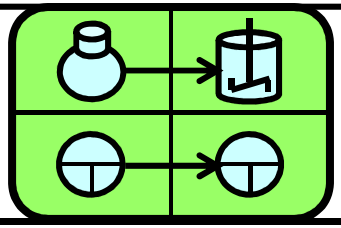
R&D Project Management in the Chemical Industry



The following collection of PowerPoint® Charts is intended to further clarify and supplement the relevant specialist publications on the subject matters dealt with. This collection in no way is used for any commercial purposes, but as learning material for students.

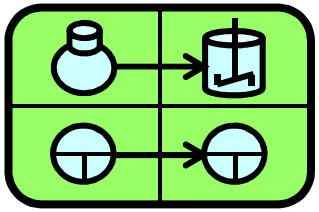
Selected sources for in-depth studies of the respective subject matters are given in some lists of references.

The chemical-technical target components, formulas, deadlines, data, project structures and action plans shown in project examples P1-P3 are widely with a practical orientation, but yet purely fictitious. They are solely used for a clear illustration of the particular topic and for learning purposes.

The names of all persons with project functions are solely fictional. Matches with the names of other people would be purely coincidental.

Rainer Buerstinghaus

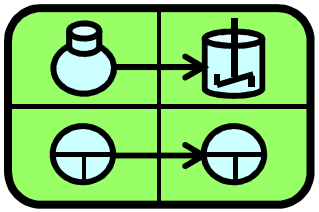
R&D Project Management in the Chemical Industry



The Subject Matter

- Innovations: Characteristics, Measures for its Promotion, Process Variants.
- Three Examples for Innovation Projects (Chemistry and Technology):
  1. Highly Elastic Clear Coats for the OEM Automotive Sector.
  2. Nitrilase Catalyzed Synthesis of a Chiral Hydroxy-Carboxylic Acid.
  3. New Metal-Organic Frameworks for the Adsorptive Storage of Gases.
- **Projects, Target Systems, Project Management in R&D.**
- Appropriate Organization and Effective Structure Planning of R&D Projects.
- Project Flow Planning, Milestones, the Stage-Gate®-Process, Network Diagrams.
- Effective Implementation and Control of R&D Projects, Trend Analyses.
- Success Risks: Identification, Classification and Treatment.
- Recruitment and Lead of Project Staff:
  Chemists (m/f/d) – Team Players, Pacemakers and Executives in Projects.
- Project Manager (m/f/d): Tasks, Leadership Functions and Personality Profile.
- The Systematic Evaluation of Individual R&D Projects.
- R&D Strategy: The Planning of a Project Portfolio.

R&D Project Management in the Chemical Industry



Subject Matter →

Projects.

Projects

Project, Origin of the Word: (→ Latin)

Proiectum (lat.): → The thrown forward.

→ The projected.

Pro: before, for; **Iacere**: throw, fling.

Projectum (17th Century): Draft, plan, intention.

Later (20th Century): Instrument for planning and realization of larger intentions.

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Projects

Big, Realized Projects from the Past.

Construction and Building Projects:

- Construction of the King Pyramids in ancient Egypt.
- Design and construction of the Great Wall in China.
- Building of the Cologne Cathedral by master Gerardius.
- Construction and assembly of the Eiffel Tower in Paris.
- Planning and development of Suez or Panama Canal.
- Construction of the Oeresund Bridge between DK and S.
- Planning and construction of Chongqing Airport (CHN).

Projects

Big, Realized Projects from the Past.

Infrastructure, Space and Military Projects:

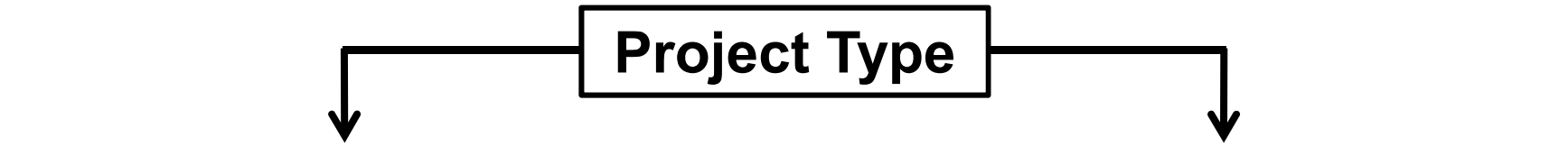
- Building of the East-West Railway in the U. S. A.
- Nationwide Electrification of the U. S. A.
- Installation of an EU-wide 5-G mobile network.

- First Manned Moon Landing: "Apollo11" Mission.
- Exploration of the "Big Gas Planets" with "Voyager".
- Mars Rover "Perseverance", construction and flight.

- Manhattan Engineering District Project (U. S. A.,1941).

Projects

Different Types ("-Projects") in Terms of their Orientation to Targets, Tasks or Sectors:



(Goal/Task Orientation)	(Goal/Sector Orientation)
▪ Research ▪ Development ▪ Investment ▪ Organization ▪ M&A, Divestment	▪ Chemistry ▪ Engineering ▪ Aerospace ▪ Informatics ▪ Telecommunications

DIN 69901−(1−5): Projects are *Unique* Intentions.
Check: ⟶ Routine Operations? / Unique Operations?

Projects

R&D Intentions, Check of Their Project Character:

ROUTINE?	⟷	PROJECT?

Are there pending known process sequences that often repeat themselves (routine) or are there pending *new, one-time process sequences*, combined with unknown results and high changes in dynamics?

Projects

R&D-Intentions, Check of Their Project Character:

Routine: Repetitive Process Sequences.	"Gray Zone": Partial Repetitive Process Sequences.	Non-routine: One-time, New Process Sequences.
▪ Daily planning of laboratory work. ▪ Execution of test series. ▪ Evaluation of the laboratory results. ▪ Reviewing new publications. ▪ Evaluation of disclosed patents.	▪ Introduction of new analysis methods in the production plants. ▪ Testing of alternative synthesis methods in the laboratory. ▪ Preparation of the R & D annual plan, project portfolio.	▪ New GABA-Cl^- Chan.-Modulators. ▪ Highly effective mRNA-Vaccines. ▪ Quantum Computer. ▪ Self-healing polymer layers. ▪ Materials for the H_2−Storage.

Projects

Routine and Non-Routine: ⟶
Both are Necessary for the Success of a Company!

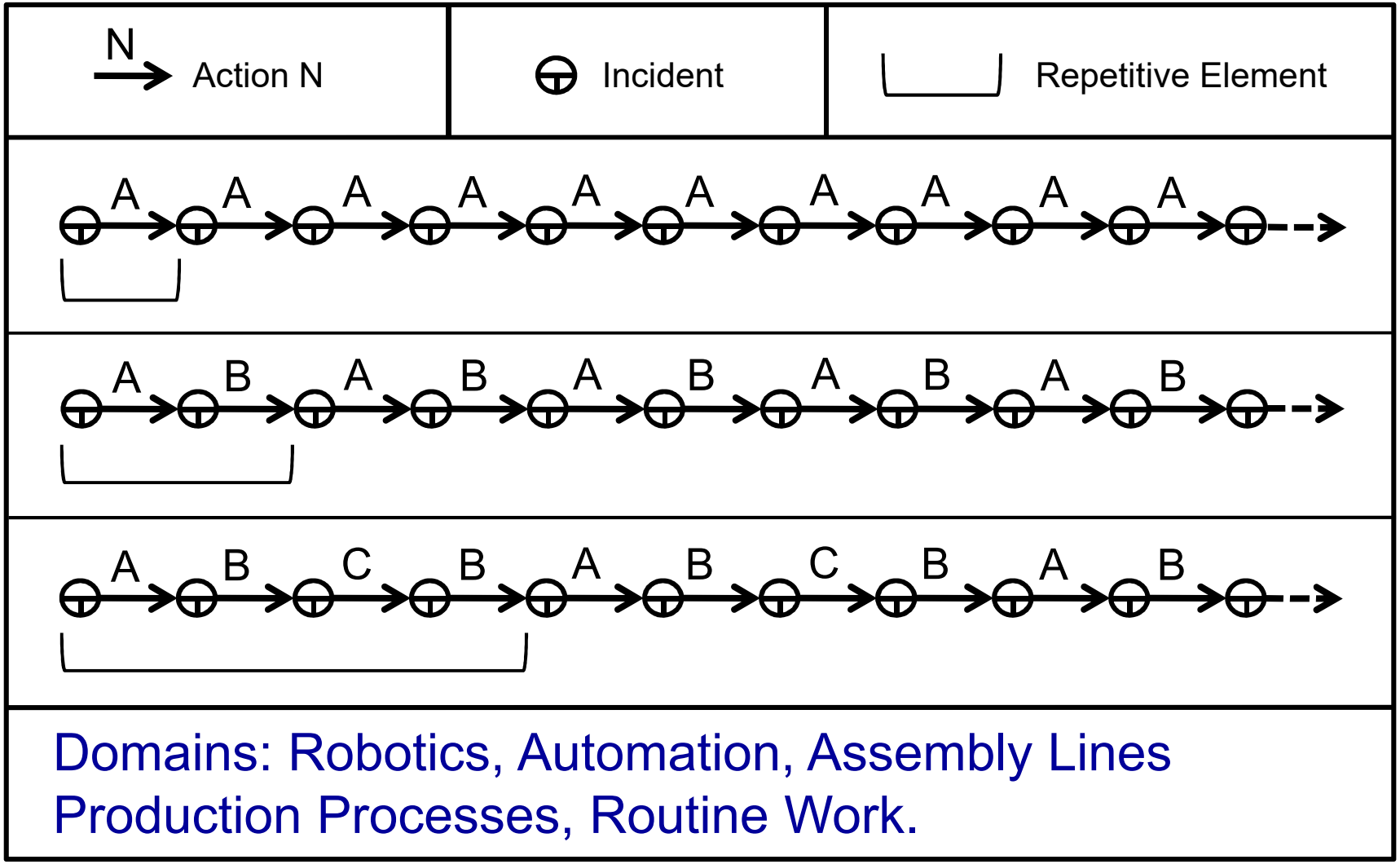
Routine is valuable in order to be efficient and **productive** within the own company!

Renewal and "leaving the beaten tracks" are important in order to remain **attractive** to customers!

Wanted for the emergence and continued existence of successful companies: **Experienced innovators!** ☺

Repetitive Process Sequences:

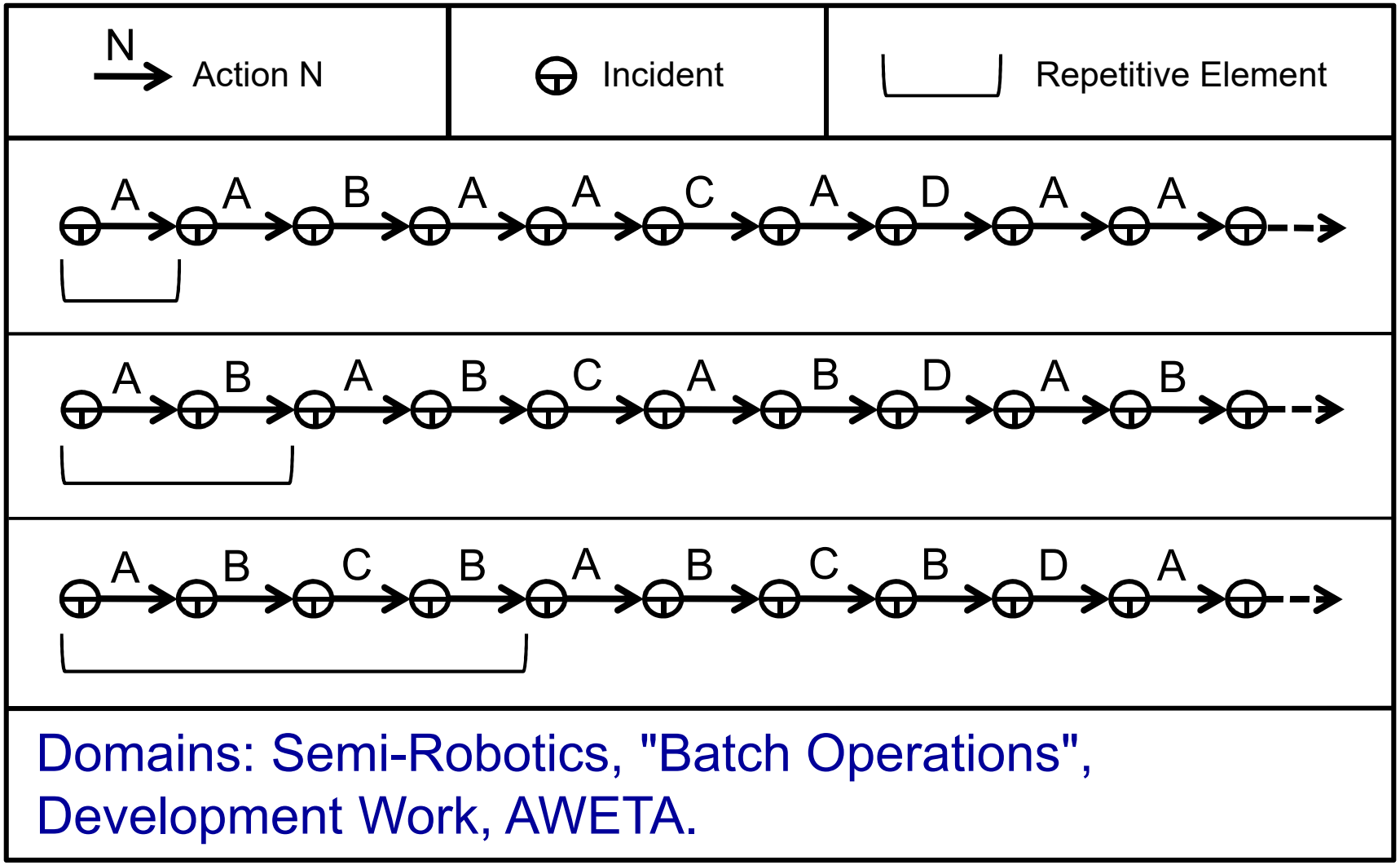
Examples



Domains: Robotics, Automation, Assembly Lines
Production Processes, Routine Work.

Partly Repetitive Process Sequences:

Examples

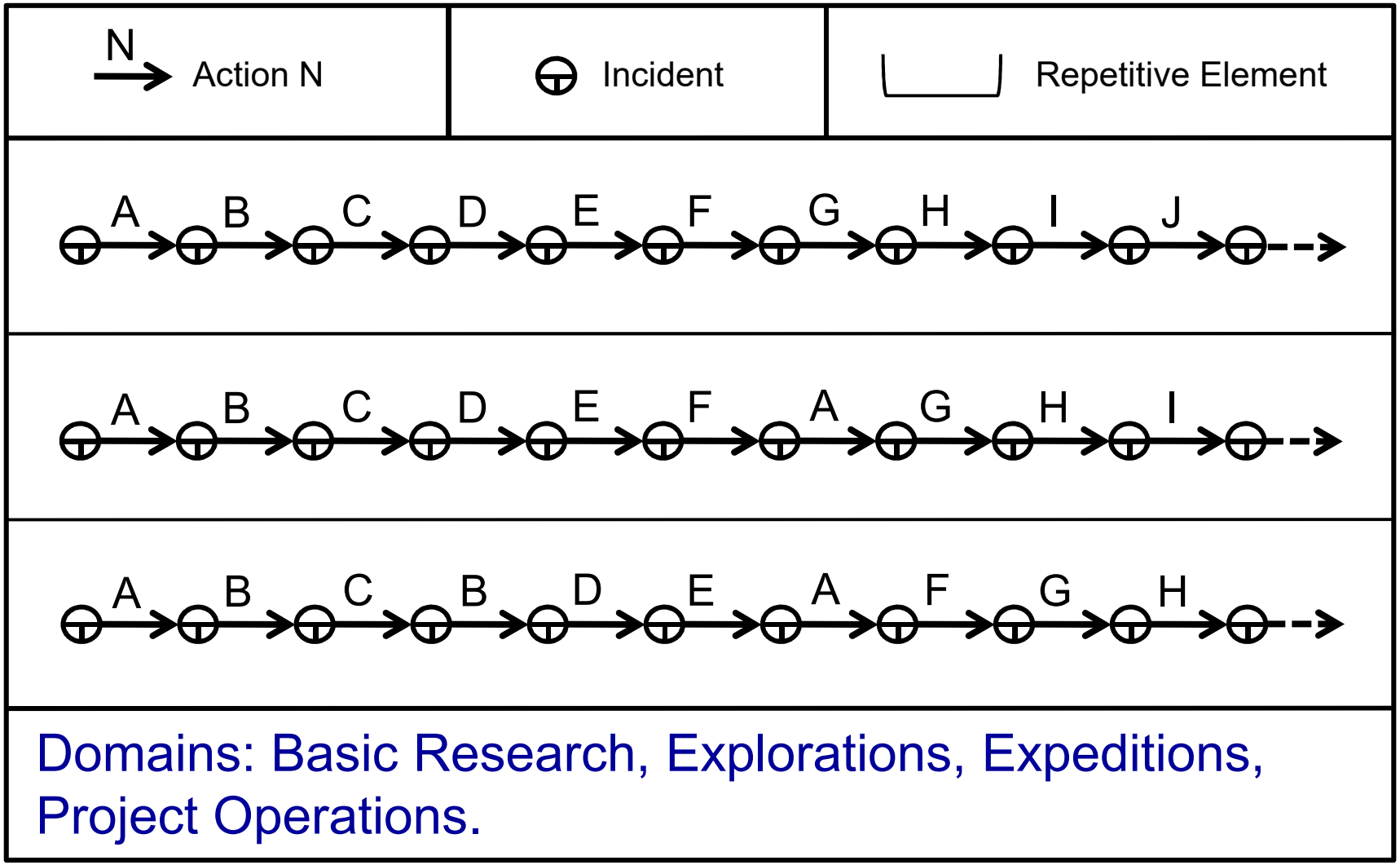


Domains: Semi-Robotics, "Batch Operations", Development Work, AWETA.

Projects

Non Repetitive Process Sequences:

Examples



Domains: Basic Research, Explorations, Expeditions, Project Operations.

Projects

Definition; General Characteristics.

DIN 69901−(1−5) ⟶ Project Definition

Undertaking that is essentially characterized by the uniqueness of the conditions in their entirety.

Projects

Definition; General Characteristics.

Project, More Detailed Definition →

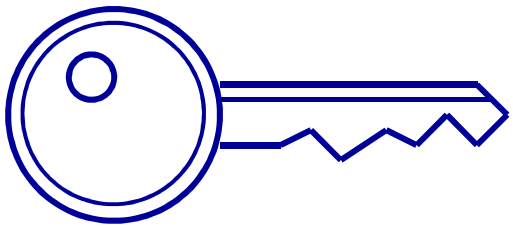
An unique, complex undertaking with limited resources, which is determined in time and is planned and carried out in a cross-functional organizational form in order to achieve a goal that meets defined requirements.

Various Project Types, Relative Shares in Europe (EU):

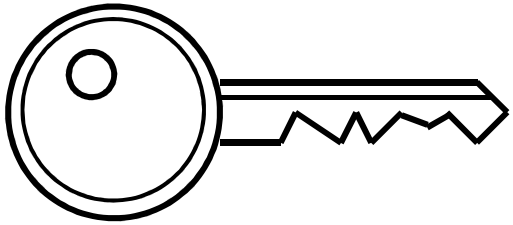
Project Type	Share in the Total Number
Research Projects	→ **about 25%**
Projects in Public Administration	about 10%
Construction / Infrastructure Projects	about 25%
Software Development Projects	about 15%
Product Development Projects	→ **about 10%**
Exhibition/Event Projects (e.g. AChema)	about 05%
Other Project Types: (e.g. Organizational Projects, Media Projects, Art and Cultural Projects)	about 10%

Projects

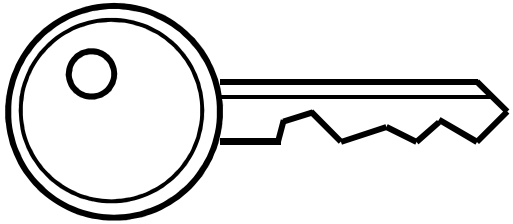
→ **Keys with Strong Operational "Leverage Effects" for the Future Design of Companies!**



R&D Projects → Innovations

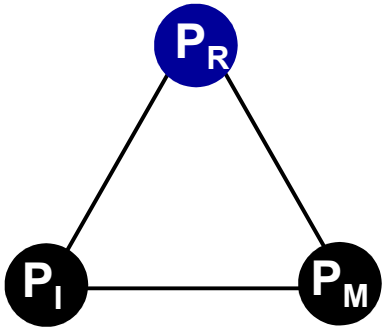


Projects → Investments



Projects → M&A, Divest-ment Activities

Crosslinking of these Three Types of Projects to Shape the Future of Companies!



$(K_3)\begin{bmatrix}3\\2\end{bmatrix}$

P_R	Research and Development Projects
P_I	Investment Projects
P_M	Merger, Acquisition and Divestment Projects

Projects ⟶ Project Types in the Chemical Industry

Investment Projects, Examples:

- Construction of a new laboratory/pilot plant.
- Installation of a laboratory robot (for combinatorics).
- Construction of a high-bay storage for paint raw materials.
- Building of a steam cracker.
- Planning and installation of a device for flue gas desulphurization.
- Construction and realization of a new production plant for acrylic acid.
- Building of a production plant for high-pure silicon.

Projects ⟶ Project Types in the Chemical Industry

Organization Projects, Examples:

- Introduction of a more effective business organization.
- "Realignment" after a big M&A transaction.
- Implementation of R&D project management.
- Establishment of a strategic research alliance.
- Reduction of product variety in OH-polyesters.
- Introduction of a new distribution system for natural gas.
- Installation of online-commerce for stocked chemicals.

Projects ⟶ Project Types in the Chemical Industry

M&A Projects or Divestment Projects, Examples:

- In 2018, BASF SE acquired significant parts of the global seed and the non-selective herbicide businesses from Bayer AG for EUR 5.9 billion.
- Bayer AG buys 100% of its joint venture with Blue Rock Therapeutics L. P. in 2019
- Evonik Industries AG sells its perspex division to the financial investor Advent in 2019 for EUR 3 billion.
- Covestro AG sells its European business with polycarbonate sheets to the Serafin Group in 2020.
- BASF SE acquires the polyamide business from Solvay AG in 2020.

Projects ⟶ Project Types in the Chemical Industry

R&D-Projects, Examples:

- Insecticidal GABA Chloride Channel Modulators.
- New mRNA vaccines against viral infections.
- Protein chip for the selection of highly effective antimalarial substances.
- Microvascular polymer networks for "self-healing" coatings.
- Superconducting "metamaterials" for quantum computers.
- New microreactor systems for high-performance miniplants.
- Display-suitable OLED materials with a long service life.

Projects ⟶ "Pure" Research Projects

Characteristics (⟶ Compare Doctoral Theses!):

- Research projects are conducted to explore specific, delimited research fields.
- They often extend over longer periods (years).
- The weighting of the quality of the experiments (accuracy of each individual experiment!) often exceeds the weighting of the required resources.
- The real project goals and the entire scope of the project are not yet clear at the very beginning.
- Novel activities with an open outcome.
- High dynamics of change in the project parameters.
- Time-consuming, intellectual work is required: Literature studies on the state of science, as well as creative, unconventional approaches to problem solving.

Projects ⟶ Differences to Experiments

Basically Different Starting Positions and Methodical Approaches Within the R&D Domain.

Experiment:
- Results: Initially open
- Methods: Clear and exact

Actionism:
- Results: Unknown
- Methods: Unclear

Line Task:
- Results: Clear
- Methods: Clear, known

Project:
- Results: Clear (Goals!)
- Methods: Initially open

Result: ⟶ What (Goals)? For What (Purpose)?
Methods: ⟶ How (Solutions, Process Sequences)?

Projects ⟶ **Differences to Experiments**

Basic Research, e. g. at Universities and Max Planck-, Helmholtz- or Leibniz-Institutes.

Experiment:
- Results: Initially open
- Methods: Clear and exact

Actionism:
- Results: Unknown
- Methods: Unclear

Line Task:
- Results: Clear
- Methods: Clear, known

Project:
- Results: Clear (Goals!)
- Methods: Initially open

"Anyone who expects, anticipates or even plans *certain* results at the beginning of basic experiments is *not really* doing research!"

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Projects → **Differences to Experiments**

Company-Owned, Cross-Divisional Exploration in Research-Intensive Industrial Companies.

Experiment: ←
- Results: Initially open
- Methods: Clear and exact

Actionism:
- Results: Unknown
- Methods: Unclear

Line Task:
- Results: Clear
- Methods: Clear, known

Project:
- Results: Clear (Goals!)
- Methods: Initially open

Result: → What (Goals)? For What (Purpose)?
Methods: → How (Solutions, Process Sequences)?

Projects ⟶ **Differences to Experiments**

Universities, MPI`s: Projects of Multi-Step Total Syntheses of Stereospecifically Defined, Complex Molecules.

Experiment:
- Results: Initially open
- Methods: Clear and exact

Actionism:
- Results: Unknown
- Methods: Unclear

Line Task:
- Results: Clear
- Methods: Clear, known

Project:
- Results: Clear (Molecule!)
- Methods: Initially open

Result: ⟶ What (Goals)? For What (Purpose)?
Methods: ⟶ How (Solutions, Process Sequences)?

Projects

Research and Development Projects.

⟶ **"R&D Projects", Characteristics:**

Today, 2020

R&D Projects are *the* **entrepreneurial instruments for the realization of inventions in the market (Innovations).**

Such inventions are solutions to problems that are based on the results of (basic) research as well as contain brilliant ideas that come from creative experimenters, designers, "hobbyists"/"tinkerers" or from resourceful market experts (each m/f/d).

Projects

Research and Development Projects.

⟶ **"R&D Projects", Characteristics:**

Today, 2020 (* Technical Steering Committee)

R&D Projects are *the* **instruments for the transformation of research results and inventions into the market .**

R&D projects are approved for implementation by the steering committee (T. S. C. *) of a company on the basis of defined target systems and related business cases. They are mostly planned, implemented and controlled by temporarily organized, transdisciplinary teams.

Projects

Mandatory also in R&D!

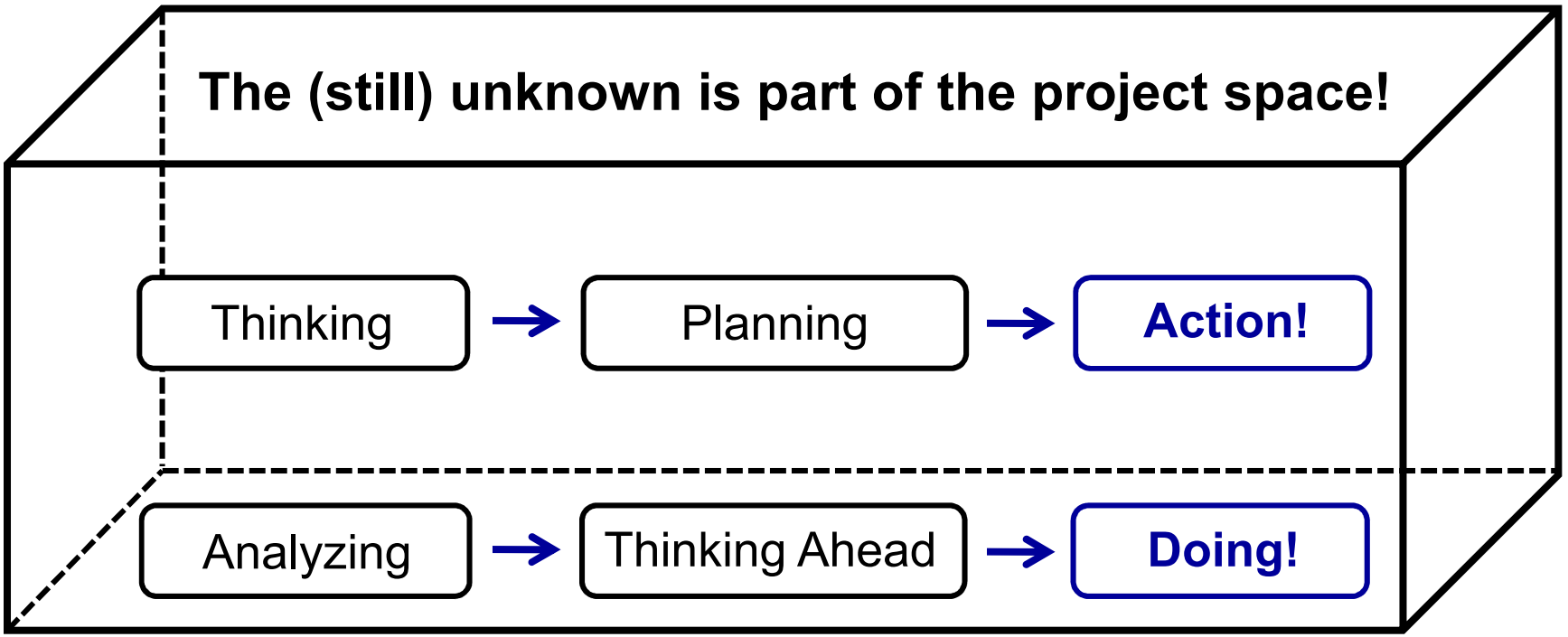
→ **Project Course in Three Defined Phases:**

1. Project Clarification	→ (Analytical) Thinking
2. Project Planning	→ (Forward) Thinking
3. Project Processing	→ Acting!

As of 2010: Increased trend towards project economy "Nothing is more routine – nearly everything becomes a project!"

Projects → Research and Development Project

Invitation to True Entrepreneurial Action!



R&D: Exploration → Idea ☆ → Invention → **Innovation**

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Projects

Typical Project Shares in Industrial Research and Development Activities:

Research →

- Approximately 2/3 Basic Function (Goal: Effectivity as initiators and impulse generators for innovations).
- **Approximately 1/3 Projects (Goal: Innovations).**

Development →

- **Approximately 2/3 Projects (Goal: Innovations).**
- Approximately 1/3 Basic Function (Goals: Professional chemical-technical service and customer satisfaction).

Projects

Different Core Tasks and Performance Factors in R&D Projects!

Research ⟶

- **Knowledge Gain, Problem-Solving, Identification of Goals (!)**

- Exploration culture, "curiosity“.
- Broad access to information; Completeness of communication.
- Teams with a high degree of transdisciplinary networking.

Development ⟶

- **Optimization, "Fine-Tuning" and Rapid Processing.**

- Innovation culture with a strict customer orientation.
- Suitable and progressive methods and equipment.
- Sound flow planning, consistent controlling.

Projects

Characteristics of R&D Projects: ($\wedge$ → Conjunction!)

- Target Agreements: → Target System →  (K_3) ($\wedge$)

- Limited Time Frame. ($\wedge$)
- Novely, Uniqueness, Actions away from the Routine. ($\wedge$)
- Limited Resources and Equipment. ($\wedge$)
- Complexity of Structure and Processes. ($\wedge$)
- Specific Organizational Form(s) Required. ($\wedge$)
- Transdisciplinary Cooperation. ($\wedge$)
- Uncertainties, Risks. ($\wedge$)

- Open Exploration/Experimental Fields. ($\wedge$)
- High Dynamic with Changes.

} **R&D!**

Projects → Characteristics of R&D-Projects

Target Agreements, Target System.

Concrete:

- Technical targets.
- Temporal targets.
- Economic targets.

- Complete linkage of these three target species.
- Target agreements always with the most important internal and external stakeholders or partners.

Projects ⟶ Characteristics of R&D-Projects

Limited Time Frame.

Concrete:

- Defined time (date) of the project start.
- Defined time (date) of the project end.

Projects ⟶ Characteristics of R&D-Projects

Novelty, Uniqueness, Actions away from the Routine.

Concrete:

- The sequence of actions in the project does not follow a rigid, predetermined scheme or a previously defined algorithm.

- New scientific-technical insights and "surprising" inventions are often the basis of highly specific actions in the project.

Projects ⟶ Characteristics of R&D-Projects

Limited Resources and Equipment.

Concrete:

- People with excellent technical expertise.
- Their "availability" by the specialist department.

- Highly specific measuring/analysis devices.
- (Laboratory) Apparatuses / Technical facilities.
- Sufficient financial budget.

Projects ⟶ Characteristics of R&D-Projects

R&D-Projects, Resources (Budget) as f(Project Size):

Project Size	Budget	Work Packages
Small: ≤ 025 FTE	≤ 005.000.000 €	≤ 0050 WP
Medium: ≈ 125 FTE	≈ 025.000.000 €	≈ 0250 WP
Big: ≥ 500 FTE	≥ 100.000.000 €	≥ 1000 WP

FTE = Full Time Equivalent (One employee for one year)
Costs ⟶ NE: ≈ 240.000 €; TE: ≈ 160.000 €.

NE: Non-Tariff Employee
TE: Tariff Employee

WP = Work Package, Single Task in One Specialized Unit.

Projects ⟶ Characteristics of R&D-Projects

Complexity of Structures and Processes.

Concrete:

- Branched project structures:
  Subprojects, main and secondary tasks.

- Large number of participating organizational units with various functions, each with high degrees of specialization and with different paradigms.

- Hardly manageable project sequences:
  Crosslinking and interdependencies of many individual processes. Numerous simultaneous activities.

Specific Organizational Form(s) Required.

Concrete:

- Suitable, defined organizational structure.
- Suitable, defined process organization.

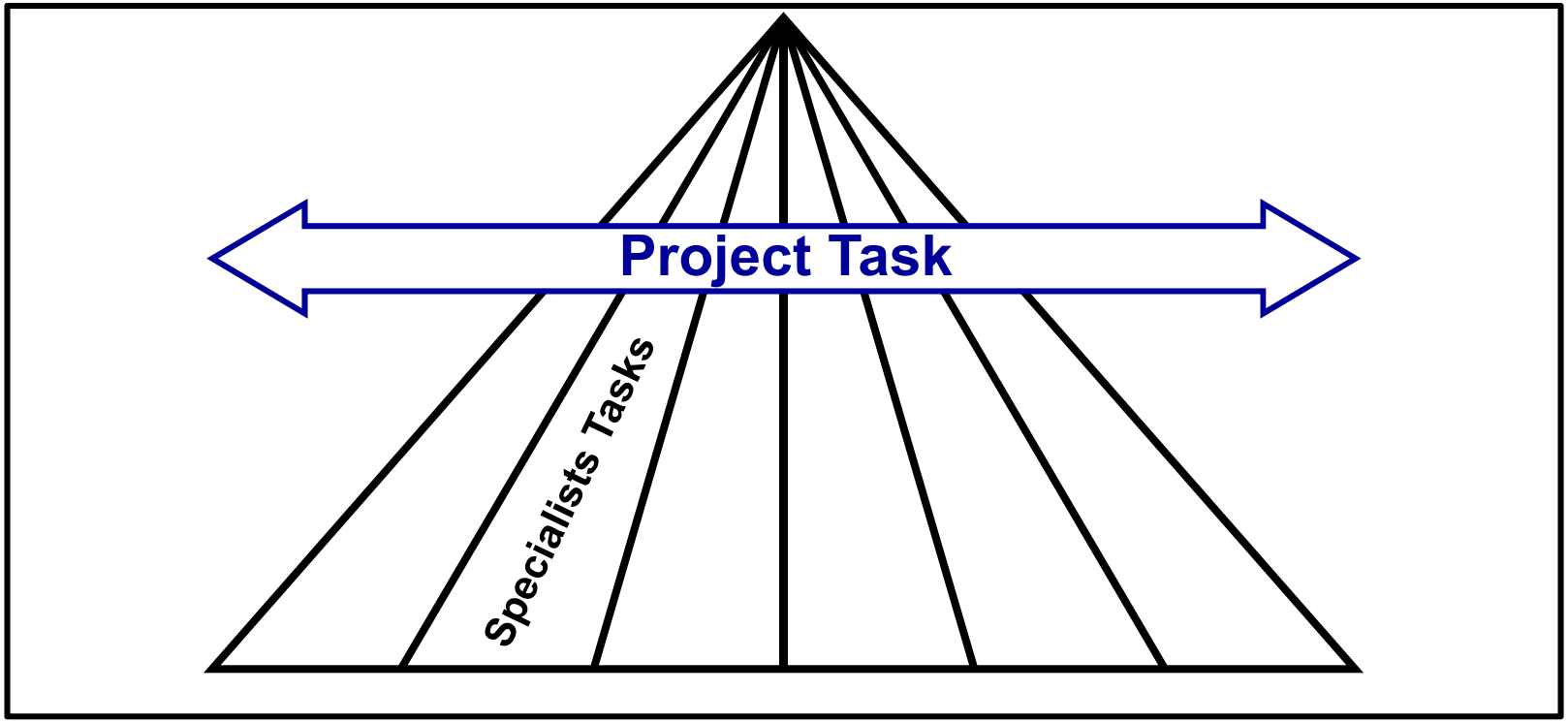
Projects ⟶ Characteristics of R&D-Projects

Transdisciplinary Cooperation.

Concrete:

- People from different disciplines work together in various functions.
- Several companies from different sectors are involved (subcontractors, consortia, working groups, etc.).
- The communication between different subject matter experts is indispensable and critical to success.

R&D-Project Work – Transdisciplinarity:



Attention!

Different interests between line management and project management!

Projects ⟶ Characteristics of R&D-Projects

R&D-Project Work – Transdisciplinarity:

"Senders" of Thought-Provoking, Effective Impulses

- Chemists
- Physicists
- IT-Specialists
- Mathematicians
- Engineers

- Biologists
- Agronomists
- Doctors
- Pharmacists
- Toxicologists

- Merchants
- Lawyers

- Economists
- Other Professionals

Projects → Characteristics of R&D-Projects

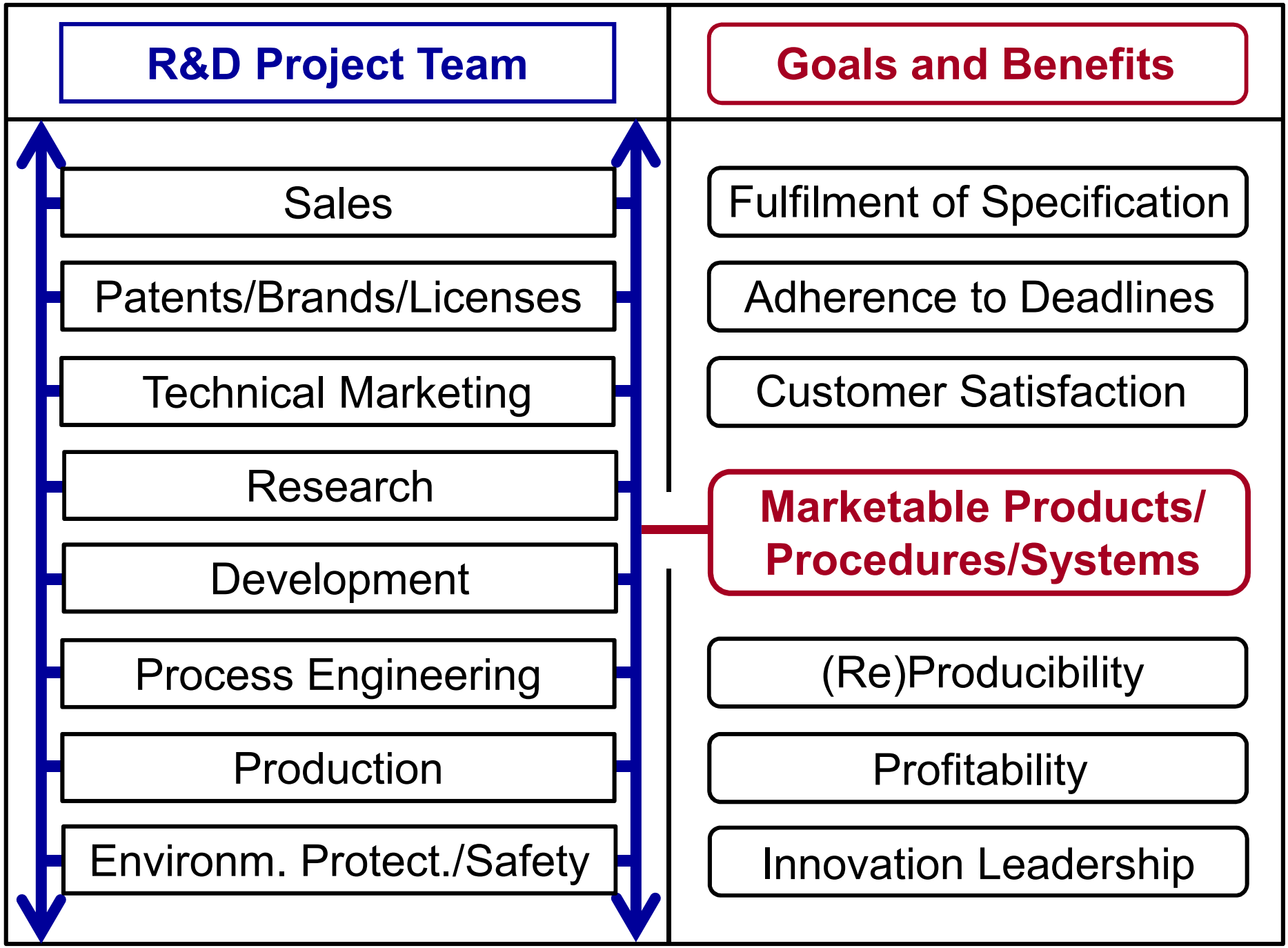
Typical Project Participants in the Chemical Industry:

Professional Experts

- Chemists
- Physicists
- Biologists
- Agronomists
- Economists
- Merchants
- Engineers
- Lawyers
- Journalists

"Function Holders"

- Researcher/Developer
- Process Engineer
- Safety Specialists
- Environmental Experts
- QM-Experts
- Producers
- Lab Analysts
- Application Technicians
- Marketing Professionals



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Projects ⟶ Characteristics of R&D-Projects

Uncertainties, Risiks.

Concrete:

- Real exploration automatically entails uncertainties: Chemical-technical realization risks, deadline risks, expense risks (costs), legal risks, risks of misuse, acceptance risks and / or environmental risks.

- Risks must always be taken when entering new territory. Their "minimization": Through professional risk management!

Projects ⟶ Characteristics of R&D-Projects

Open Exploration / Experimental Fields.

Concrete:

- Chemical-technical experiments are carried out in a precise and very exact manner, however, often with open and unpredictable results.

- Many project-tied R&D activities break *new ground,* scientific and technical.

Projects ⟶ Characteristics of R&D-Projects

High Dynamics of Change.

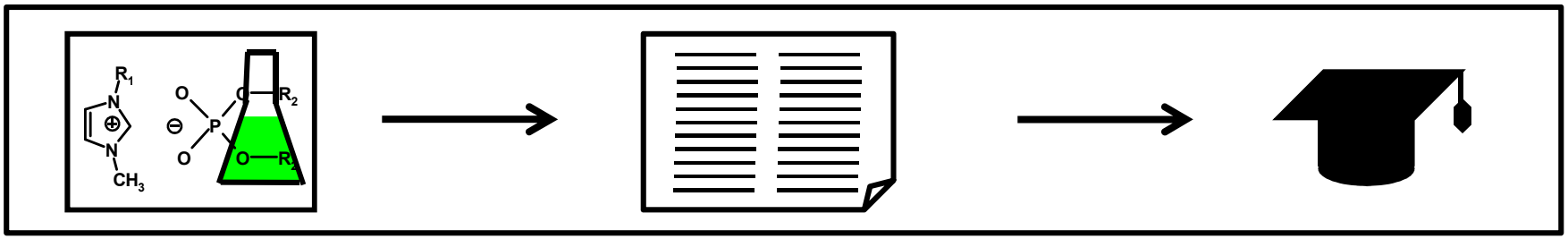
Concrete:

- *Research:* Continuous progression of the "State of science". Numerous, worldwide publications on new methods (syntheses, analyzes) and findings.

- *Development:* Change of specific customer requirements and the related volatility of the target markets. "Design changes" during the project period are not rare. Continuous progress of the prior art.

Your Doctoral Thesis as a Research Project (?): Check of the Corresponding Characteristics.

Target System?	
Limited Time Frame?	
Limited Resources?	
Novelty?	
Uncertainties?	
Uniqueness?	
Complexity?	
Dynamic of Changes?	
Transdisciplinarity?	



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Your Doctoral Thesis as a Research Project (?): Check of the Corresponding Characteristics.

Target System?	**Yes !: Signed doctoral certificate. Accepted publication text. Deadline: Until 31.08.2024.**
Limited Time Frame?	Yes! (Duration of the scholarship/employment)
Limited Resources?	Yes! (Scholarship or job budget)
Novelty?	Yes! (Indispensability of a dissertation)
Uncertainties?	Absolutely! (Failed experiments)
Uniqueness?	Yes! (Indispensability of a dissertation)
Complexity?	Yes! (Structuring of all experimental findings)
Dynamic of Changes?	Absolutely! (Unexpected research results)
Transdisciplinarity?	Almost always! (Cooperations in CRCs/GCs,..)

Involved Parties: Doctoral candidate; Professor (s); other Ph.D. students; Analytical laboratory; Spectroscopy; Equipment Storage/Dispensing; Chemical storage; Safety officers; Laboratory service providers; Laboratory cleaners; Librarian; Examiners of other subjects; Examinations office.

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1. Highly Elastic Clear Coats for the OEM Automotive Sector

Example P1

Indicators for the Project Character:

- Target Agreements: Chemical-technical √ , temporal √ , economic √ , see "specification sheet".
- Limited Time Frame: Project period: 3,0 Years (Project start − Project end).
- Uniqueness, Novelty: Not yet described or realized, off-patent, ⟶ "pioneer character".
- Limited Resources: 29 FTE (ø) per year (11 NE; 18 TE), Project budget: 19,8 Millions €, of which 3,2 Millions € for the equipment.

1. Highly Elastic Clear Coats for the OEM Automotive Sector

Example P1

Indicators for the Project Character:

- Complexity:
  Simultaneous actions in R&D, production, as well as at the selected pilot automobile producer.
- Specific Organizational Form:
  Transcompany-Project ([…GmbH1], [Automotive…AG1], [Conveyor…AG2], Fraunhofer-Gesellschaft, et al, are represented in the project team and in the steering committee, respectively).
- Transdisziplinarity:
  Chemists, physicists, engineers, economists, merchants, etc., work together.

1. Highly Elastic Clear Coats for the OEM Automotive Sector

Example P1

Indicators for the Project Character:

- Exploration Fields:
  Clarification of hitherto unknown structure-property correlations.
- Uncertainties, Risks:
  Active competitors with newly disclosed key patents.
  Possibly high investment costs for the customer.
- High Dynamics of Changes:
  Deadline changes (Period reductions!) by the customer during the project period are likely.

2. Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid

Example P2

Indicators for the Project Character:

- Target Agreements:
  Chemical-technical √, temporal √, economic √,
  see "specification tableau" with target system.
- Limited Time Frame:
  Project period: 4,6 Years (Project Start − Project End).
- Uniqueness, Novelty:
  Nitrilase has not yet been applied for the stereospecific synthesis of aliphatic α-hydroxy-carboxylic acids on an industrial scale: the target product has a pioneering and a pilot character.
- Limited Resources:
  15,0 FTE (ø) per year (5,0 NE; 10,0 TE); Project budget: 20,2 million €, thereof 7,3 million € for materials.

2. Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid

Example P2

Indicators for the Project Character:

- Complexity:
  Simultaneous actions in R & D (chemistry, microbiology, analytics, biophysics), in the technical biotransformation plants, as well as at pilot customers.
- Specific Organization:
  "Pool Organization" with integration of highly specialized functions.
- Transdisciplinarity:
  (Bio)Chemists, microbiologists, (bio) physicists, engineers, merchants, business economists, etc.

2. Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid

Example P2

Indicators for the Project Character:

- Exploration Fields:
  Expression of hitherto unknown DNA recombinants to new enzymes, clarification of hitherto unknown structural (base sequences) activity correlations.
- Uncertainties, Risks:
  Handling genetically modified, labile microorganisms; Problems with introns and/or foreign codons in the host organism.
- High Dynamics of Changes:
  Fluctuations in selectivity, activity, stability of microorganisms and nitrilases.

3. New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas

Example P3

Indicators for the (Sub)Project Character:

- Target Agreements: Chemical-technical √, temporal √, economic √, see "specification sheet".
- Limited Time Frame: Project period: 4,5 years (Project Start − Project End).
- Uniqueness, Novelty: Until today not yet realized with the desired storage capacity on an industrial scale.
- Limited Resources: 16,3 FTE (ø) per year (6,3 NE; 10 TE) Project budget: 17,3 million €, thereof 3,3 million € for materials.

3. New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas

Example P3

Indicators for the (Sub)Project Character:

- Complexity:
  Simultaneous actions in R&D, in the in-house pilot plant, as well as at the participating fuel cell producer as a subsequent customer.
- Specific Organization:
  "Pool organization" in the own company, follow-up project (efficiency/energy efficiency) provided by a pilot company.
- Transdisziplinarity:
  Chemists, physicists, materials scientists, engineers, business managers, etc.

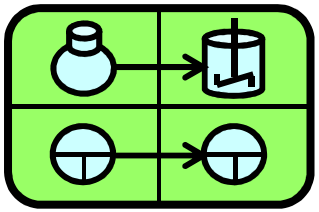
3. New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas

Example P3

Indicators for the (Sub)Project Character:

- Exploration Fields:
  Clarification of hitherto unknown structure-property correlations.
- Uncertainties, Risks:
  Toxicological properties of the most active materials (toxic/carcinogenic heavy metals?), flammability, a. o.
- High Dynamic of Changes:
  Changes during the scale-up (In particular during the drying processes).

R&D Project Management in the Chemical Industry



Subject Matter →

Target Systems.

Rainer Buerstinghaus

Target Systems

Goals, Strategic Importance.

"The slowest person who never loses sight of his goal always goes faster than one who wanders around aimlessly!"

(According to Gotthold Ephraim Lessing)

"When we lost sight of the goal,
we redoubled our efforts."

(According to Mark Twain)

Target Systems	**Goals, Strategic Importance.**

"If you want to live a happy life, tie it to goals, not to people or things."

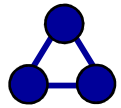
(According to Albert Einstein)

Targeted research and development ⟶

The R&D goals must be *internalized* from each individual project actor, not just exist "externalized"!

This means that the objectives for research projects must not come exclusively from third parties, and the achievement of these goals must not be monitored only externally (For example, by controllers or stakeholders).

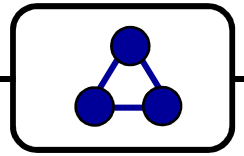
Target Agreements, Target System:



- **Target system:** All striven and interdependent results, which have to be *definitely* achieved by the actions of *all* project participants.

- The **definition** takes place involving the participation and involvement of *all* experts required in the project. They need to be known by *all*, and must be supported and internalized by *all* those interested in the project results (internal and external stakeholders).

Target Systems



→ Target Agreements, Target System.

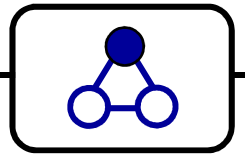
The target system always covers the following, completely interconnected three components ("3-clique"):

- **Chemical-Technical Target Components (P):**
  Product properties; Process characteristics;
  "Product features": Exact qualitative and quantitative description of the new product or process.

- **Temporal Target Components (T):**
  Compliance with “milestone agreements“.

- **Economic Target Components (E):**
  Operating income, contribution margins, market shares of the resulting products in defined periods;
  Compliance with the agreed project budget.

Target Systems



→ **Target Agreements, Chemical-Technical.**

Important: Measurability and verifiability of the attainment for each chemical-technical goal!

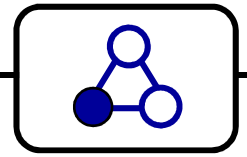
- Number + physical quantity.
- Fulfillment of a standard (DIN, CEN, ASTM, ANSI). Standard (No.) fulfilled: yes/no: Measured values.
- Minimum statement in a research project: All planned/relevant work packages were professionally and accurately carried out, and fully documented with the related results.

Target Systems

→ Target Agreements, Standardization Organizations:

Standard	Institution, Official Designation, Country.
DIN	Deutsches Institut für Normung e.V., **D**
CEN	Comité Europeen de Normalisation, **B**
CENELEC	Comité Européen de Normalisation Électrotechnique, **B**
ETSI	European Telecommunications Standards Institute, **F**
ISO	International Standardization Organization, **CH**
ASTM	American Society for Testing and Materials, **U. S. A.**
ANSI	American National Standards Institute, **U. S. A.**

Target Systems

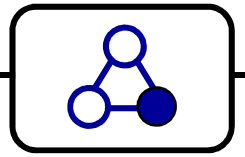


→ **Target Agreements, Temporal.**

Important: Measurability and verifiability of the attainment for each temporal goal!

- On-time project end (*Target date*).
- Duration of the project (*Period* between the beginning of the project and the end of the project), as well as "time to market" requirements.
- Timely achievement of defined milestones or sub-project goals.

Target Systems



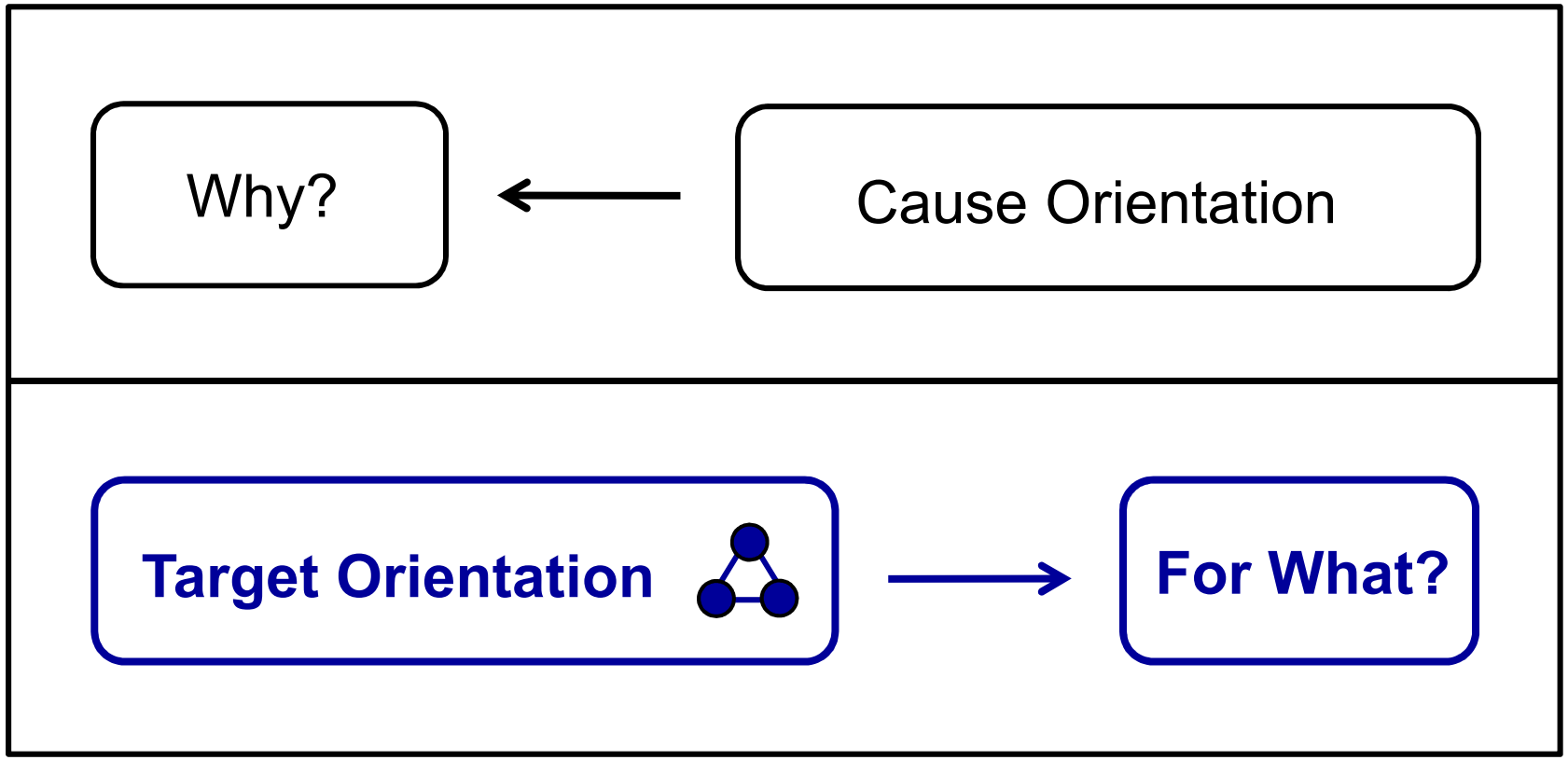
→ Target Agreements, Economic:

Important: Measurability and verifiability of the attainment for each economic goal!

- Reliable figures on earnings, increases in sales, growth in market shares, contribution margins or earnings contributions from new products and/or process improvements.
- Budget compliance:
  Final result on the account of the project cost center (Surpluses, *no* serious underfundings).

Target Systems

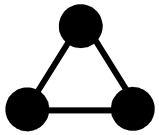
Target Orientation: Application Purpose in Focus!



Target Systems → **Target Orientation.**

"Ethical Framework" for Striven Innovations:

Target System



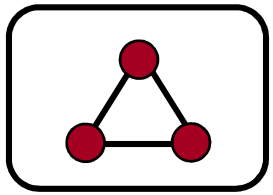
For What?

- Benefits for the people.
- Safety during application.
- Environmental compatibility.
- Climate protecting features.
- Consistently high quality.
- Reasonable purchase price.
- Fair production conditions.
- Legitimated supply chains.
- Low risk of abuse.

Rainer Buerstinghaus

Example P1

Target Agreements (Partial View):



Project	**"Highly Elastic Clear Coats for the OEM Automotive Sector".**
	→

Target Agreements: Highly Elastic Clear Coats…

Technical Components (P, Excerpt):

- Gloss retention of the clear coats, AMTEC-Kistler-test: >90%.
- Nanoindentation-test: 95% Elastic recovery (AFM, at $\vec{F}$ = 80 µN).
- Elasticity of the 4-layer structure (Erichsen-test DIN-ISO 1520): 3,5 mm.
- UV-Resistance: 2000h UVcon-A (λ ≥ 320 nm), UVcon-B (λ ≥ 280 nm).
- Adhesion to the base coats, 20ºC; Cross-hatch test (DIN-ISO 2409): 0. → →

Temporal Components (T, Excerpt):

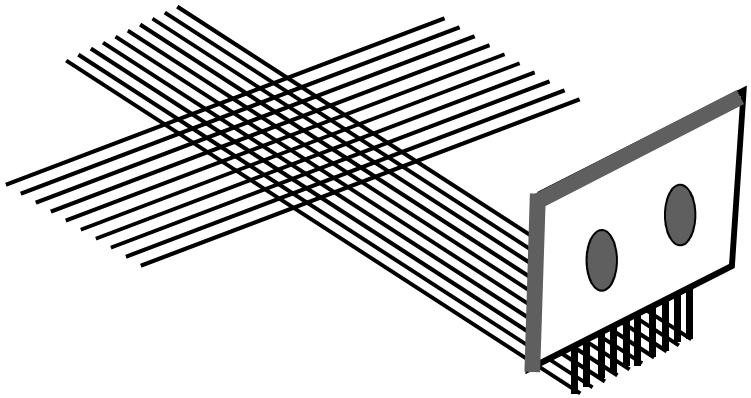
- Project Start: 01.08.2019; Project End: 31.07. 2022. → →

Economic Components (E, Excerpt):

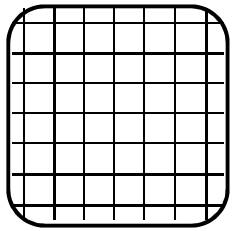
- Market share for automotive-OEM clear coats within EU: 35%.
- System supplier at [Automotive…AG1], assembly line Munich.
- Project costs: 19.800.000 €; Return of investment period: From 01.04.2025.
- Production costs of the clear coat: Maximum of 5,70 €/kg. → →

Target Agreements: Highly Elastic Clear Coats…

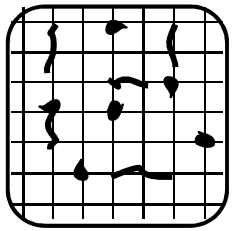
Cross-Hatch Test DIN ISO 2409, Adhesion to the Ground:



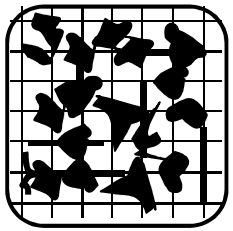
Multi Cutting Device



Gt 0



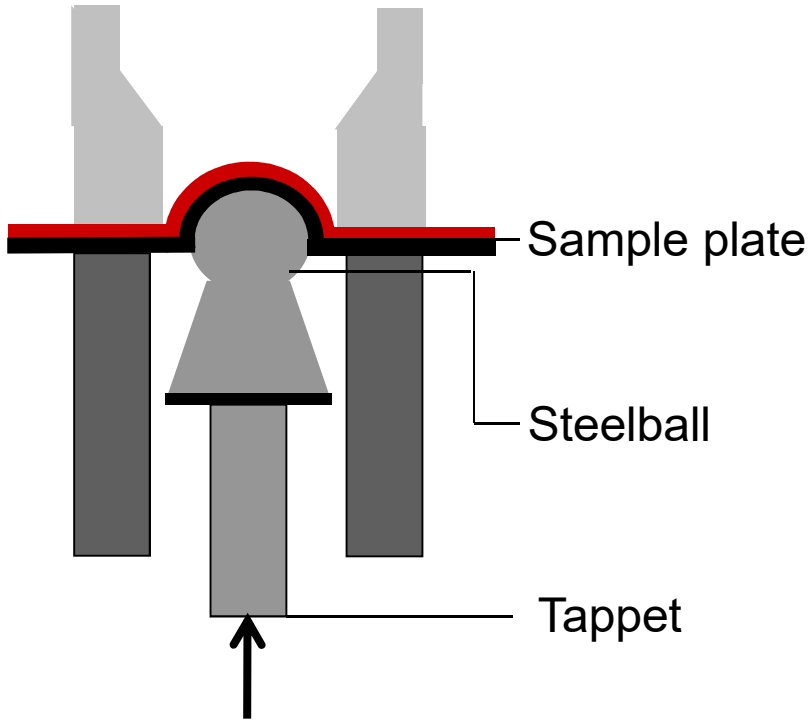
Gt 2



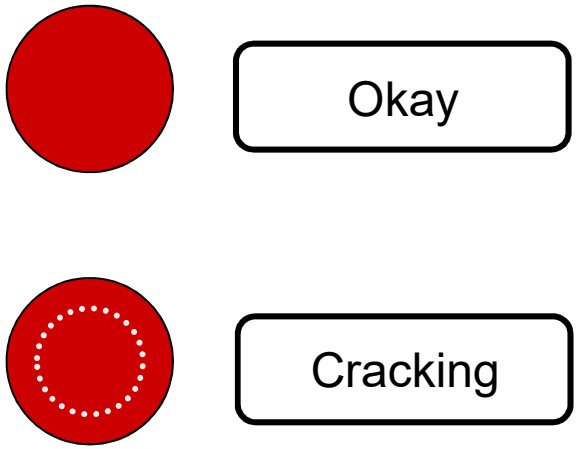
Gt 4

Target Agreements: Highly Elastic Clear Coats…

Erichsen Deep Drawing Device DIN ISO 1520,
Two-Dimensional Extension Elasticity (Forming Technology):



Deep drawing device, scheme



View from above through
a stereomicroscope.

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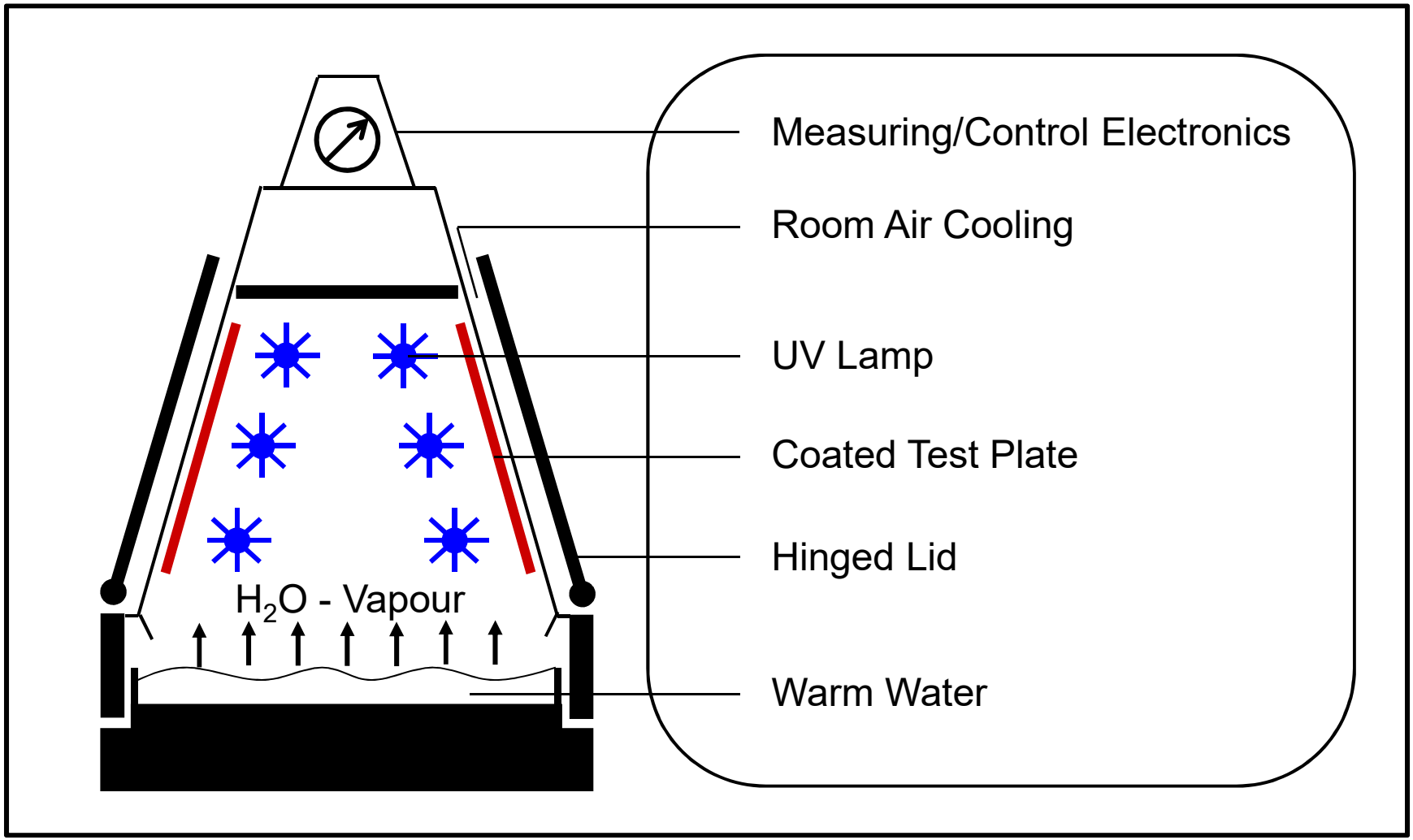
Target Agreements: Highly Elastic Clear Coats…

Test for Short-Term Weathering: UV-con-Device, Cross Section.



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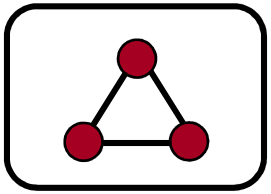
Example P2

Target Agreements (Partial View):



Project	**"Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid".**
	→

Target Agreements: Nitrilase-Catalyzed Synthesis…

Technical Components (P, Excerpt):

- Crystalline (R) -2-hydroxy-3-methoxy-3-methyl-butanecarboxylic acid (10 kg scale) with a purity> 97%.
- Optical purity of butanecarboxylic acid: enantiomeric excess (ee) ≥ 98%.
- "Turnover Number„ of nitrilase: > 4.5 x 10^3 per second at pH 7.0 and 30°C. Concentration of the pure enzyme in the bioreactor: ≤ 0.001%.
- Temperature stability of nitrilase-producing microorganisms: At least 24 hours at 55°C.
- Robust, genetically stable and phage-resistant microorganism strain (Shelf life under production conditions: > 10 months). → →

Temporal Components (T, Excerpt):

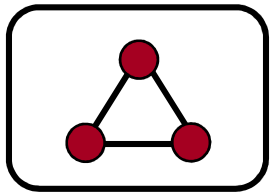
- Project start: 01.01.2019; Project end: 31.07.2023. → →

Economic Components (E, Excerpt):

- Continuous production in a loop reactor with flow equilibrium of 8.0 kg acid/24h. CMI in the third year after the market launch: € 21.50/kg.
- Project costs: 20.200.000 €. Return of investment period: From 12/2025. → →

Example P3

Target Agreements (Partial View):



Subproject	**"New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas".**
	→

Target Agreements: New Metal Organic Framework…

Technical Components (P, Excerpt):

- Storage capacity of H_2 at 77K: > 6% by weight (DoE, U. S. A.).
- Inner surface of the MOFs: > 2,500 m^2/g. Material density: 0.1-0.2 g / cm^3.
- Adsorption energy for molecular H_2: ≤ 4.0 kJ/mol.
- Average pore diameter d_P: 10 - 16 Å.
- At most, traces of Cr, Co, Ni in the MOFs; Content ≤ 0.0005%. → →

Temporal Components (T, Excerpt):

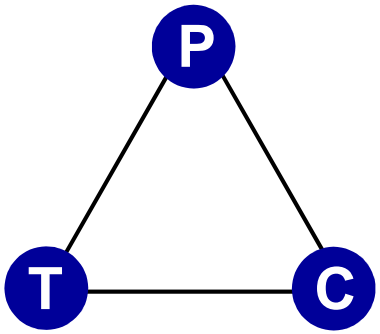
- Project start: 01.01.2019; Project end: 30.06.2023. → →

Economic Components (E, Excerpt):

- Space-time yield during production: ≥ 3,000 kg / m3 in 24h; DBI in the third year after launch: € 7.20/kg.
- Global market share of MOFs for hydrogen storage among fuel cell manufacturers in the EU: 40%.
- Project costs: 17.300,000 €; Return of investment Period: From 03/2026. → →

Mutual Dependencies of the Target Components

Target System: "Magic Target Triangle", "3-Clique" ( )



$(K_3)\begin{bmatrix}3\\2\end{bmatrix}$	**"Magic Target Triangle"**

P	Product Properties, Quality.
T	"Time to Market", Deadlines.
C	Project Costs, Budget Compliance.

P	T	C
P	T	C
P	T	C

P	**T**	C	→	Effective
P	T	**C**	→	Provitable
P	**T**	**C**	→	Productive

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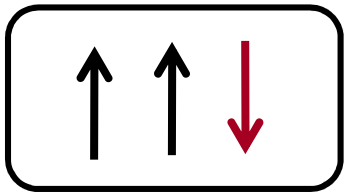
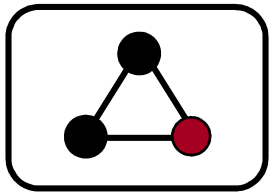
"Magic Target Triangle" for the Project "Highly Elastic Clear Coats…"

Example P1



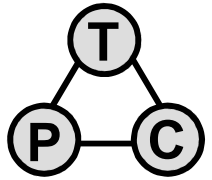


$(K_3)\begin{bmatrix}3\\2\end{bmatrix}$

T: Deadline (Project): 31.07.2022

P: Gloss retention AMTEC-test: >90%

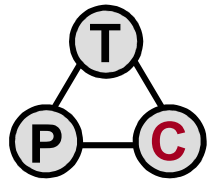
C: Project costs as per plan: ≈ 19.800.000 €



T: Deadline (Project): 01.12.2021

P: Gloss retention AMTEC-test: >95%

C: Project costs as per plan: ≈ 23.700.000 €



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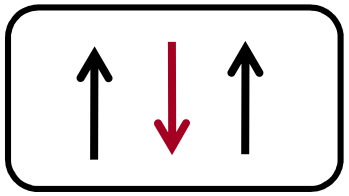
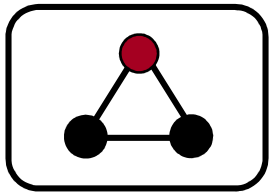
"Magic Target Triangle" for the Project "Highly Elastic Clear Coats…"

Example P1



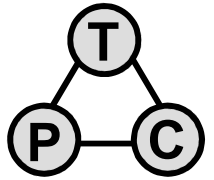


$(K_3)\ \begin{bmatrix} 3 \\ 2 \end{bmatrix}$

T: Deadline (Project): 31.07.2022

P: UV con-A: 2.000h: o.k.

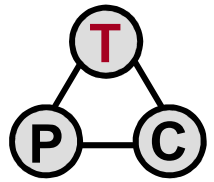
C: Project costs as per plan: ≈ 19.800.000 €



T: Deadline (Project): 01.06.2023

P: UV con-A: 3.500h: o.k.

C: Project costs as per plan: ≈ 18.300.000 €



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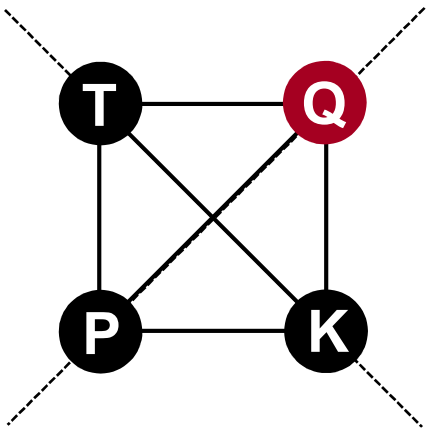
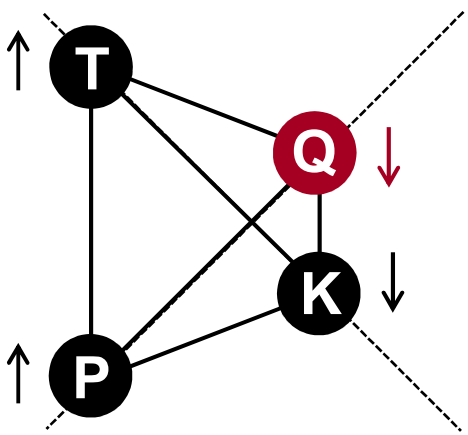
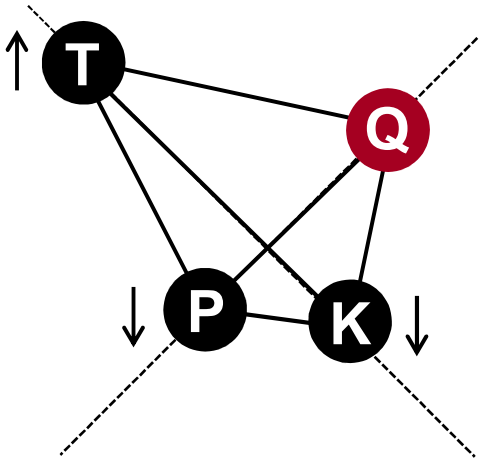
Square of the Target Values and the "Project Productivity"







Variable im K_4-System K_4: $\begin{bmatrix} 4 \\ 2 \end{bmatrix}$	
T: Deadline, Project Term	**Q**: Quality, Reproducibility
P: Product Properties	**C**: Costs, Expenditure
The enclosed areas in the K_4-Simplex in total remain almost constant with changes of (T, Q, P, C) (Empirical Knowledge).	

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Target Systems

→ **Minimum Requirements for the Formulation of Meaningful, Action-Driving Objectives.**

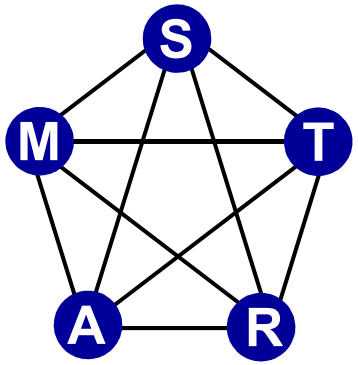
Their fulfillment serves as the basis for drawing up a *realistic, implementable* project schedule:

S	Specific	Complete and precise formulation of the desired final state ("Design").
M	Measurable	Concrete measurands that give information about the project status and about the project success.
A	Acceptable	The required quality claim is consistent in itself and is accepted and favored by the customer.
R	Realistic	High level, but chemically and technically feasible with the available resources (Staff, €).
T	Time Limited	Clearly defined start time and finish time, thus, an agreed total duration. Defined milestones.

Target Systems

→ **Minimum Requirements for the Formulation of Meaningful, Action-Driving Objectives.**

Their fulfillment serves as the basis for drawing up a realistic, implementable project schedule:



S	Specific (Design Stipulations).
M	Measurable (Physical Unit, Test.
A	Acceptable (o.k. of Customers).
R	Realistic (Reachable).
T	Time Limited (Dates).

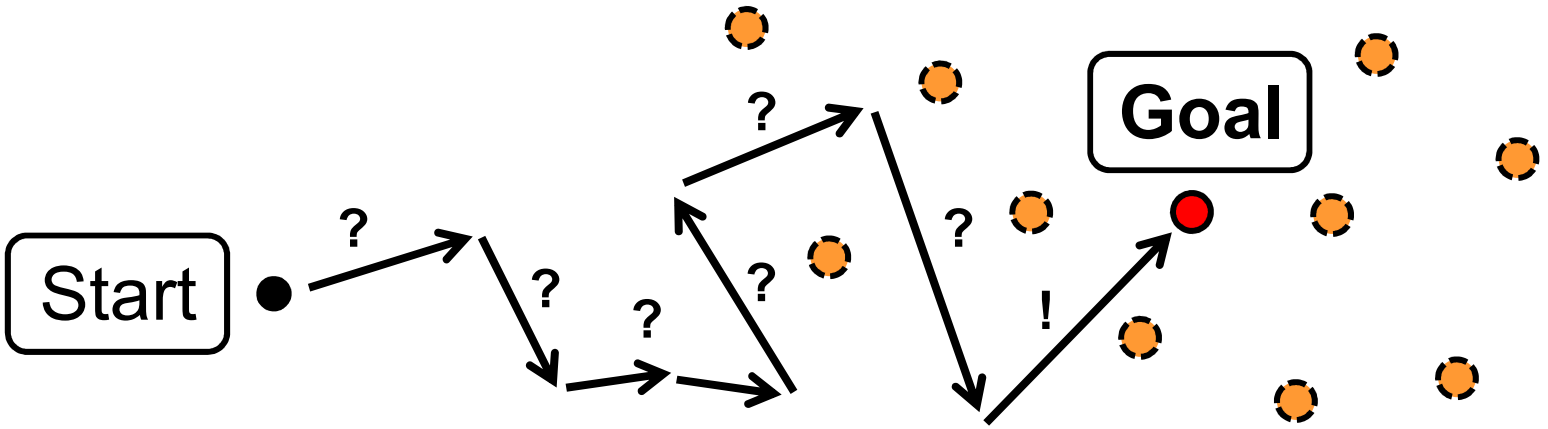
(K_5) $\begin{bmatrix} 5 \\ 2 \end{bmatrix}$ → Complete graph with **SMART** as vertices.

Rainer Buerstinghaus

Research Project: Exploration of Potential Targets.

"Vague" Objectives at the Start: ⟶

- Incomplete (If necessary statistical) experimental plans.
- Surprising, unpredictable results.
- High dynamics of changes, many course corrections.
- Special and additional actions.
- A high flexibility and creativity are required equally.



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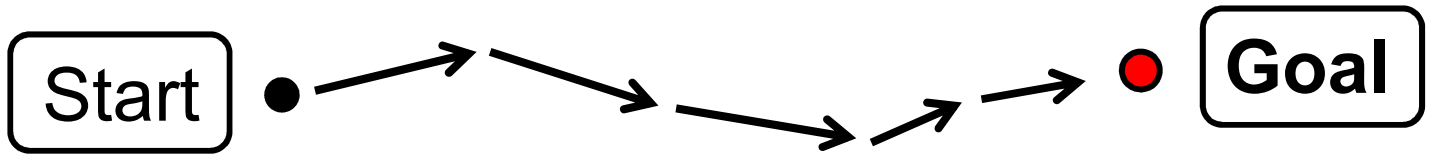
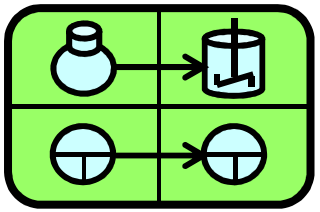
Development Project: Clear Goals for an Optimization.

Precise Targets at the Start: ⟶

- Only partially novel results.
- Partial steps that repeat often.
- Sufficiently solid, reliable planning basis.
- Consistent systematics/High degree of order.
- Controllable dynamics of changes.



R&D Project Management in the Chemical Industry



Subject Matter →

Project Management in R&D.

Rainer Buerstinghaus

Project Management in Research and Development

Project, Origin of the Word: (⟶ Latin)

manus agere (lat.): lead by the hand.
manu agere (lat.): working by hand.
mansionem agere (lat.): keeping the house.

to manage (engl.):
handle, accomplish, steer, organize, "wangle".

Management (engl.): direction, leadership, controlling.

Management (today):

"Way of thinking" and solid "craftsmanship", which lead to a goal oriented kind of entrepreneurial thinking and acting, to effectiveness and consequently to results.

R&D Project Management, Definition (According to DIN):

The entirety of management tasks, management organization, management techniques and management tools for the initiation, definition, planning, control and completion of R&D projects.

According to DIN 69901−(1−5)

Project Management in Research and Development

Definition:

Organization and steering of the target-oriented cooperation of people with different professional backgrounds in a precisely defined, challenging innovation project.

Project Manager (m/f/d)

Target System | **Resources**

Project Management in Research and Development

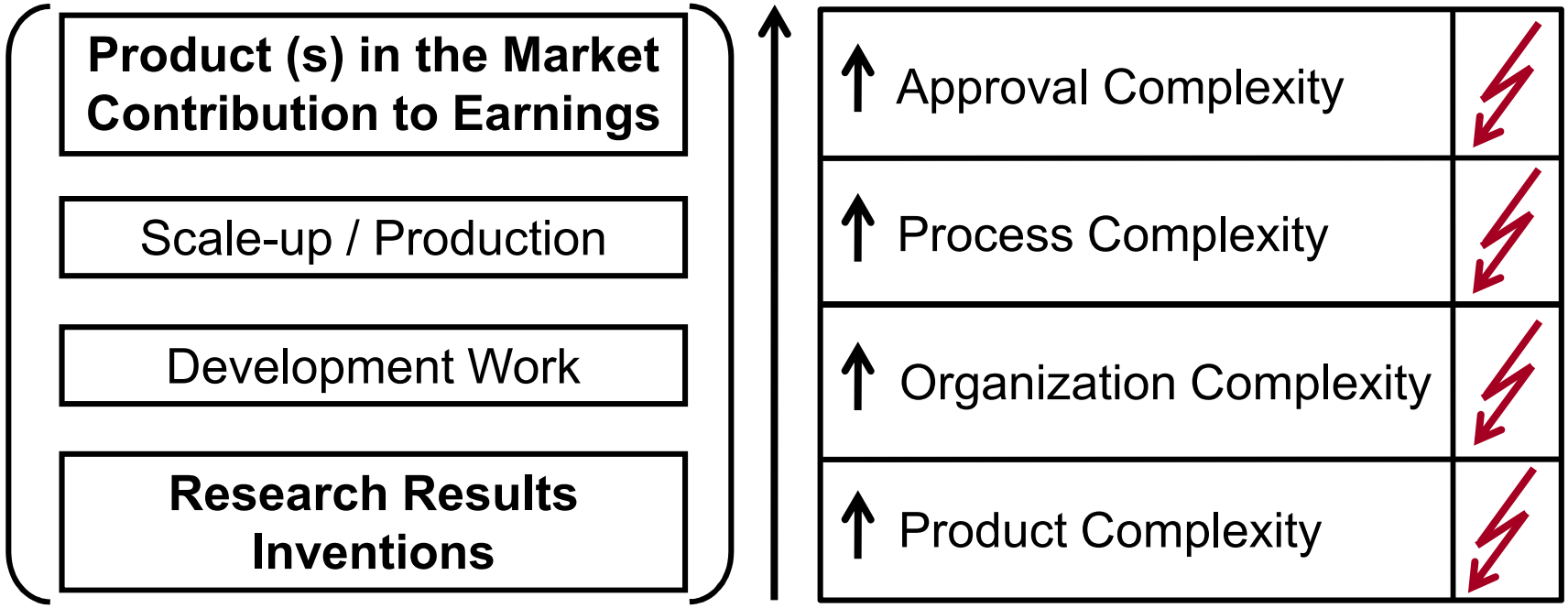
"Incalculability" / "Unpredictability" of the Results of R & D Projects with a High Degree of Exploration.

- Target Agreements
- Limited Time Frame
- **Uniqueness, Novelty**
- Limited Resources
- **Complexity**

- Specific Organization
- Transdisciplinarity
- **Exploration Fields**
- **Uncertainties, Risiks**
- **Dynamics of Changes**

Project Management in Research and Development

Necessity Due to Increasing Complexity Requirements:



- → **Progressive specialization and division of labor.**
- → **Permanent expanding method repertoire.**
- → **Increasing planning and control efforts.**
- → **Heightened time pressure (Time to Market).**

Project Management in Research and Development

Characteristics:

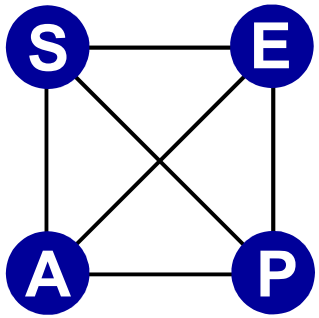
Holistic management concept for the target-oriented realization of ambitious innovation projects.

Components of Effective Project Management:

S	Components of structuring.
E	Components of the professional expertise.
A	Components of action implementation.
P	Components of the psychological/social.

Project Management in Research and Development

Component System of Effective Project Management:



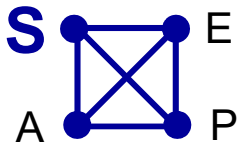
$(K_4$ –Graph) $\begin{bmatrix} 4 \\ 2 \end{bmatrix}$

S	Components of structuring.
E	Components of the professional expertise.
A	Components of action implementation.
P	Components of the psychological/social.

Project Management in Research and Development

Components of an Effective Project Management.

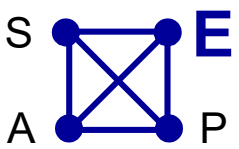
Structural Components:



- Target hierarchy, definition of a structured target system.
- Development of a valid and complete structure planning.
- Realistic, clear allocation of resources and costs.
- Choice of a suitable organizational structure.
- Choice of a reasonable process organization.
- Use of suitable IT resources / databases.
- Development of valid reporting and controlling systems for effective and efficient project management.

Components of an Effective Project Management.

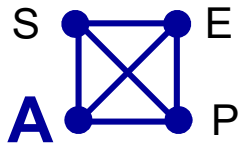
Expertise Components:



- Knowledge of the state of science and technology.
- Excellent technical experts, availiability of knowledge.
- Capable problem-solving processes and experiments.
- Inventions/patent protection, own publications.
- Suitable equipment/ IT equipment and – IT software.
- Professionally working engineers and technicians.
- Strategically oriented, technical purchasing.
- Sound market knowledge, competent pilot customers.

Components of an Effective Project Management.

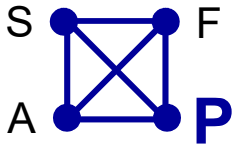
Action Components:



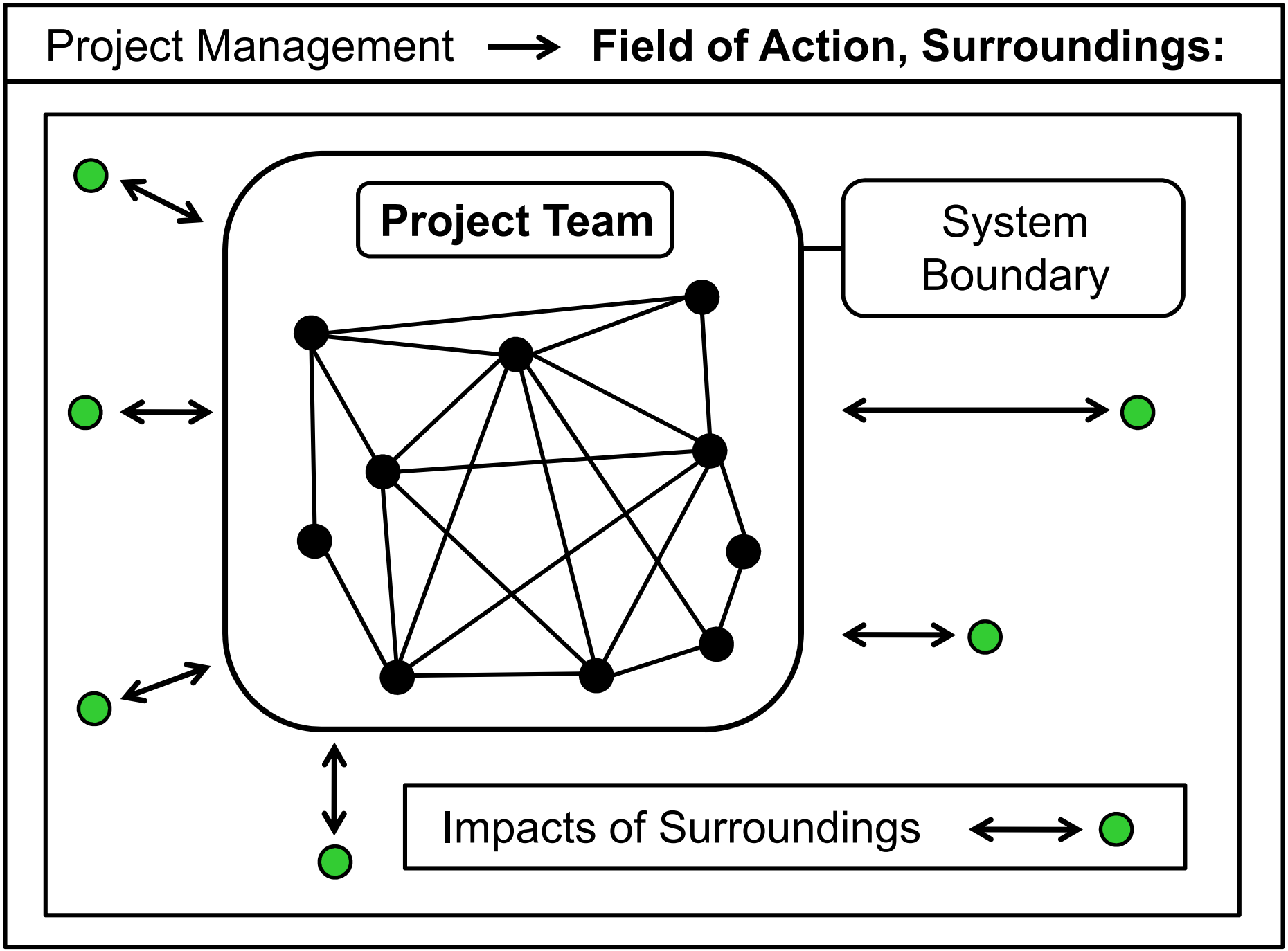
- Reasonable and clear assignment of the individual tasks/processes (specialist units/persons).
- Regular deadline monitoring.
- Compact, clear and unambiguous action plans.
- Active control of critical, purposeful operations.
- Usage of synergies, guarantee of logistics.
- Documentation of *all* results (successes/failures).

Components of an Effective Project Management.

Psychological-Social Components:



- Effective leadership by maintaining the "intrisic motivation" of each project participant (m/f/d).
- Reasonable demands from the team members.
- Promotion of constructive cooperation within the team.
- Formation of creative and flexible networks.
- Honest feedback to the individual team members.
- Own role model behavior towards all participants.



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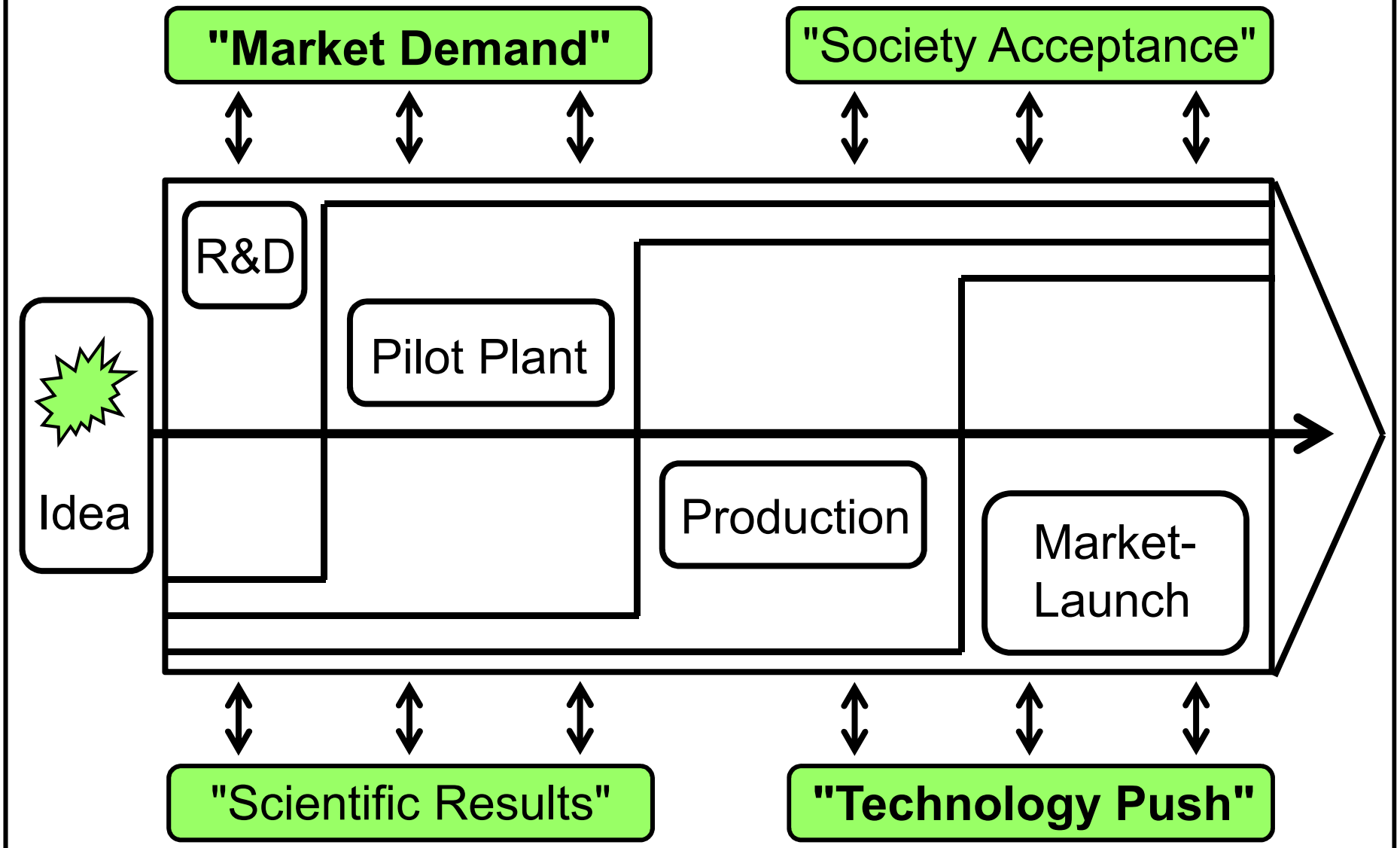
Project Management – External Influences:



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Advantages of this Method for Target Achievement.

1. Effective Tool for Leadership:

- Establishment of constructive co-operative, goal-oriented and self-responsible teams.
- Intrinsically motivated employees (m/f/d), each with an "self identifying" commitment.
- Individual willingness to accept and implement "challenges".
- Intensive communication across line boundaries.
- Transparent and broad accepted decisions.
- Individual learning and experience curves will be passed through.

Advantages of this Method for Target Achievement.

2. Time Saving, Efficiency Improvements:

- Clear time goals due to periods and strict deadlines.
- Rapid planning, execution and evaluation of necessary. and meaningful (simultaneous) work. High "agility".
- Fast and "resilient" decisions.

3. High Effectiveness:

- Optimized and expedient use of resources.
- Highly effective problem-solving expertise for complex tasks.
- Professional realization of the "purposeful" experiments.

Advantages of this Method for Target Achievement.

4. Cost Control and Compliance with the Budget Plan:

- Establishment of a (transparent) project cost center.
- Effective steering and monitoring of the financial and human resources.
- Clear economic and financial criteria for the project start, project completion or project stop.

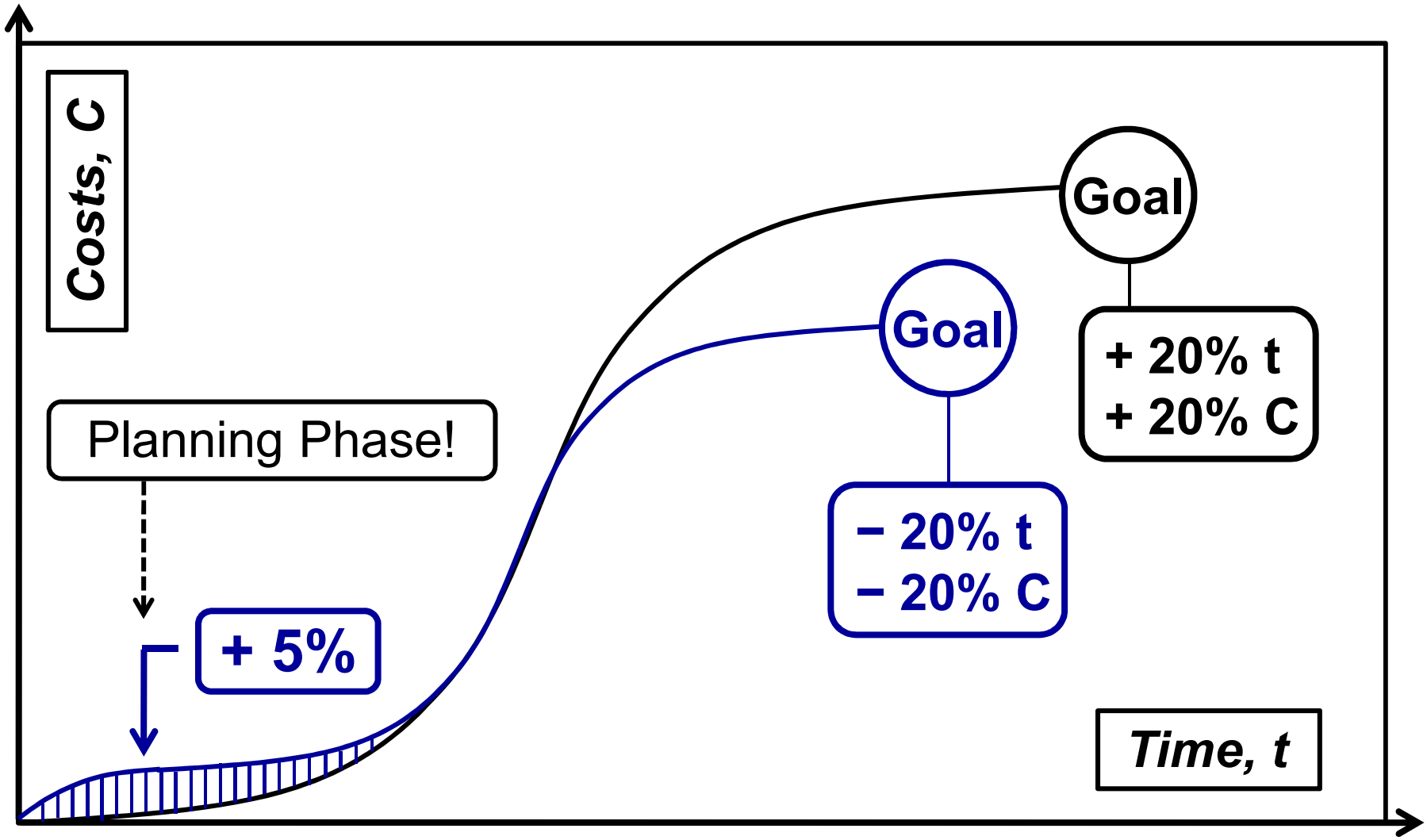
Advantages of this Method for Target Achievement.

5. Answer to Competitive Pressure and Market Dynamics:

- Consistent customer orientation when planning and monitoring of the project course.
- Flexibility with changing market requirements.
- Quick, professional approach to plan changes.
- First-time supplier (pioneer) in the market, attainment of innovation leadership.

Project Management in Research and Development

Advantage: Cost and Time Savings (→ Rule of Thumb).



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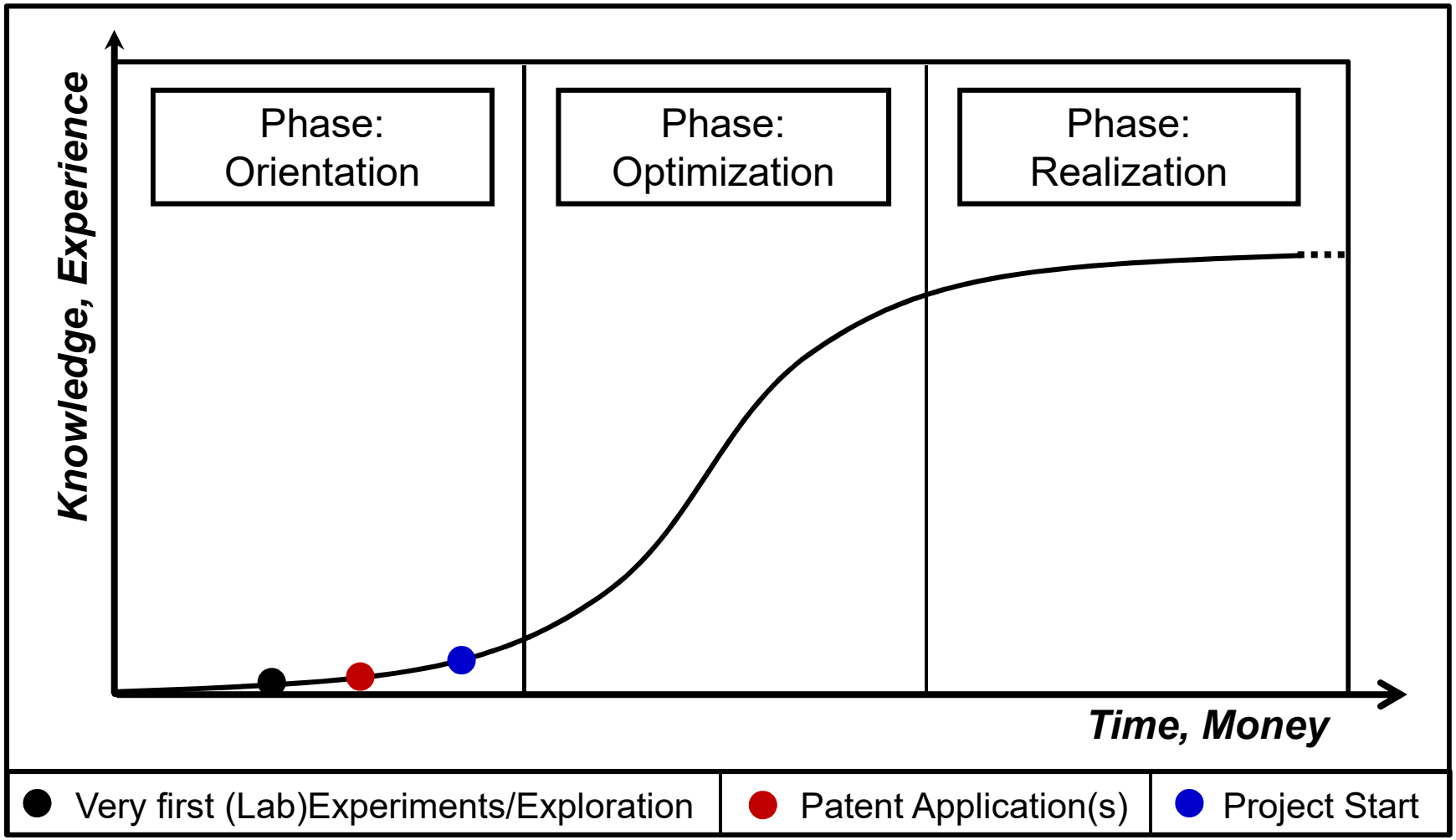
Project Management in Research and Development

The Passage through a "S-Learning Curve" in Three Phases.
From Invention → to Innovation.



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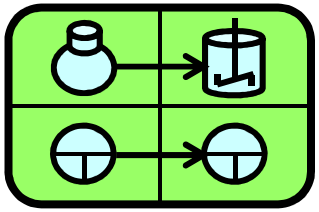
Project Management in Research and Development

Preconditions of Success:

- Unequivocal support of the top management of a company or an organization to the project, its target system and its budget (financing/personnel).
- Joint definition of a clear target system.
- Result-oriented collaboration of the best people.
- Systematic approach to planning and acting.
- Clear and strict rules to be followed.
- Consistent target, result and market orientation.

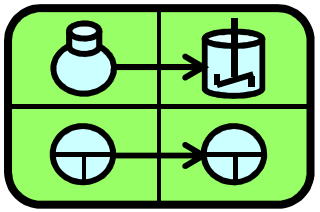
R&D Project Management
in the Chemical Industry

The Subject Matter



- Innovations: Characteristics, Measures for its Promotion, Process Variants.
- Three Examples for Innovation Projects (Chemistry and Technology):
  1. Highly Elastic Clear Coats for the OEM Automotive Sector.
  2. Nitrilase Catalyzed Synthesis of a Chiral Hydroxy-Carboxylic Acid.
  3. New Metal-Organic Frameworks for the Adsorptive Storage of Gases.
- Projects, Target Systems, Project Management in R&D.
- **Appropriate Organization and Effective Structure Planning of R&D Projects.**
- Project Flow Planning, Milestones, the Stage-Gate®-Process, Network Diagrams.
- Effective Implementation and Control of R&D Projects, Trend Analyses.
- Success Risks: Identification, Classification and Treatment.
- Recruitment and Lead of Project Staff:
  Chemists (m/f/d) – Team Players, Pacemakers and Executives in Projects.
- Project Manager (m/f/d): Tasks, Leadership Functions and Personality Profile.
- The Systematic Evaluation of Individual R&D Projects.
- R&D Strategy: The Planning of a Project Portfolio.

R&D Project Management in the Chemical Industry



Subject Matter →

Appropriate Organization of R&D Projects.

Appropriate Organization of R&D Projects

R&D Project Organization, Definition, Purpose:

Definition →

Structural and procedural organization for the execution of a specific R&D project.

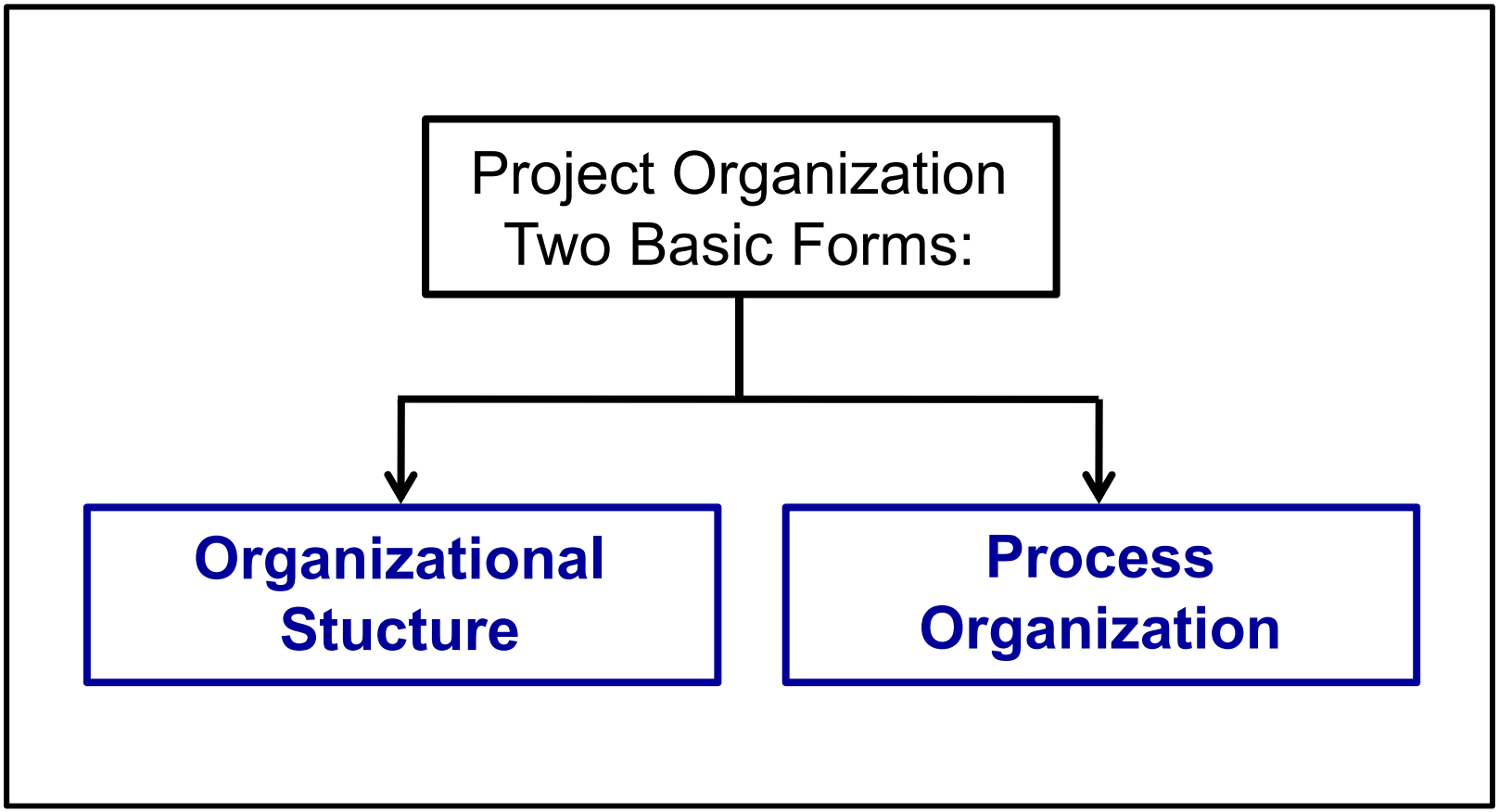
(According to DIN 69901−(1−5)).

Purpose →

Target-oriented, meaningful and structured use of all available human, financial and material resources.

Appropriate Organization of R&D Projects

Fundamental Forms of R&D Project Organization:



Fundamental Forms of R&D Project Organization:

Project, Organizational Structure

At First: Structured collection of all target-derived tasks.

- Necessary specialist functions.
- Type of integration (Who? With whom?).
- Networking/Types of cooperation/Communication channels.

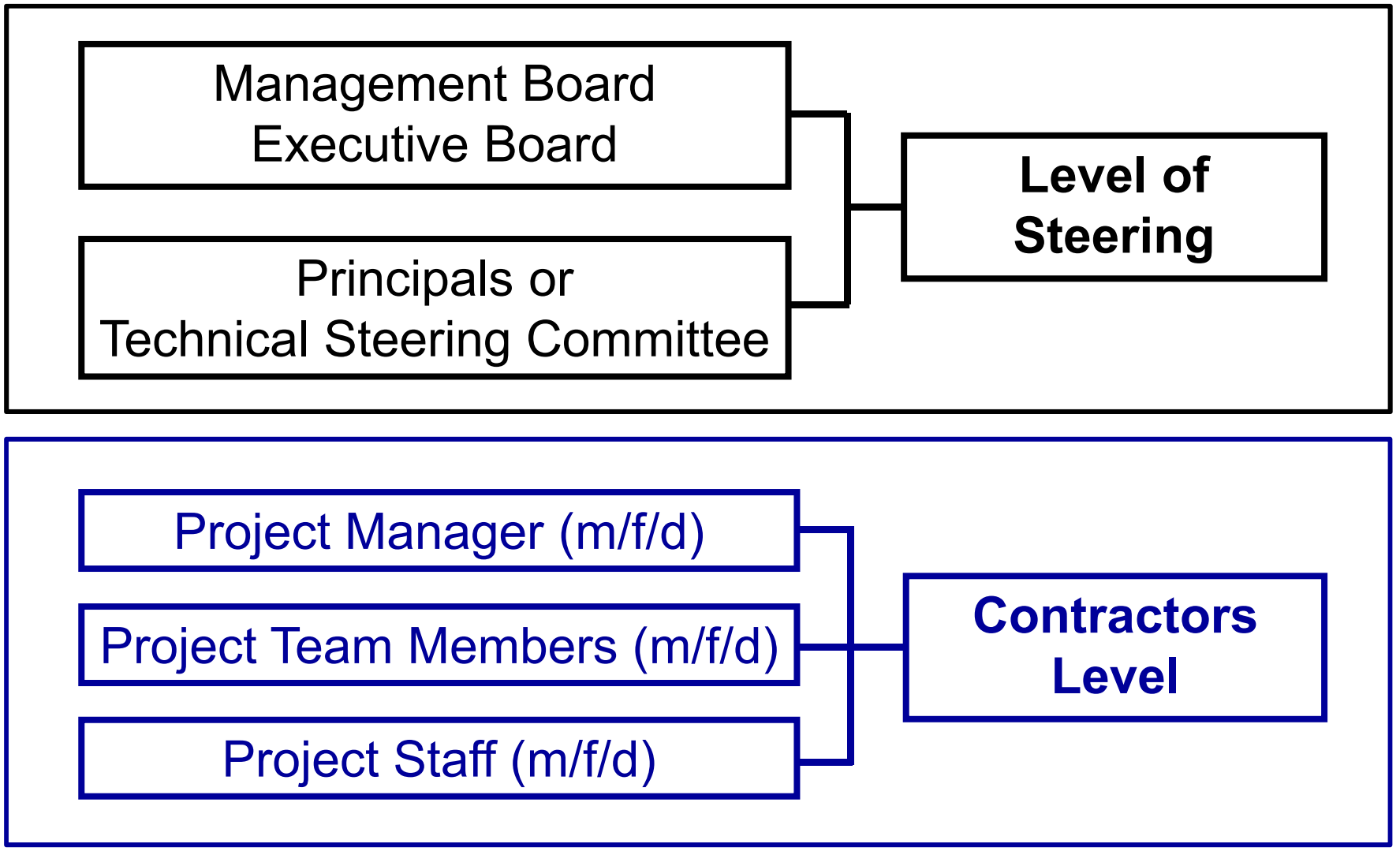
Project, Process Organization

At First: Structuring of all target-oriented operation sequences.

- Necessary actions (What?). Duration (How long?).
- When? (Start times, deadlines, dates).
- Dependencies/Checking of results/Controlling.

Appropriate Organization of R&D Projects

Organizational Structure, Vertical Organization:



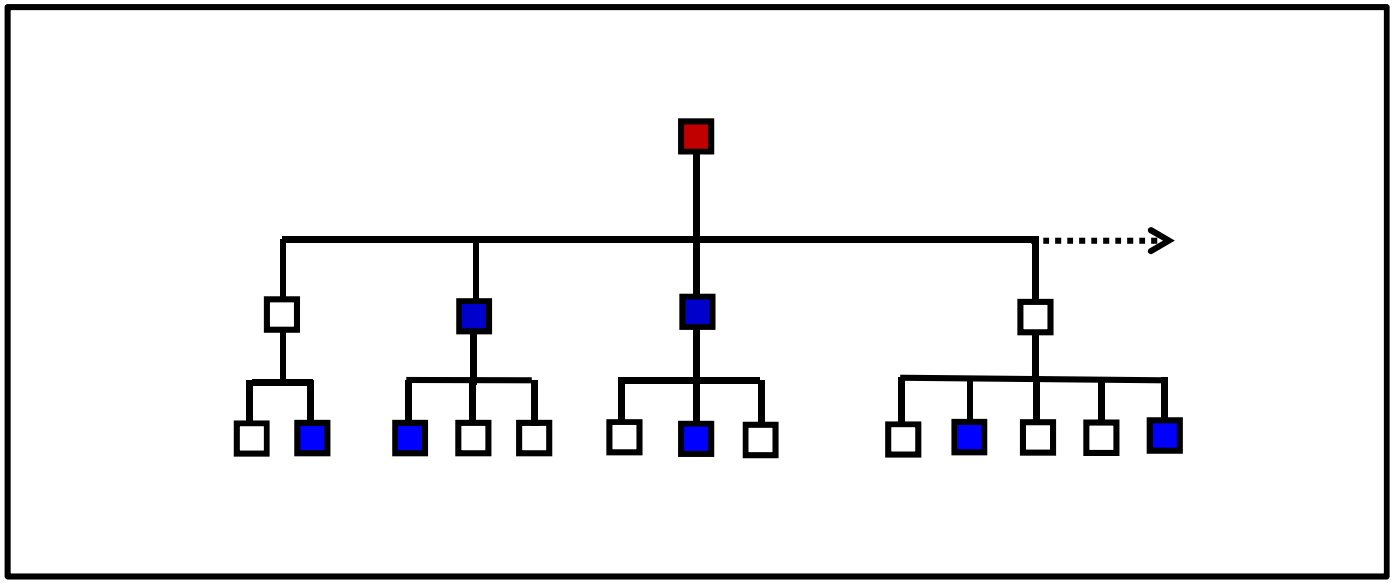
Appropriate Organizational Structures of R&D Projects

R&D-Project Management: The TPR-Matrix as Basis for Effectiveness of the Levels in a Structural Organization:

Level ↓	Task (T) → ↓	Power (P) ↓	Responsibility (R) ↓
Technical Steering Committee	Checking the sense of the project; Project portfolio planning.	Appointment of project managers; Project release. Project order.	The project is in line with the corporate strategy.
Project Manager (m/f/d)	Project plan; Organization of the needed resources. Project steering.	Power to sign. Project-related instructions.	Achievement of the objectives (Product, procedure, dead-lines, costs).
Team Member (m/f/d)	Planning support; Implementation.	Order placement.	Implementation of individual work packages.

Appropriate Organizational Structures of R&D Projects

Changes as Times go by; The "Old" Hierarchy Structure:

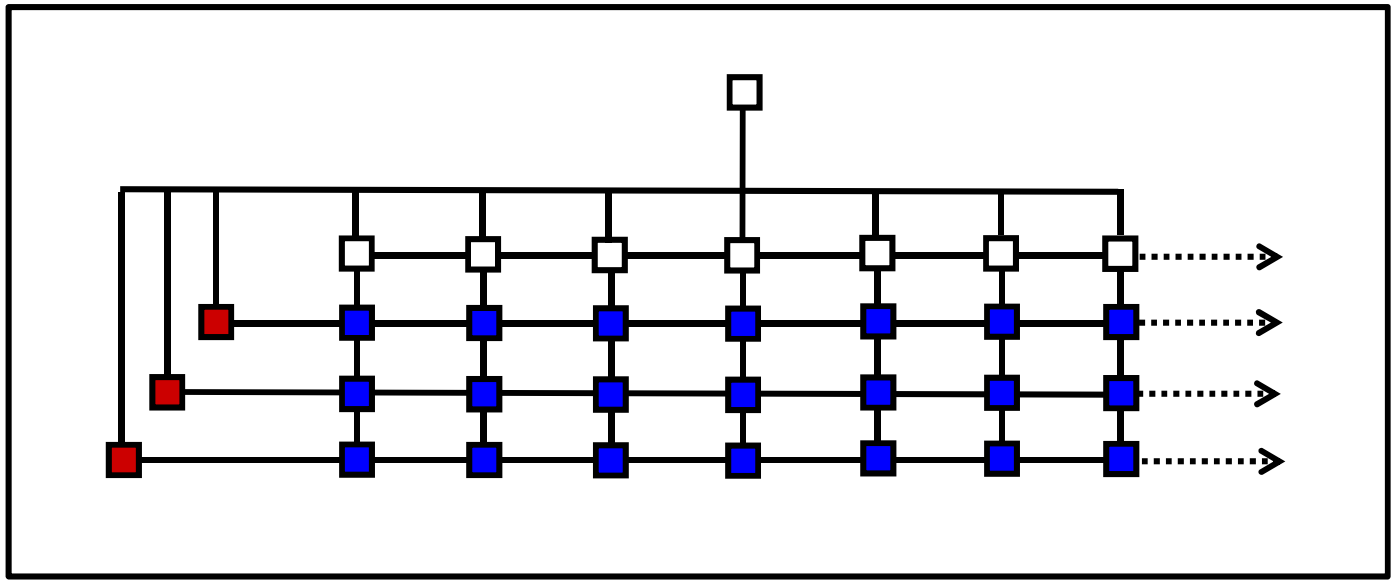


Project Leader (m/f/d)
Project Team Member

Hierarchy

Appropriate Organizational Structures of R&D Projects

Changes as Times go by; The Matrix Structure:



Project Leader (m/f/d)
Project Team Member

Matrix

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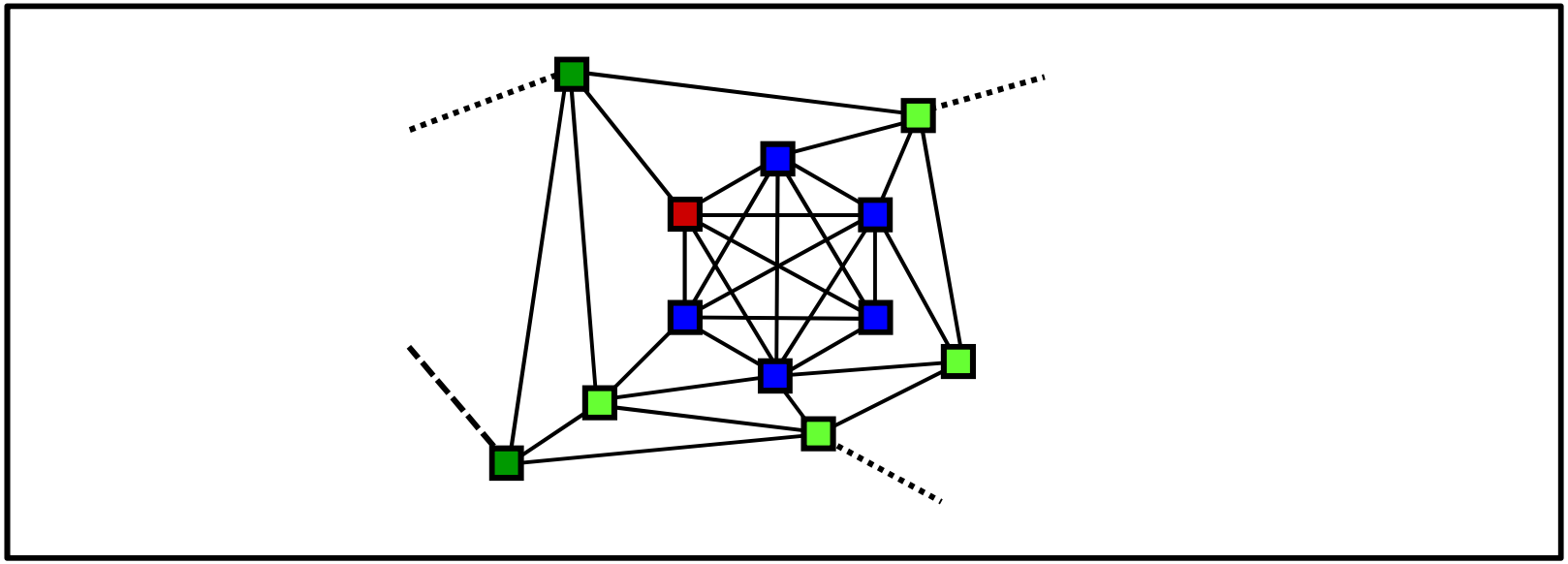
Appropriate Organizational Structures of R&D Projects

Changes as Times go by; The (Regular) Simplex Structure:

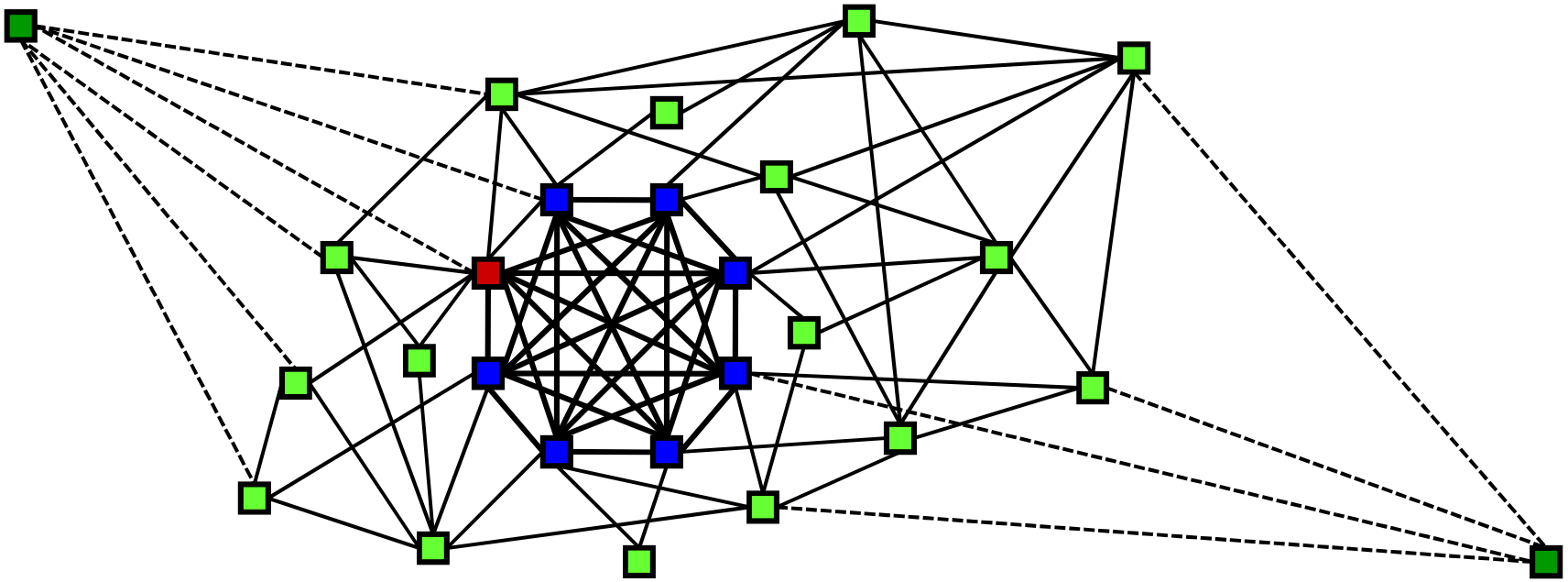


- Project Leader (m/f/d)
- Project Team Member
- Stakeholder, internal
- Stakeholder, external

Simplex within Net: (R&D Project Team as "Clique" in a System).

Appropriate Organizational Structures of R&D Projects

Large Group Corporation: Integration into an internal and external, trans-functional corporate network.



- Project Leader (m/f/d)
- Project Team Member
- Stakeholder, internal
- Stakeholder, external

Simplex within the network of a group.

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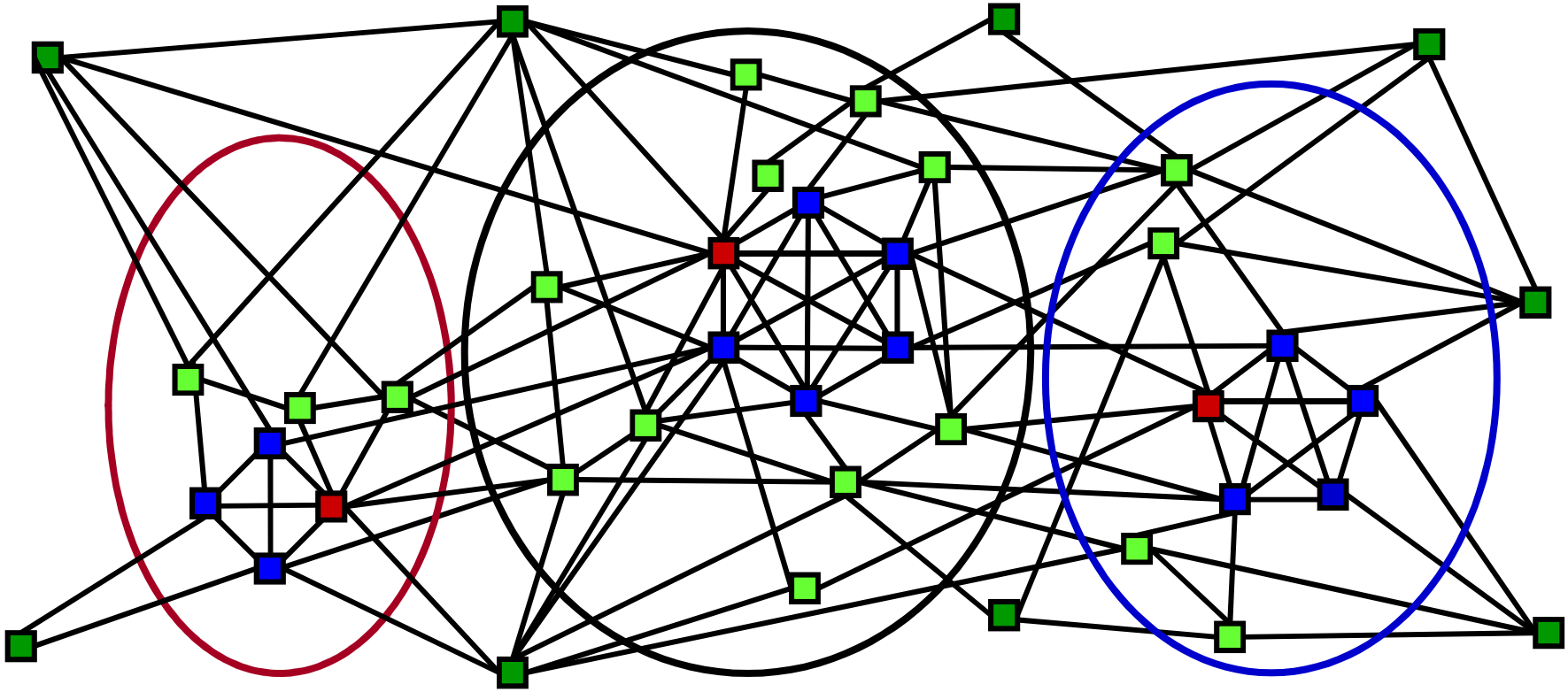
Organizational structure of R & D projects: System structure

SMEs: Integration into an (external) company system.



- Project Leader (m/f/d)
- Project Team Member
- Stakeholder, internal
- Stakeholder, external

Simplexes within a Net: SME-System.

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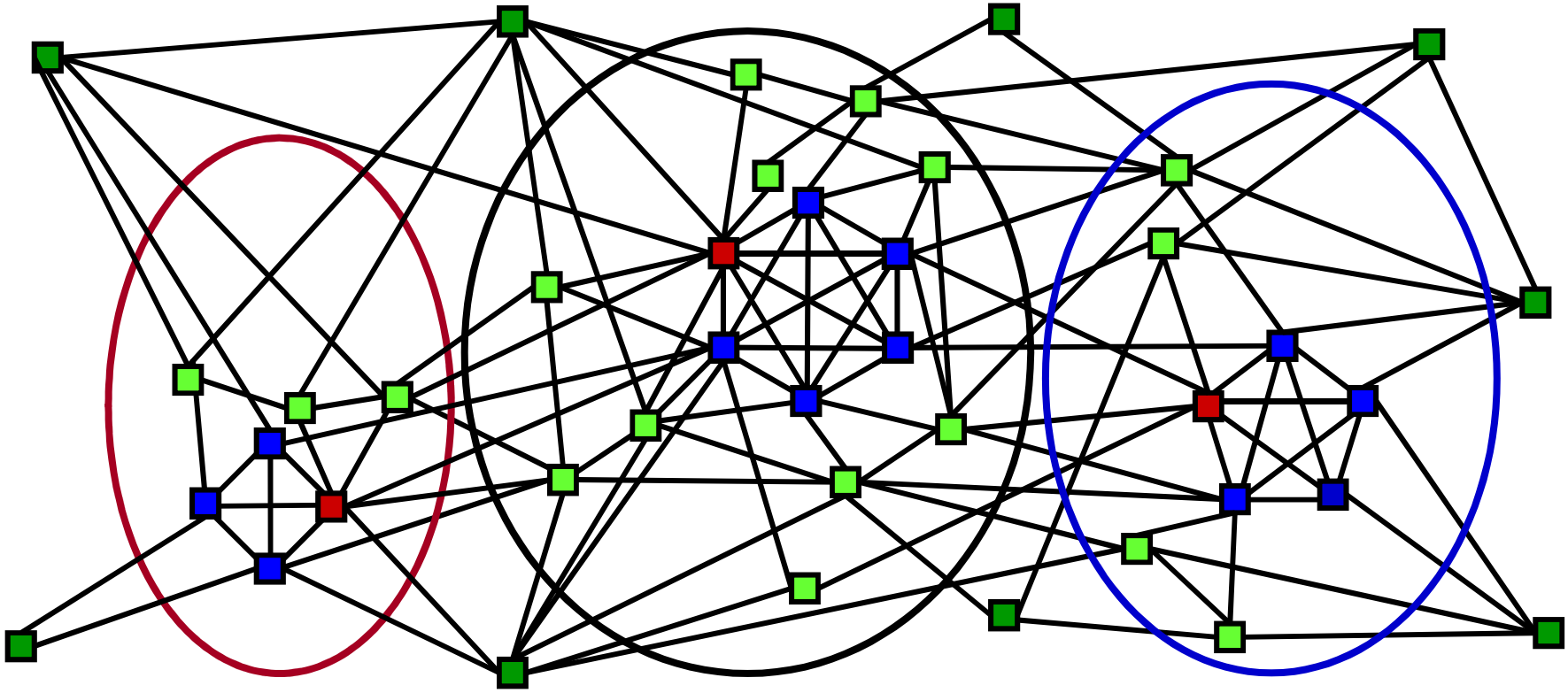
Organizational Structures of R&D-Projects

Changes as times go by; System Structure:

Example P1



[Conveyor…AG1]

[…GmbH1]

[Automotive…AG1]

- Project Leader (m/f/d)
- Project Team Member
- Stakeholder (internal)
- Stakeholder (external)

Simplexes within a Net: SME-System.

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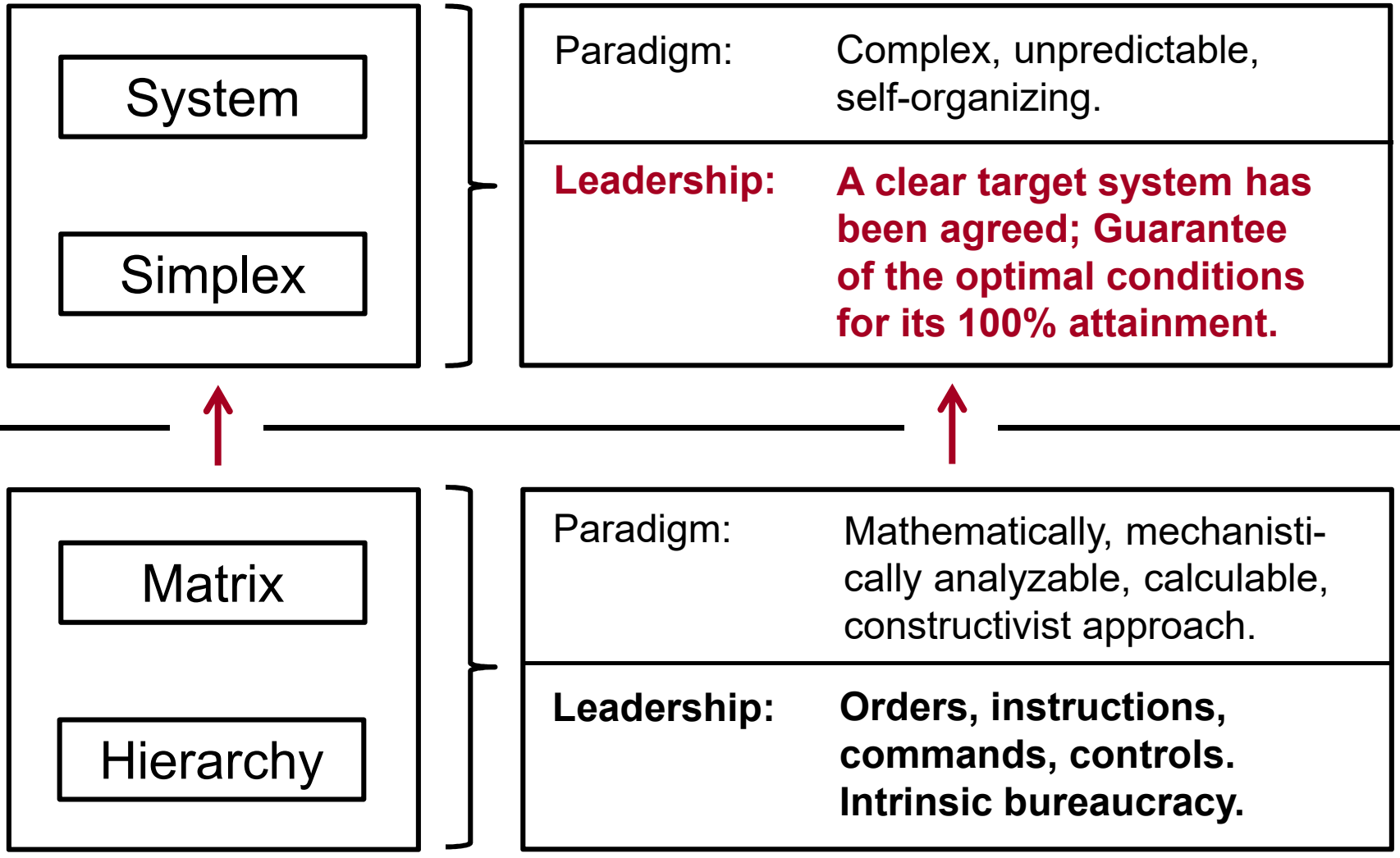
Appropriate Organizational Structures of R&D Projects

Changes as times go by:



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Appropriate Organizational Structures of R&D Projects

Changes as times go by; System-Structure:

Συστημα (Greek): The Structure, the Interconnected

The totality of elements that interact with each other in a task, meaning and purpose-oriented way, and which is differentiated from the environment.

"The whole thing is more than the sum of its parts"

"Something new arises from known individual parts"

Emergence!

Appropriate Organizational Structures of R&D Projects

Changes as times go by; Stakeholders:

Stakeholders:
People who have an clear interest in the company's success, as well as in the definition and achievement of R&D project goals.

- **Internal Stakeholders:**
  Project Manager, Team Members, Line Managers, Steering Committee Members, all (!) Company Employees.

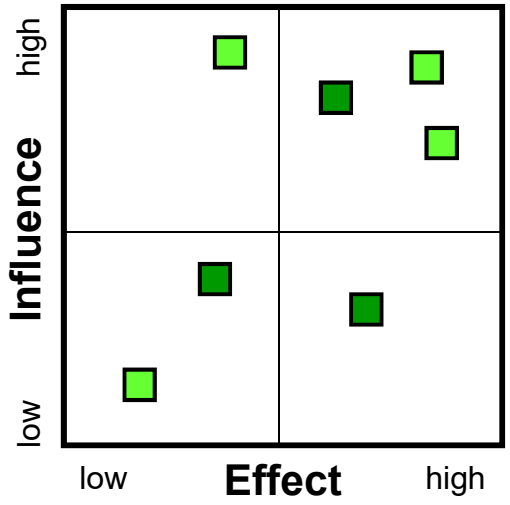
- **External Stakeholders:**
  Customers, Suppliers, Investors, Public Authorities; Government, Research Institutes, Universities.

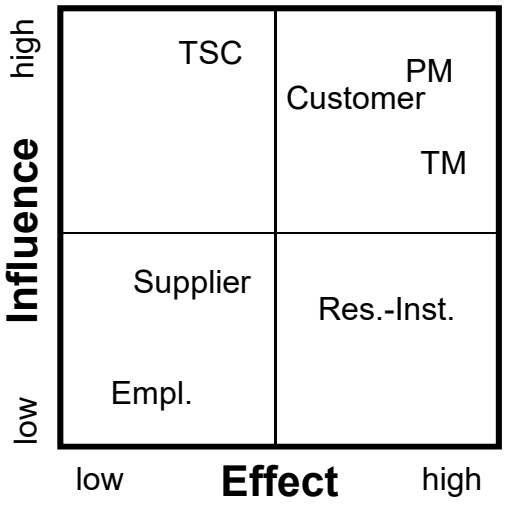
Appropriate Organizational Structures of R&D Projects

Stakeholders; Influence and Effect (Impact):

Each of the Stakeholders (internal ■ and external ■)

- has varying **influence on** the **target planning.**
- has different **effects on** the **support of goal attainment.**





R&D project organization, adapted to the company size.
Project work in a large group corporation (⟶ LGC) or in a small or medium-sized enterprise (⟶ SME): Differences.

LGC, Research in a Large Group Corporation (Partially!):

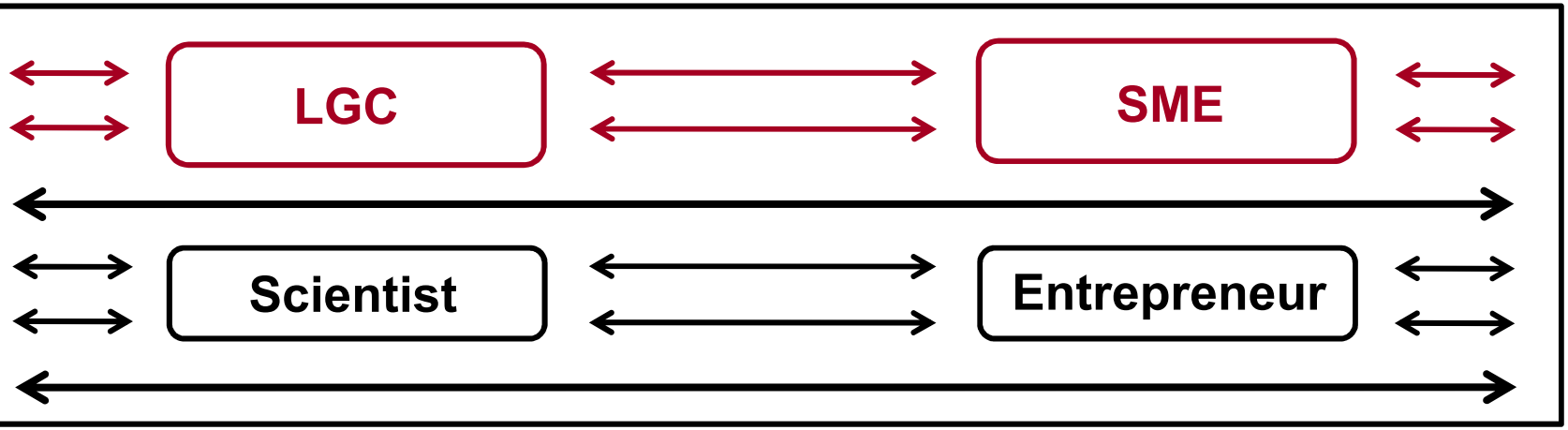
- Group Culture: Corporate Governance.
- Oligofunctional work processes for chemists (m/f/d).
- Chemists (m/f/d) as pace setters in the corporate network.
- Use of natural scientists (m/f/d) as "High-Skill-Scientists".

SME, Research in Small/Medium Sized Enterprises (Partially!):

- Enterprise Culture: Project Governance.
- Multifunctional work processes for chemists (m/f/d).
- Chemists (m/f/d) as pacemakers within the integrated network.
- Use of natural scientists (m/f/d) as "High-Skill-Entrepreneurs".

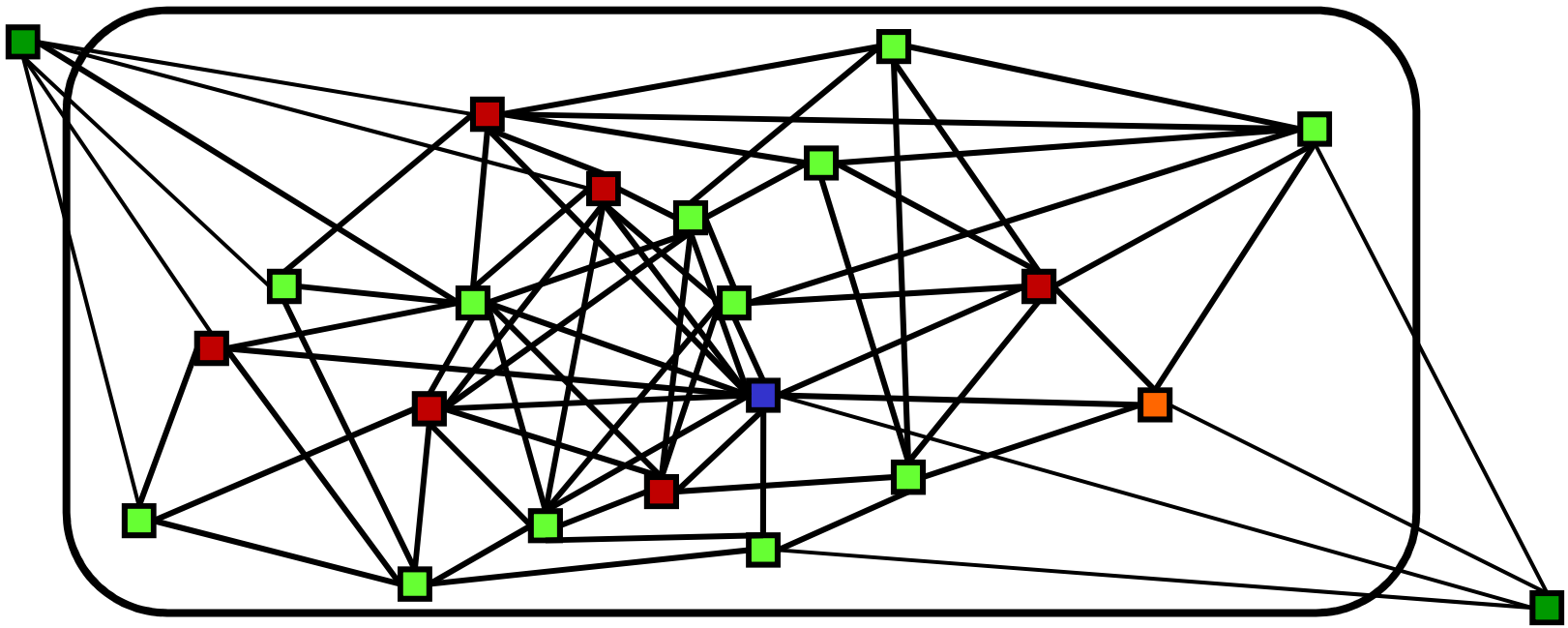
SMEs with each, < 500 employees make up about **90% of the 2.000 companies** in the German chemical industry and generate around 30% of the total turnover with about 30% of all employees.

R&D Project work *within a Group (→ LGC) or within a small or medium sized enterprise (→ SME): Differences.*



"Variety" of functions/tasks as a researcher/entrepreneur.

University: Integration Into an (Internal) Work Group Network:



- Doctoral Student (m/f/d)
- Professor (m/f/d)
- Assistant Professor (m/f/d)
- Stakeholder, in house
- Stakeholder, ex house

Work Group Network

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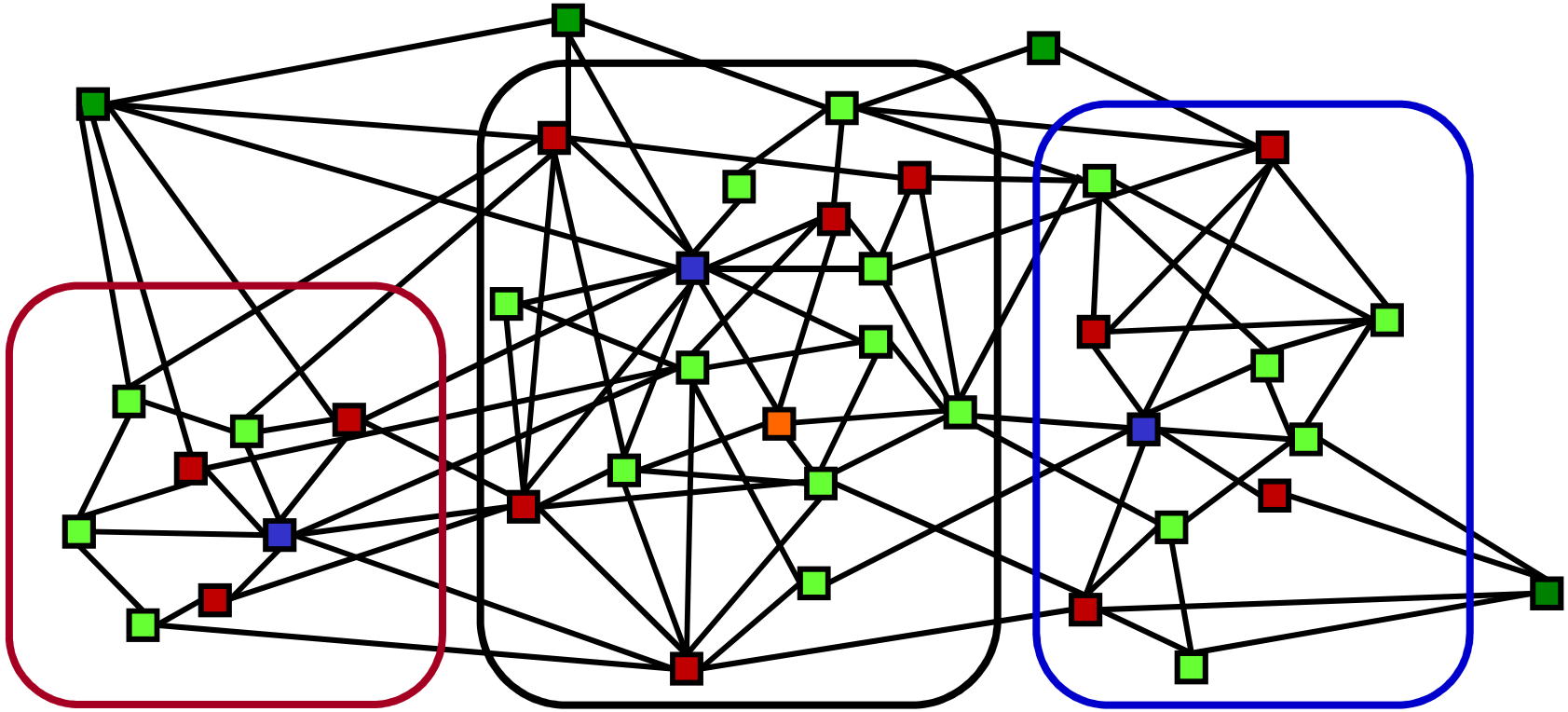
CRCs, GCs: Integration Into a Cross-Institutional System:



- Doctoral Student (m/f/d)
- Professor (m/f/d)
- Assistant Professor (m/f/d)
- Stakeholder, in house
- Stakeholder, ex house

→ **CRC/GC-System**

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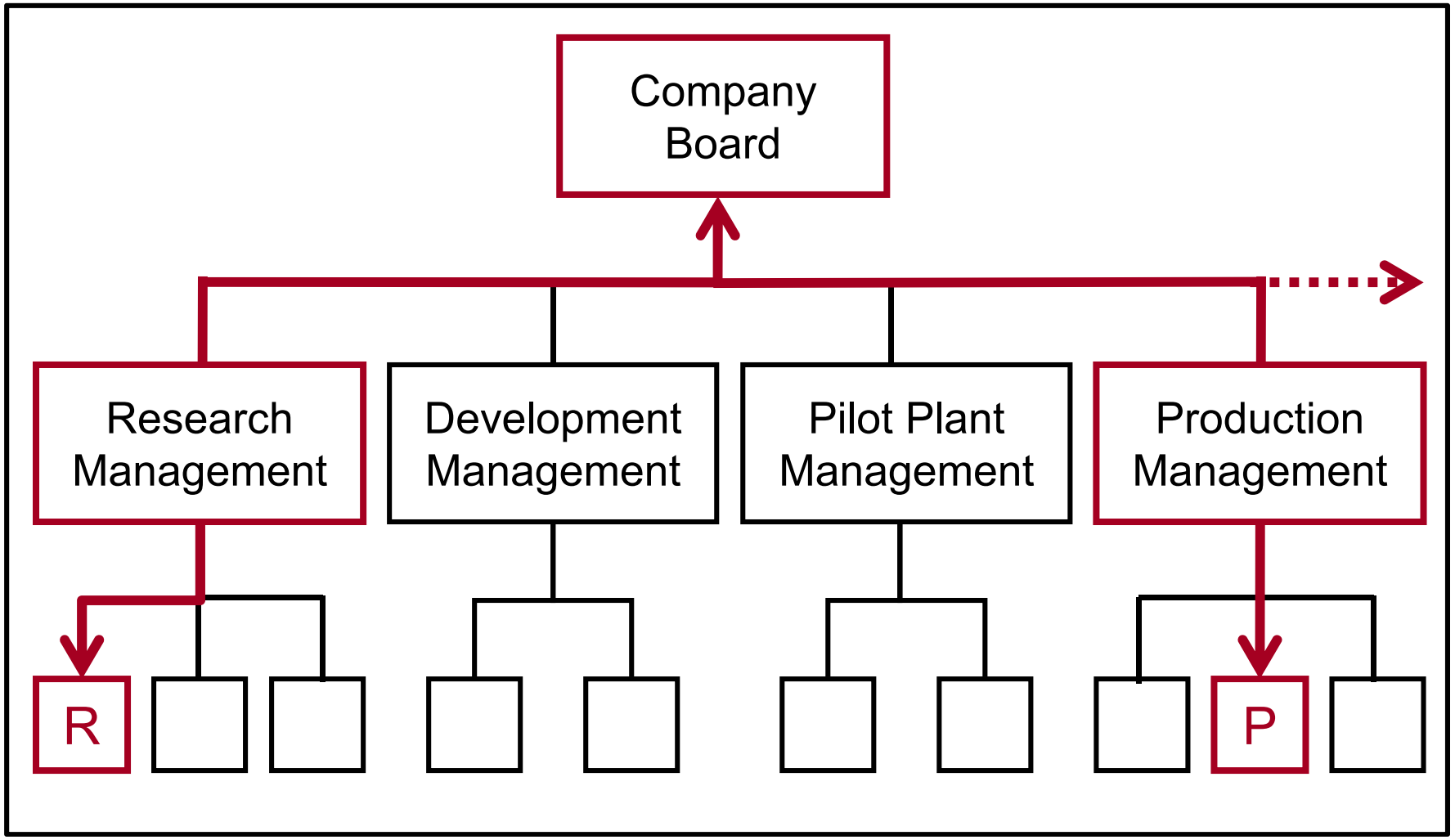
Ways of Information and Decision-Making

Classic Hierarchical Organization in Companies:



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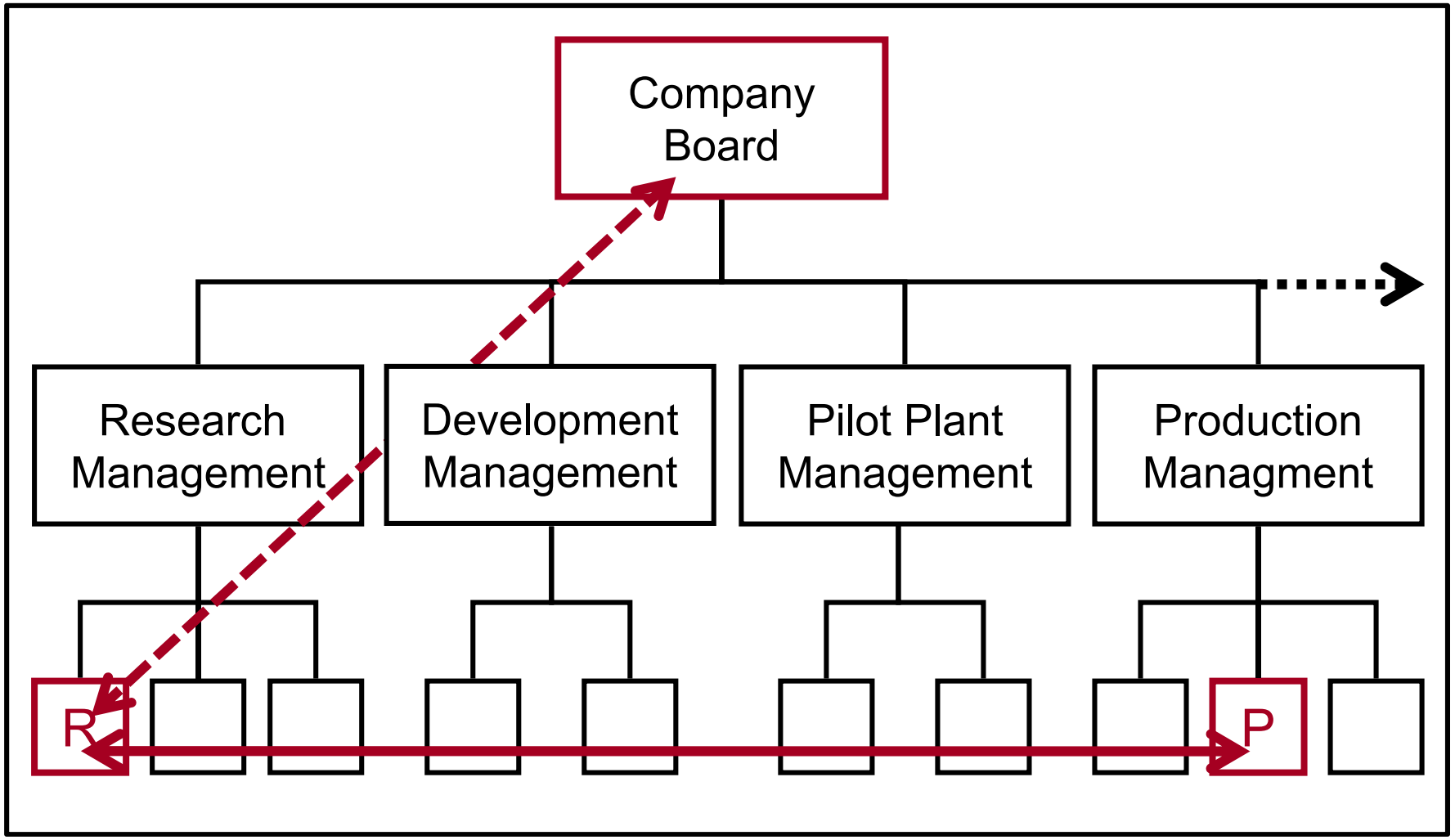
Information and Decision-Making

Project-Oriented, "Poor on Hierarchy" Organization:



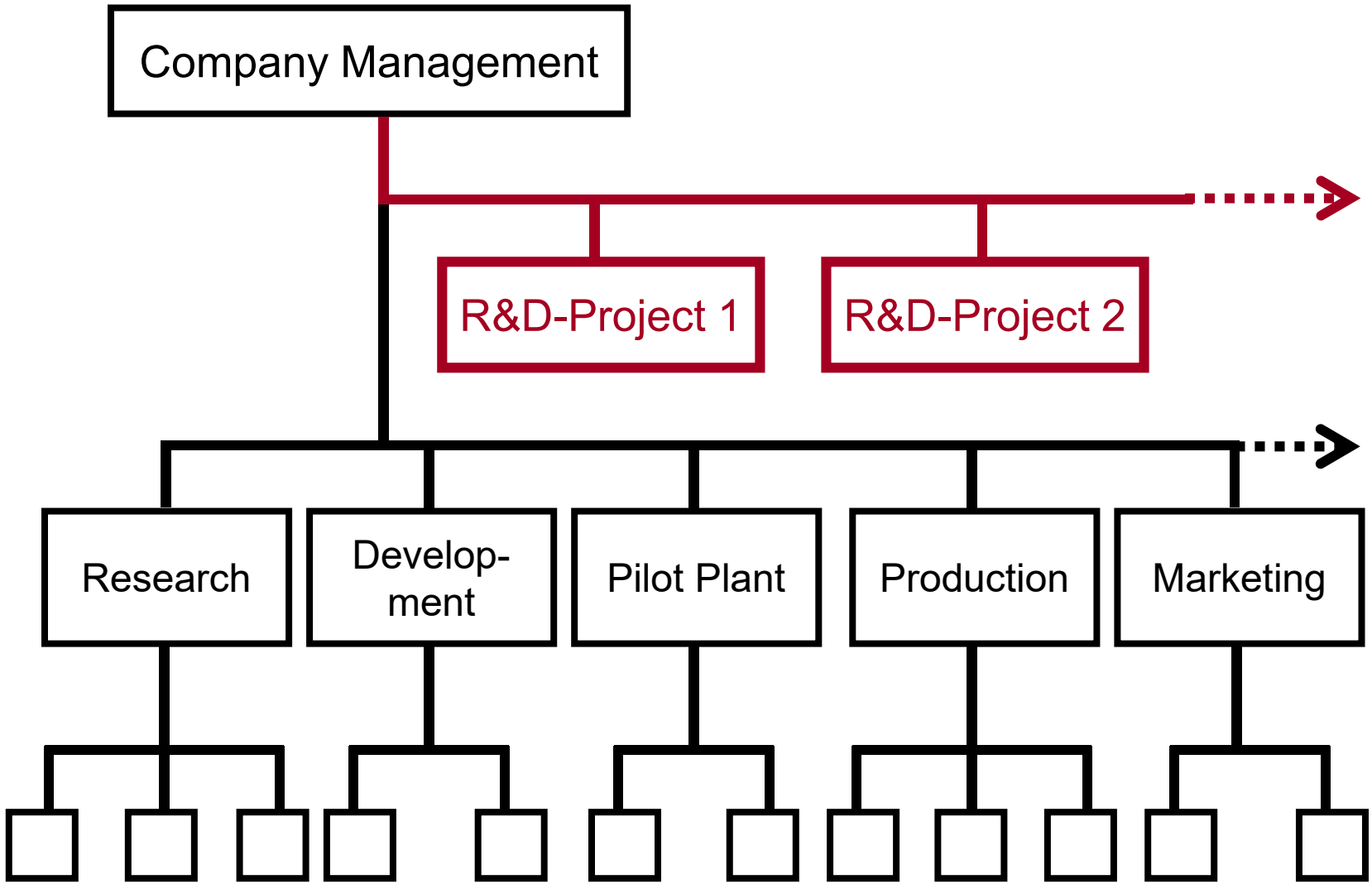
Appropriate Organizational Structures of R&D Projects

Basic Forms of Organizational Structure in Projects:

- Staff/Coordination Organization.
- Pure Project Organization.
- Matrix Organization.

Appropriate Organizational Structures of R&D Projects

Staff/Coordination Organization:



Appropriate Organizational Structures of R&D Projects

Staff/Coordination Organization:

Advantages:

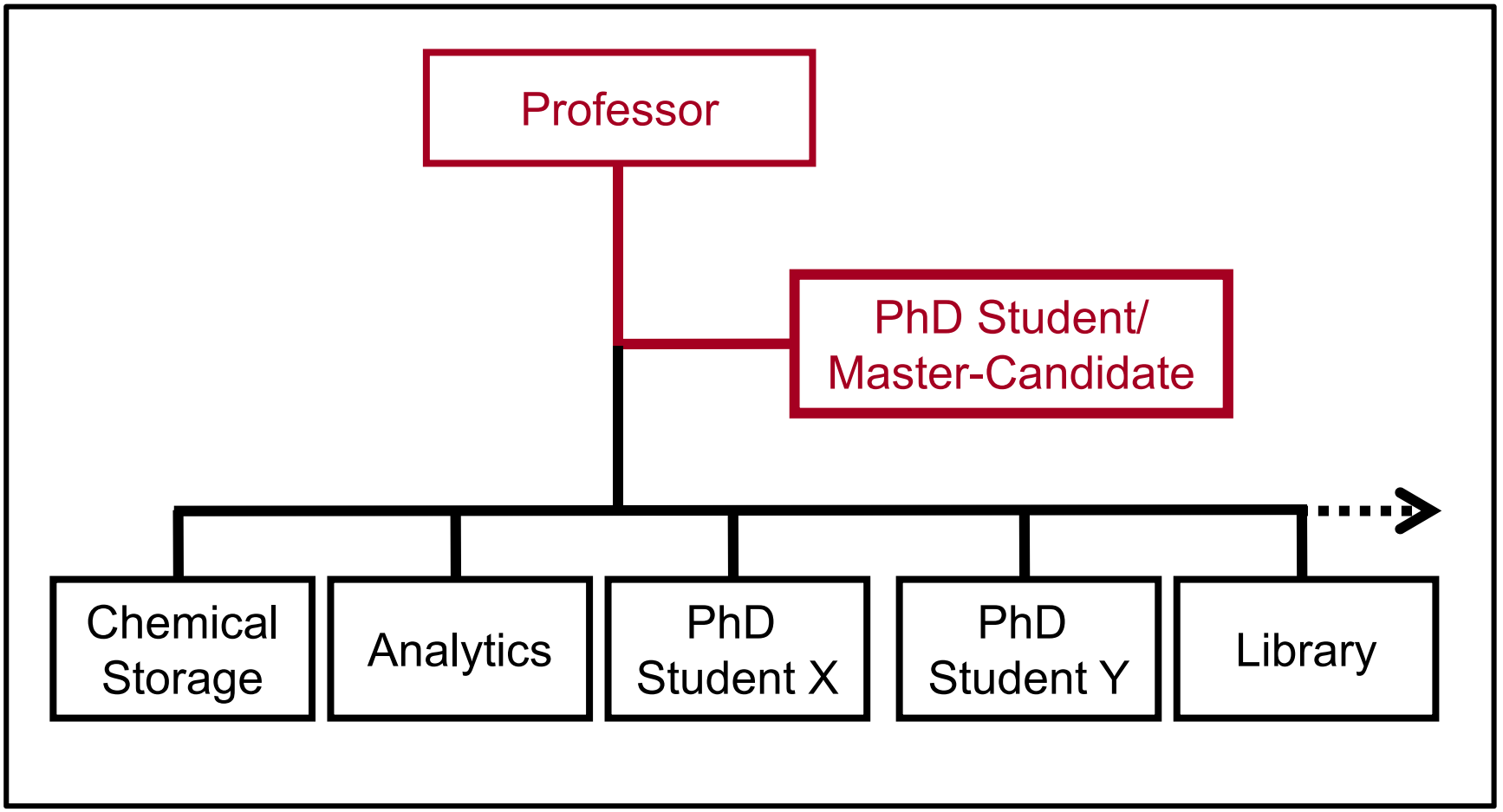
- Flexible deployment of staff, with multiple involvement.
- No additional organizational unit needed.
- The project experience remains in the specialist unit.

Disadvantages:

- Communication problems by departmental boundaries.
- Sometimes long lasting decision-making.
- The project manager (m/f/d) has hardly right of instruction.
- Project participants do not feel fully responsible.
- There arises no real team spirit.
- Synergies and emergences are not fully developed.

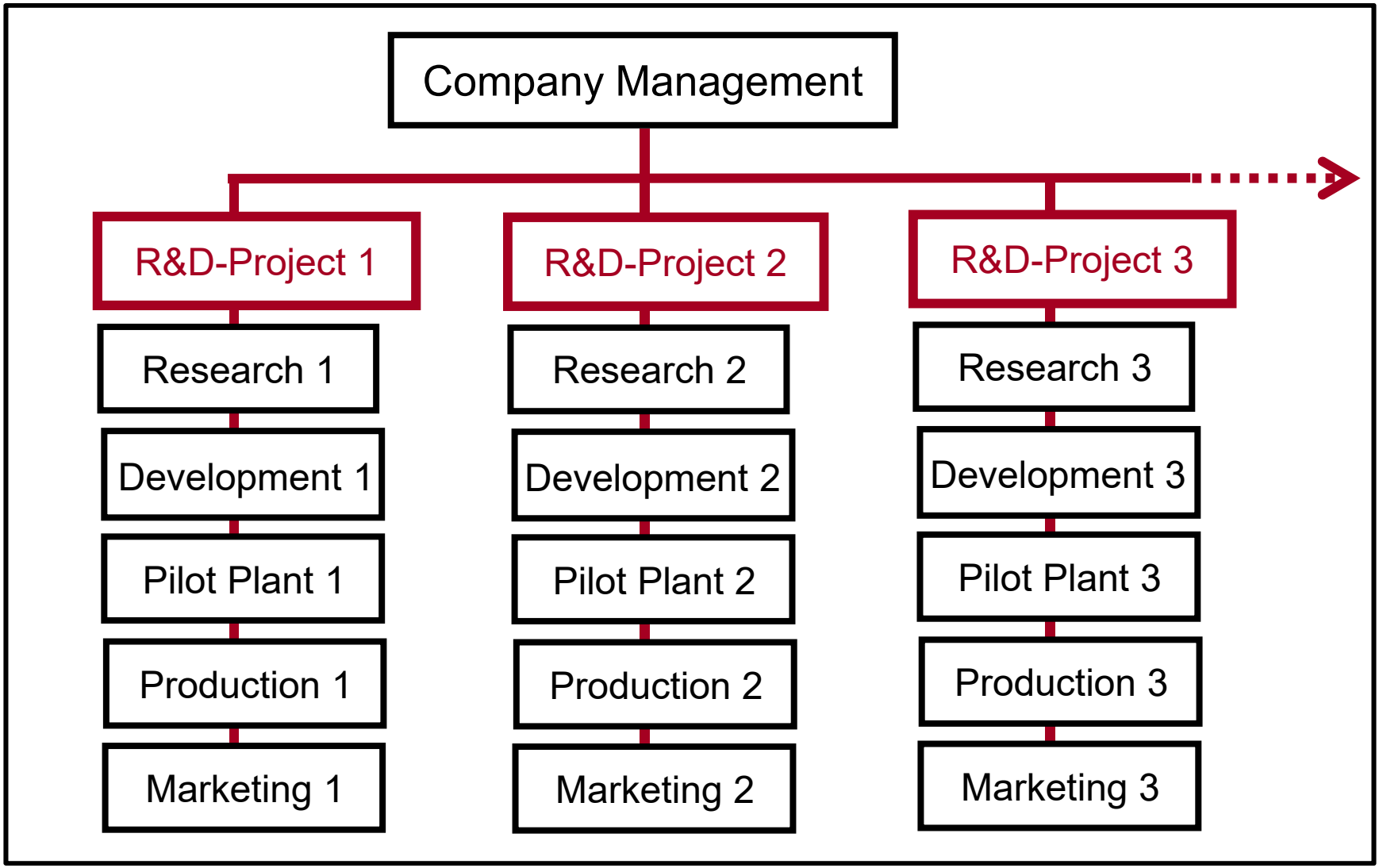
Appropriate Organizational Structures of R&D Projects

Coordination Organization at Research Work on Universities:



Appropriate Organizational Structures of R&D Projects

Pure Project Organization: (→ "Taskforce")



Appropriate Organizational Structures of R&D Projects

Pure Project Organization: (⟶ "Taskforce")

Advantages:

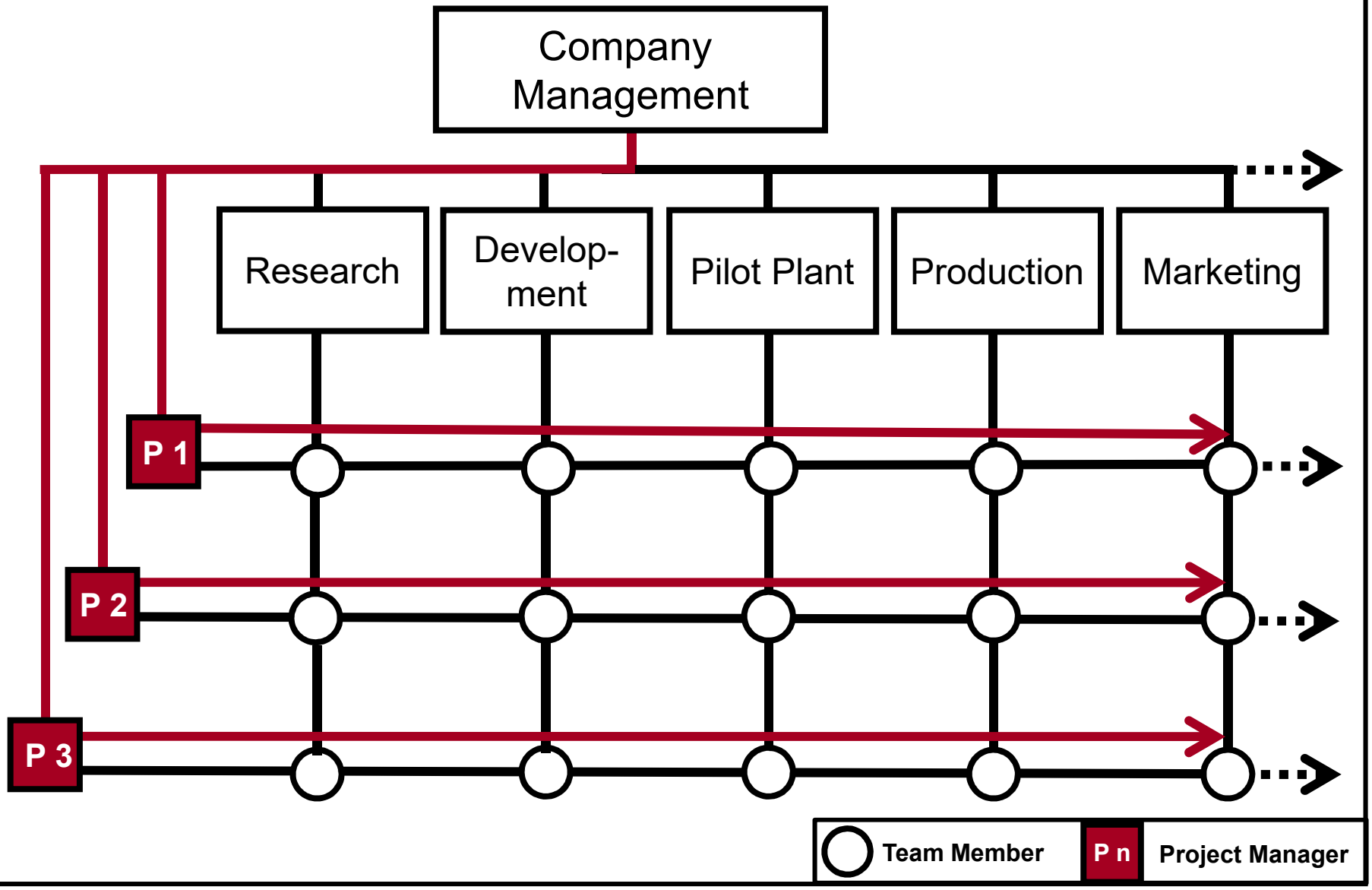
- The total labor power is 100% focused in the project.
- Short decision paths, fast reaction times.
- High identification of the team players with the project.
- The project manager (m/f/d) has the full right of instruction.

Disadvantages:

- Insufficiently used synergy effects between different R&D projects. Underdeveloped temporary integration of external specialists.
- At project completion: The project know-how can be lost.
- Team resolution can create reintegration issues with the line departments for each member.

Appropriate Organizational Structures of R&D-Projects

Matrix-Organization:



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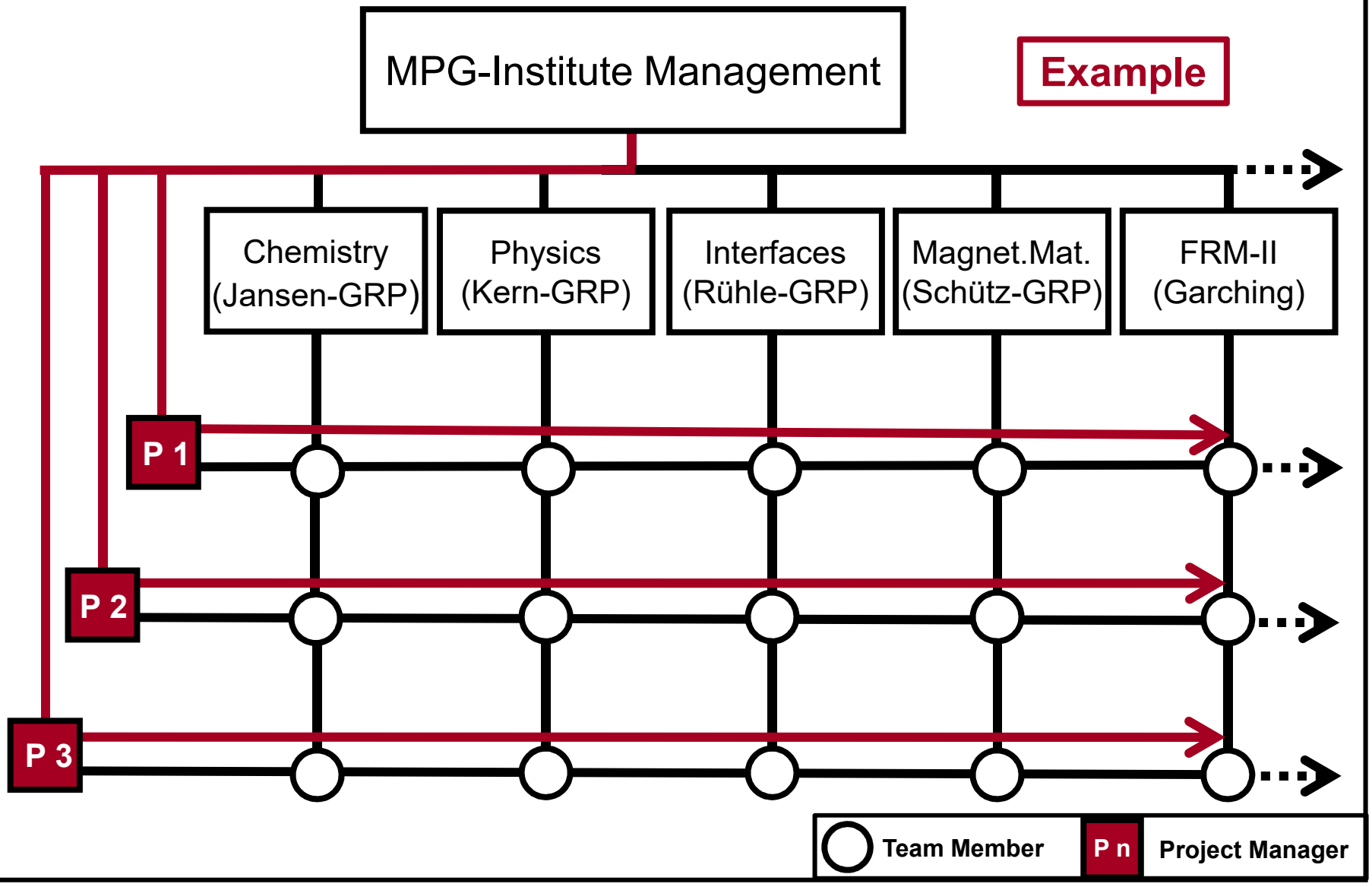
Appropriate Organizational Structure. **Matrix Organization in Research Institutes with CRCs or Graduate Colleges**:



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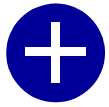
Appropriate Organizational Structures of R&D-Projects	**Matrix-Organization:**



Advantages:

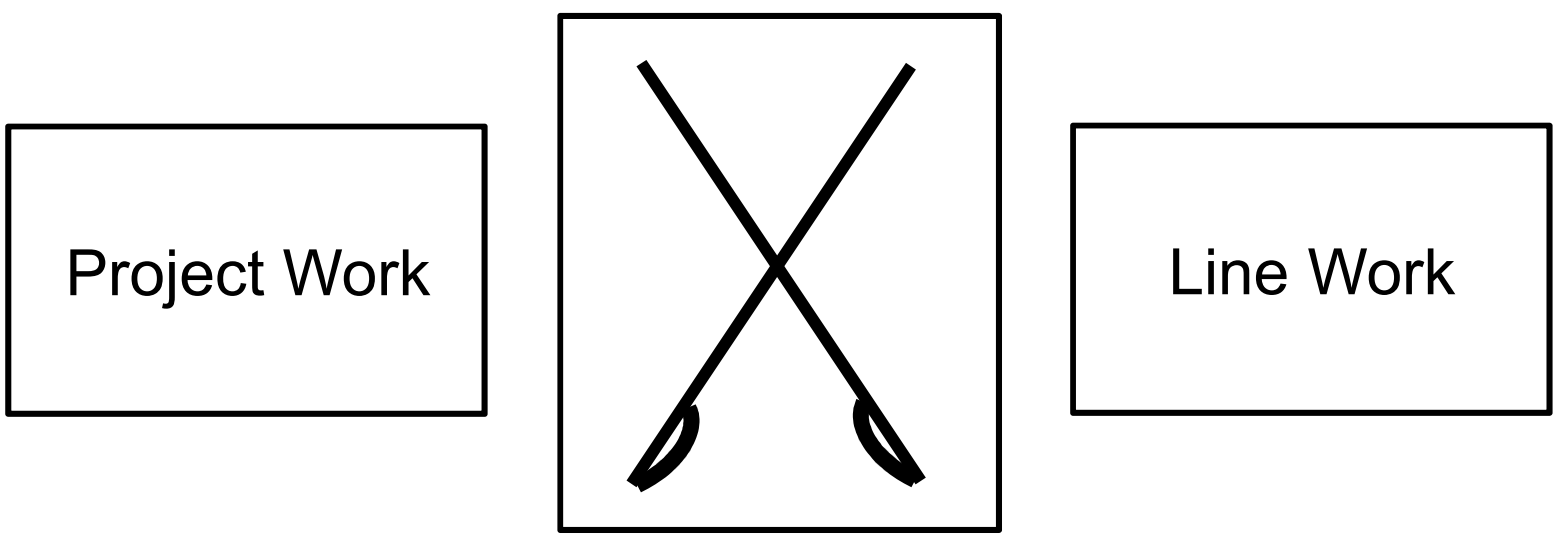
- Flexible staff deployment, which guarantees the continuity of the employee's career in the line.
- Targeted integration of specialists from other departments.
- Transdisciplinary view, synergies through high networking.
- The project manager (m/f/d) is responsible for the realization.

Disadvantages:

- Conflicts of interest "line ↔ project" are possible.
- Sometimes conflicts of competence "PM ↔ Line Chiefs".
- Danger of a "silent" project boycott by the line staff.
- "Braking effects" of longer decision times.
- The strict concentration on the target system may suffer.

Appropriate Organizational Structures of R&D Projects

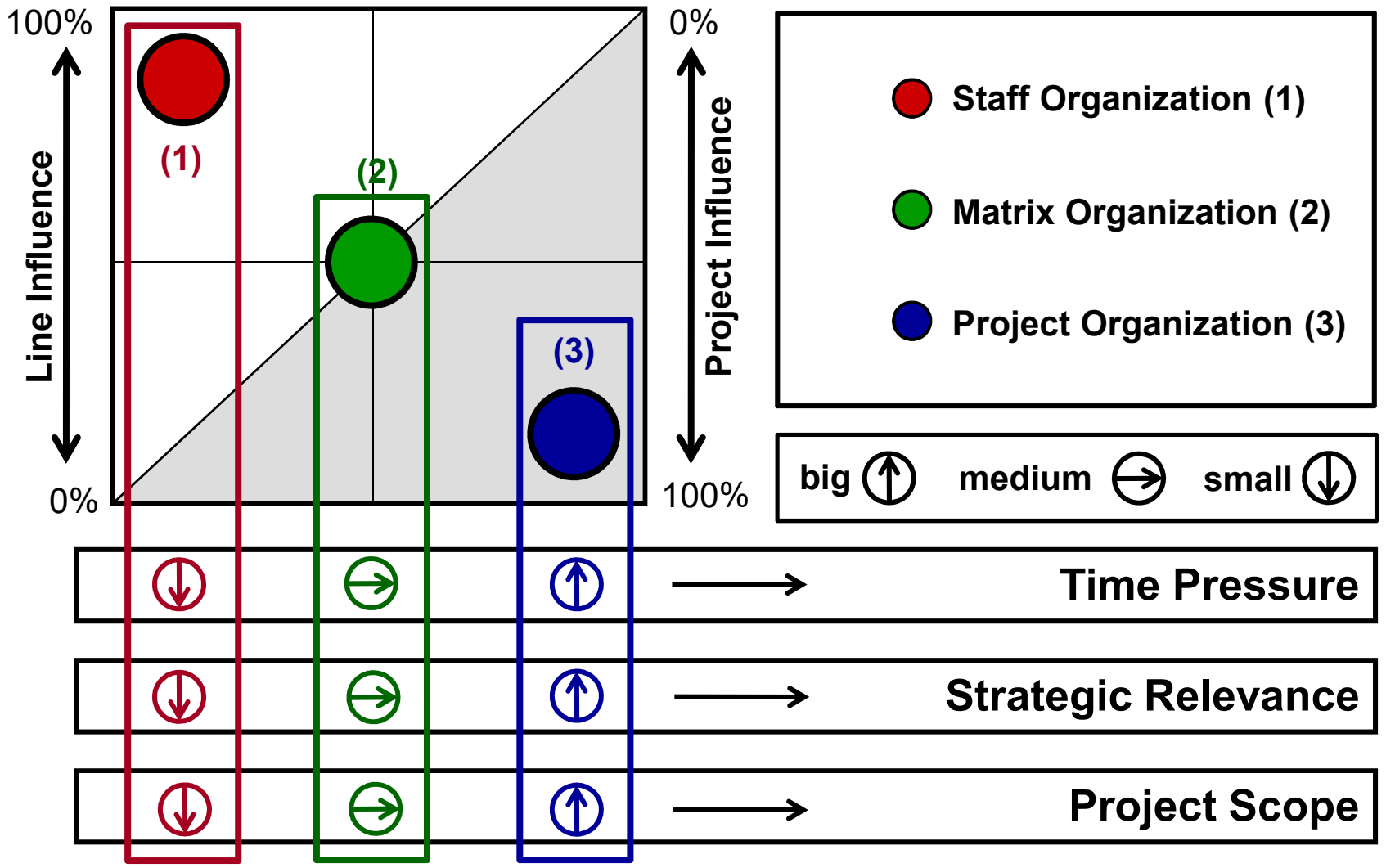
Matrix Organization: Line Goals ⟷ Project Goals.



Necessary: "Enforcement" of the project interests against the (legitimate) line interests.

Appropriate Organizational Structures of R&D Projects

Instructions/Decisions: Influences (Line ⟷ Project):



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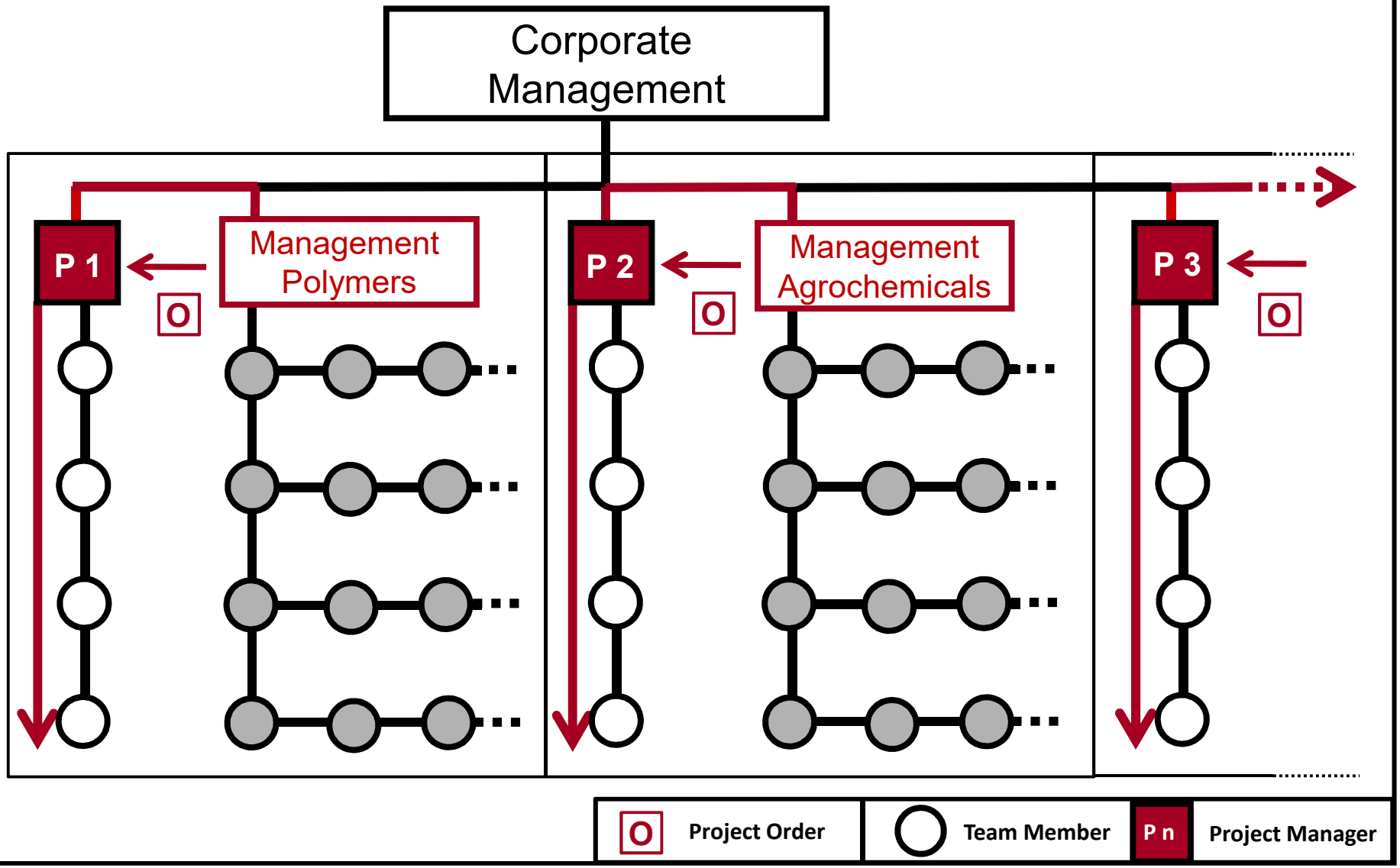
Appropriate Organizational Structures of R&D Projects

Some Supplementary Forms of the Organizational Structure:

- Product Organization/Order Organization.
- Pool Organization.
- Tensor Organization.
- Virtual Organization.
- Cross-Company Organizational Forms.

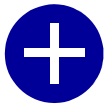
Appropriate Organizational Structures of R&D Projects

Product Organization/Order Organization:



Appropriate Organizational Structures of R&D Projects

Product Organization/Order Organization:



Advantages:

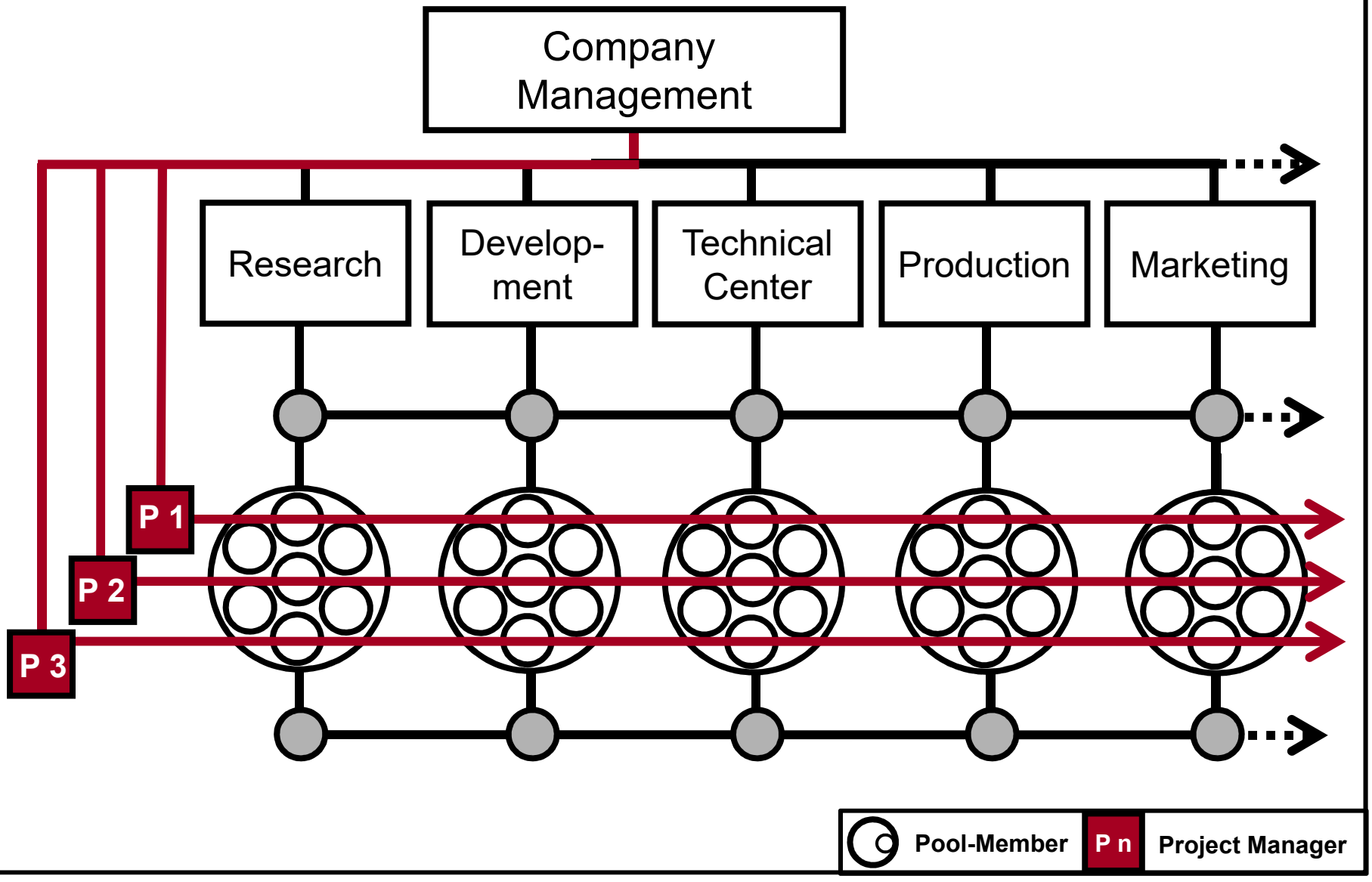
- The project manager (m/f/d) has the full right of instruction.
- No reintegration problems with the end of the project.
- High identification of the participants with the project.
- External customers have a defined contact.
- Suitability for large companies/corporations.

Disadvantages:

- Danger of an "isolated" company within the company resulting in little technical exchange.
- Possible "competitive thinking" between the divisions.

Appropriate Organizational Structures of R&D-Projects

Pool Organization:



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Appropriate Organizational Structures of R&D-Projects

Pool Organization:

Advantages:

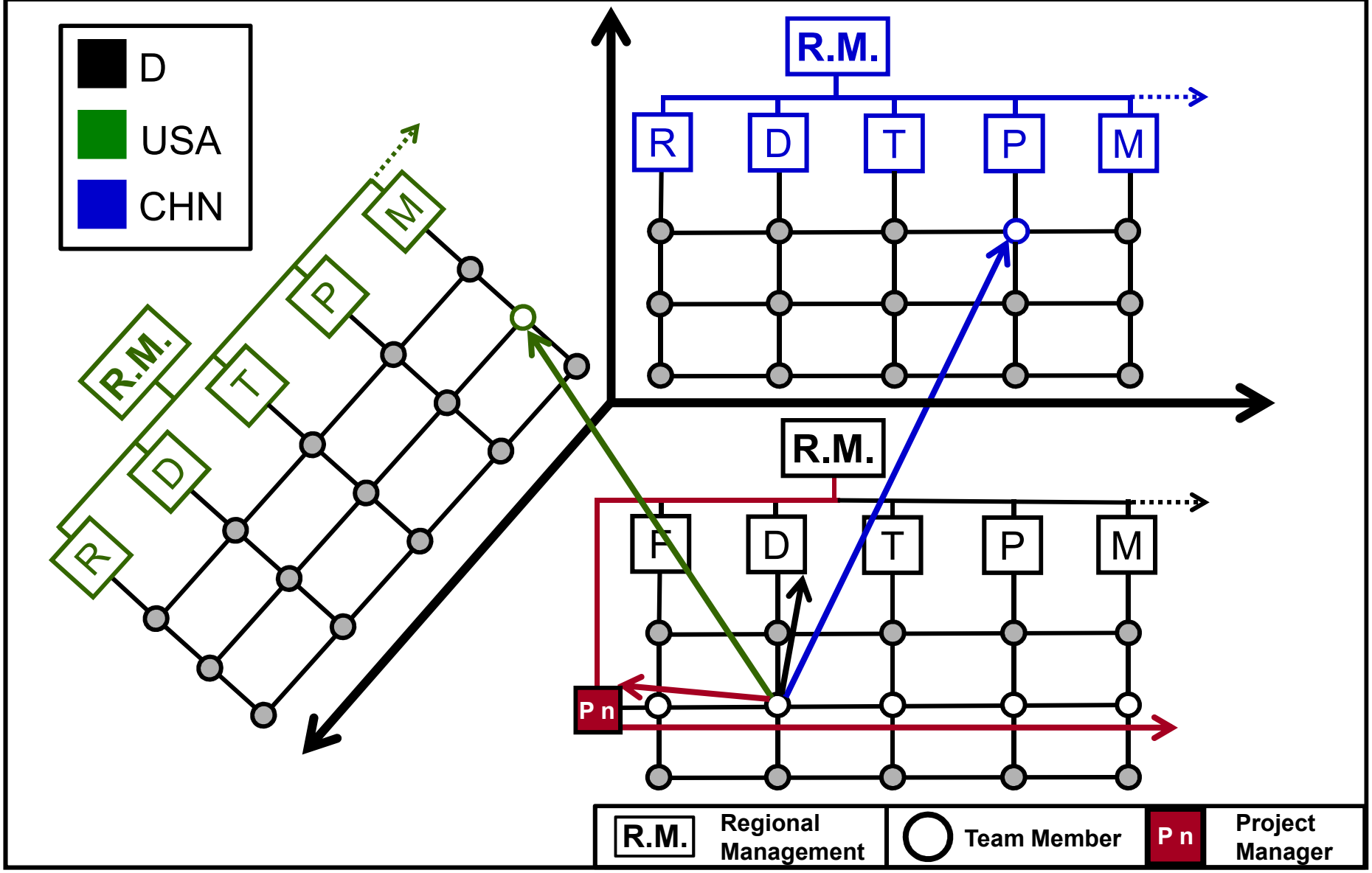
- Some advantages of the pure project organization.
- No "dissolution" of the line organization required.
- Time limited and customized use of specialists.
- Project members see themselves as service providers.
- The required experts have strong project experience.

Disadvantages:

- The "Top Experts" in the pool are often "fully booked".
- Priority conflicts with "Multi Project-Specialists".

Appropriate Organizational Structures of R&D-Projects

Tensor Organization:



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Appropriate Organizational Structures of R&D-Projects	**Tensor Organization:**

Advantages:

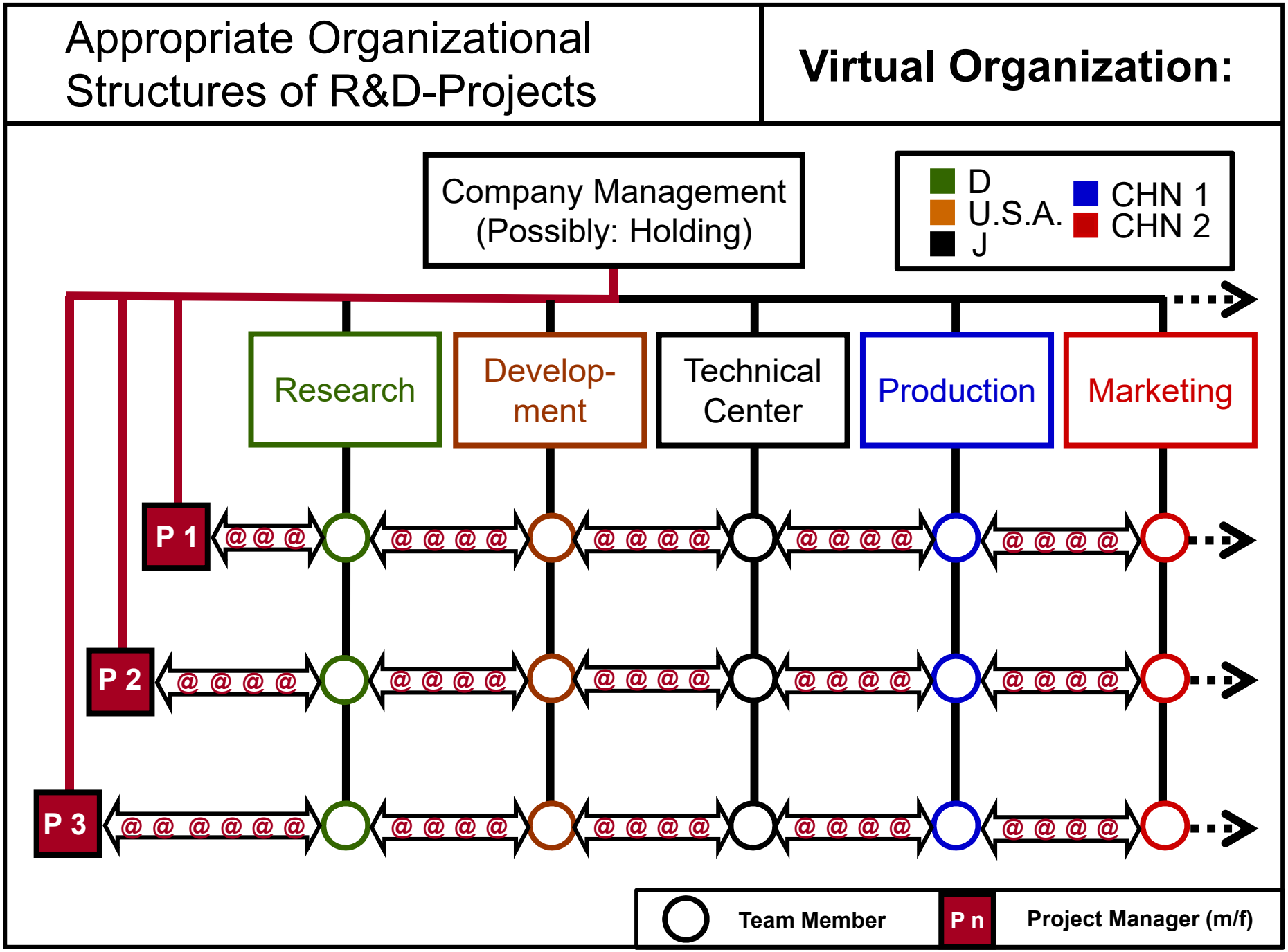
- Flexible, immediately effective personnel deployment.
- Effective involvement of different regions.
- Transnational view, synergies through high networking.
- Project Manager (m/f/d) is responsible for the process.

Disadvantages:

- Conflicts of competence in important decisions.
- Several "supervisors" per team member.
- Complicated project management, coordination effort.
- Sometimes long decision and reaction periods.

Appropriate Organizational Structures of R&D-Projects

Virtual Organization:



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Appropriate Organizational Structures of R&D-Projects

Virtual Organization:

Advantages:

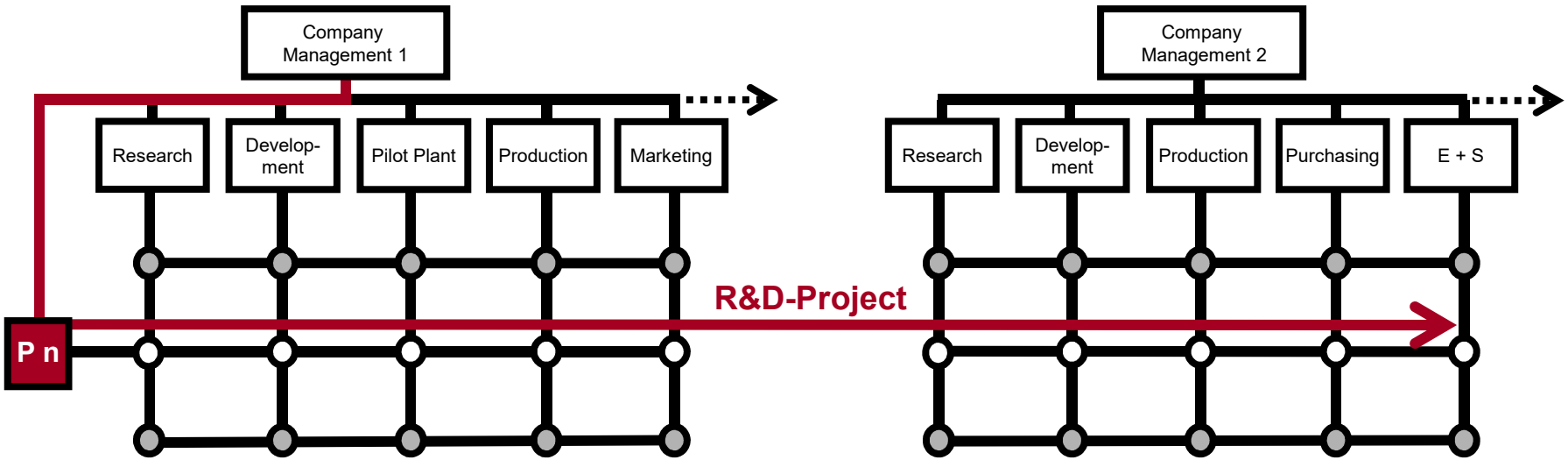
- The worldwide involvement of project participants is possible.
- Continuous development despite local time differences.
- Use of regionally different expertise.
- Low labor costs in other countries.
- The work results can be continuously forwarded (@).

Disadvantages:

- Danger of "virtual disorganization", "information overload".
- Additional communication effort.
- Team building and team work can become complicated.
- Susceptibility to espionage/know-how outflow.

Appropriate Organizational Structure of R&D Projects

Cross-Company Project Organizational Form:
Research Alliance with a Duplex Matrix Structure.

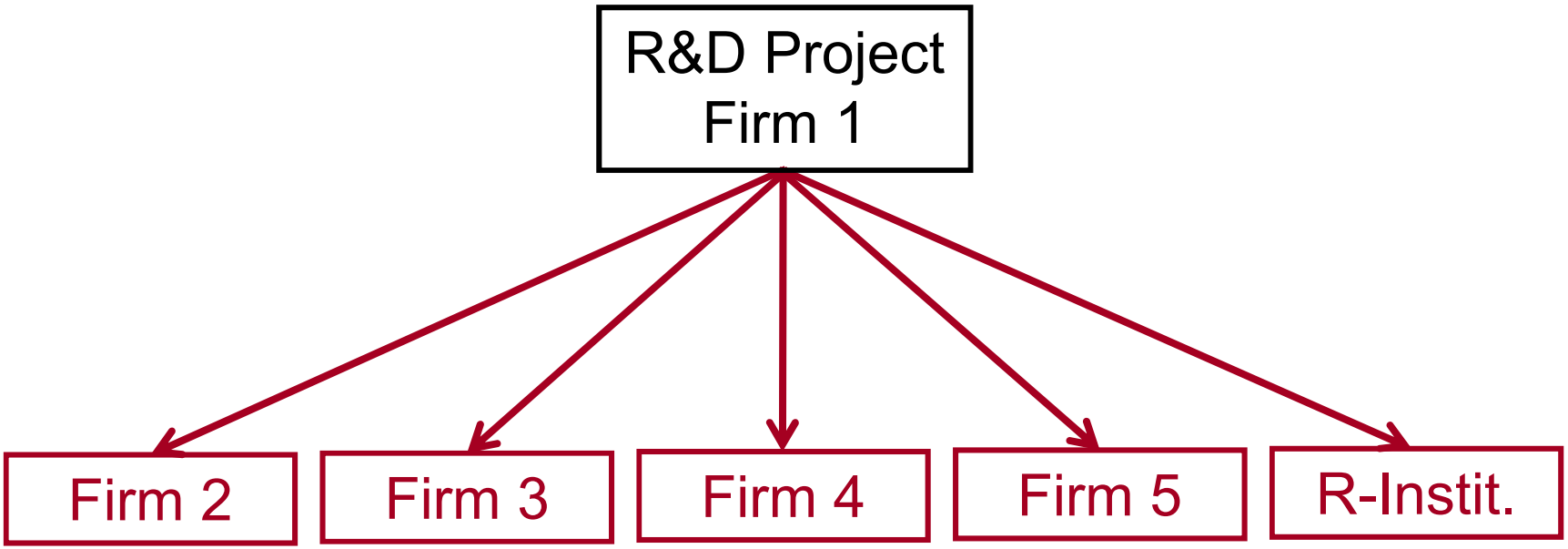


Strategic Research Alliance

Team Member | P n | Project Manager

Appropriate Organizational Structure of R&D Projects

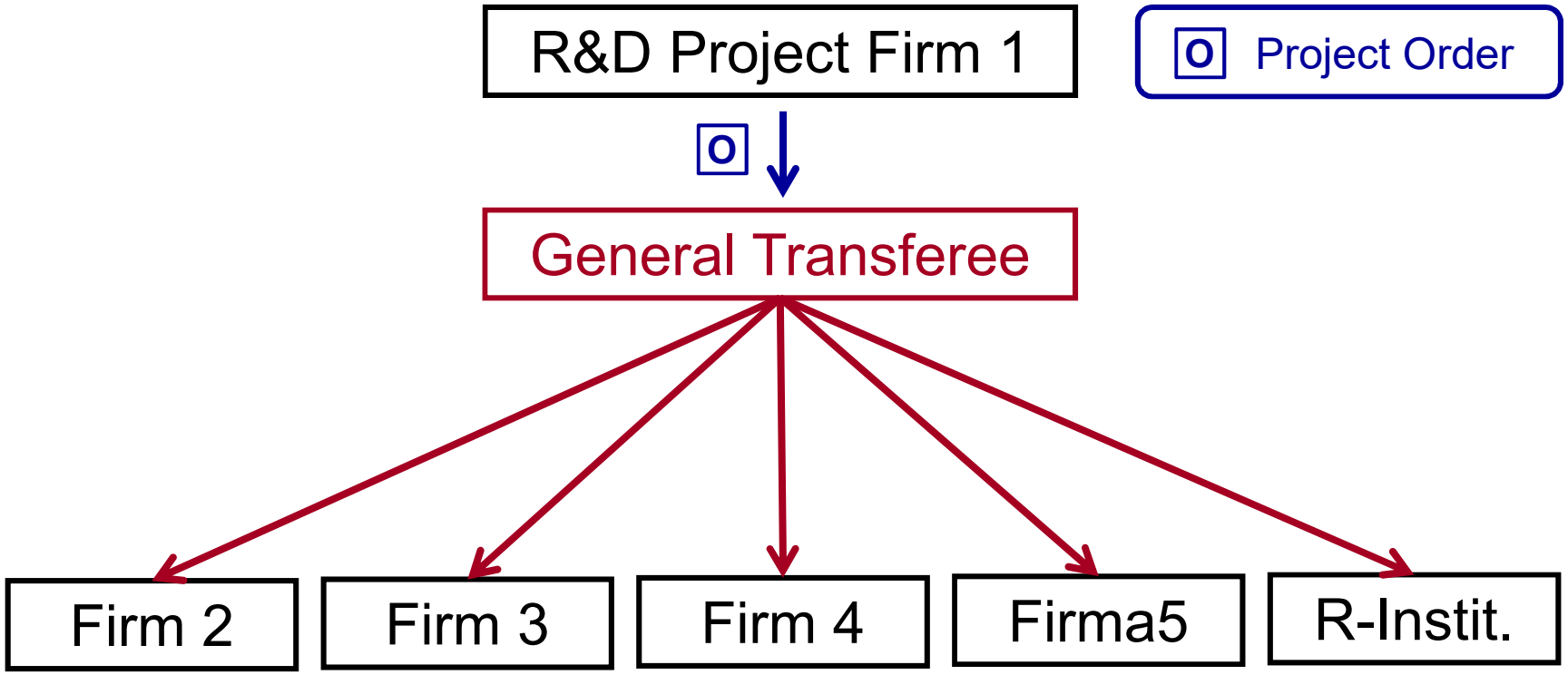
Cross-Company Project Organizational Form:
Individual contracts with defined, goal oriented orders.



Commissioning of individual orders to companies and institutes.

Appropriate Organizational Structure of R&D Projects

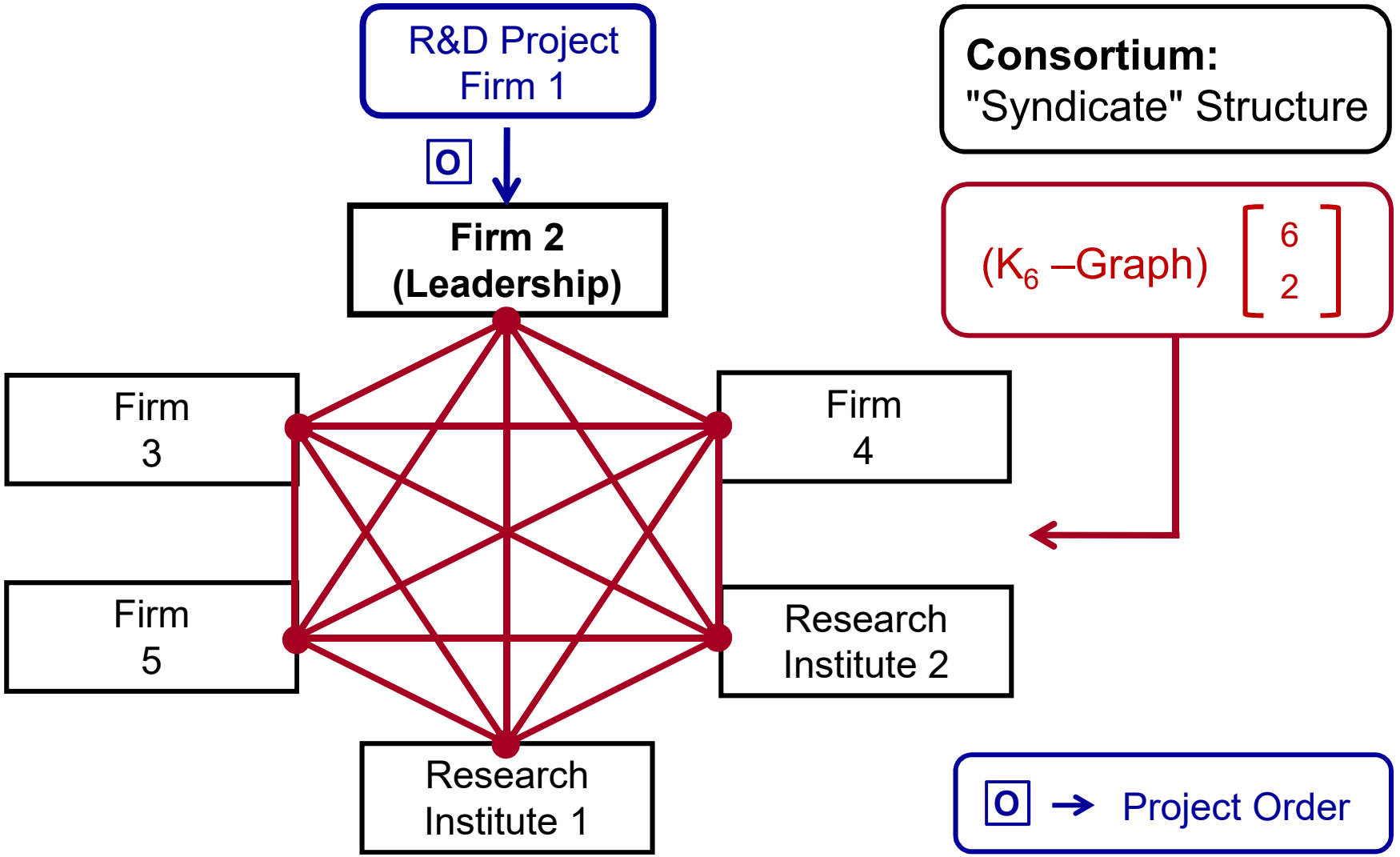
Cross-Company Project Organizational Form:
Project Management Contract with One "General Transferee".



Project assignment to *one* competent *general transferee*.

Appropriate Organizational Structure of R&D Projects

Cross-Company Organizational From: → Consortium.



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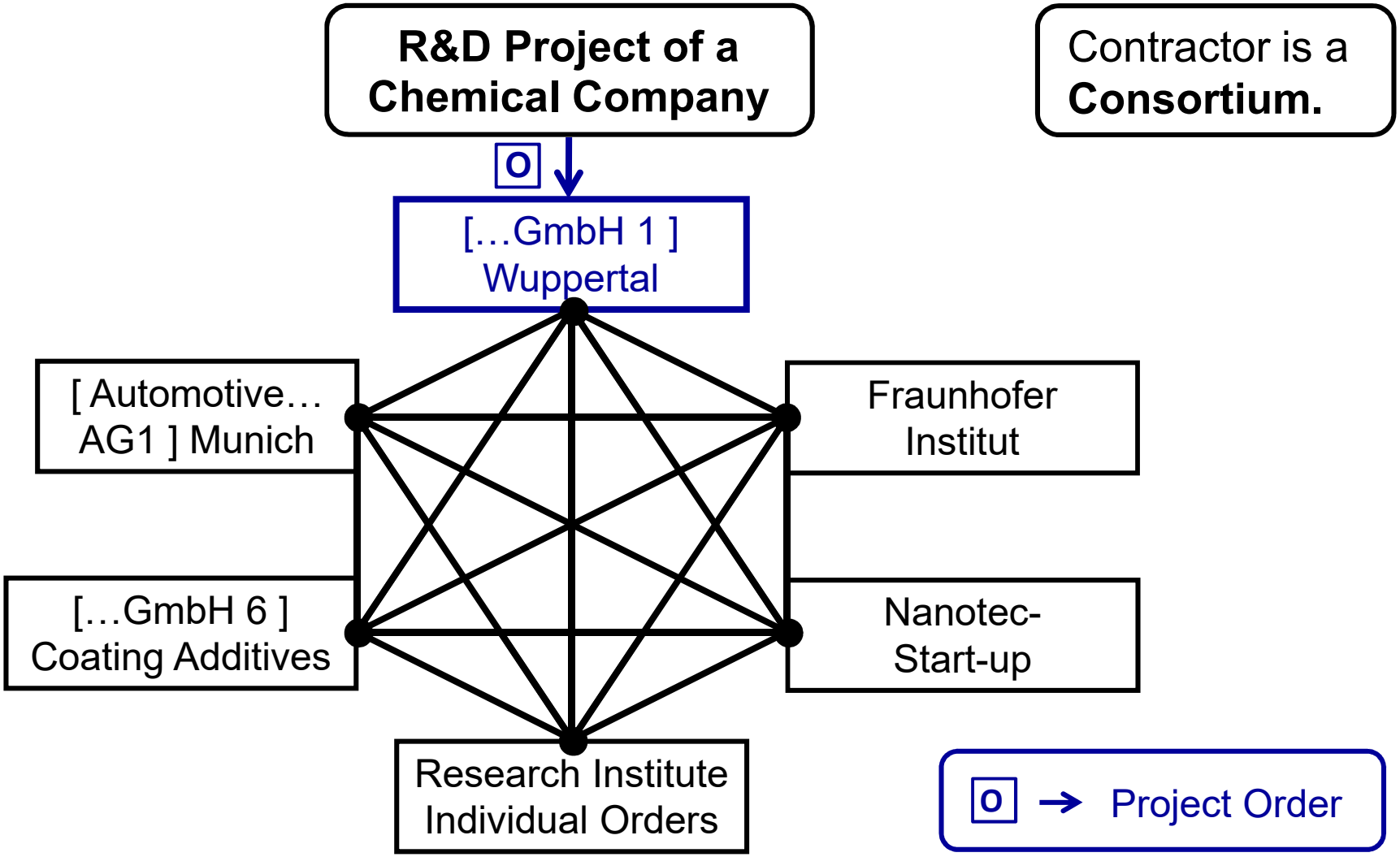
Cross-Company Organizational Form:
Project: "Highly Elastic Clear Coats…"

Example P1



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Appropriate Organizational Structure of R&D Projects

Cross-Company Organizational Forms.

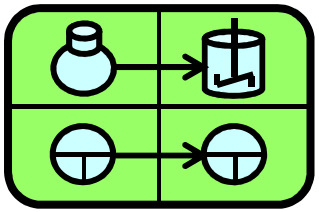
Advantages:

- Good organizational framework for transregional and cross-industry major projects.
- Transparency of the work results for all companies (@).
- Smooth project flow despite different branches.
- Ways to apply for state funding .

Disadvantages:

- Different corporate cultures may act as "barriers".
- Divergent structures or processes in other companies.
- Very high coordination effort.
- High probability of a "virtual disorganization".

R&D Project Management in the Chemical Industry



Subject Matter →

Effective Structure Planning of R&D Projects.

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Effective Structure Planning of R&D Projects

Planning of R&D Projects, Characteristics:

Planning is the prerequisite and **preparation for future activities** in order to make them goal-oriented, effective and economical.

Careful and complete planning **anticipates the future of a project** ("draft in advance"!). And thus its prospect of success!

Effective Structure Planning of R&D Projects

Planning of R&D Projects, Characteristics:

What the project team does not plan, it will hardly achieve! After careful ***cogitation***, it must move on to determined ***thinking ahead***!

According to a first draft, the project planning, especially in the case of R&D projects, comprises a **periodically repeating, "iterative" process** that is characterized by constant improvement and precision!

Effective Structure Planning of R&D Projects

Planning Certainty of R&D Projects, Limits:

Very important:
"Plan only what indeed can be planned!" (For example, the experiments by type and number, experimental setups, chemicals, laboratory equipment, reaction conditions, personnel requirements, etc.).

R&D projects are "unpredictable", with regard to the desired goal achievement "risky" projects, which are connected by their novelty and uniqueness with high uncertainty of results and high change dynamics!

"Research can be planned,
but research results can not be planned!"

(Source: R. Criegee, Karlsruhe, D. Seebach, Zürich)

Effective Structure Planning of R&D Projects

Planning Effort for R&D Projects: Necessity!

Far too often, **projects are started with unclear target systems and without sufficient planning**, with the mistaken assumption that this will minimize the project terms and the costs.

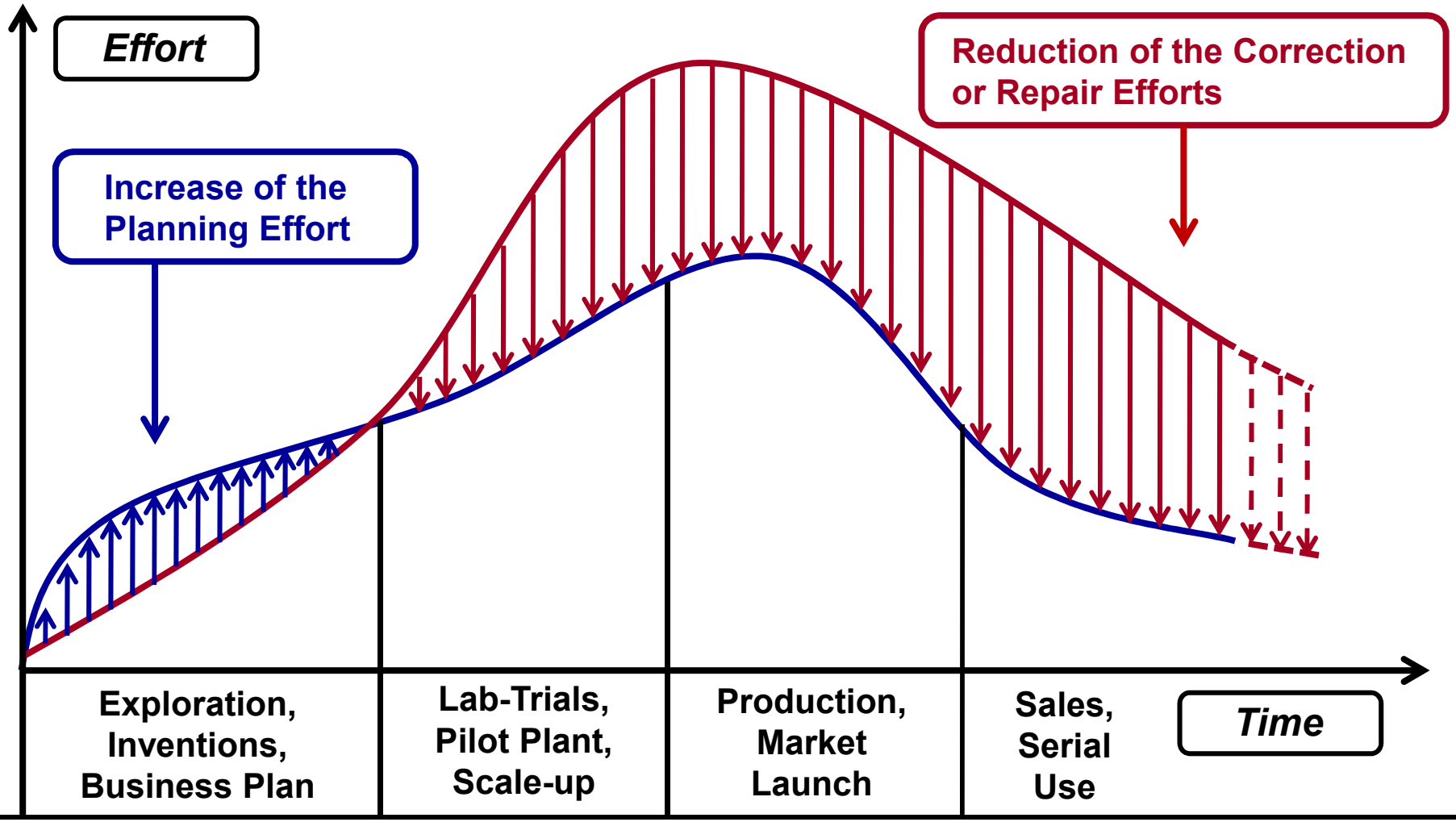
Corresponding deficits before the start of the project are the actual causes for time and cost overruns. Because during the planning, the target systems are defined, the "roadmaps" for the process are drawn, the basic decisions are made and the most suitable team players are involved in the projects.

The professional start is therefore particularly important!

One wisdom among project leaders sounds as follows:
"Tell me how your project starts, and I'll tell you how it will end ..."

Effective Structure Planning of R&D Projects

Reduction of Implementation and Testing Efforts:



Advantage of early and solid planning: Reduction of the total effort.

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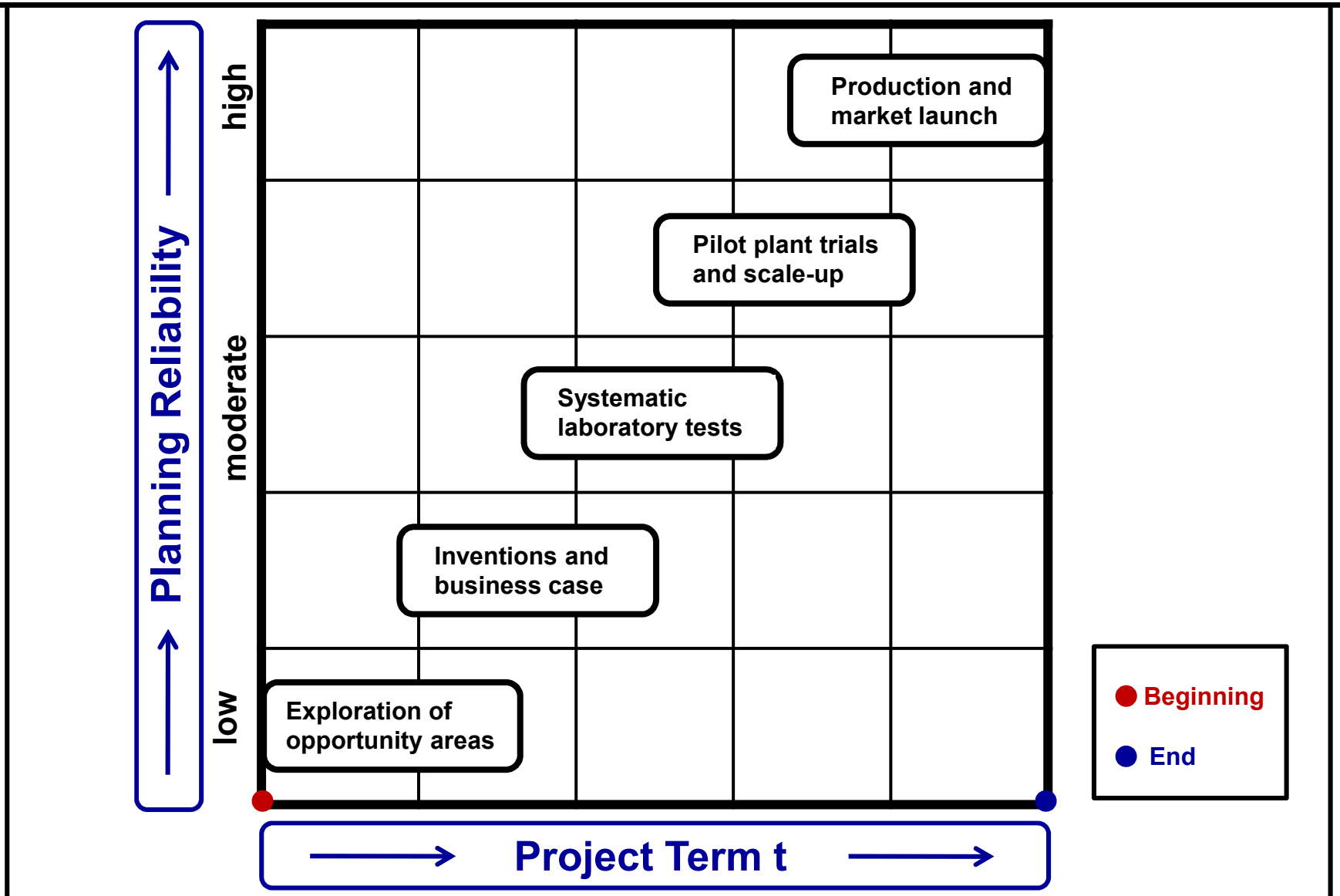
Effective Structure Planning of R&D Projects

The Planning Reliability Grows with the Project Term t!



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Effective Structure Planning of R&D Projects

Objectives of Structure Planning: ⟶

- Clarity for all stakeholders.
- Knowledge of the complexity of the entire project.
- Planning security regarding required resources (FTE, €).
- Effectiveness with regard to the required actions.
- Possible reduction of project costs.
- Possible reduction of project duration.
- Increase of the control and steering ability.
- Risk minimization during project execution.

Effective Structure Planning of R&D Projects

Consequences of severe bad planning in R&D projects.
Typical "reaction cascade" after planning errors:

1. Enthusiasm for the R&D project, optimism ...
2. Significant deviations between target/actual values ...
3. Disillusionment from all sides in the team ...
4. "Escape" of those responsible for planning ...
5. Search for the guilty parties ...
6. Premature termination of the R&D project ...
7. Destruction of all data and facts about the failures ...

:=) → Here: "Worst Case Scenario"!

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Effective Structure Planning of R&D Projects

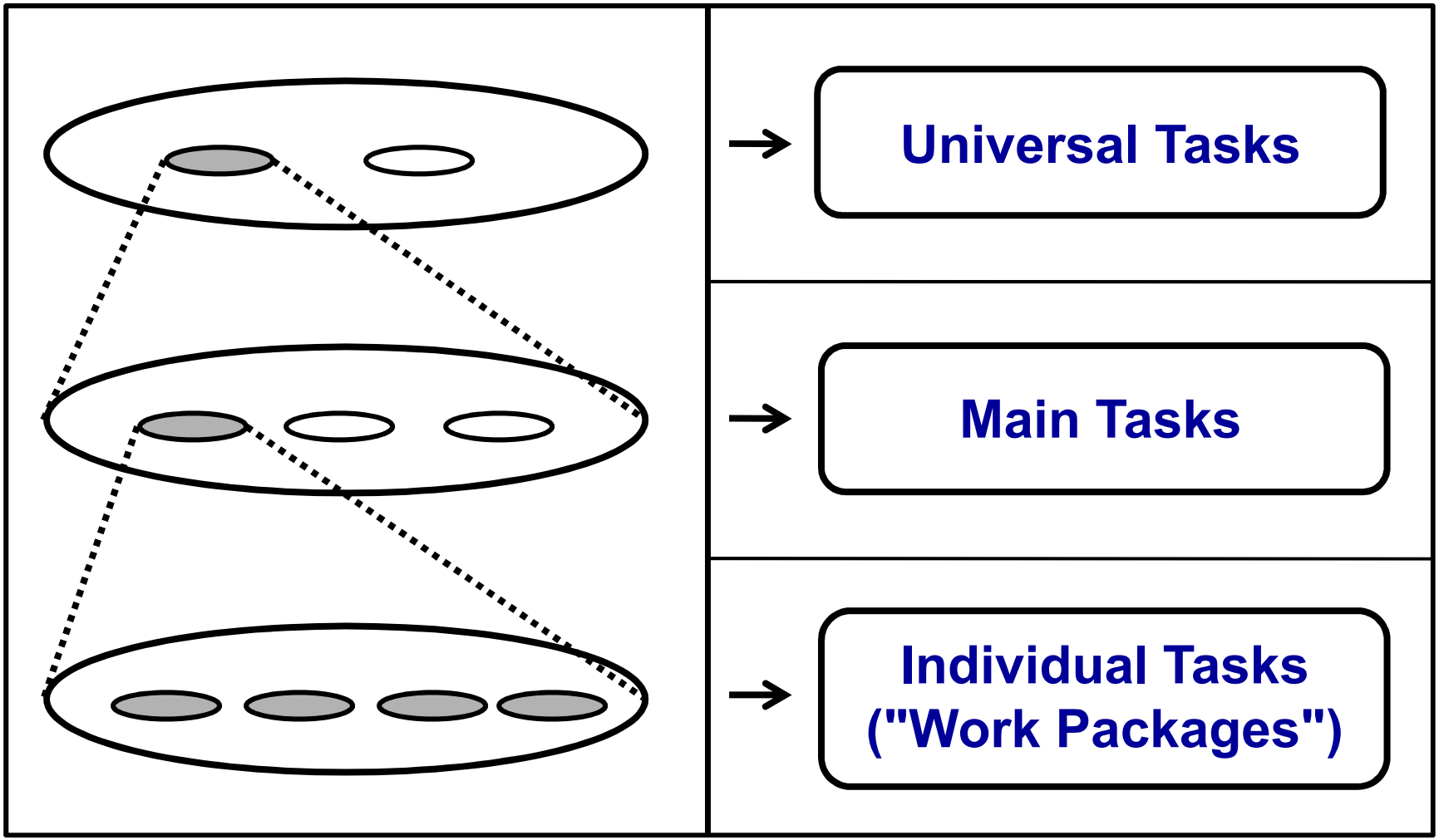
Practical, Goal-Oriented Execution.

Important in Practice:

- Representatives of *all* functions in the project must participate!
- Plan first in width, then (!) go depth!
- Principle: From the rough to the details!

Effective Structure Planning of R&D-Projects

Hierarchy of Task-Related Planning Levels:



Effective Structure Planning of R&D-Projects

Structure Planning: Necessary Steps for the Attainment of Clarity in a Complex, Universal Task.

These four steps have to be performed: One after the other

1) Joint definition of the complete target system.
2) Collecting all goal-relevant tasks to be solved.
3) Classification of these tasks by the number of in each case participating specialist units/specialist departments.
4) Construction of a hierarchically divided structure plan.

Effective Structure Planning of R&D-Projects

Structure Planning: Necessary Steps for the Attainment of Clarity in a Complex, Universal Task.

Step 1	→ **Definition of the target system**: Joint agreement on technical, temporal and economic objectives.
Step 2	→ Joint **collecting of all tasks** to be solved for the complete achievement of the objective system.
Step 3	→ **Classifying these** goal-relevant **tasks** according to the number of specialized units (S. U.) involved in their solution.
Step 4	→ **Building of a structure plan** with hierarchically divided planning levels, which interconnects related tasks by corresponding lines.

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Step 1 → **Definition of the target system:** Joint agreement on technical, temporal and economic objectives.

Technical (P):

- Technical property A: Description with verifiable data.
- Technical property B: Description with verifiable data.
- Technical property C: Description with verifiable data.
- Technical property D: Description with verifiable data.
- Technical property E: Description with verifiable data. → →

Temporal (T):

- Project start: Date; Project end: Date. → →

Economic (E):

- Market share in a given market: Percentage and specification of a timing.
- Project costs: Stated in EURO; Date, connected with "Return of Investment".
- Production costs: Stated in EURO/kg. → →

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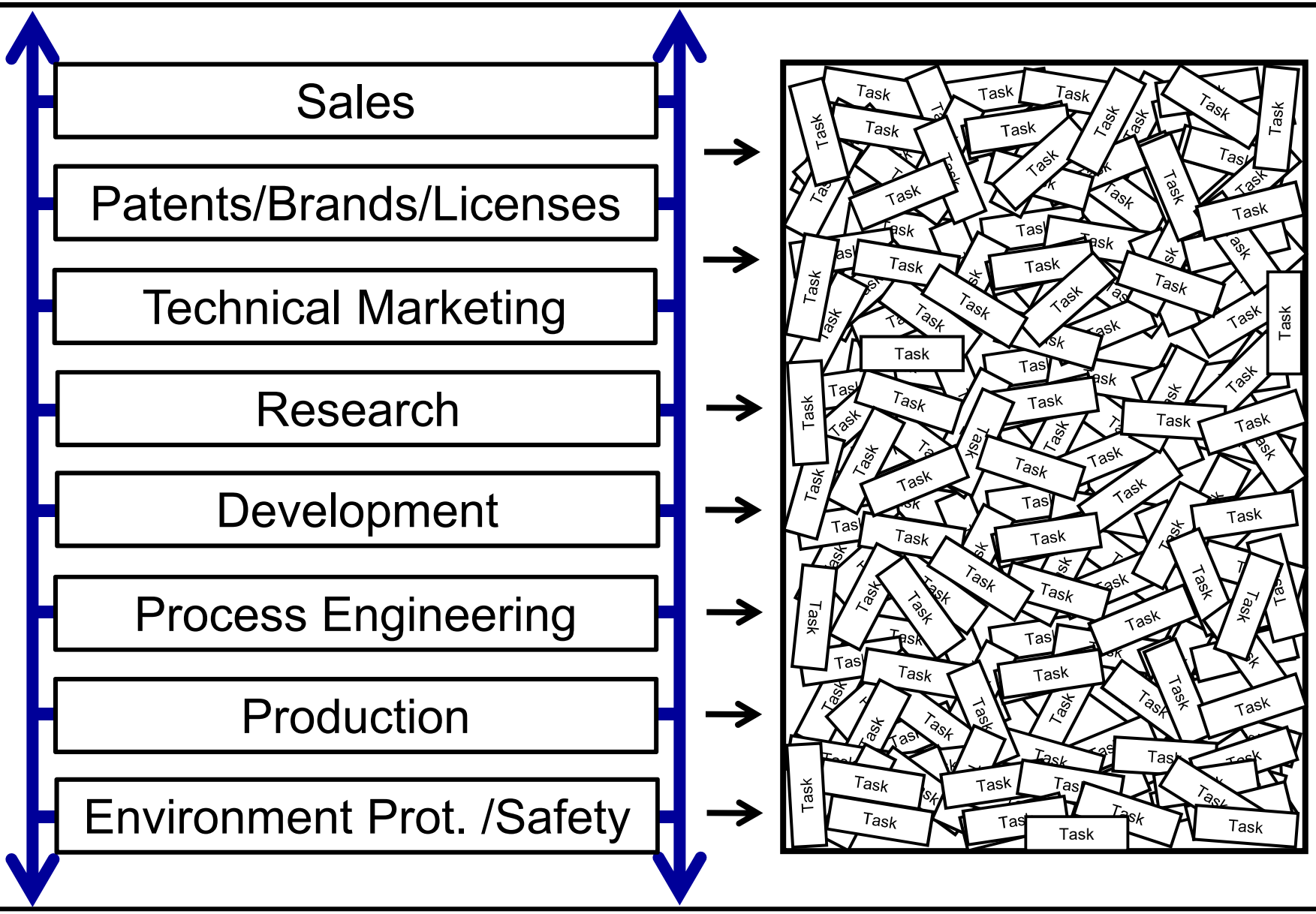
Step 2 → [Joint **collecting of all tasks** to be solved for the complete achievement of the objective system.]



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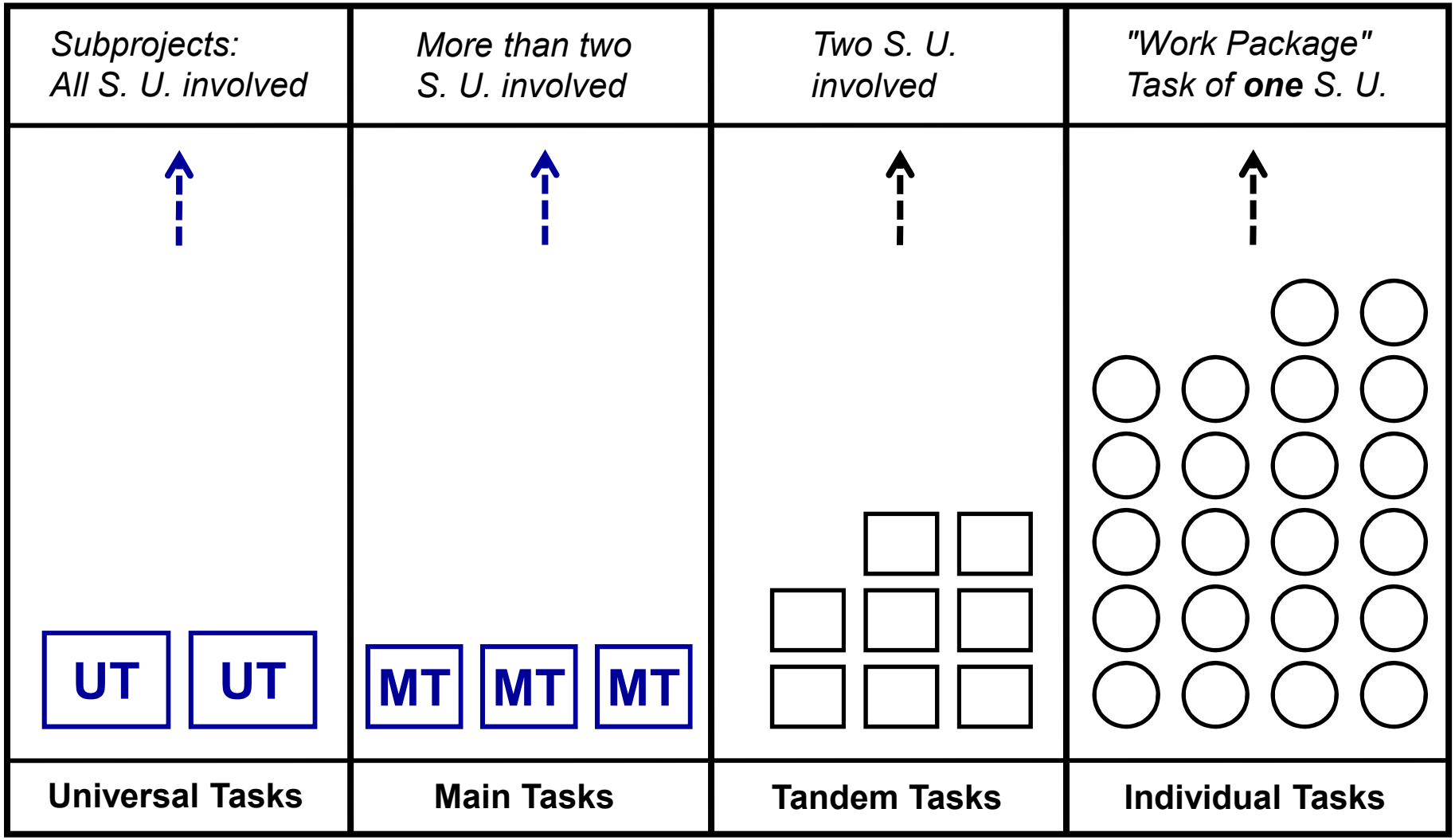
Step 3 → **Classifying these** goal-relevant **tasks** according to the number of specialized units (S. U.) involved in their solution.



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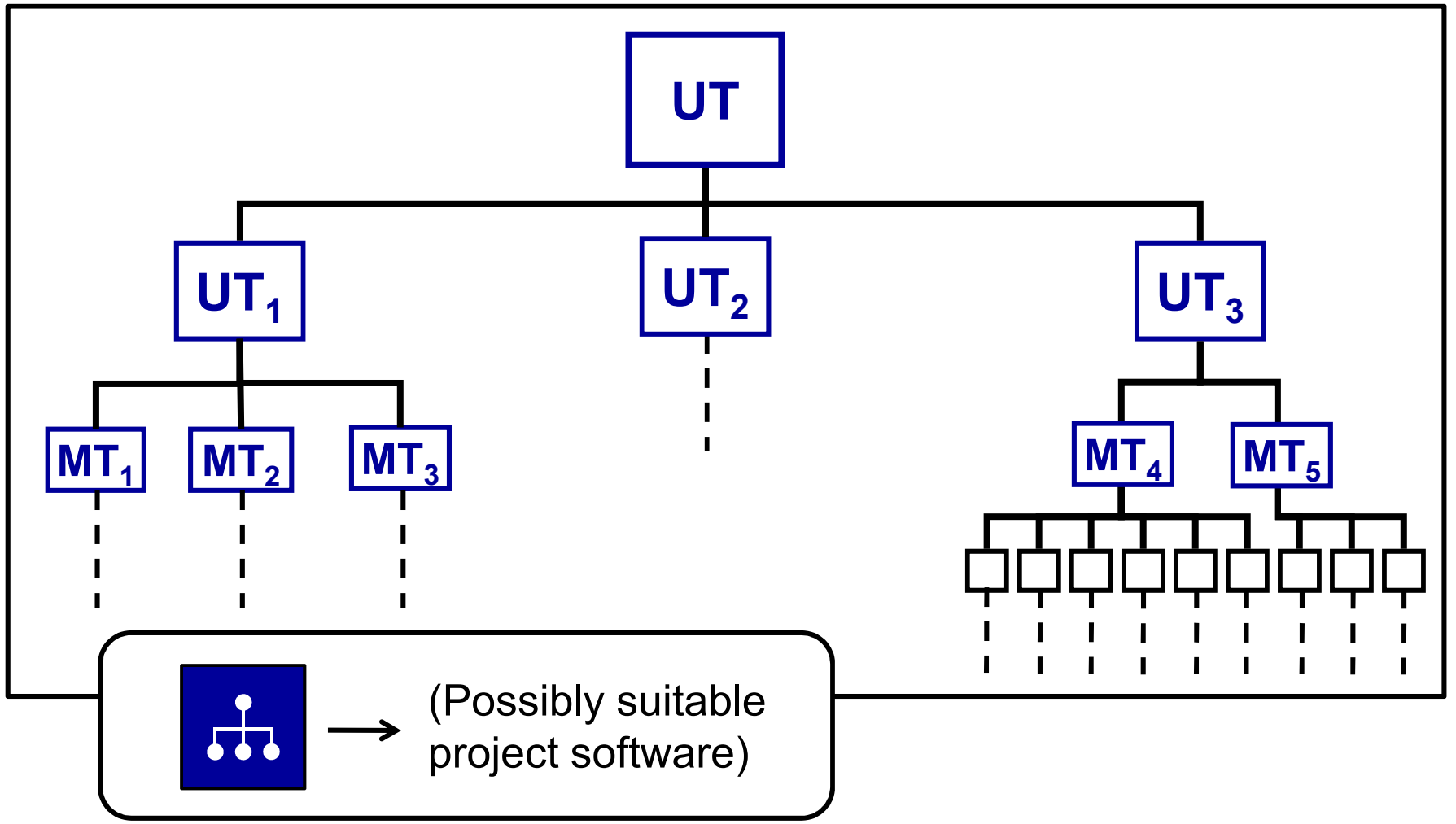
Step 4 → **Building of a structure plan** with hierarchically divided planning levels, which interconnects related tasks by corresponding lines.



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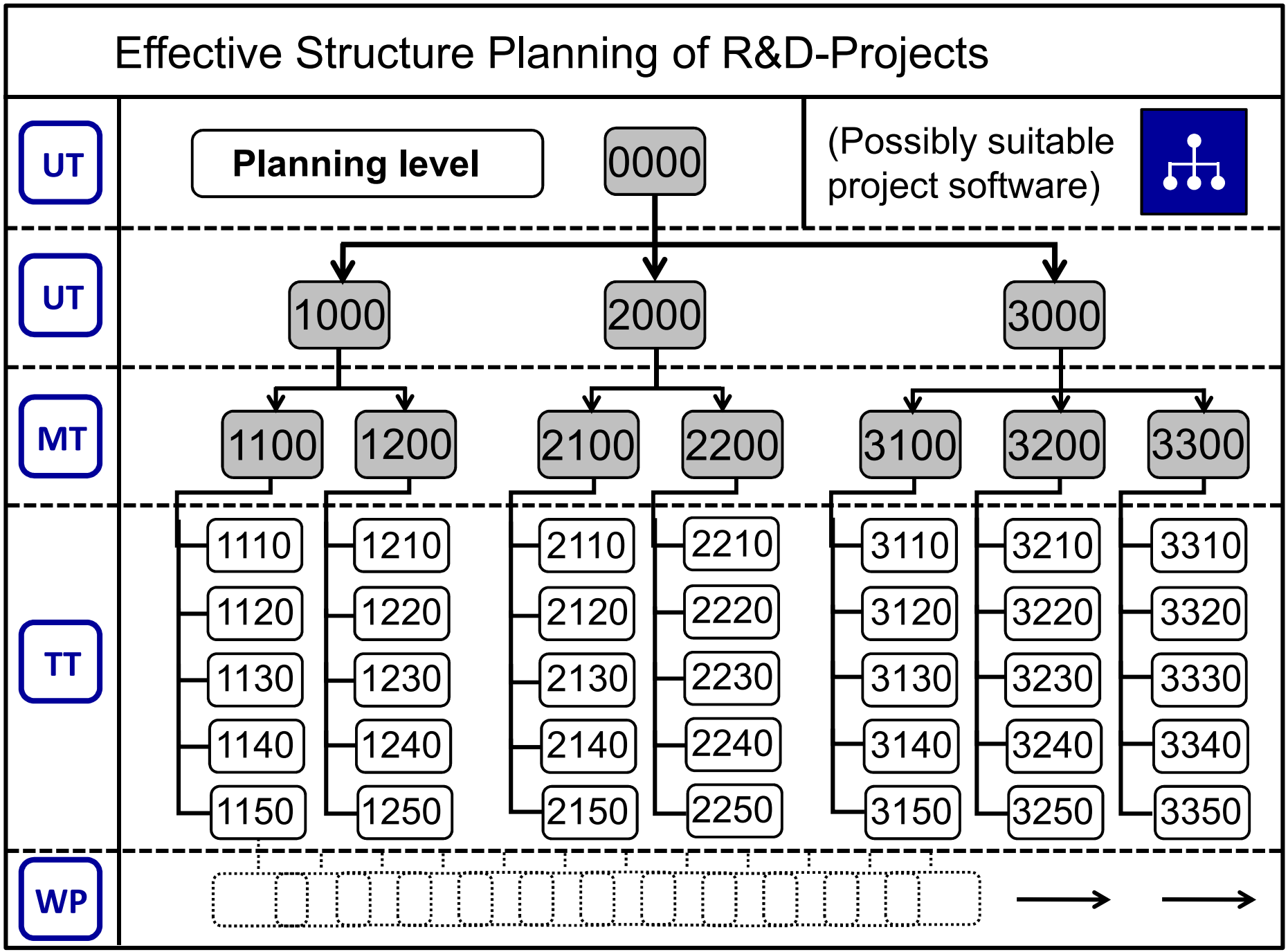
Effective Structure Planning of R&D-Projects



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Effective Structure Planning of R&D Projects

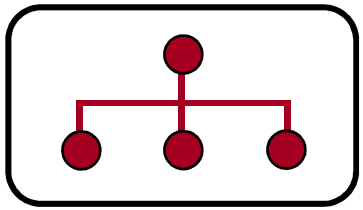
"Work Package (W. P.)" in R&D Projects, Definition:

- **Clearly defined individual task, which is prepared and implemented only in *one* organizational unit.**

- Exact content-related description of the individual task (of the "work package").
- Probable time required for the implementation (e.g. FTE-days).
- Possibly: Cost estimate for the implementation of the individual task, cost center assignment.
- Designation of a person responsible for the work package (team member, m/f/d).

Example P1

Structure Planning (Excerpt):



Project	**"Highly Elastic Clear Coats for the OEM Automotive Sector".**
	→

Step 1 → **Definition of the target system**:
"Highly Elastic Clear Coats for the OEM…"

Technical Components (P, Excerpt):

- Gloss retention of the clear coats, AMTEC-Kistler-test: >90%.
- Nanoindentation-test: 95% Elastic recovery (AFM, at $\vec{F}$ = 80 µN).
- Elasticity of the 4-layer structure (Erichsen-test DIN-ISO 1520): 3,5 mm.
- UV-Resistance: 2000h UVcon-A (λ ≥ 320 nm), UVcon-B (λ ≥ 280 nm).
- Adhesion to the base coats, 20ºC; Cross-hatch test (DIN-ISO 2409): 0. → →

Temporal Components (T, Excerpt):

- Project Start: 01.08.2019; Project End: 31.07. 2022. → →

Economic Components (E, Excerpt):

- Market share for automotive-OEM clear coats within EU: 35%.
- System supplier at [Automotive…AG1], assembly line Munich.
- Project costs: 19.800.000 €; Return of investment period: From 01.04.2025.
- Production costs of the clear coat: Maximum of 5,70 €/kg. → →

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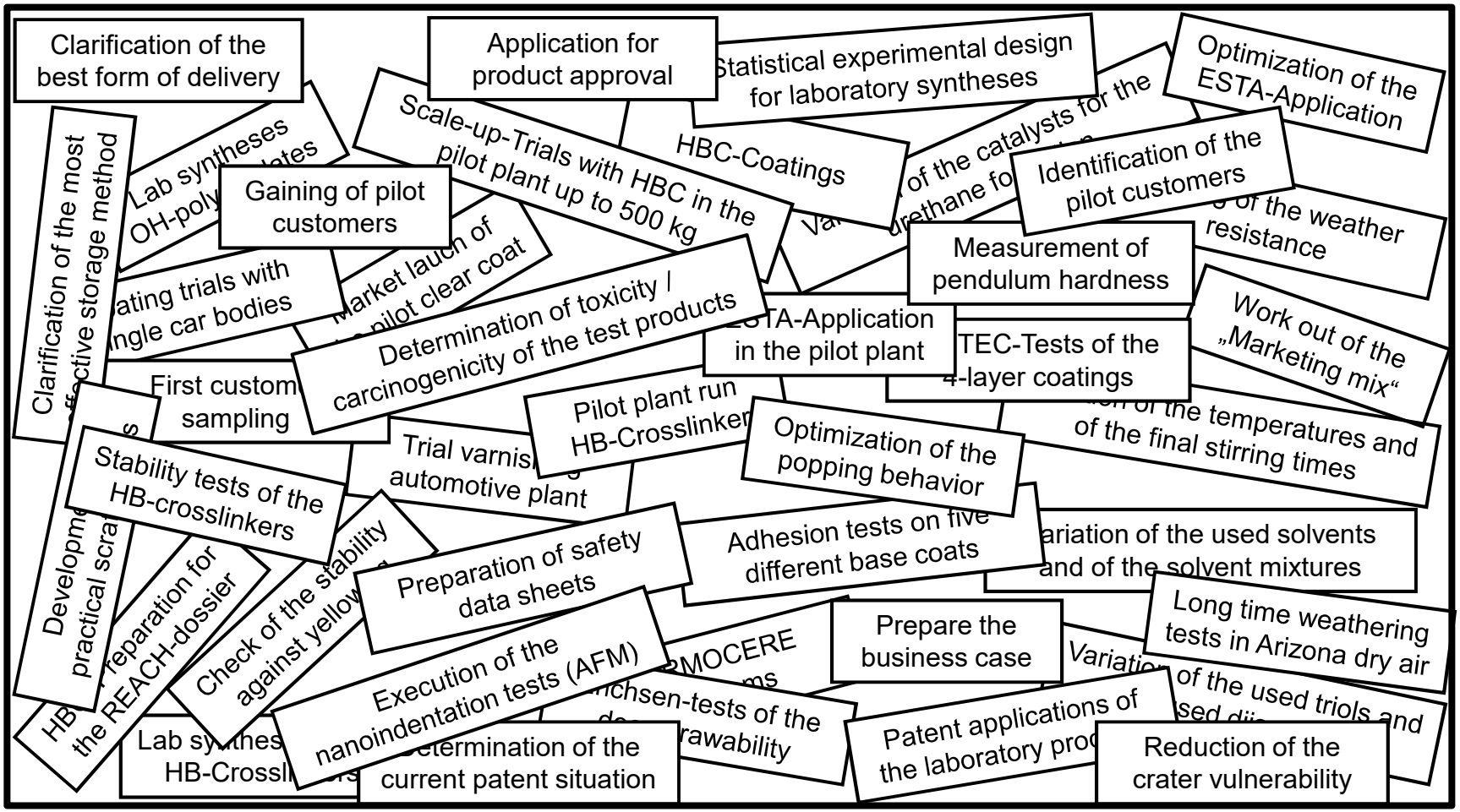
Step 2 → **Collecting of all tasks**:
"Highly Elastic Clear Coats for the OEM…".



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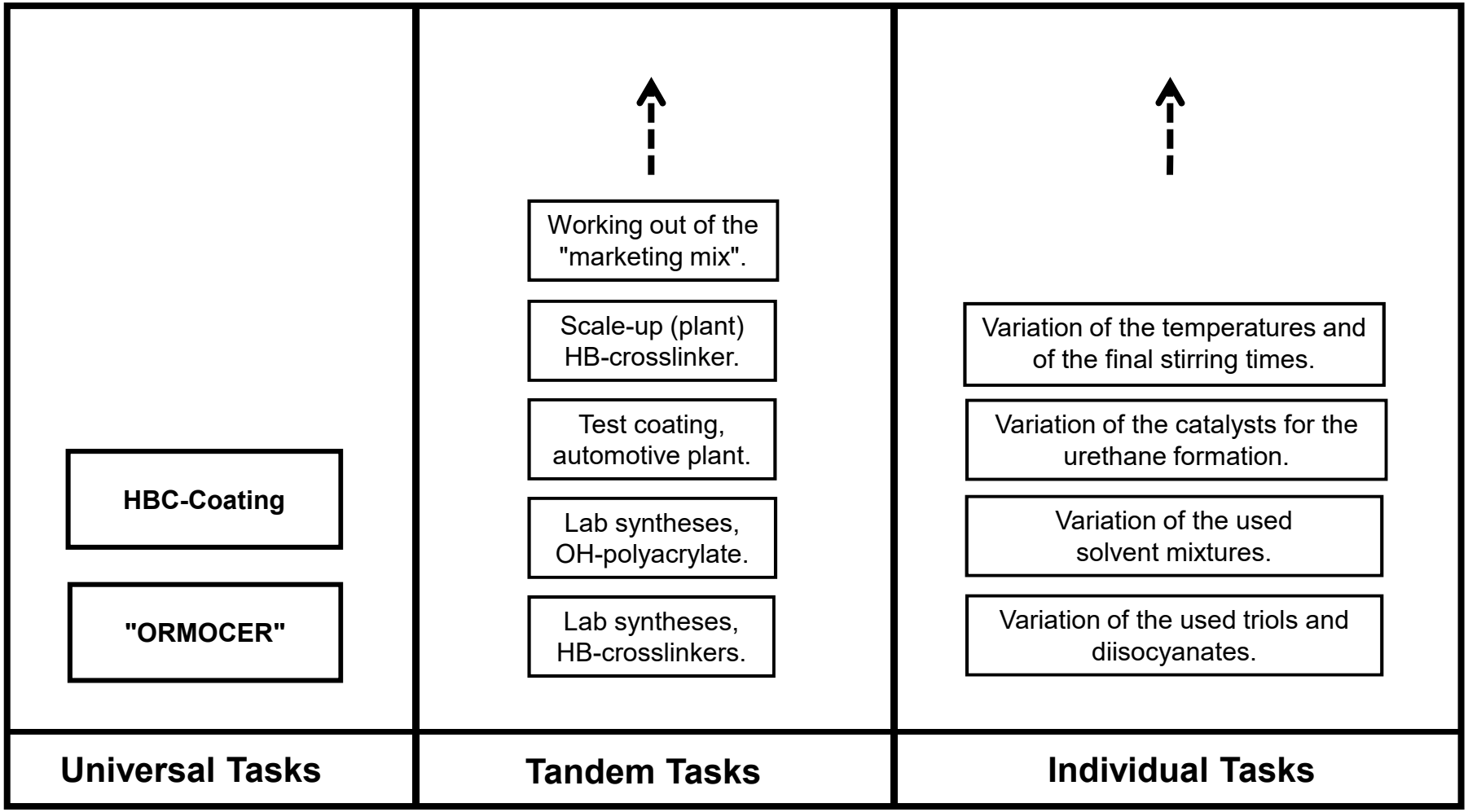
Step 3 → **Classifying these tasks**:
"Highly Elastic Clear Coats for the OEM…".



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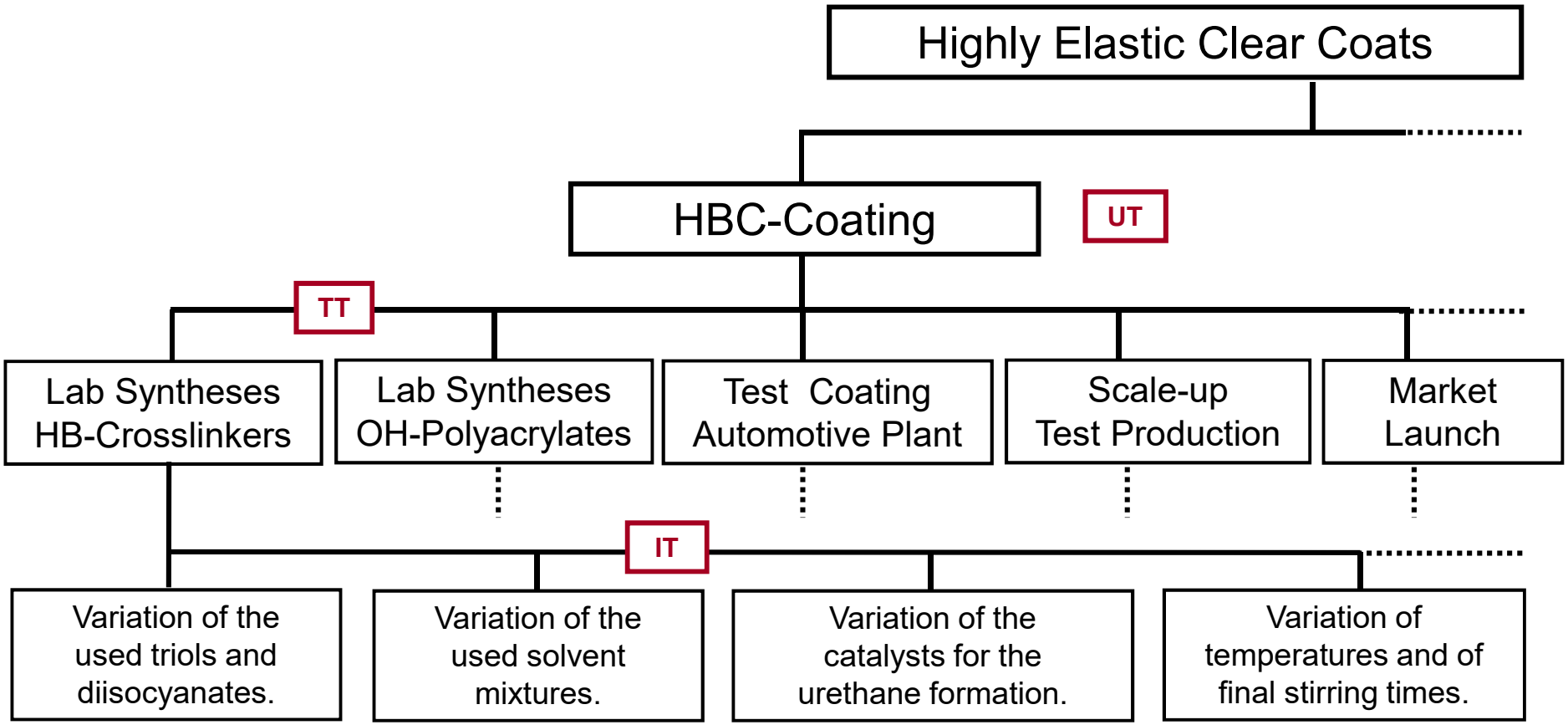
Step 4 → **Building of a structure plan**:
"Highly Elastic Clear Coats for the OEM…".



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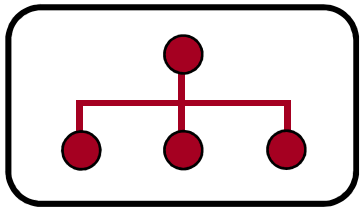
Example P2

Structure Planning (Excerpt):



Project	**"Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid".**
	→

Step 1 → [**Definition of the target system**: "Nitrilase-catalyzed…"]

Technical Components (P, Excerpt):

- Crystalline (R) -2-hydroxy-3-methoxy-3-methyl-butanecarboxylic acid (10 kg scale) with a purity> 97%. Optical purity: e. e. ≥ 98%.
- "Turnover Number„ of nitrilase: > 4.5 x 10^3 per second at pH 7.0 and 30°C. Concentration of the pure enzyme in the bioreactor: ≤ 0.001%.
- Temperature stability of nitrilase-producing microorganisms: At least 24 hours at 55°C.
- Robust, genetically stable and phage-resistant microorganism strain (Shelf life under production conditions: > 10 months). → →

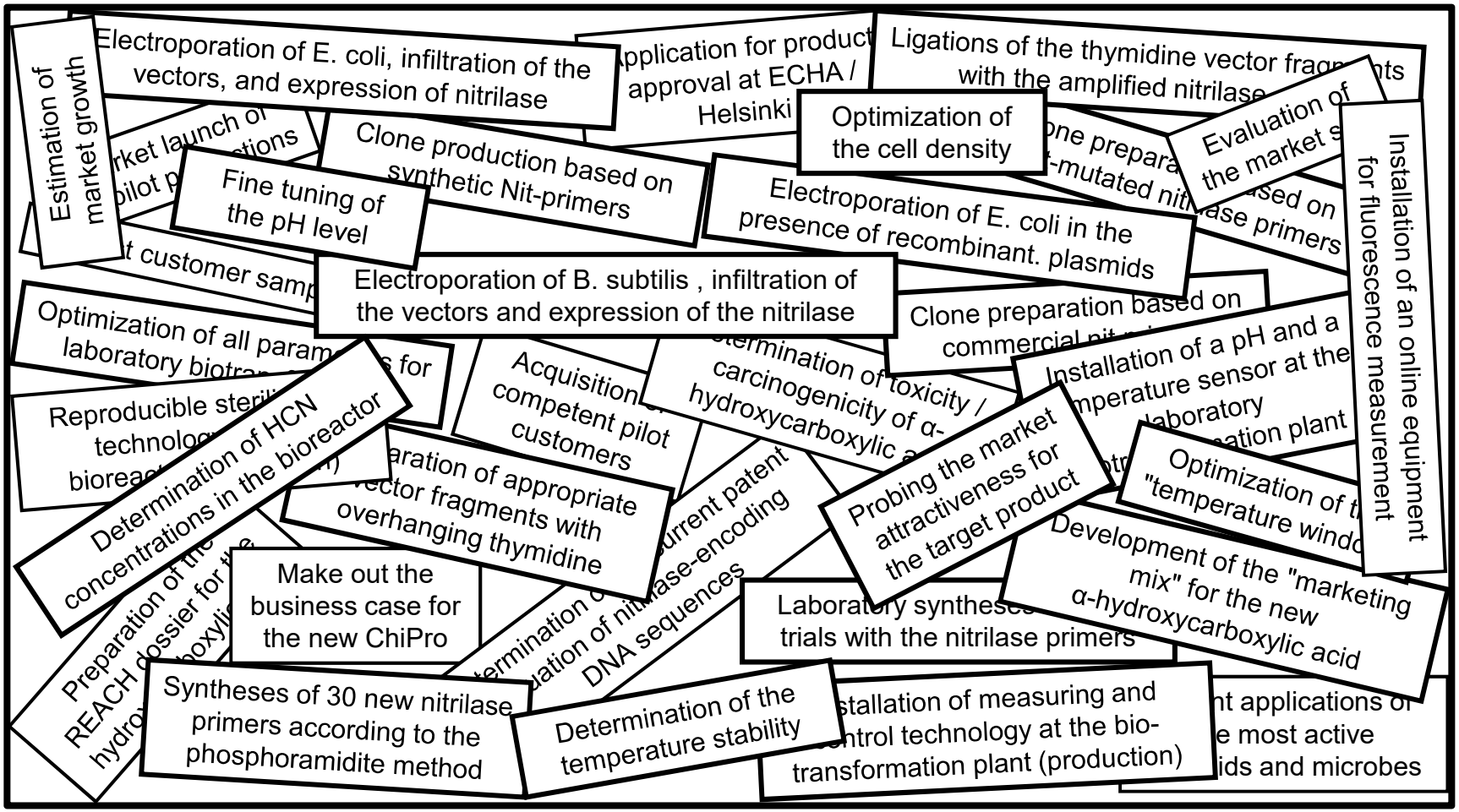
Temporal Components (T, Excerpt):

- Project start: 01.01.2019; Project end: 31.07.2023. → →

Economic Components (E, Excerpt):

- Continuous production in a loop reactor with flow equilibrium of 8.0 kg acid/24h. CMI in the third year after the market launch: € 21.50/kg.
- Project costs: 20.200.000 €. Return of investment in 12/2025. → →

Step 2 → **Collecting of all tasks**: "Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid".



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Step 3 → **Classifying these tasks**: "Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid".

Universal Tasks	Tandem Tasks	Individual Tasks
	Draft of the "marketing mix" for the new α-OH-carboxylic acid.	Installation of a pH and a temperature sensor on the laboratory bioreactor.
	Installation of the measuring, control / regulation technology.	Electroporation of E. coli, infiltration of vectors, and expression of nitrilase.
Clone preparation based on point-mutated nitrilase primers.	Optimization of all parameters for the laboratory biotransformation.	Ligations of the thymidine vector fragments with the amplified nitrilase gene.
Clone preparation based on commercial nitrilase primers.	Electroporation of E. coli in presence of recombinant plasmids.	Preparation of appropriate vector fragments with overhanging thymidine ends.
Clone preparation based on synthetic nitrilase primers.	Laboratory syntheses and first trials with the nitrilase primers.	Syntheses of 30 new nitrilase primers according to the phosphoramidite method.

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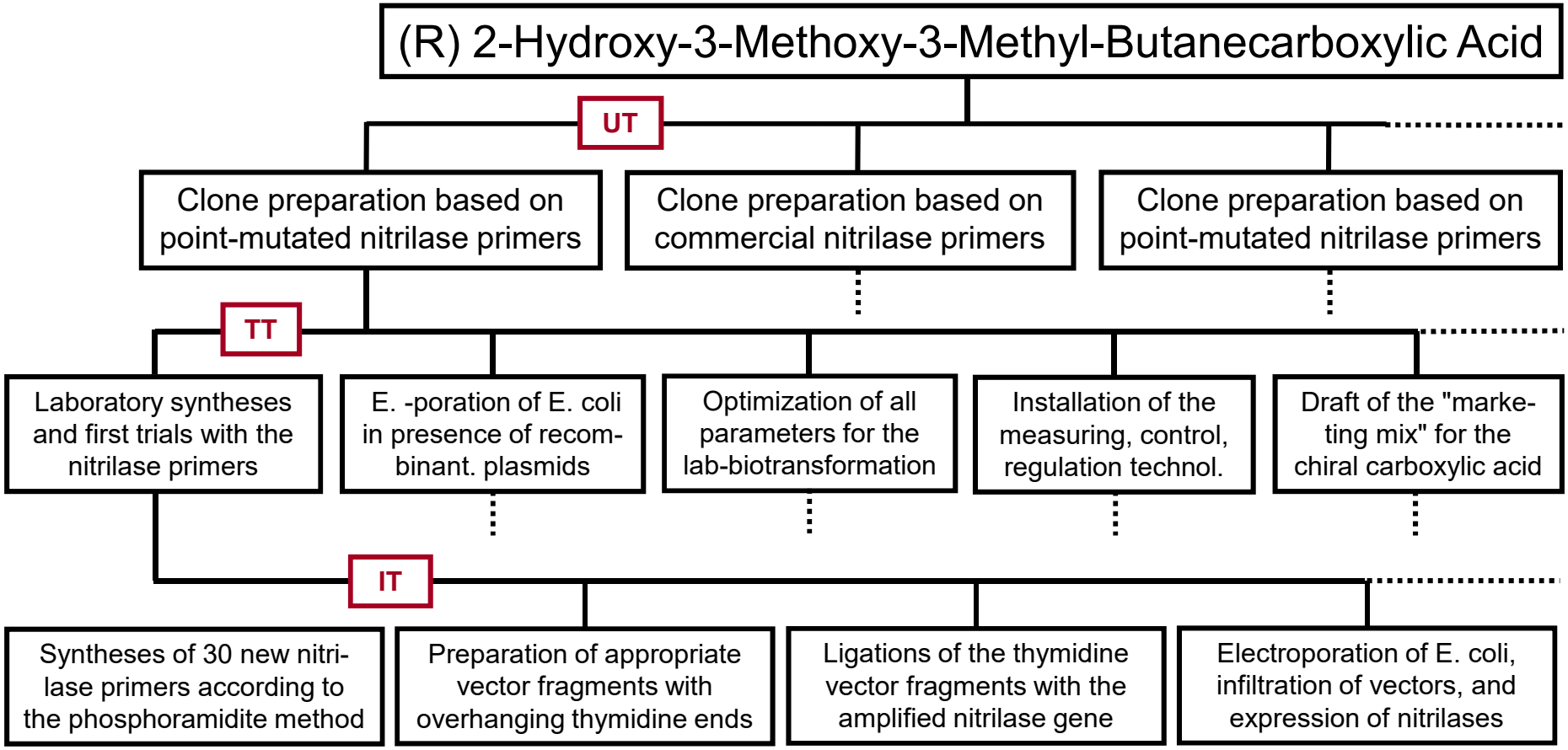
Step 4 → **Building of a structure plan**: "Nitrilase-Catalyzed Synthesis of a Chiral α-Hydroxycarboxylic Acid".



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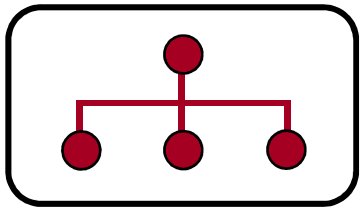
Example P3

Structure Planning (Excerpt):



Subproject	**"New Metal Organic Frame-works for the Adsorptive Storage of Hydrogen Gas."**
	→

Step 1 → [**Definition of the target system**: "New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen."]

Technical Components (P, Excerpt):

- Storage capacity of H_2 at 77K: > 6% by weight (DoE, U. S. A.).
- Inner surface of the MOFs: > 2,500 m^2/g. Material density: 0.1-0.2 g / cm^3.
- Adsorption energy for molecular H_2: ≤ 4.0 kJ/mol.
- Average pore diameter d_P: 10 - 16 Å.
- At most, traces of Cr, Co, Ni in the MOFs; Content ≤ 0.0005%. → →

Temporal Components (T, Excerpt):

- Project start: 01.01.2019; Project end: 30.06.2023. → →

Economic Components (E, Excerpt):

- Space-time yield during production: ≥ 3,000 kg / m3 in 24h; DBI in the third year after launch: € 7.20/kg.
- Global market share of MOFs for hydrogen storage among fuel cell manufacturers in the EU: 40%.
- Project costs: 17.300,000 €; Return of investment Period: From 03/2026. → →

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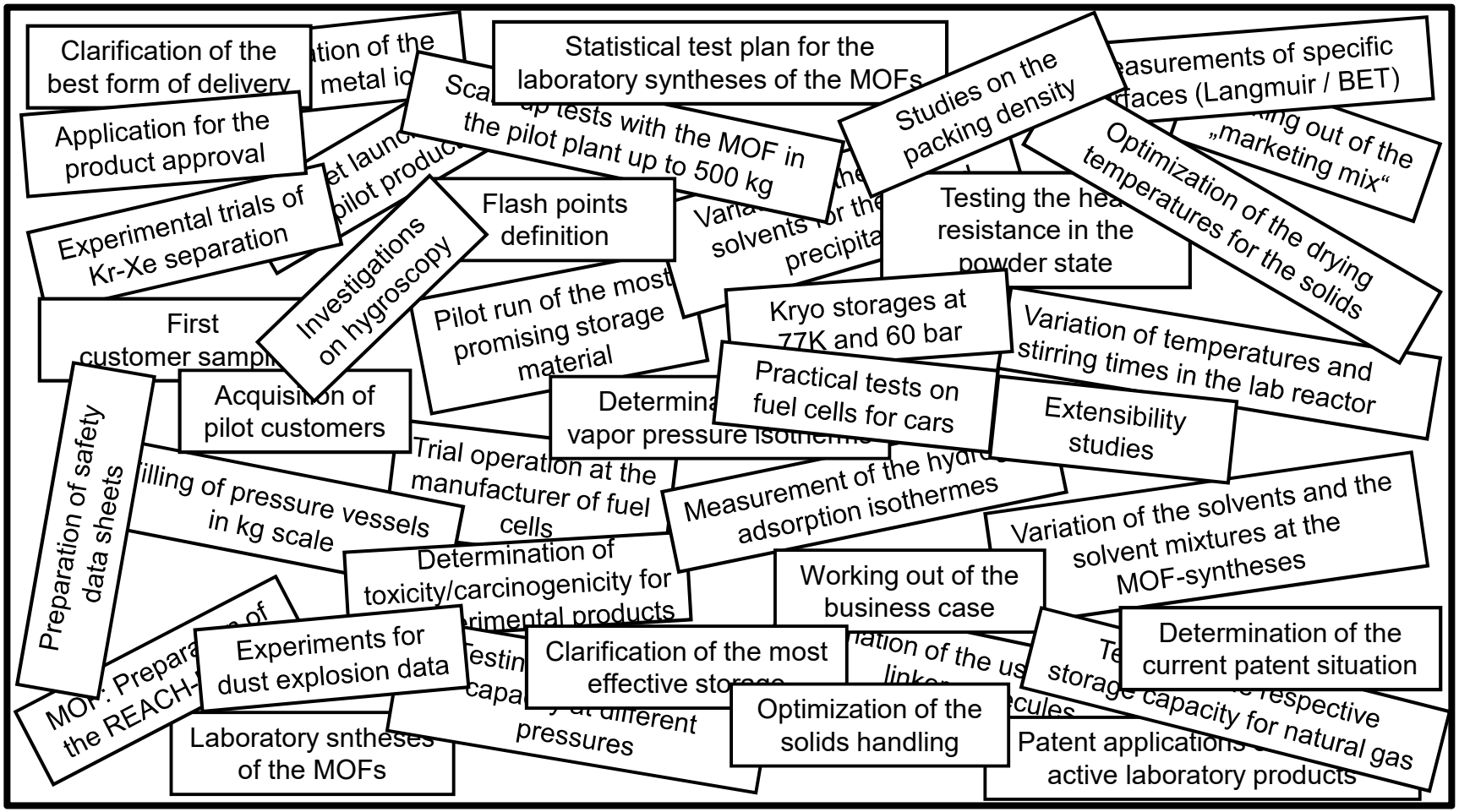
Step 2 →

Collecting of all tasks:
"New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas."



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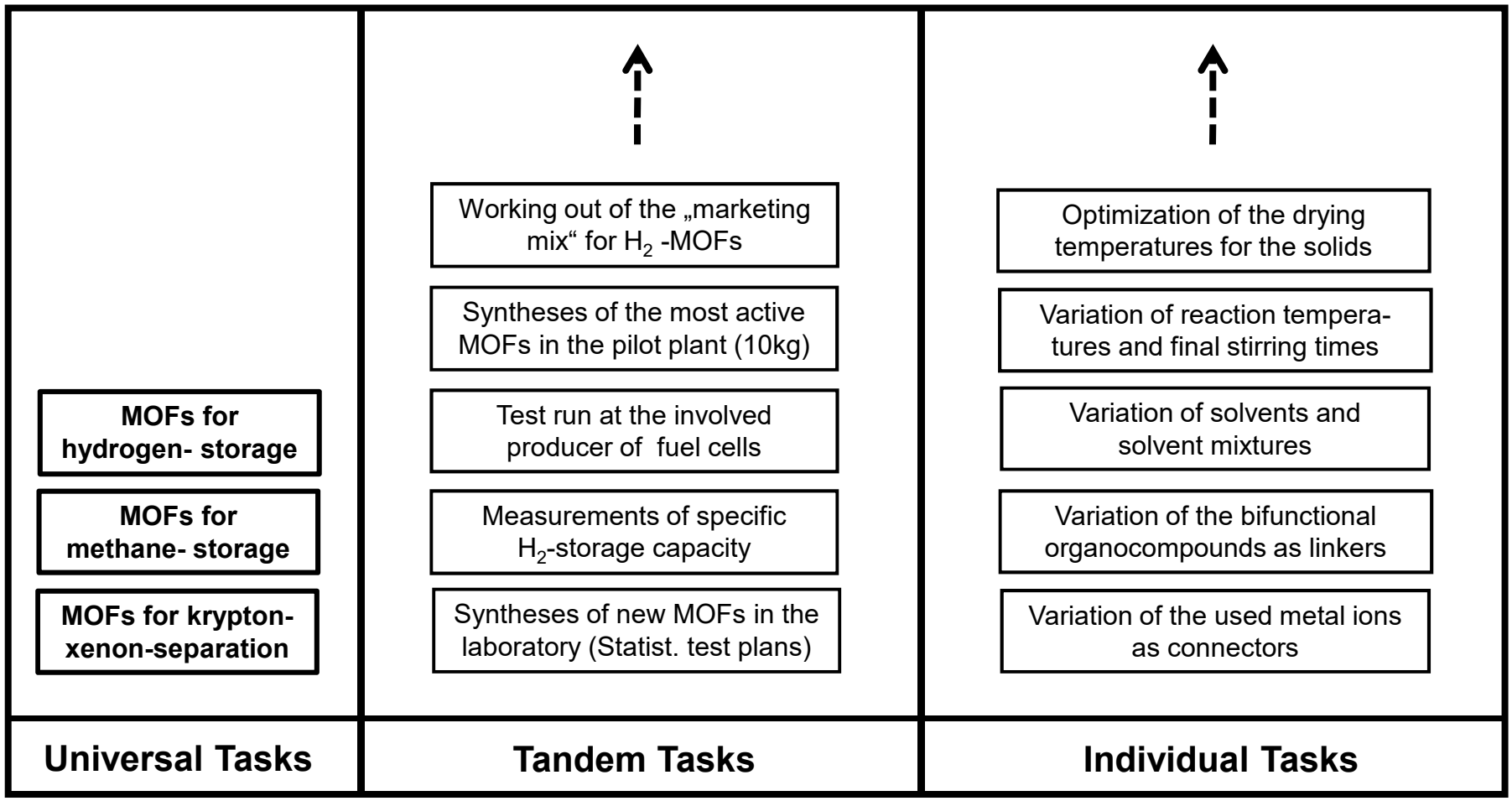
Step 3 → **Classifying these tasks**:
"New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas."



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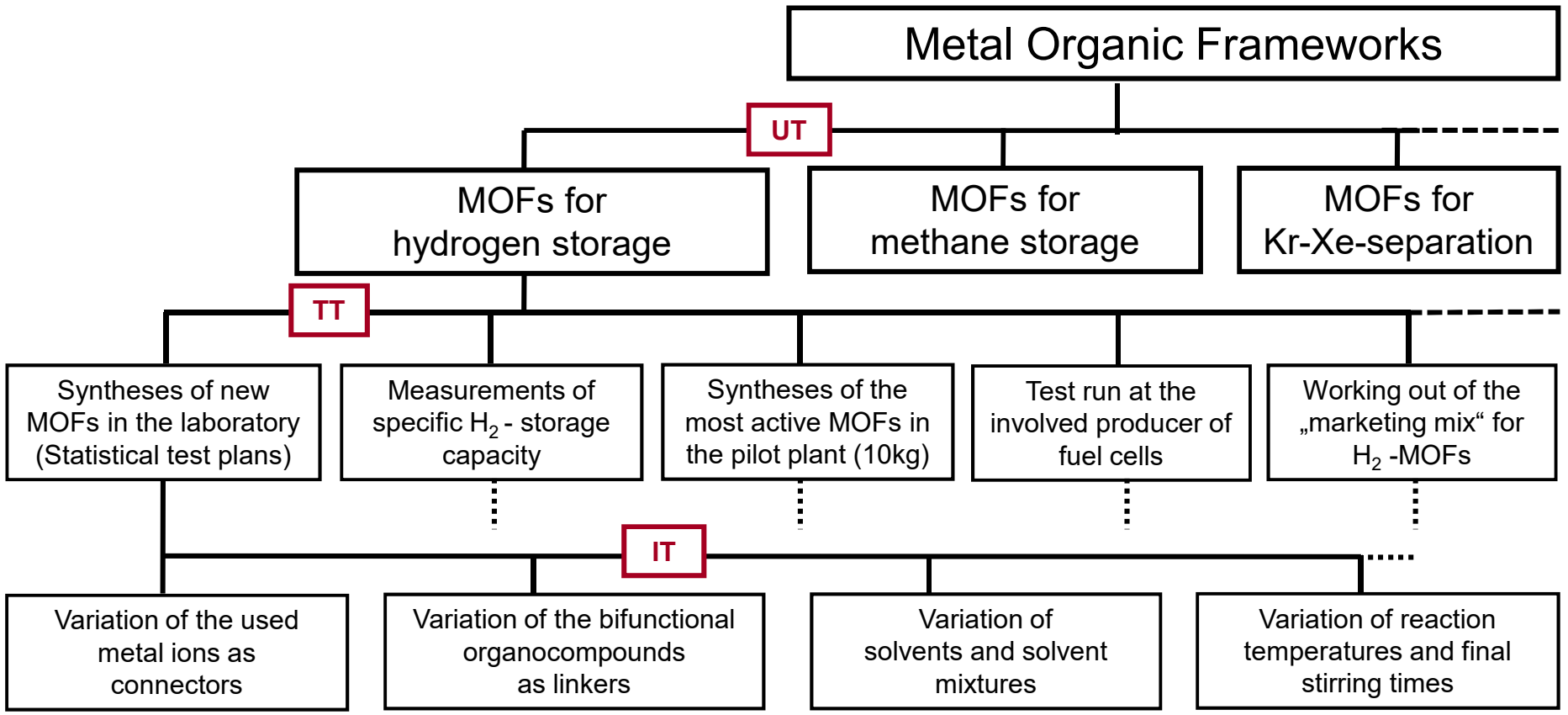
Step 4 →

Building of a structure plan:
"New Metal Organic Frameworks for the Adsorptive Storage of Hydrogen Gas."



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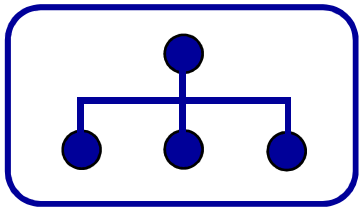
Effective Structure Planning of R&D-Projects

Aim and purpose of a *jointly* prepared project structure plan:



- The same level of information for all participants on all project tasks and the means necessary for their solution.
- Basis for an appropriate, realistic (part) budgeting (FTE,€).
- Effective document for project control.
- Clear "information platform" for the project decision makers.
- Complete overview of foreseeable risks.
- Ensuring the systematics and completeness of the subsequent project flow planning (with regard to width and depth).

Further literature on the subject of "R&D project management in the chemical industry". Selection of purchasable monographs and publications in journals or in internet.

- Leker, Gelhard, von Delft, Business Chemistry, Wiley & Sons Ltd., Oxford U. K., 2018.
- Hauschildt, Salomo, Schultz, Kock, Innovationsmanagement, Verlag Franz Vahlen, München, 2021.
- Vahs, Brem, Innovationsmanagement, Schäffer-Poeschel Verlag, Stuttgart, 2015.
- Gausemeier, Dumitrescu, et al., Innovationen für die Märkte von morgen, Carl Hanser Verlag, München, 2019.
- Cooper, Top oder Flop in der Produktentwicklung, WILEY-VCH Verlag, Weinheim, 2002.
- Russo, Gleich, Strascheg, Von der Idee zum Markt, Verlag Franz Vahlen, München, 2008.
- Loch, Kavadias, Handbook of New Product Development, Elsevier, Oxford, 2008.
- Bullinger, Fokus Innovation, Carl Hanser Verlag, München, 2006.
- Offermanns, "Steinheimer Gespräche" within the FCI, personal communications, Steinheim, 2002.

- Münch, Patente, Marken, Design von A bis Z, WILEY-VCH Verlag, Weinheim, 2012.

- Gassmann, Praxiswissen Projektmanagement, Carl Hanser Verlag, München, 2006.
- Kerzner, Projekt Management, Ein systemorientierter Ansatz, mitp, Redline Verlag, Heidelberg, 2008.
- Gessler, Kompetenzbasiertes Projektmanagement, GPM-Publikation, Nürnberg, 2016.
- Patzak, Rattay, Projektmanagement, Linde-Verlag, Wien, 2014.
- Jenny, Projektmanagement - Das Wissen für den Profi, vdf Hochschulverlag an der ETH, Zürich, 2020.
- Jenny, Projektmanagement - Das Wissen für eine erfolgreiche Karriere, vdf Hochschulverlag an der ETH, Zürich, 2020.
- Drees, Lang, Schöps, Praxisleitfaden Projektmanagement, Carl Hanser Verlag, München, 2014.
- Burghardt, Projektmanagement, Publicis MCD Verlag, Erlangen, 2018.

Further literature on the subject of "R&D project management in the chemical industry". Selection of purchasable monographs and publications in journals or in internet.

- Hesseler, Projektmanagement, Verlag Franz Vahlen, München, 2015.
- Stöger, Wirksames Projektmanagement, Schäffer- Poeschel, Stuttgart, 2019.
- Litke, Projektmanagement, Carl Hanser Verlag, München, 2007, new edition announced for 2023.
- Litke, Kunow, Schulz-Wimmer, Projektmanagement, Haufe-Lexware, Freiburg, 2018.
- Madauss, Projektmanagement, Theorie und Praxis aus einer Hand, Springer Gabler, Berlin, 2020.
- Bea, Scheurer, Hesselmann, Projektmanagement, UVK-Verlag, München, 2020.
- Braehmer, Projektmanagement für kleine und mittlere Unternehmen, Carl Hanser Verlag, München, 2009.
- Klein, Projektmanagement in der Praxis, Ebook, Verlag Interna, Bonn, 2012.
- Weichselbaumer, Bley, MS-Project 2013 in 13 Stunden, epubli GmbH, Stuttgart, Berlin, 2014.
- Dittmann, Dirbanis, Projektmanagement (IPMA®), Haufe, Freiburg, 2020.
- Schels, Seidel, Projektmanagement mit Excel, Carl Hanser Verlag, München, 2016.
- Tumuscheit, Überleben im Projekt, Redline Wirtschaft, Heidelberg, 2014.
- Tumuscheit, 55 Mythen des Projektmanagements, Orell Füssli Verlag, Zürich, 2013.
- Meyer, Reher, Projektmanagement, Springer Fachmedien, München, 2020.
- Drews, Hillebrand, Kärner, Praxishandbuch Projektmanagement, Haufe, Freiburg, 2015.
- Pautsch, Steininger, Lean Project Management – Projekte exzellent umsetzen, Carl Hanser Verlag, München, 2014.
- Cole, Barker, Brilliant Project Management, Pearson Education Ltd., London, 2015.
- Andler, Tools für Projektmanagement, Workshops und Consulting, Publicis Publishing, Erlangen, 2015.
- Hüsselmann, Lean Project Management, Schäffer-Poeschel Verlag, Stuttgart, 2021

Further literature on the subject of "R&D project management in the chemical industry". Selection of purchasable monographs and publications in journals or in internet.

- Schröder, Agile Produktentwicklung, Carl Hanser Verlag, München, 2018.
- Kuster et al., Handbuch Projektmanagement, Agil – Klassisch – Hybrid, Springer Gabler, Wiesbaden, 2019.
- Ziegler, Agiles Projektmanagement mit Scrum für Einsteiger, Independ. Published, ISBN 9781729408353, 2021.
- Cooper, Edgett, Kleinschmidt, Optimizing the Stage Gate Process, Res. Technol. Management, 45, 2002.
- Cooper, What`s Next After Stage-Gate? Res. Technol. Management, 157, 2014.
- Hirzel, Alter, Niklas, Projektportfolio-Management, Springer Gabler, Wiesbaden, 2019.
- Timinger, Modernes Projektmanagement, WILEY-VCH Verlag, Weinheim, 2017.
- www.projektmanagementhandbuch.de, PMH, 2021.
- www.projektmanagement-definitionen.de, 2021.
- www.projektmagazin.de, 2021.
- GPM Deutsche Gesellschaft für Projektmanagement e.V., Kompetenzbasiertes Projektmanagement (PM4), Handbuch für Praxis und Weiterbildung im Projektmanagement, Band 1, Band 2, Nürnberg, 2019.
- Lang, Wagner, Der Weg zum projektorientierten Unternehmen, Carl Hanser Verlag, München, 2019.

- Helm, Pfeifer, Ohser, Mathematik für Wirtschaftswissenschaftler, Carl Hanser Verlag, München, 2015.
- Grieser, Mathematisches Problemlösen und Beweisen, Springer Fachmedien, Wiesbaden, 2017.
- Krischke, Röpcke, Graphen- und Netzwerktheorie, Carl Hanser Verlag, München, 2015.
- Tittmann, Graphentheorie, eine anwendungsbezogene Einführung, Fachbuchverlag, Leipzig, 2003.
- Nitzsche, Graphen für Einsteiger, Vieweg + Teubner Verlag, Wiesbaden, 2009.
- Stegbauer, Häußling, Handbuch Netzwerkforschung, Springer Fachmedien, Wiesbaden, 2010.

Further literature on the subject of "R&D project management in the chemical industry". Selection of purchasable monographs and publications in journals or in internet.

- Festel, Hassan, Leker, Bamelis, Betriebswirtschaftslehre für Chemiker, Springer, Berlin, 2001.
- Festel, Söllner, Bamelis, Volkswirtschaftslehre für Chemiker, Springer, Berlin, 2000.
- Mühlbradt, Wirtschaftslexikon, Scriptor Reihe, Cornelsen Verlag, Berlin, 2008.
- Malik, Unternehmenspolitik und Corporate Governance, Campus-Verlag, Frankfurt/Main, 2013.
- Schierenbeck, Wöhle, Grundzüge der Betriebswirtschaftslehre, Oldenbourg Verlag, München, 2016.
- Wöhe, Einführung in die Allgemeine Betriebswirtschaftslehre, Verlag Franz Vahlen, München, 2020.

- Drucker, Die Kunst des Managements, Econ Verlag, München, 2000.
- Drucker, Alles über Management, Redline Wirtschaft, Heidelberg, 2007.
- Drucker, The Effective Executive, Verlag Franz Vahlen, München, 2014.
- Malik, Management, Das A und O des Handwerks, Campus-Verlag, Frankfurt/Main, 2013.
- Malik, Führen, Leisten, Leben, Campus-Verlag, Frankfurt/Main, 2019.
- Roth, Fühlen, Denken, Handeln, Suhrkamp Verlag, Frankfurt/Main, 2007.
- Sprenger, Mythos Motivation, Campus-Verlag, Frankfurt/Main, 2014.
- Sprenger, Vertrauen führt, Campus-Verlag, Frankfurt/Main, 2007.
- Freitag, Kommunikation im Projektmanagement, Springer-Gabler, Wiesbaden, 2016.
- Schulz von Thun, Miteinander Reden, Rowohlt Verlag, Reinbeck, 2019.
- Riemann, Grundformen der Angst, Reinhardt Verlag, München, 2019.
- Csikszentmihalyi, Flow im Beruf, Klett-Cotta Verlag, Stuttgart, 2012.

Further literature on the subject of "R&D project management in the chemical industry". Selection of purchasable monographs and publications in journals or in internet.

- Horx, Das Zukunftsmanifest, Ullstein Taschenbuch Verlag, Berlin, 2002.
- Bürkle, Aktive Karrierestrategie, Springer Gabler, Wiesbaden, 2013.
- Hesse, Schrader, Das große Bewerbungshandbuch, Stark Verlag, München, 2015.
- Hesse, Schrader, 1X1 - Das erfolgreiche Vorstellungsgespräch, Stark Verlag, München, 2014.
- Püttjer, Schnierda, Trainingsmappe Vorstellungsgespräch, Campus-Verlag, Frankfurt/Main, 2019.
- Püttjer, Schnierda, Das überzeugende Bewerbungsgespräch für Führungskräfte, Campus-Verlag, Frankfurt/M, 2019.
- Püttjer, Schnierda, Das große Bewerbungshandbuch, Campus-Verlag, Frankfurt/Main, 2019.
- Stärk, Erfolgreich im Vorstellungsgespräch und Jobinterview, GABAL, Offenbach, 2018.
- Hesse, Schrader, Die hundert häufigsten Fragen im Vorstellungsgespräch, Stark Verlag, München, 2013.
- Lüdemann, Lüdemann, Die 111 wichtigsten Fragen im Vorstellungsgespräch, Redline Wirtschaft, München, 2018.
- Rohrschneider, Lorenz, Müller-Thurau, Vorstellungsgespräche, Haufe, Freiburg und Planegg, 2018.
- Engst, Willmann, Professionelles Bewerben, Bibliografisches Institut, Berlin, 2019.

- Drewermann, Glauben in Freiheit oder Tiefenpsychologie und Dogmatik, Band 1, Walter-Verlag, Olten, 1994.
- Schuler, Psychologische Personalauswahl, Hogrefe Verlag, Göttingen, 2014.
- Kanning, Personalauswahl zwischen Anspruch und Wirklichkeit, Springer-Verlag, Berlin, 2015.
- Herrmann, Die Auswahl, Wiley-VCH Verlag, Weinheim, 2016.
- Riedel, Agile Personalauswahl, Haufe Fachbuch, Freiburg, 2017.
- Autorenkollektiv „Diagnostik- und Testkuratorium“, Personalauswahl kompetent gestalten, Springer, Berlin, 2018.

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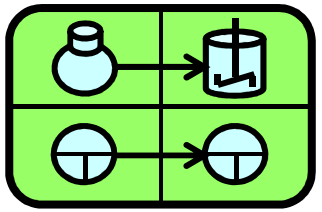

End of Lecture Module 04

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