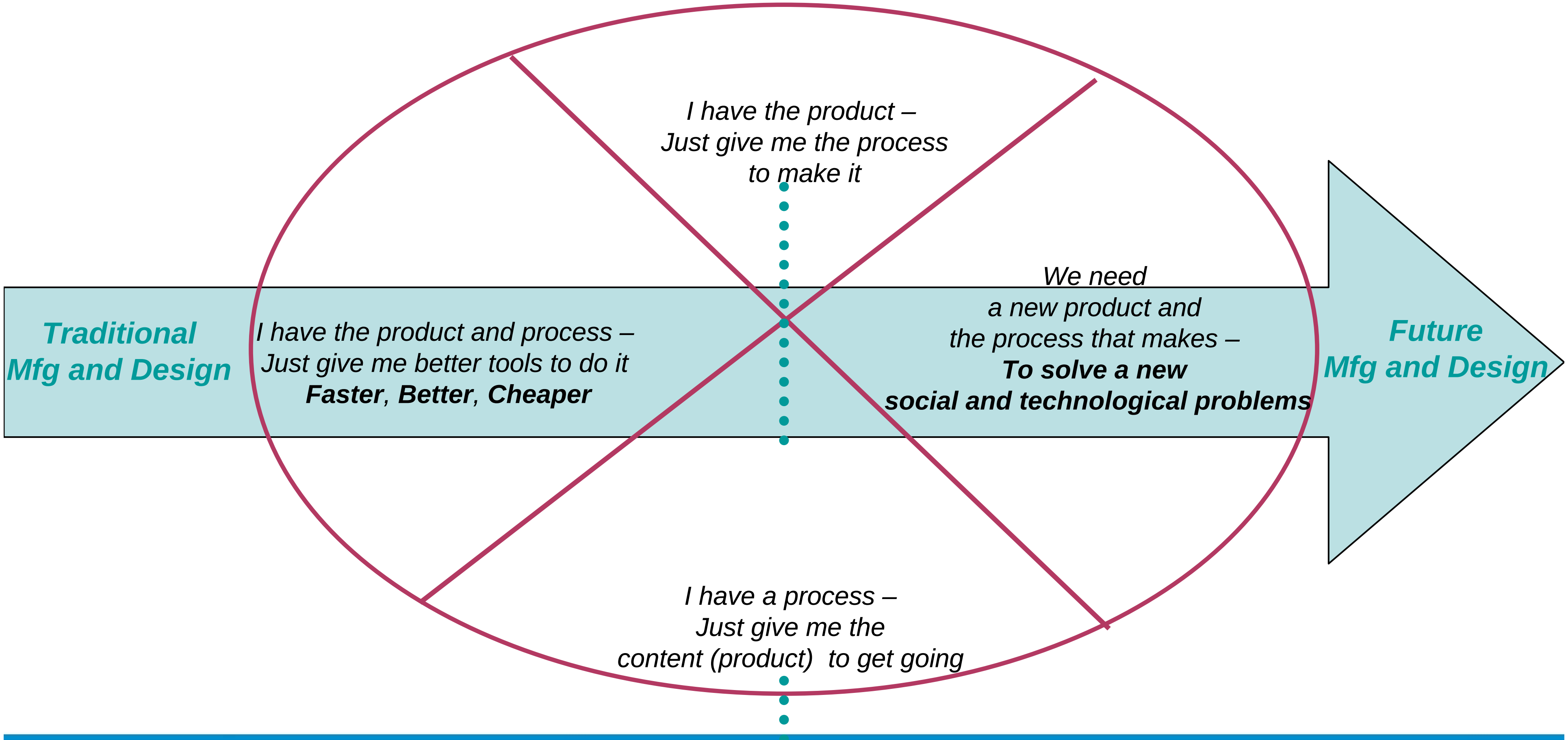
Full Research for Sustainable Industry



Example 2

Product-Process Matrix

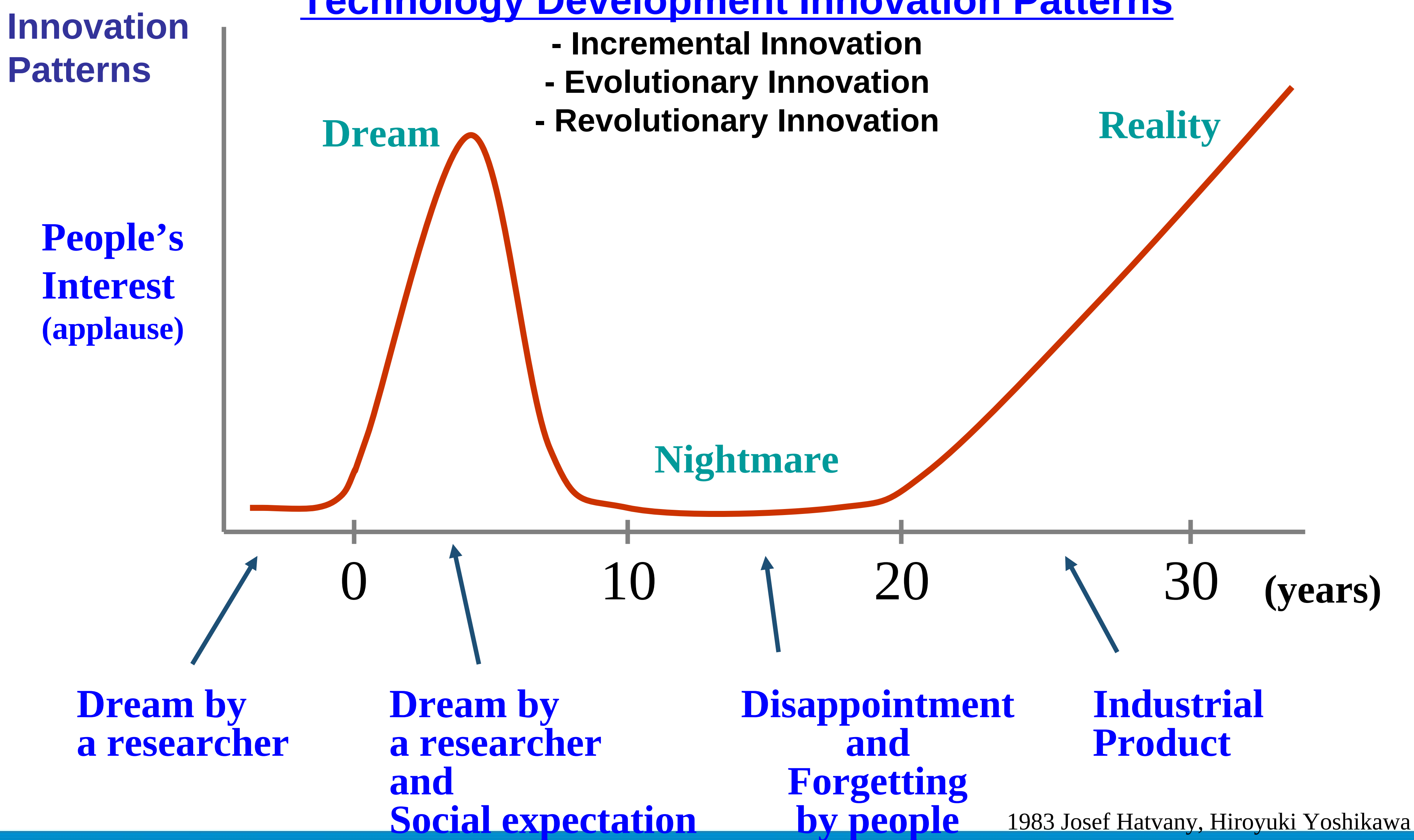
- Incremental Innovation
- Evolutionary Innovation
- Revolutionary Innovation



Example 3

Technology Development Innovation Patterns

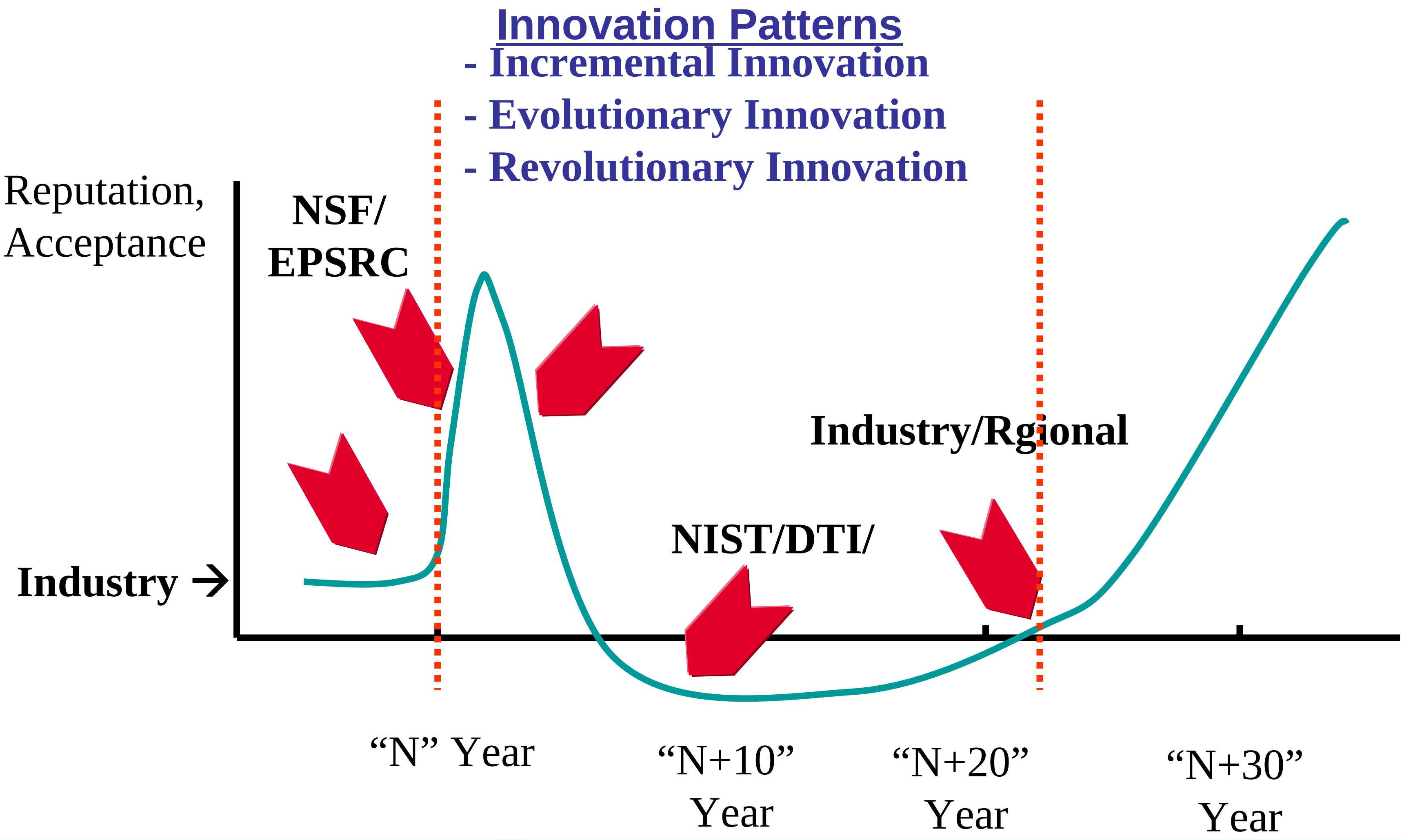
- Incremental Innovation
- Evolutionary Innovation
- Revolutionary Innovation



1983 Josef Hatvany, Hiroyuki Yoshikawa

Example 3

Technology Development Innovation Patterns vs. Funding Strategy



Challenges in Manufacturing RTD

- Integration of several knowledge domains
- Skills and absorptive capacities needed to participate in innovations
- The balance between self-organisation and design
- The balance between openness and closure
- From innovation to diffusion networks
- Uncertain outcomes and the need for new forms of evaluation practices
- Timing and coordination of policies affecting innovation networks
- Innonvation vs. Scalability

Manu*Future* Workshop recomendations for RTD

At member states

- Foster the creation of clusters at national and/or regional level, creating research and transfer nodes, and integrating OEMs and SMEs into networks. These can then join and support the creation of clusters at EU level;

- Develop competence in high-value complex manufacturing technologies which are unique and difficult replicate outside of Europe;

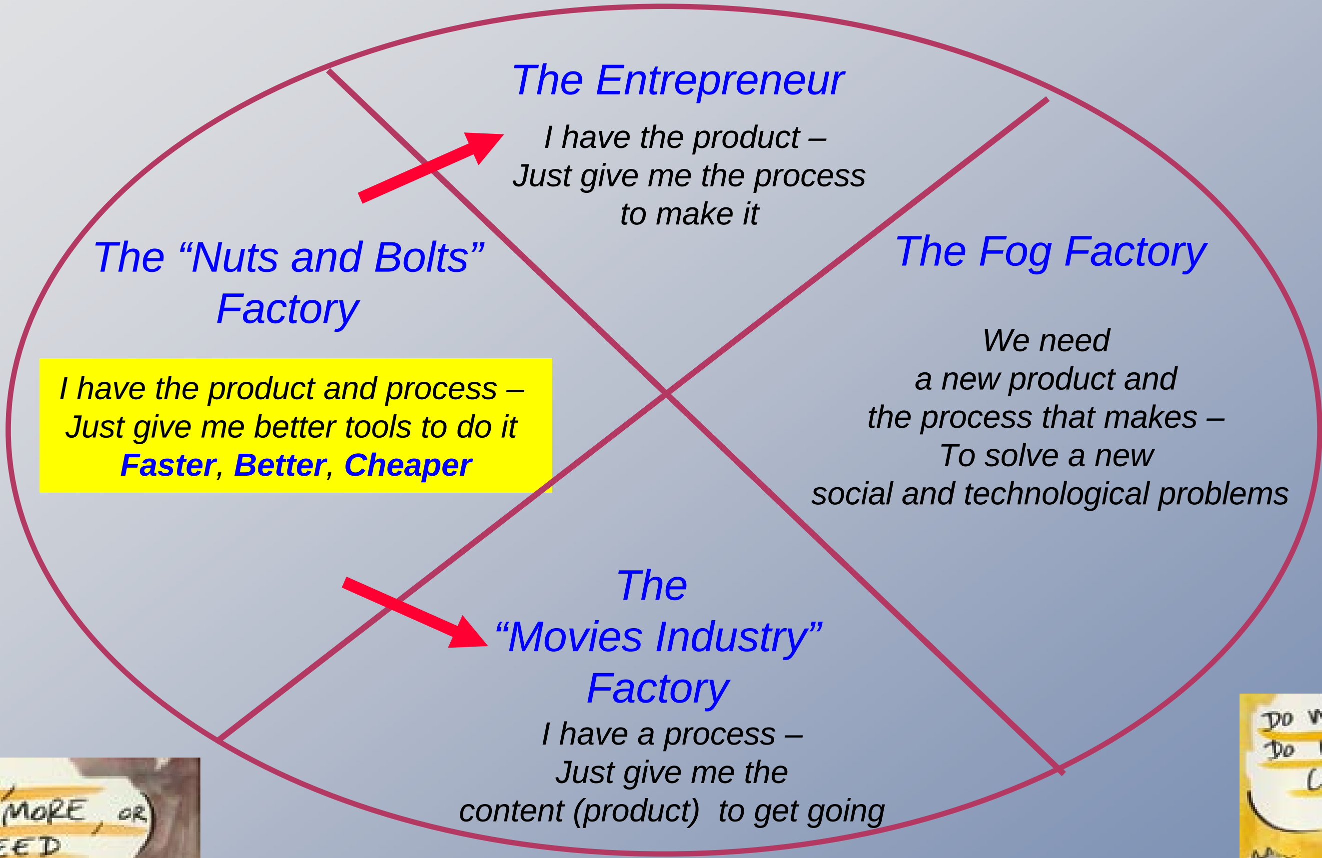
- Establish regional/local centres of excellence in manufacturing, incorporating a Manufuture network of educational and research communities

- Develop reference model and framework for Digital Economy

- Anchor research and innovation on nucleus of company staff which will then network to access and transfer external competencies.

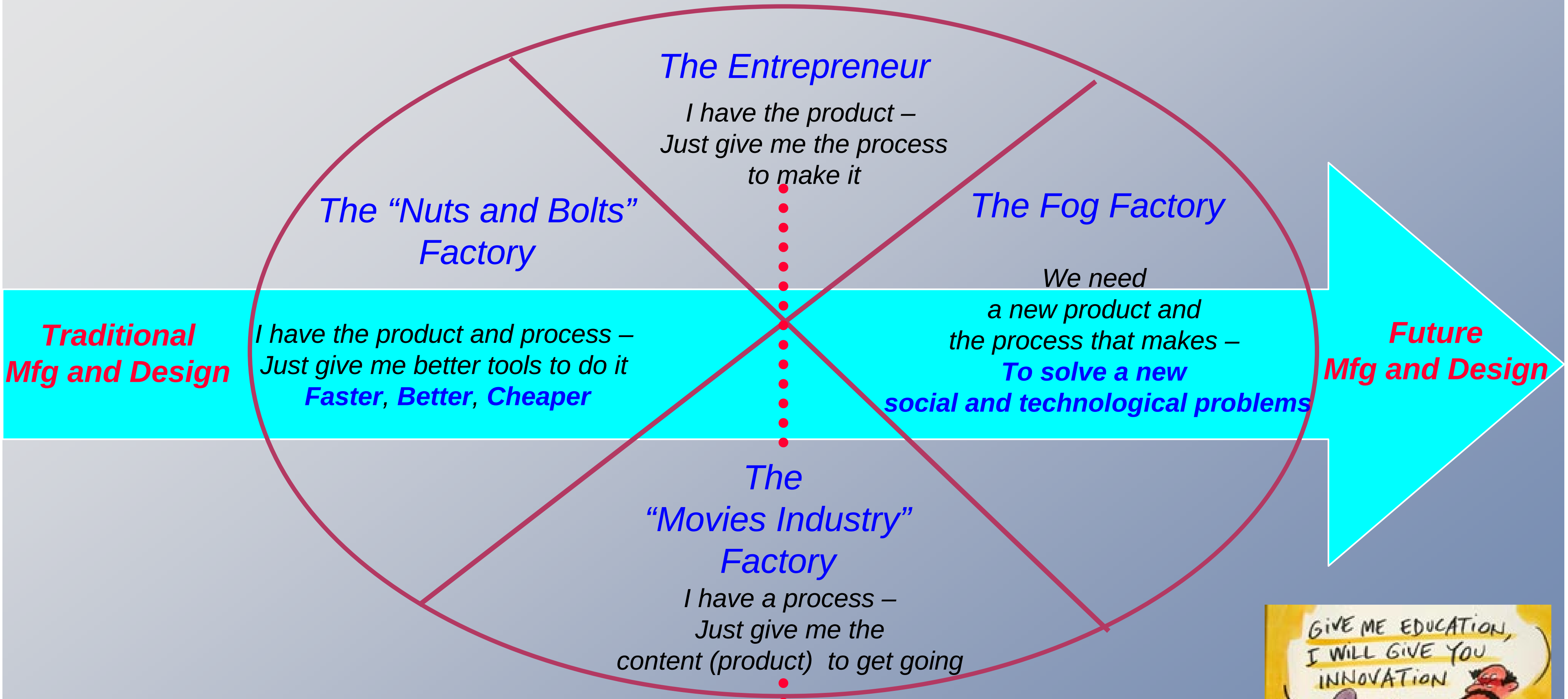
BACK UP SLIDES

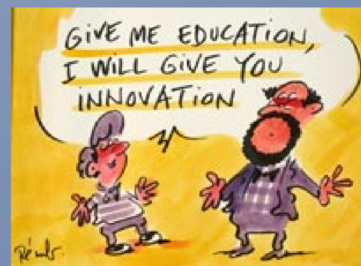
Product-Process Matrix



Traditional Mfg and Design

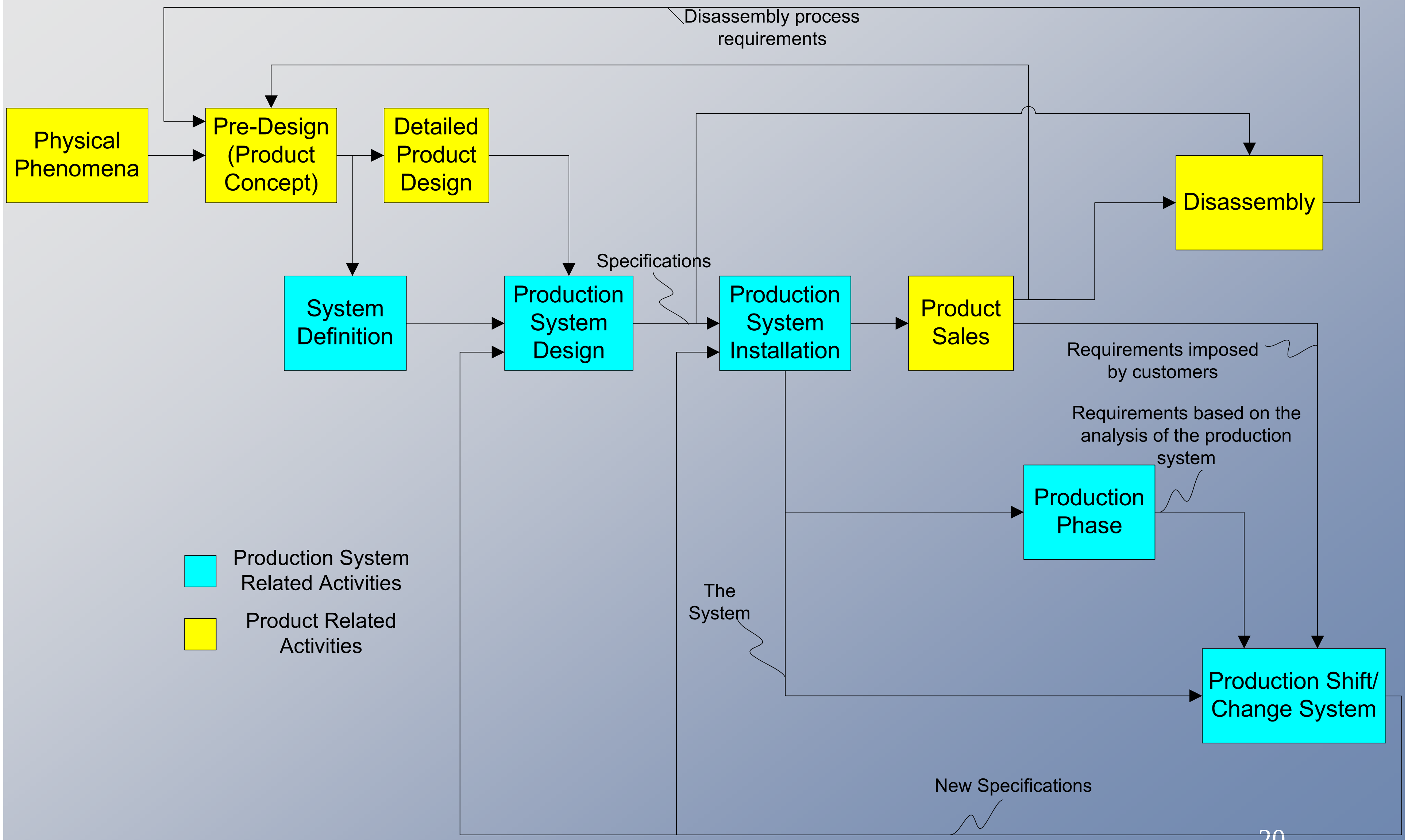
Product-Process Matrix



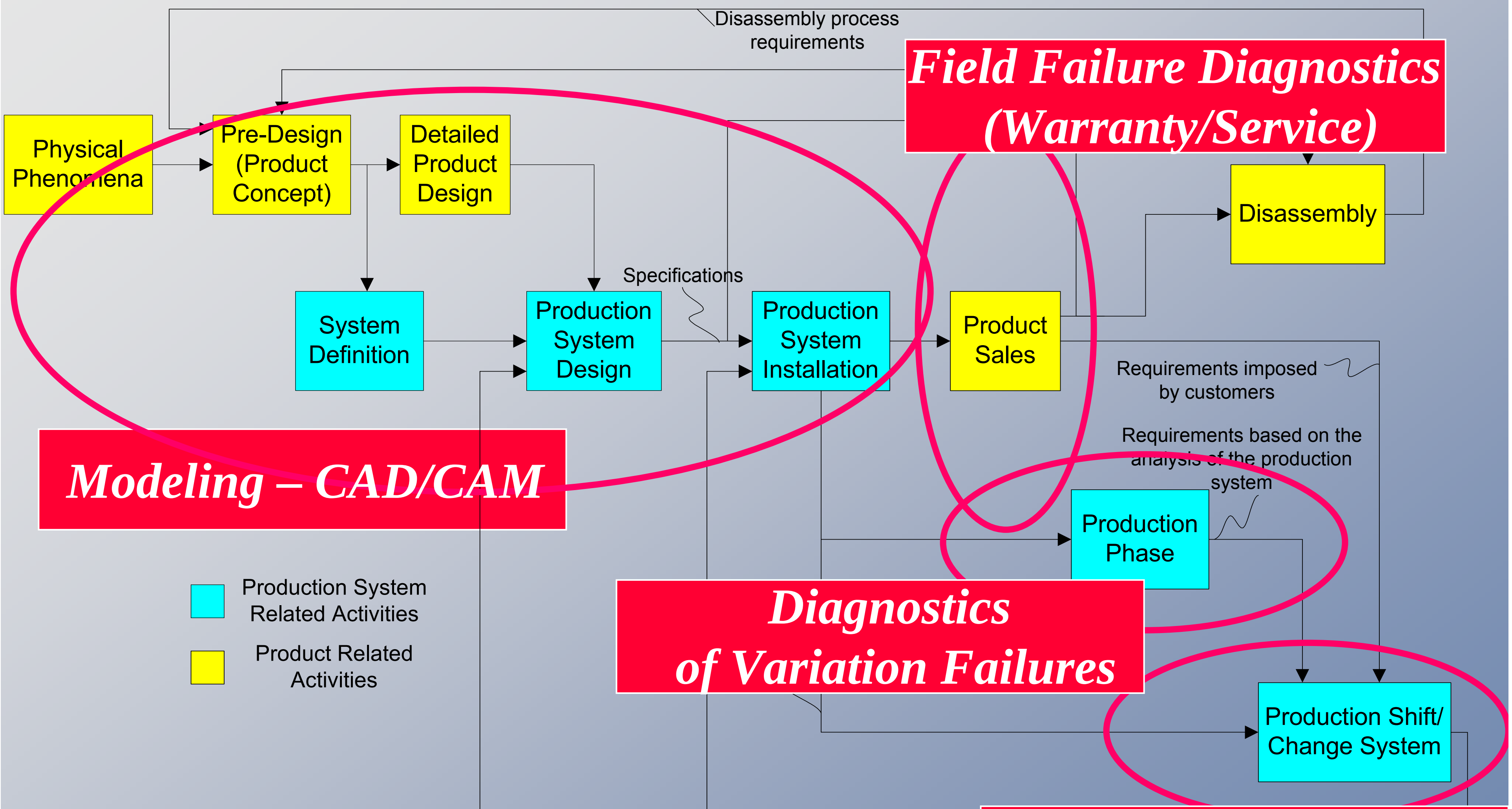


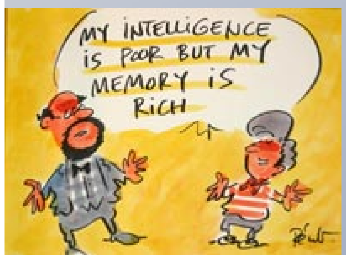
Product-Process Evolution

Product-Process Roadmap



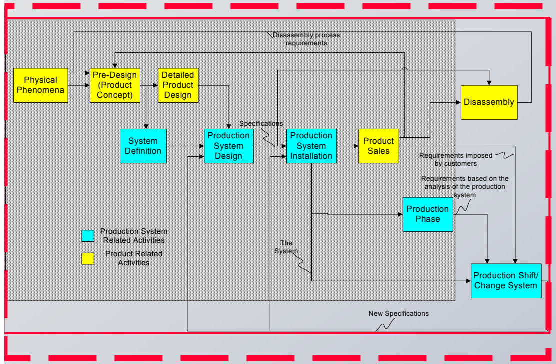
Product-Process Roadmap

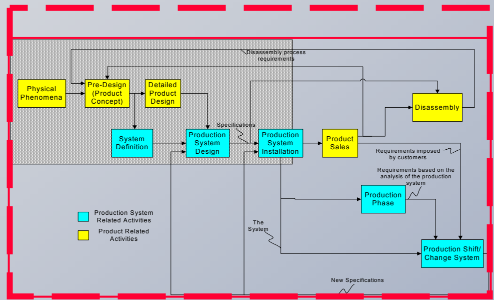


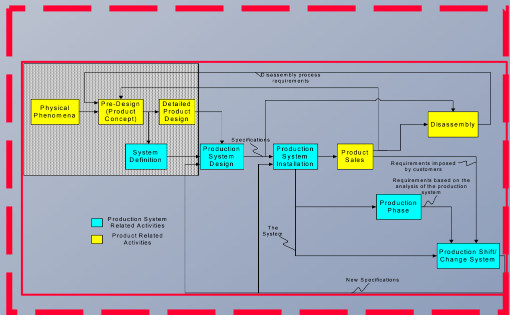


Product-Process Evolution

Traditional vs. Emerging Products and Processes







Bio. Mfg. Processes:

- Process knowledge discovery
- System level research on Bio. Mfg. processes

Micro (Molecular) Mfg:

- Process knowledge discovery

Traditional (Macro) Mfg:

- Integration of design and manufacturing
- Information fusion for performance improvement
- Disassembly and supply chain issues

Current NEEDS → **Future NEEDS**

Product-Process Evolution

Sustainable Manufacturing for Sustainable Products

Products	Physics/Measurement/Process
Semi conductor	Quantum physics, Nano-scale controls
Carbon nano-tube	Nano-space science
Bio-sensor	Bio/nano tech. Geometrical chemistry
Fuel Cell	Catalyst, Nano-particle
Diamond electronics	Catalyst, Ultimate condition
Sustainable Products	Nano-scale manipulation Quantum physics Spin-electronics Bio-science Ultimate condition Environmental science ------------

(Prof. Yoshikawa, CIRP Round Table, 2003)

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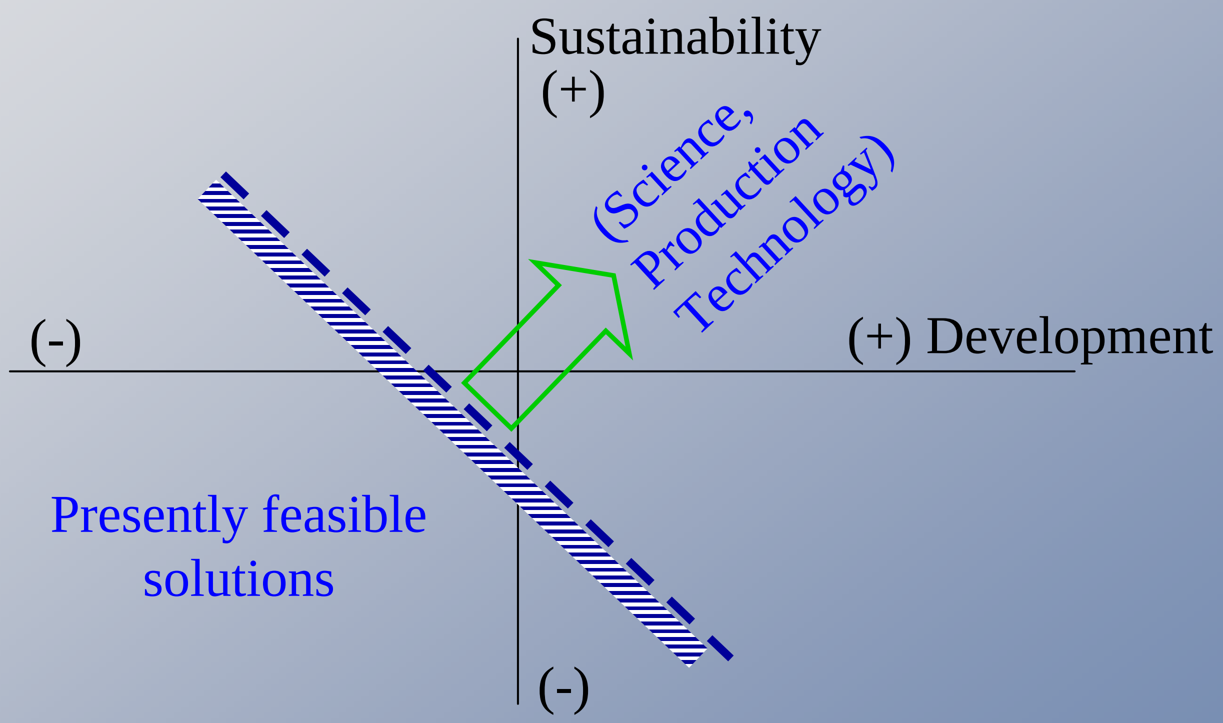
Product-Process Evolution

Sustainable Manufacturing for Sustainable Products

‘Sustainable Development’

(S,D) = 0 : S > 0, D > 0 ?



(Brundtland Commission, United Nation : Commission for Environment and Development)

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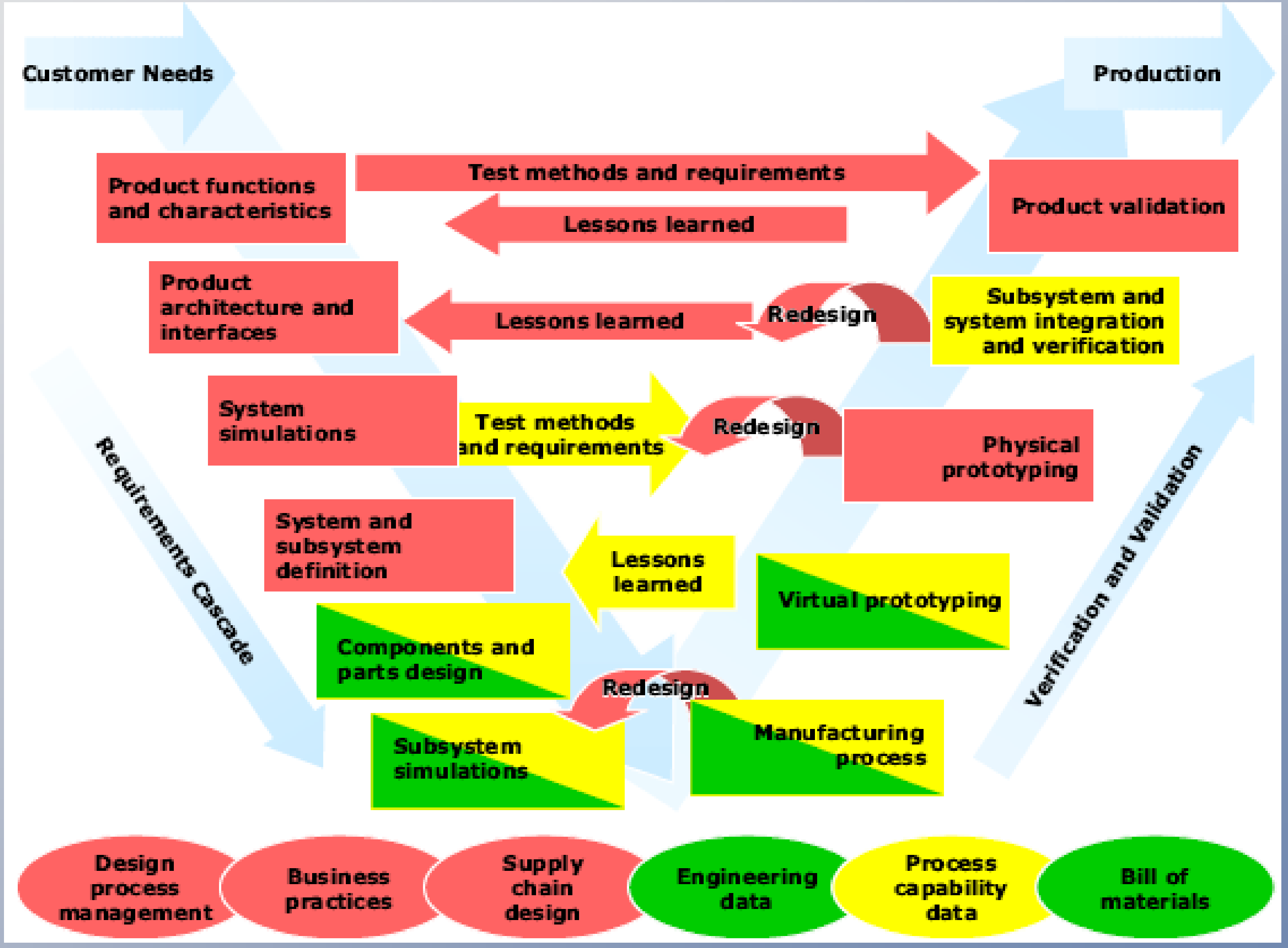
Product-Process Development

Summary of commercially available simulation tools

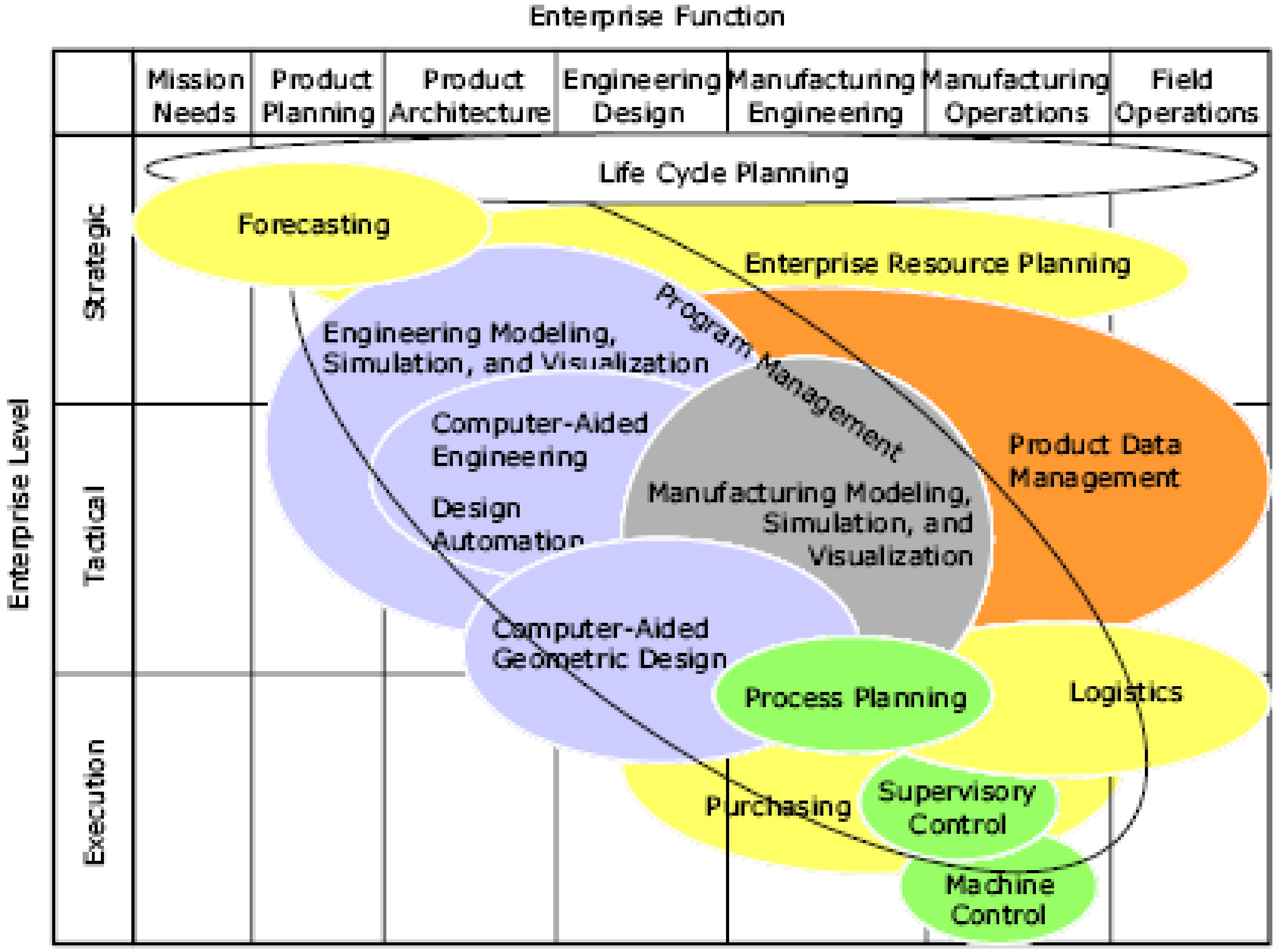
- NOT Available (red)
- Emerging (yellow)
- Common (green)



NAE Report (2004): Retooling manufacturing

Product-Process Development

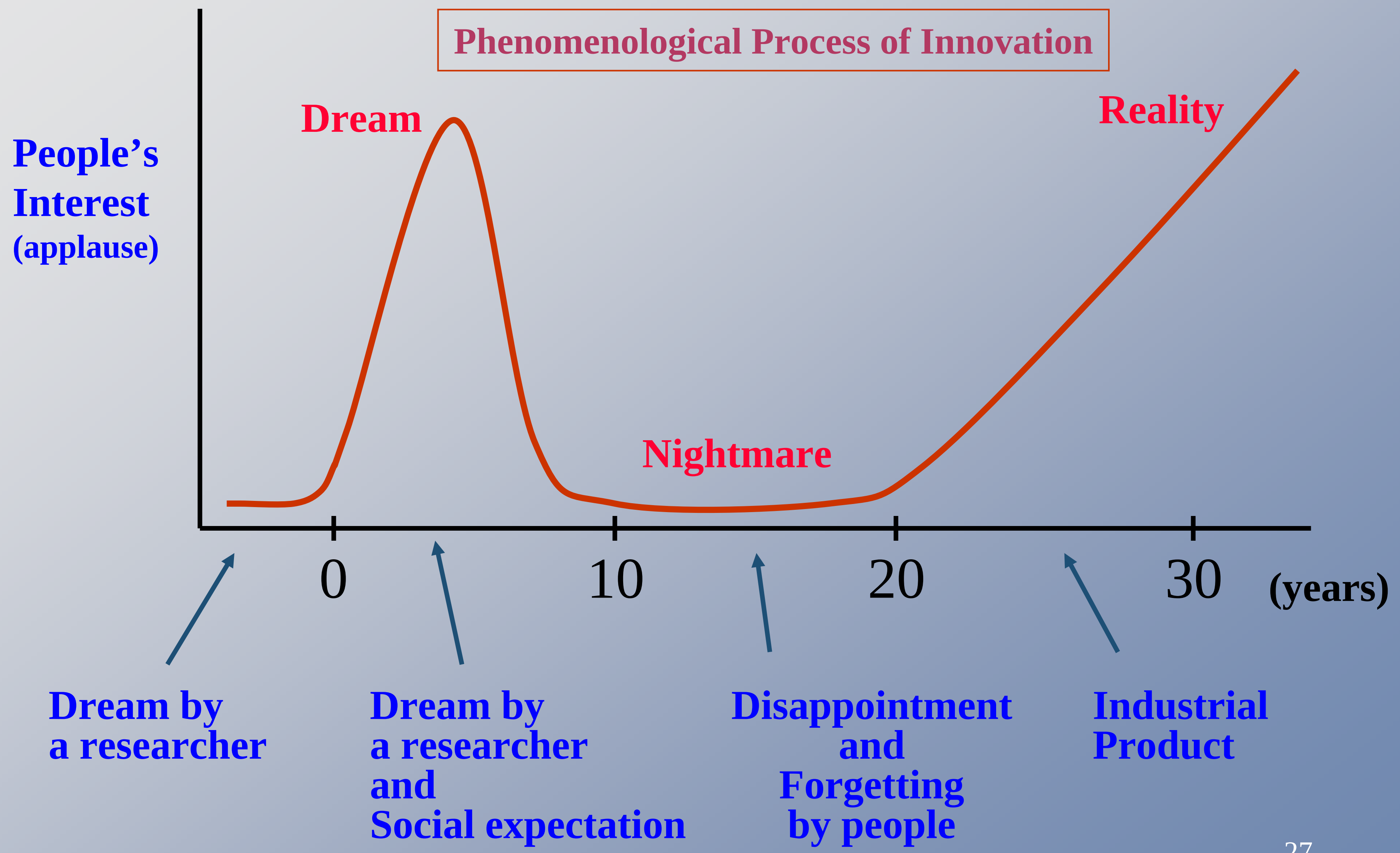
Summary of commercially available simulation tools



Product-Process Development

Technology Development Pattern

Innovation Patterns

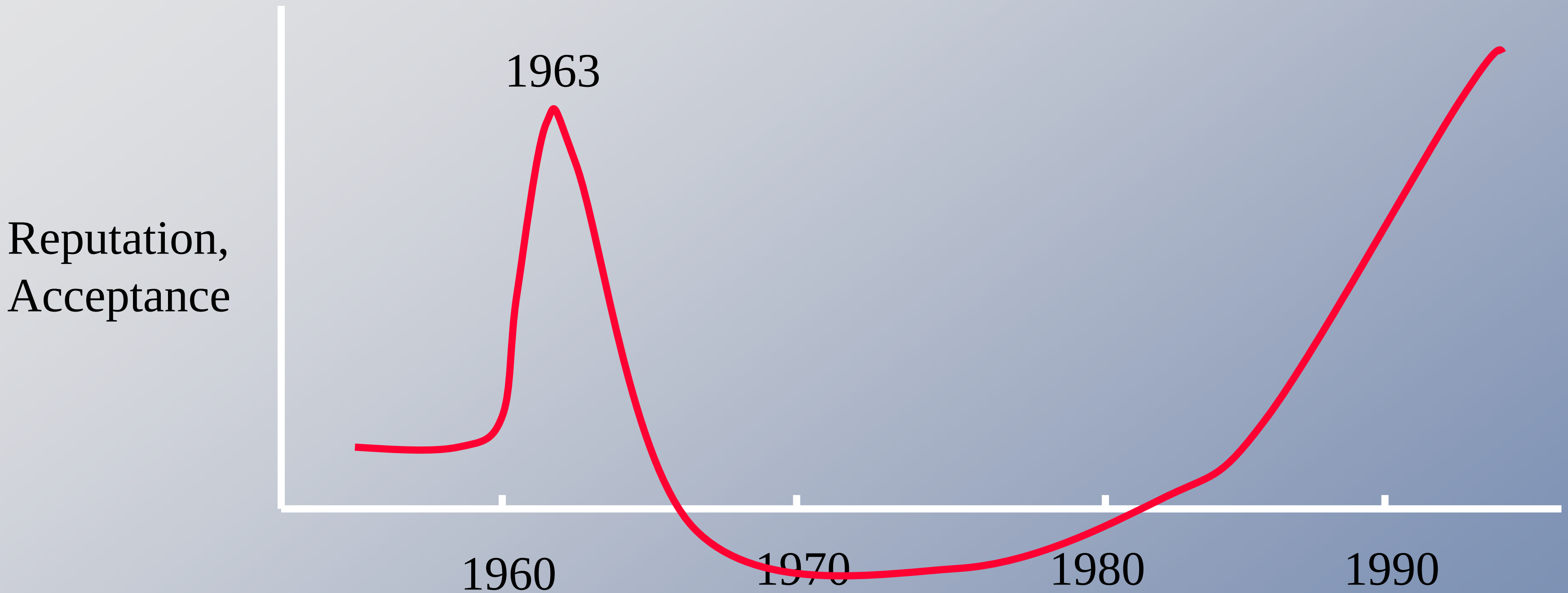


1983 Josef Hatvany, Hiroyuki Yoshikawa

Product-Process Development

Technology Development Pattern

EXAMPLS: CAD proposed by Sutherland (MIT)



Computing machinery
Computer language
Computational geometry
Artificial intelligence
Database technology
Networking

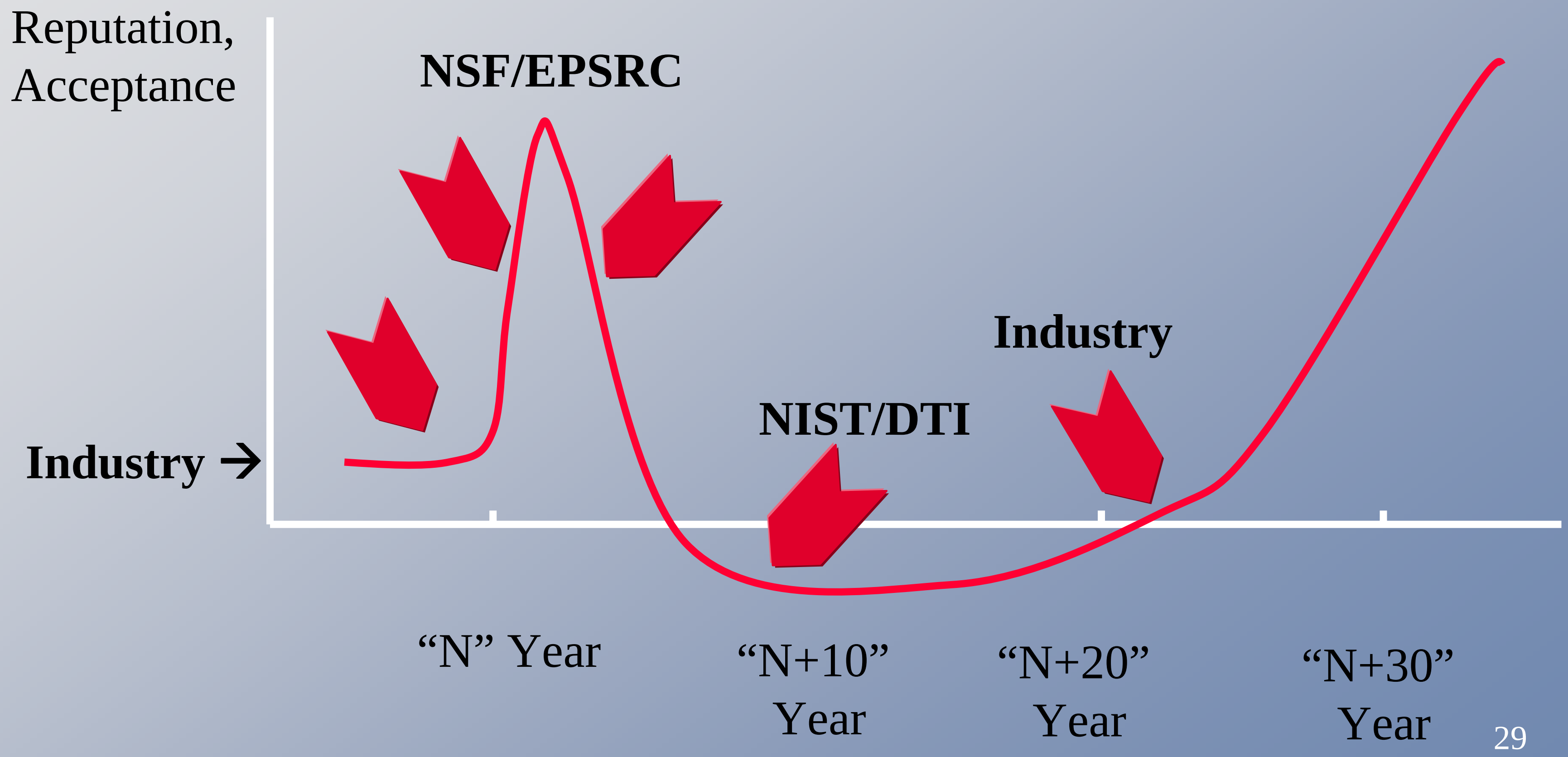
1983 Josef Hatvany, Hiroyuki Yoshikawa

Product-Process Development

Funding Strategy for Technology Development

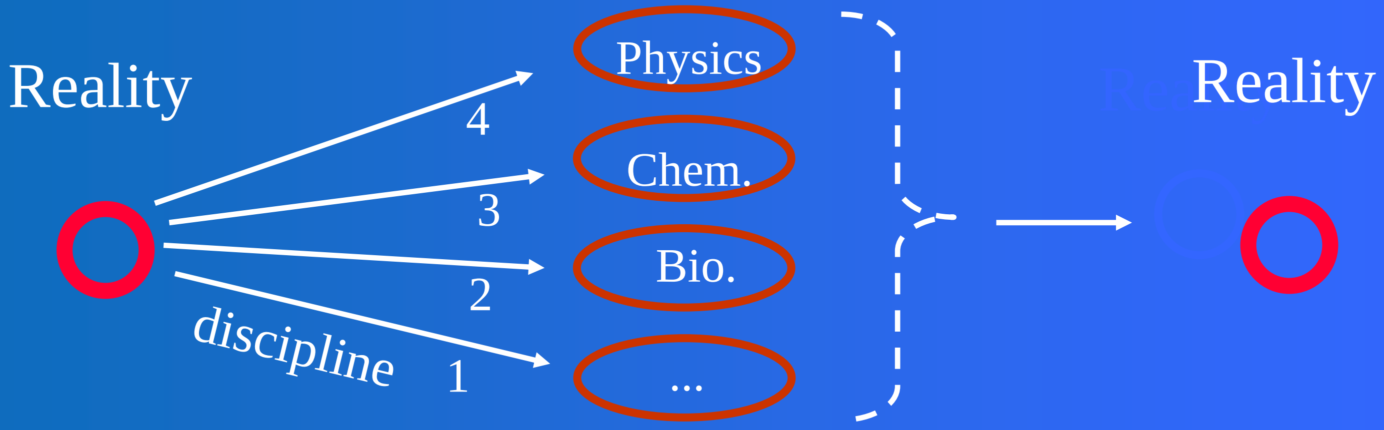
Innovation Patterns

- Incremental Innovation
- Evolutionary Innovation
- Revolutionary Innovation



4. Innovation/Evolution of Product/Production System Paradigm

Asymmetry Between Science and Engineering / Design



disciplinary Laws

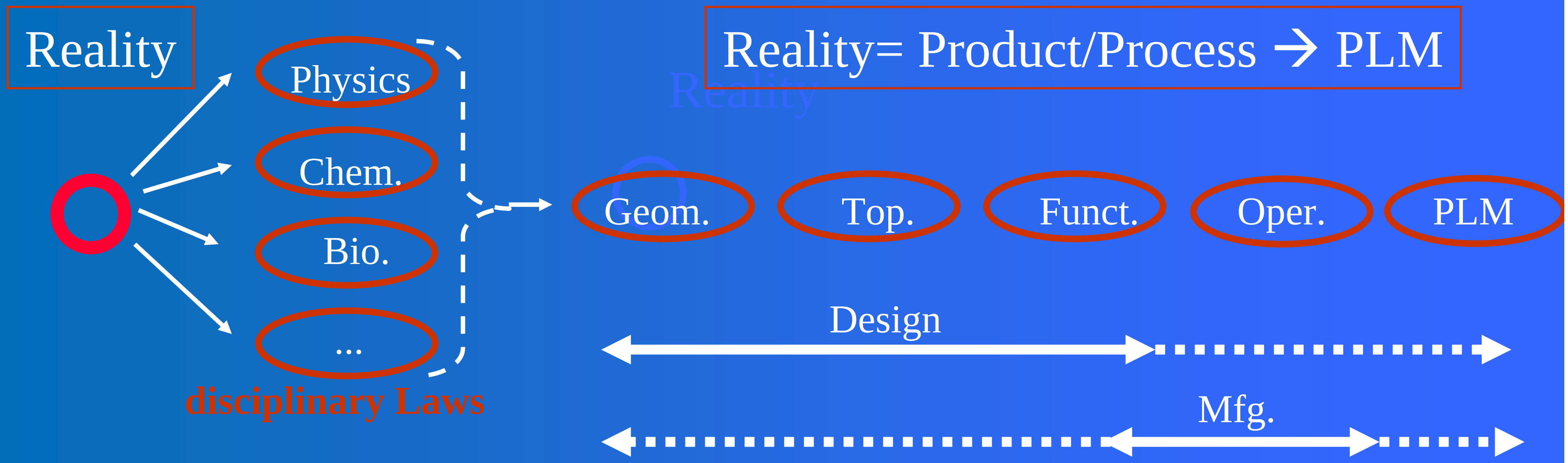
Science for Analysis

Science for Synthesis

MISSING/Incomplete !!!

5. Innovation/Evolution of Product/Production System Paradigms (Cont.)

Engineering / Design Boundaries

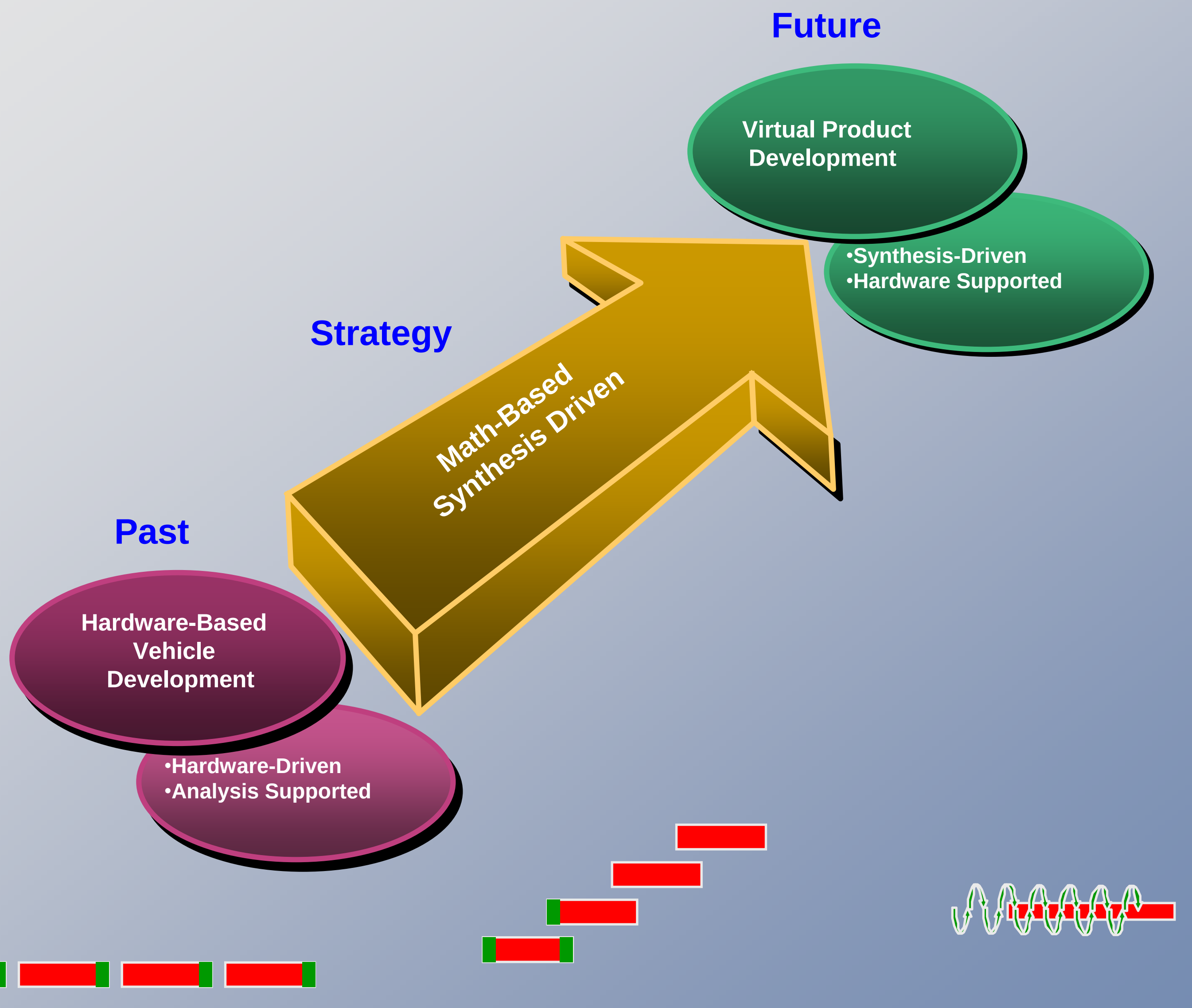


Science for Analysis

Science for Synthesis


Vision
D-PLM: Product-Process Development

Future Directions: Product-Process Development



24-36+ Month VDP

- Consecutive, Hardware Based Learning
- Math Basis for Analysis('Check & Fix')

18-24 Month VDP

- Concurrent, Compressed Hardware Based Learning
- Math Basis for Synthesis (Virtual Builds) and Analysis

<18 Month VDP

- Continuous, Synthesis Based Learning
- Hardware to Confirm Synthesis and Validate Integrated Vehicle

Future Directions: Product-Process Development

INDUSTRY IS TURNING THE

PRODUCT DEVELOPMENT PROCESS UPSIDE DOWN

VIA VIRTUAL!

- ☺ **Tremendous Capability Growth**
- ☺ **Vastly improved IT Infrastructure**
- ☺ **Global Deployment via Standardized Work**

“Ask not what math can be applied to reduce hardware, but rather what hardware is required to confirm my math!”

“. . . The ‘virtual’ car precedes the real one . . . before physical prototypes are created -- and promising, one day, to entirely eliminate them!”

Maryanne N. Keller
“The Evolution of Competitive Advantage in the Auto Industry,”
Keynote at SAE Banquet, February 27, 1997

With Math...

$$L = \int_{t0}^{t1} (T - V)\,dt$$