iMDE
Lecture 6 – Product development

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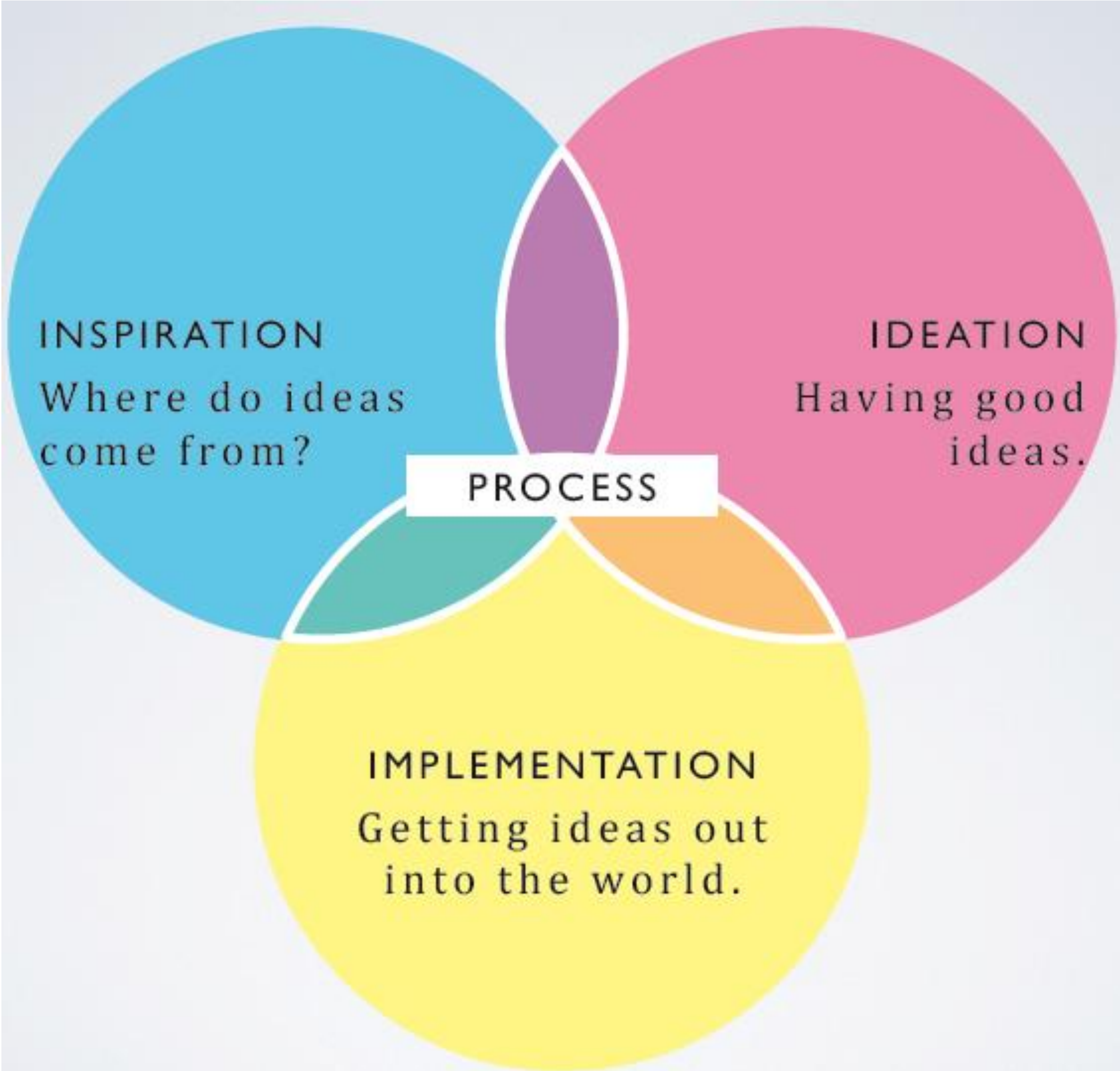


If you performed this project in or for an industrial company, how would this process be altered, if at all, and how would the subsequent major parts of the development look like?

Assumptions and constraints

- Each team has developed an idea or concept for a product (goods, software and/or service)
- We are now assuming that this product is to be developed and offered to the market by an industrial company
- Our presentation is focusing on how an industrial company is handling the development of a product
- In Part 1 of our presentation we focus on the overall development in an industrial company
- In Part 2 we give an overview of some key activities of the product development – here exemplified by some activities emanating from the mechanical engineering and industrial design processes
- In Part 3 we extend the view of developing products from the local or international company to the global company

Agenda

PART 1: Product development in its overall industrial context

- Briefly on the product innovation process
- The product planning process

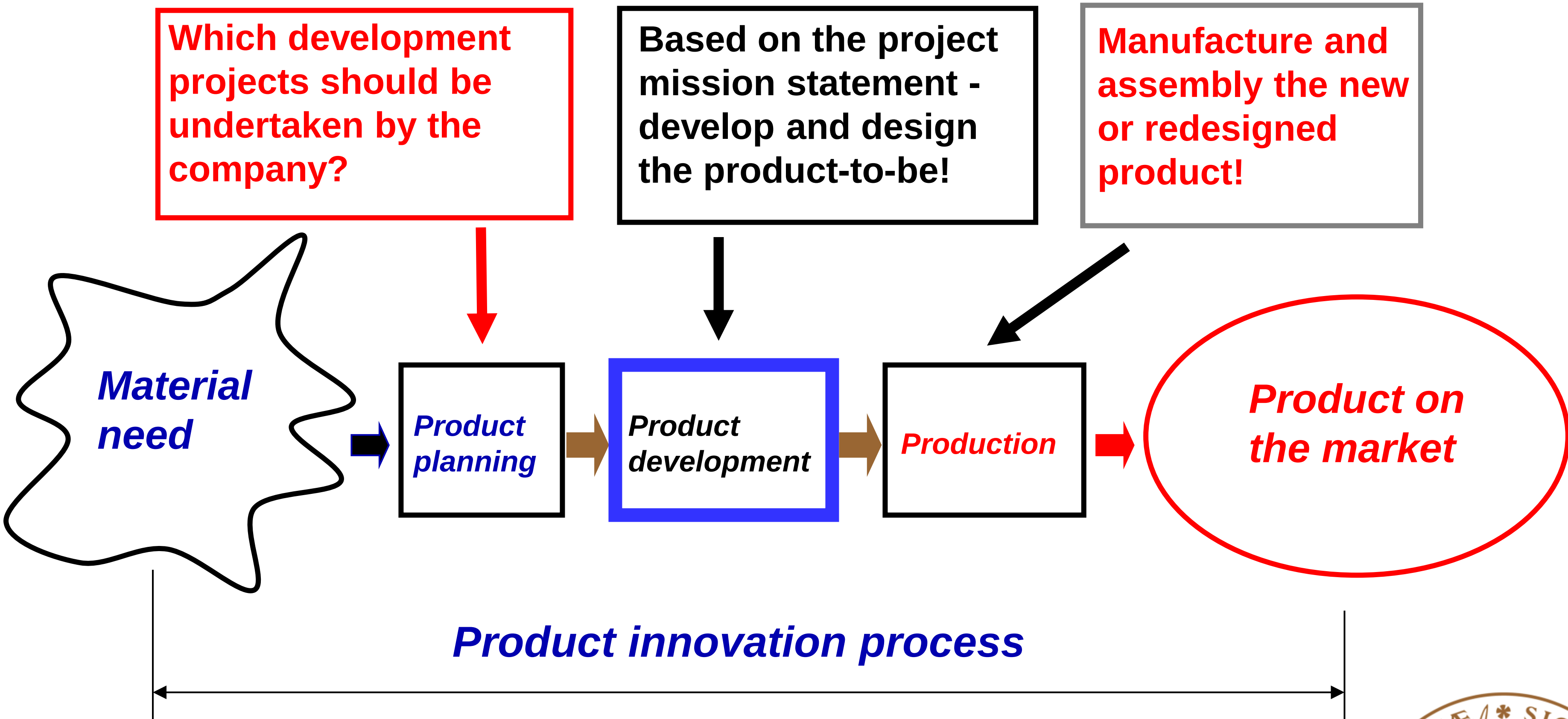
PART 2: Product development and engineering design

- Development of engineered, discrete, physical products: review of activities
- Specific engineering design activities
  - Detail design (embodiment and computer based design analysis)
  - Design analysis
  - Interaction between engineering design, industrial design, and production

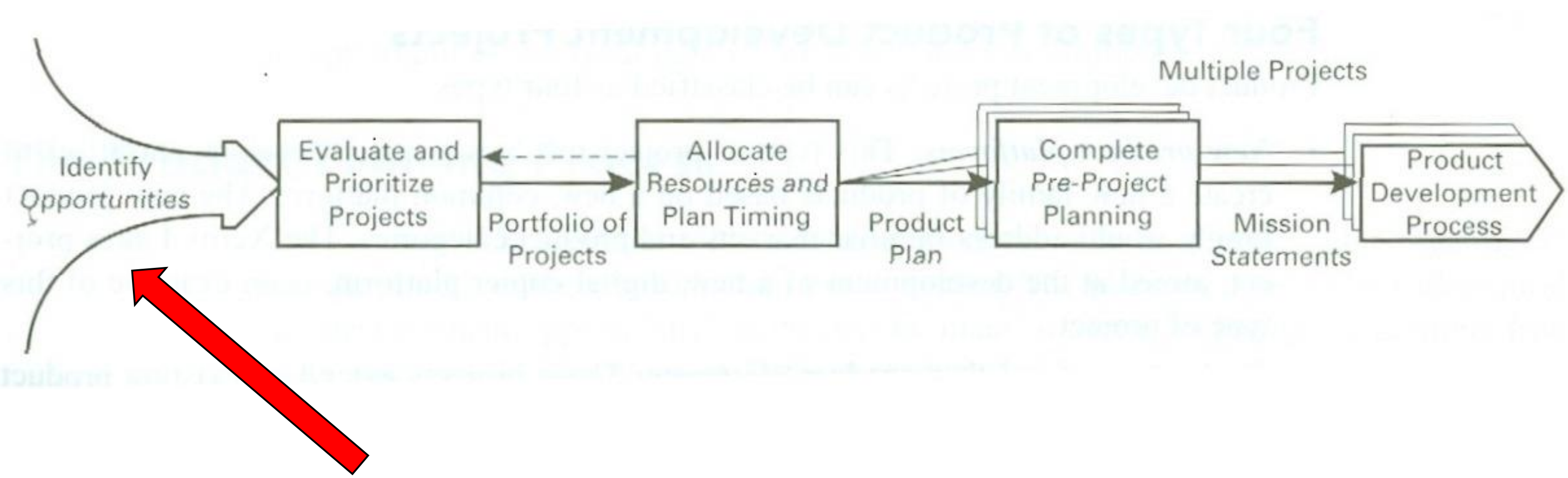
PART 3: Global Product Development - GPD

PART 1: Product development in its overall industrial context

The overall industrial development process



The product planning process

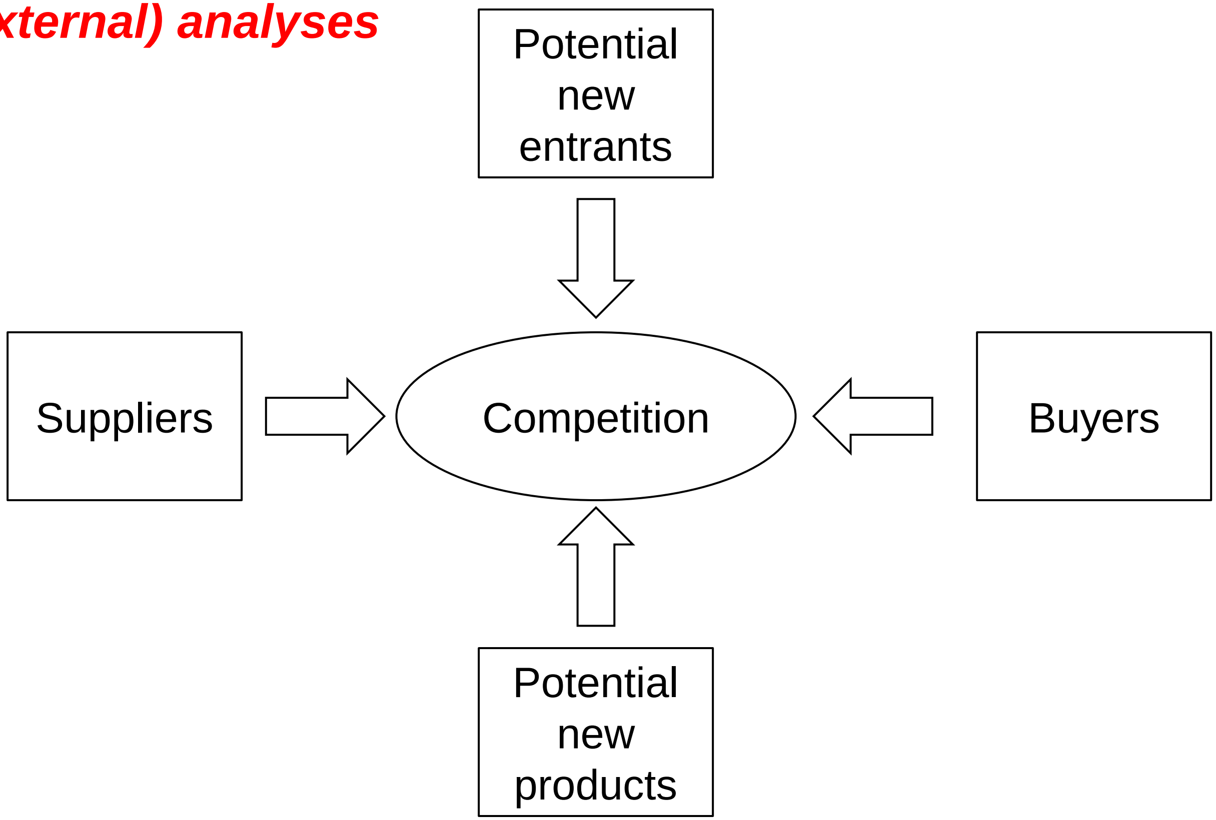


Does the result(s) emanating from your projects represent an opportunity to industrial companies?

(Ulrich & Eppinger 2012, p.56)

Product planning – some specific required activities

Market (external) analyses



(from Porter 1979)

Product planning – some specific required activities

Internal analysis:

- Company strategy
- SWOT:
  - Strengths
  - Weaknesses
  - Opportunities
  - Threats
- Product policy

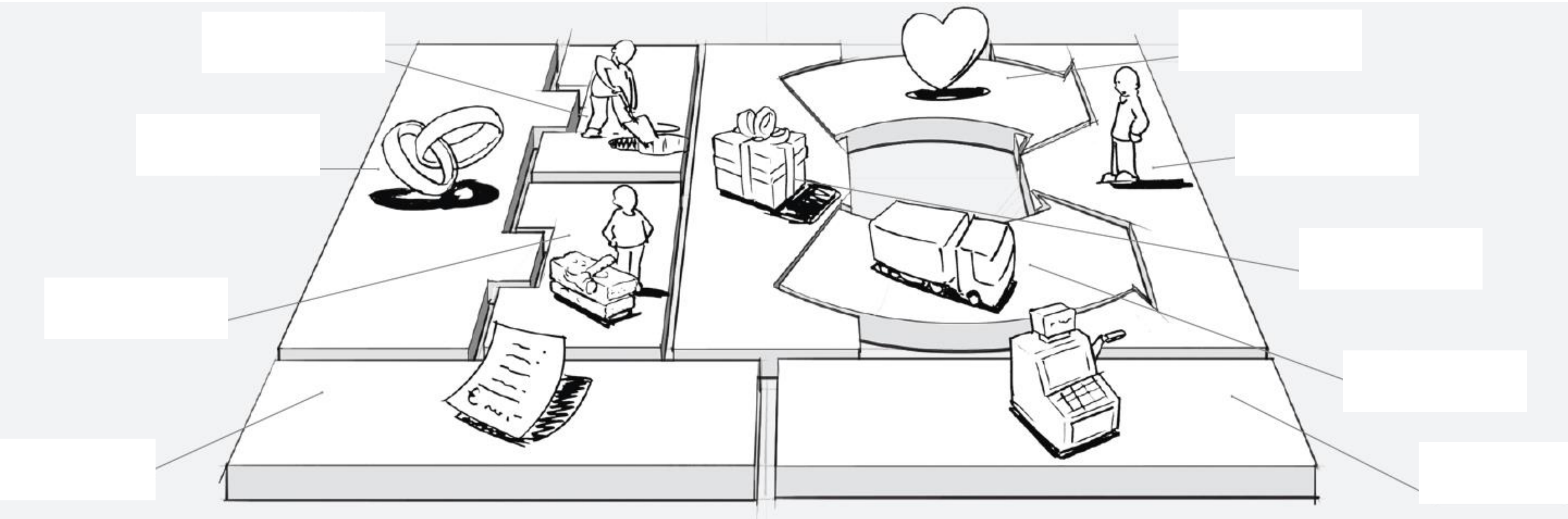
(Olsson 1995)

Product planning – some specific required activities

- Needfinding, Trendwatching, Techwatching (cf. ***lecture 2***)
- Ideation: idea generation (cf. ***lecture 3***)
- Establishment of:
  - proof of concept (is the concept technically feasible)
  - proof of value (for the customer, for the company, for the business network)
  - proof of innovation (differentiation with competition)
- Selection of projects

Product planning – some specific required activities

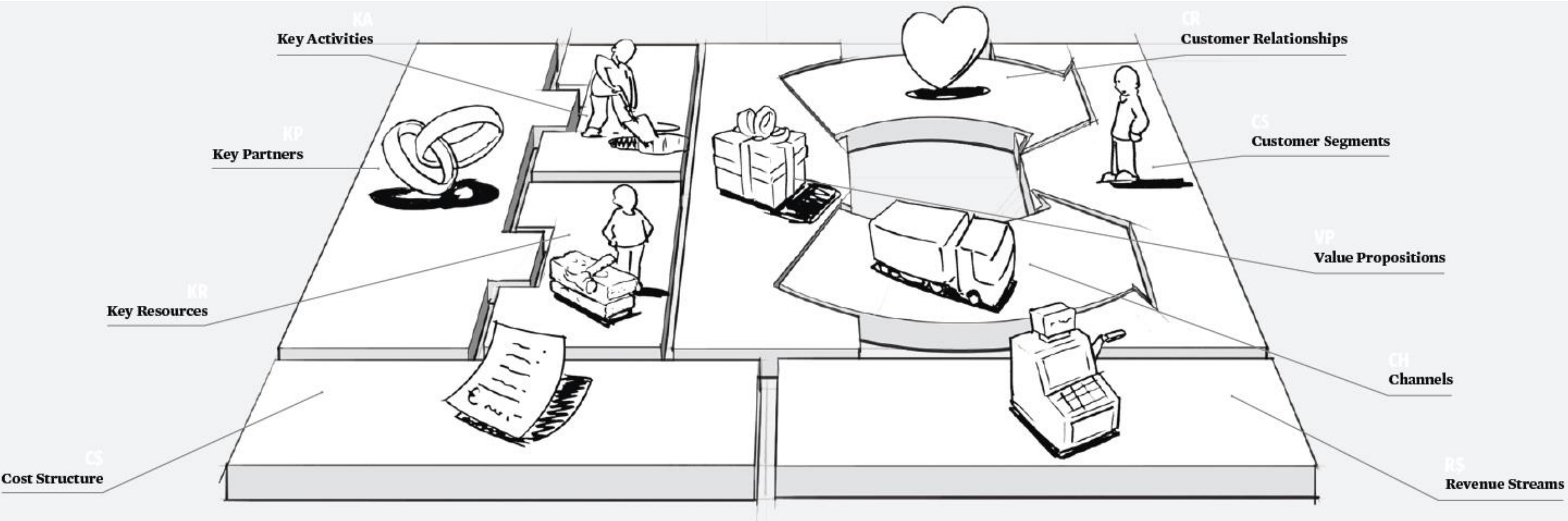
The elements of each different project are outlined in a ***business model*** (***lecture 7***)



(Osterwalder & Pigneur 2009, pp. 18-19)

Product planning – some specific required activities

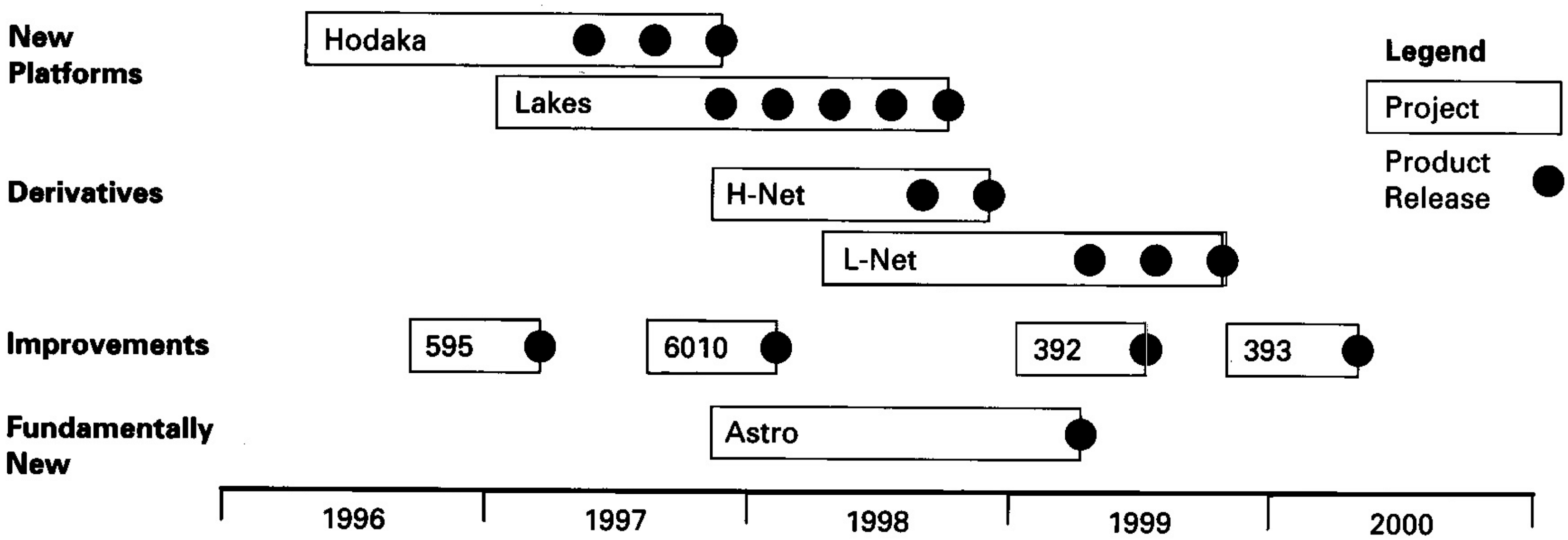
The elements of each different project are outlined in a ***business model*** (***lecture 7***)



(Osterwalder & Pigneur 2009, pp. 18-19)

Product planning – some specific required activities

The prioritization and timing of the projects in the project portfolio – the product plan



(Ulrich & Eppinger 2012, p.55)

Product planning – some specific required activities

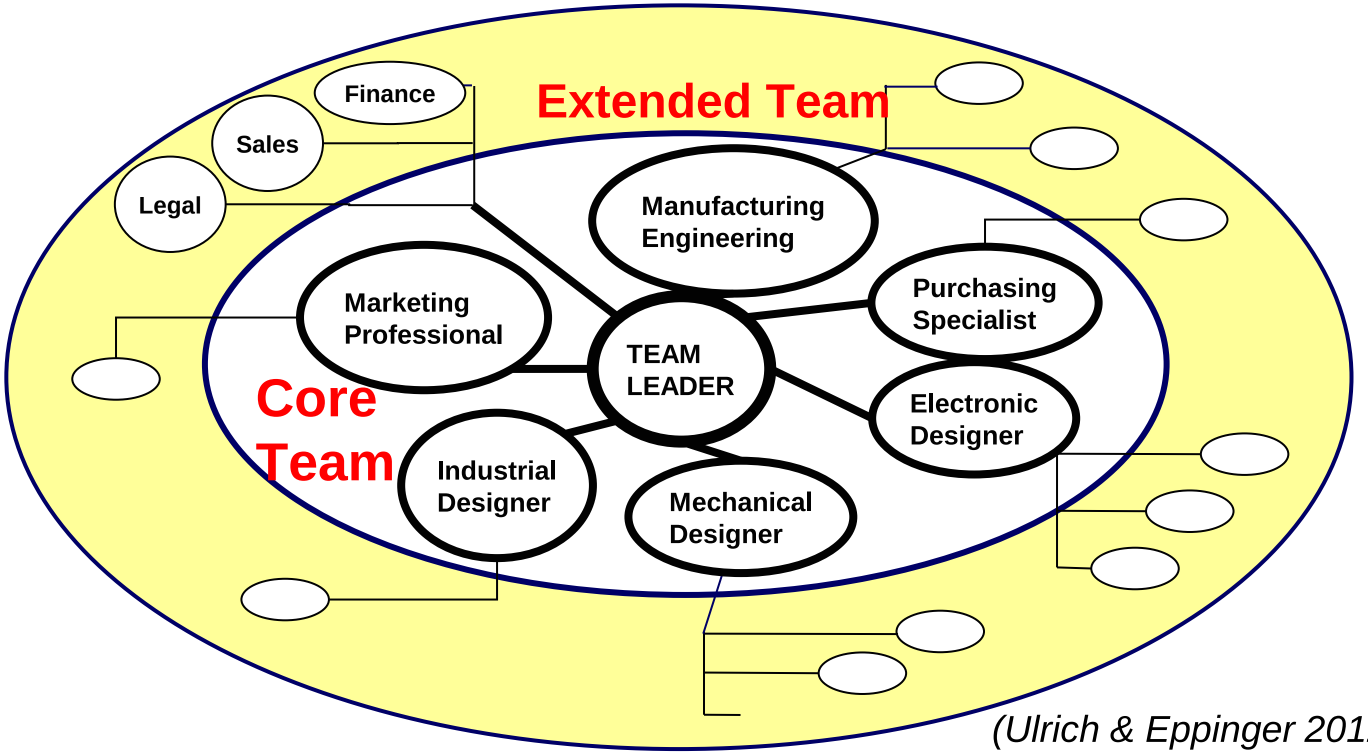
The ***(project) mission statement*** is an extraction from the business plan and may include the following:

- Brief (one-sentence) description of the product
- Key business goals
- Target market(s) for the product
- Assumptions and constraints that guide the development effort

PART 2: Product development and engineering design

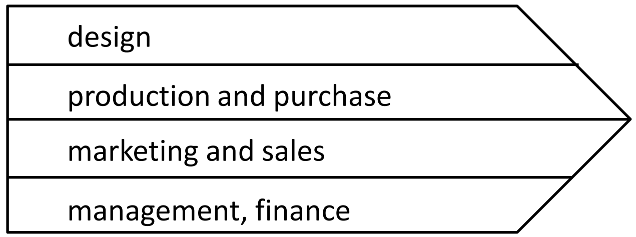
Product development – an overview

- The product development process starts with the mission statement and ends with the documentation necessary for the production and sale of the product
- The process is performed by a cross-functional team



(Ulrich & Eppinger 2012 p. 4)

Product development – the constitutive functions and some of their different activities

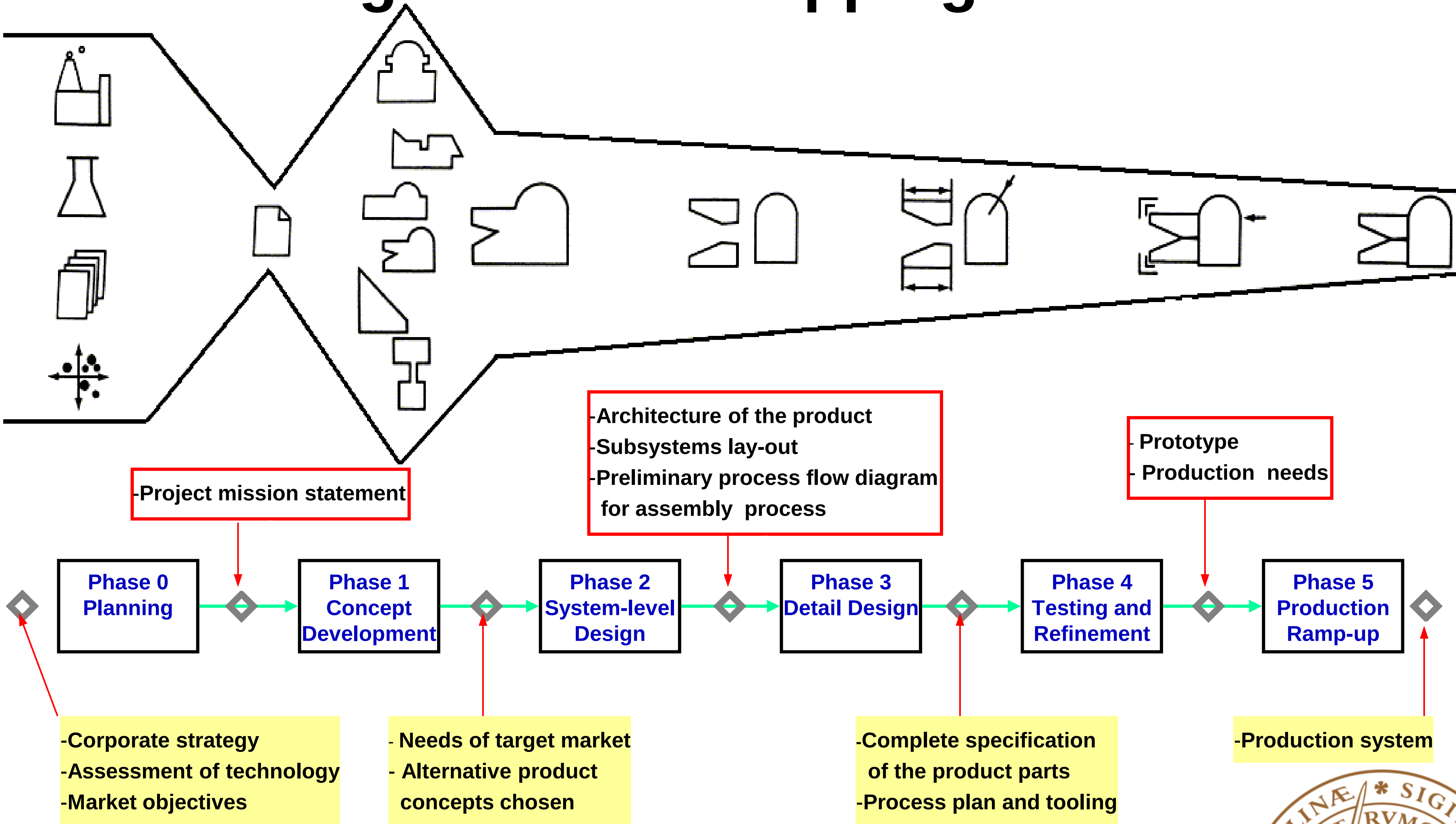


- Design:
  - Establishment of the product architecture
  - ***Establishment of details layout and form***
  - ***Design analysis***
  - ***Industrial design***
  - Testing: performance, reliability, durability
  - Design for X: Environment, DFMA…
- Production and purchase:
  - Establishment of product manufacturing and assembly process
  - Tooling design
  - Identification and negotiation with key suppliers

Product development – the constitutive functions and some of their different activities

- Marketing and sales (***lecture 8***):
  - Development of marketing plan
  - Development of promotion and launch material
  - Development of sales plan
- Management:
  - Project management, control and follow-up
  - Making major decisions
- Finance:
  - Facilitation of economic analysis
  - Make-buy analysis

The Generic Product Development process – according to Ulrich & Eppinger



(Ulrich & Eppinger 2012, p.14)

	Stanley Tools Jobmaster Screwdriver	Rollerblade In-Line Skate	Hewlett-Packard DeskJet Printer	Volkswagen New Beetle Automobile	Boeing 777 Airplane
Annual production volume	100,000 units/year	100,000 units/year	4 million units/year	100,000 units/year	50 units/year
Sales lifetime	40 years	3 years	2 years	6 years	30 years
Sales price	$3	$200	$300	$17,000	$130 million
Number of unique parts (part numbers)	3 parts	35 parts	200 parts	10,000 parts	130,000 parts
Development time	1 year	2 years	1.5 years	3.5 years	4.5 years
Internal development team (peak size)					
External development team (peak size)					
Development cost					
Production investment					

From Ulrich & Eppinger (2012)

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Development time	1 year	2 years	1.5 years	3.5 years	4.5 years
Internal development team (peak size)	3 people	5 people	100 people	800 people	6,800 people
External development team (peak size)	3 people	10 people	75 people	800 people	10,000 people
Development cost	$150,000	$750,000	$50 million	$400 million	$3 billion
Production investment	$150,000	$1 million	$25 million	$500 million	$3 billion

From Ulrich & Eppinger (2012)

Establishment of details layout and form

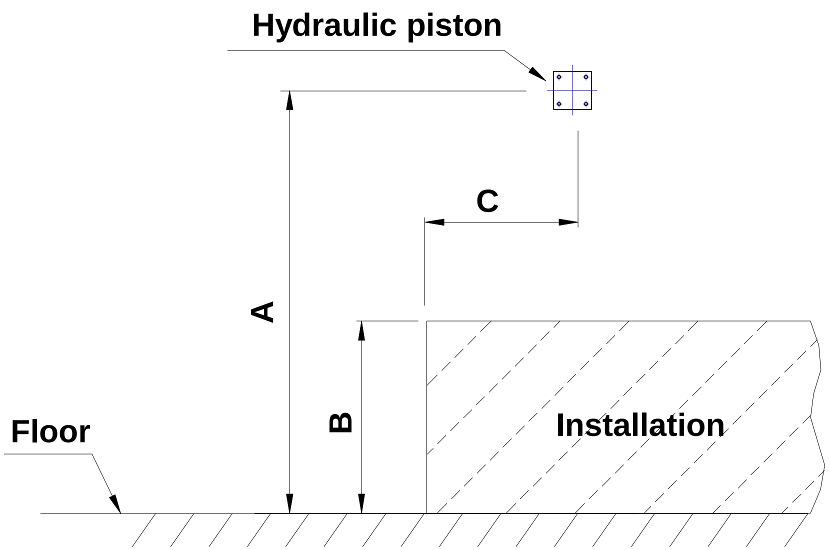
The main objective set out for this activity is:

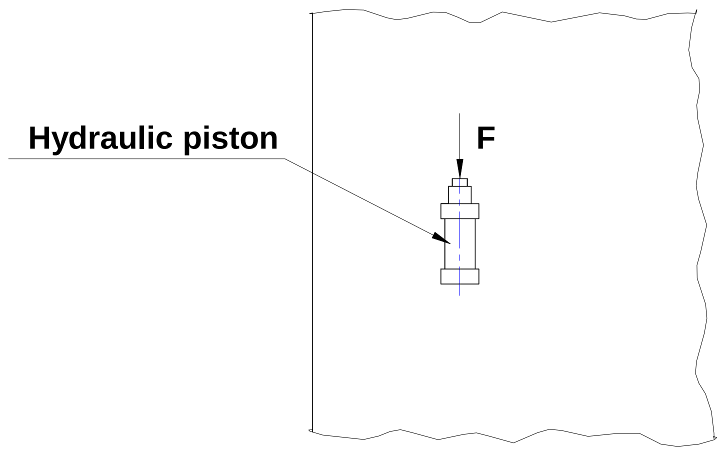
- to establish the actual form and dimensions of the product-to-be (including selection of materials and corresponding choice of manufacturing methods etc.)

This activity requires detailed technical insights and usually extensive experience of similar products and phenomena.

An example of a minor detail design project

The design task: design and establish the dimensions of a support for a hydraulic piston that has to be fixed to the workshop floor.

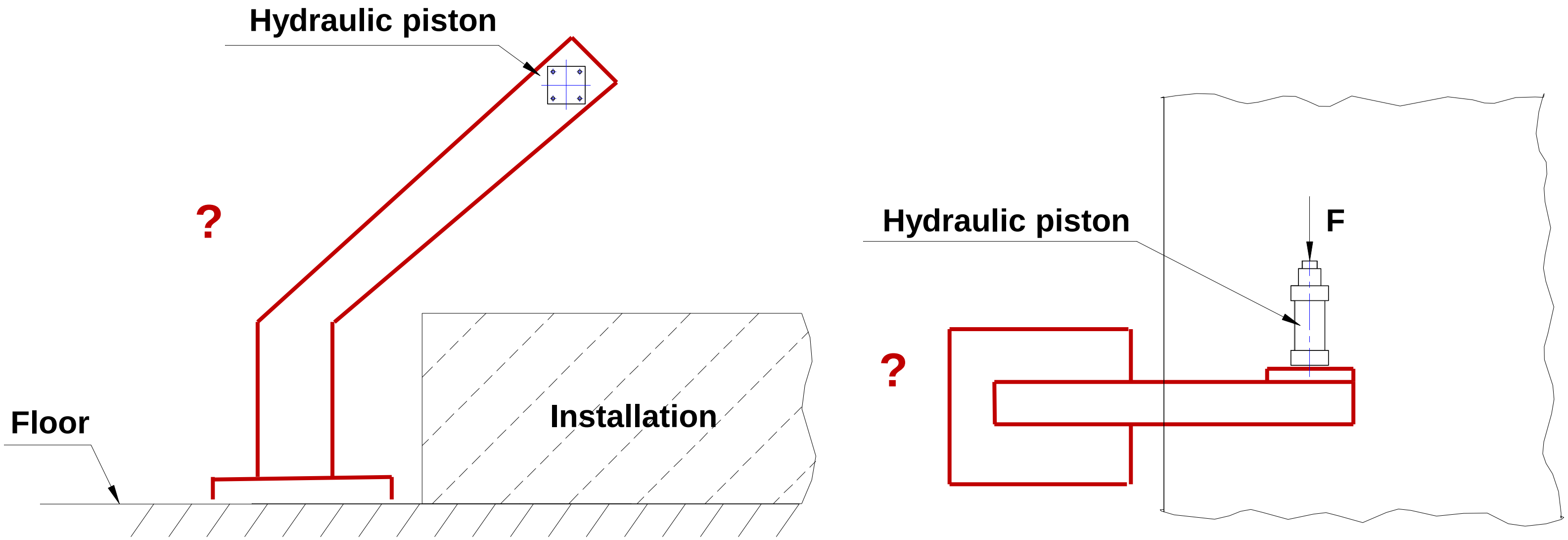




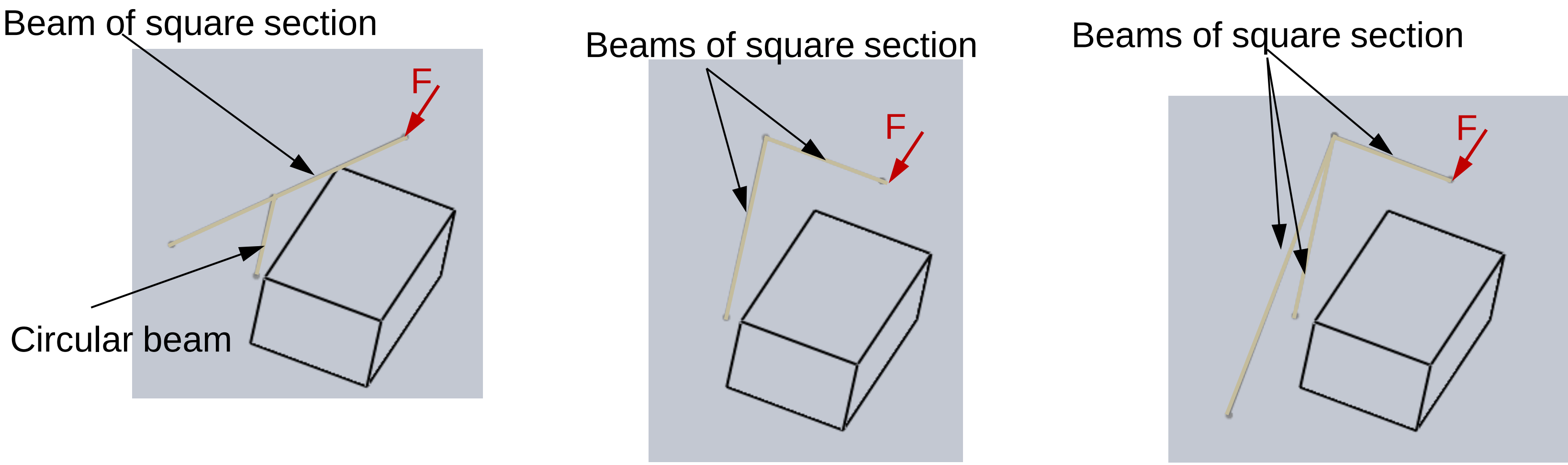
(Per-Erik Andersson, Machine Design, Lund University)

An example of a minor detail design project

A rough layout



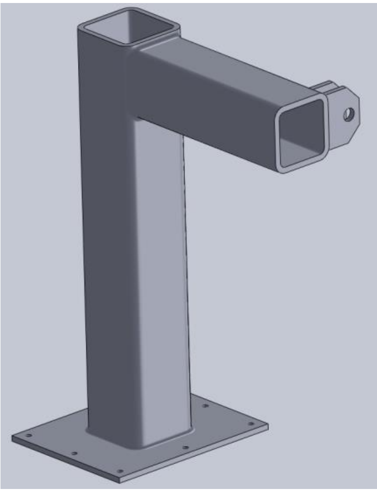
An example of a minor detail design project

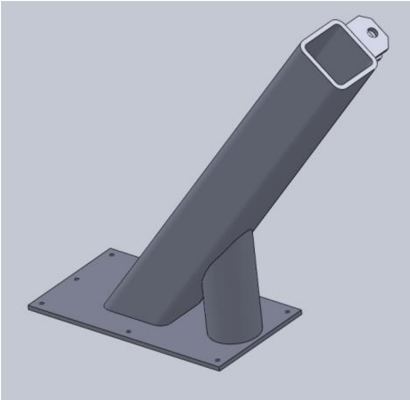


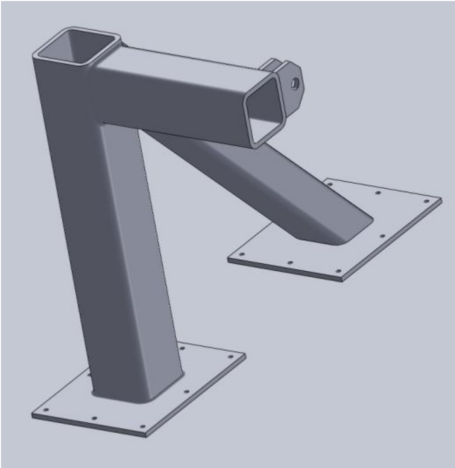
Additional examples of layout configurations

An example of a minor detail design project

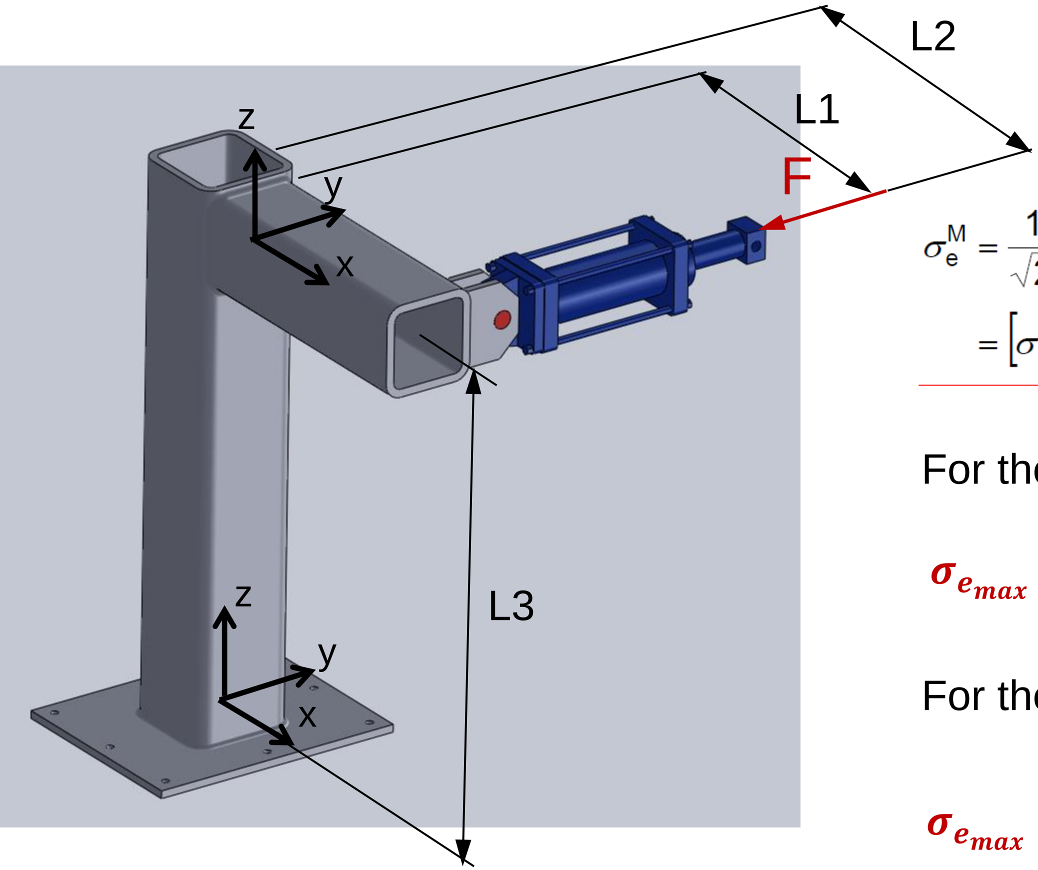
Examples of actual embodiment designs







Design analysis



Equivalent stresses according to von Mises:

$$\sigma_e^M = \frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2}$$

$$=\left[\sigma_x^2+\sigma_y^2+\sigma_z^2-\sigma_x\sigma_y-\sigma_y\sigma_z-\sigma_z\sigma_x+3\tau_{xy}^2+3\tau_{yz}^2+3\tau_{xz}^2\right]^{1/2}$$

For the horizontal beam:

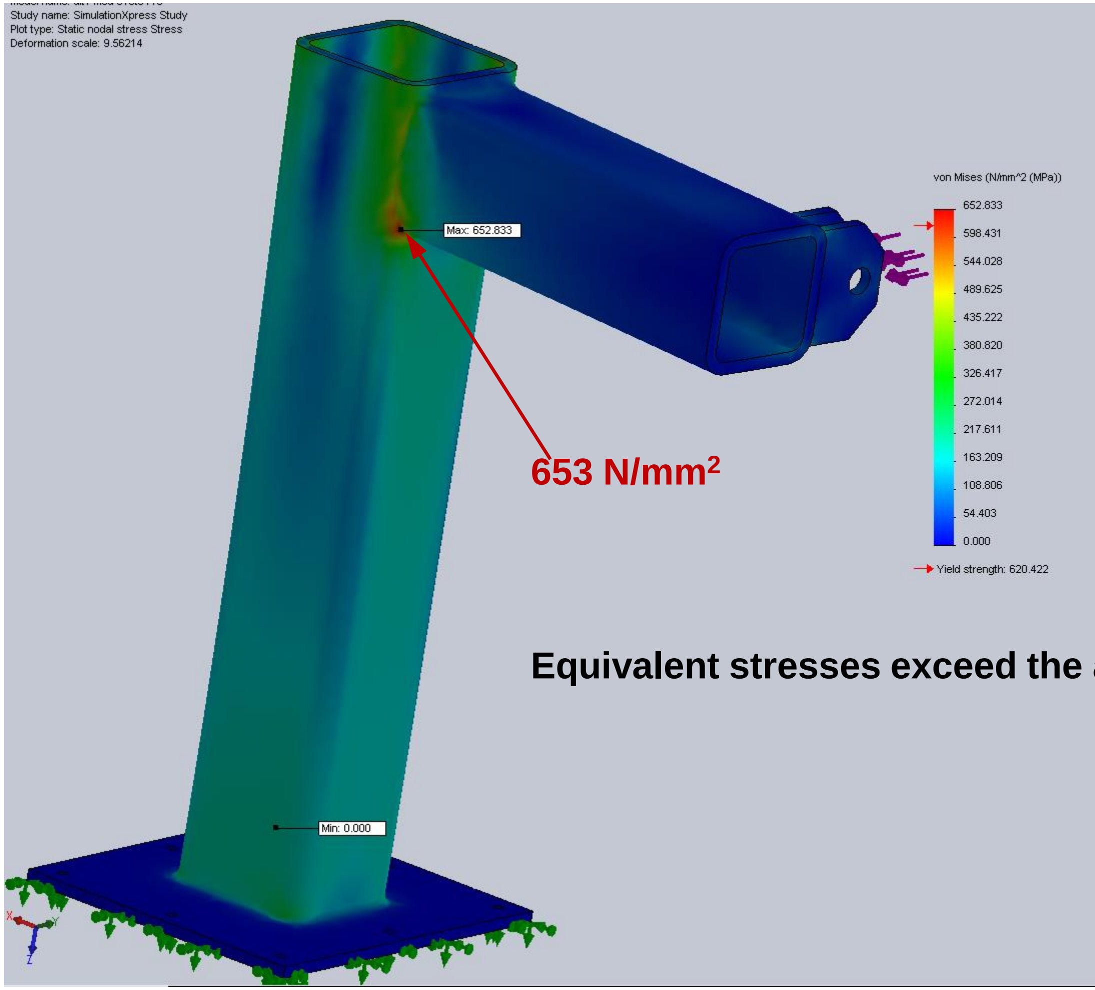
$$\sigma_{e_{max}} = \frac{F \cdot L1}{W_z} = 110\ N/mm^2$$

For the vertical beam:

$$\sigma_{e_{max}} = \sqrt{\left(\frac{F \cdot L3}{W_x}\right)^2 + 3\left(\frac{F \cdot L2}{W_v}\right)^2} = 225\ N/mm^2$$

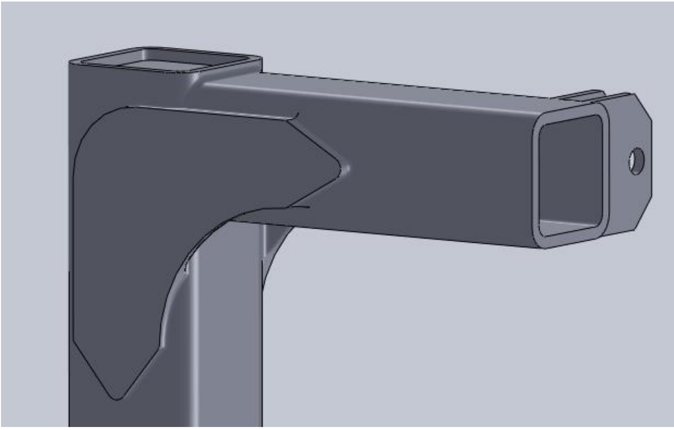
What about using FEM-analysis for this task?

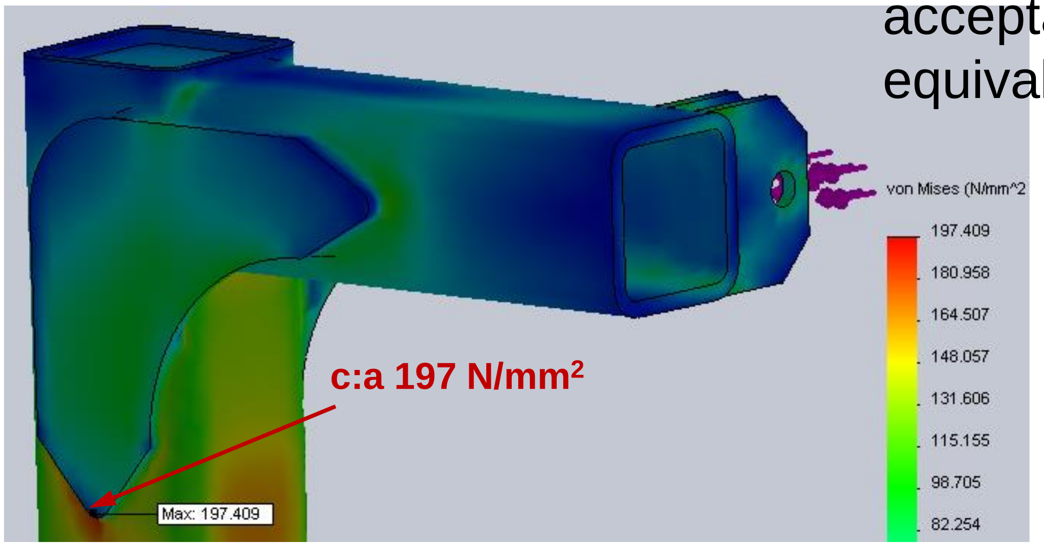
FEM-analysis



Equivalent stresses exceed the allowed stress level!

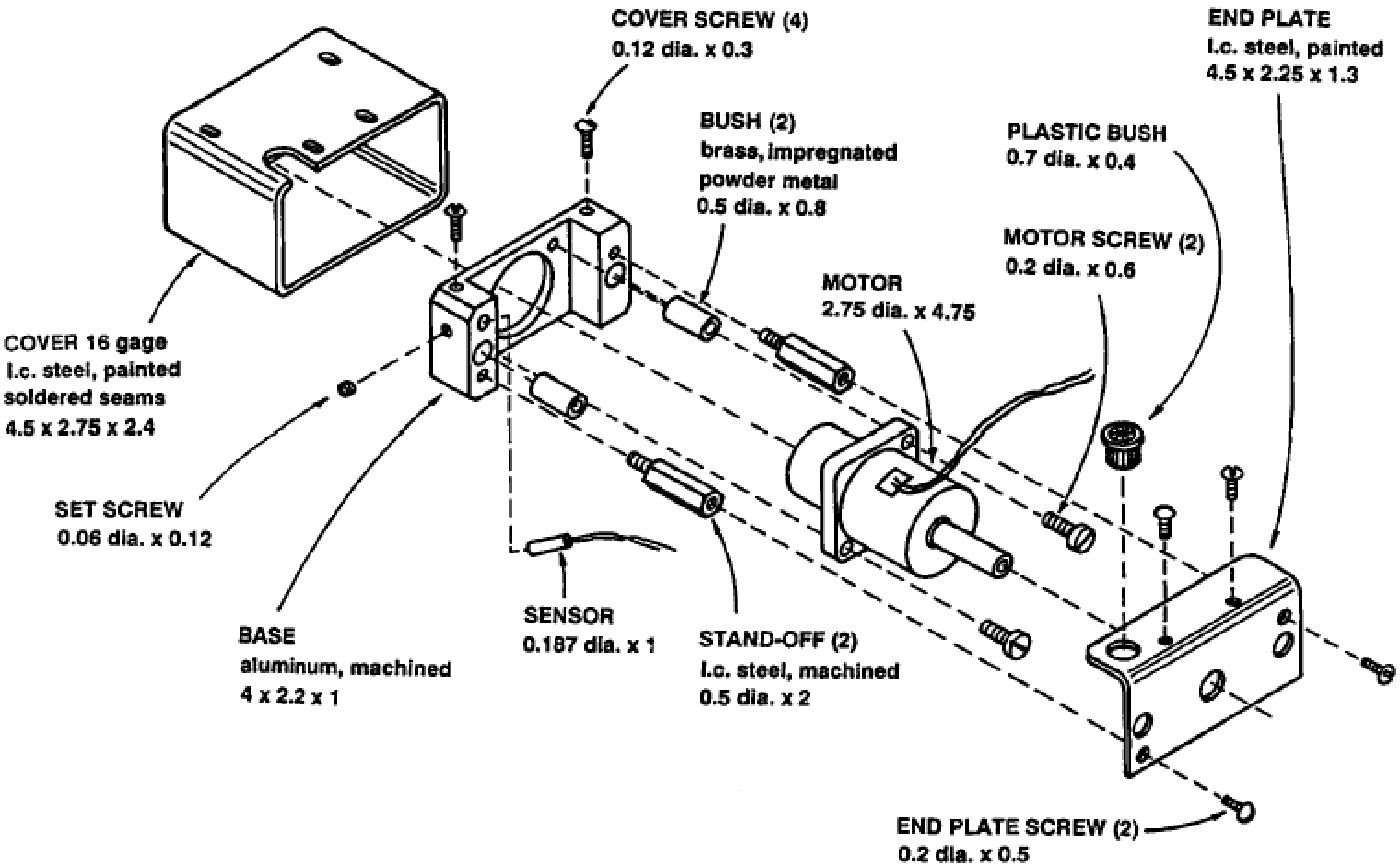
Reinforcing the structural strength by adding additional plates of suitable form and dimensions





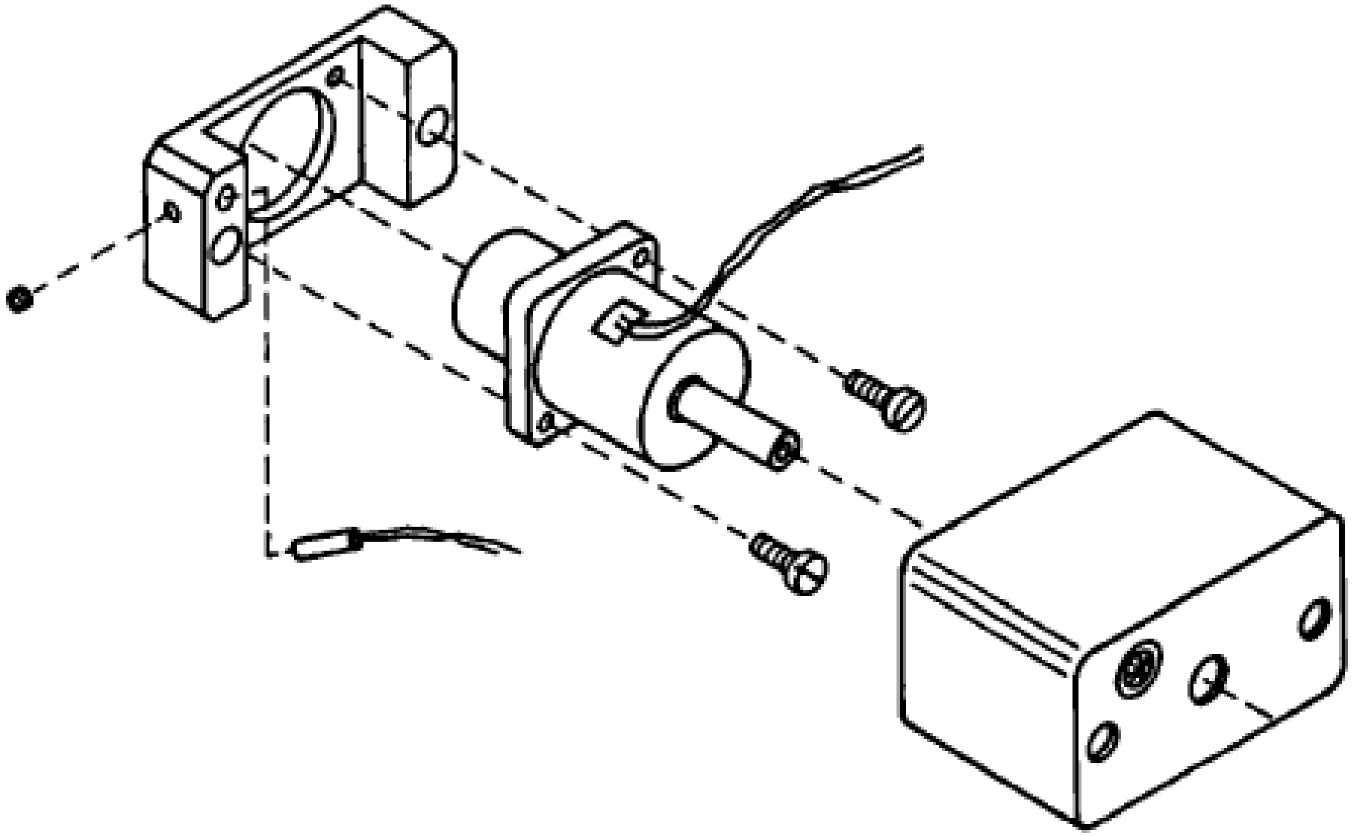
Result – significant and acceptable lowering of the equivalent stress level!

DFMA – Proposed Design of Motor Drive Assembly



(Boothroyd et al 2002, p. 10, dimensions in inches)

DFMA – Redesigned product



(Boothroyd et al 2002, p. 13)

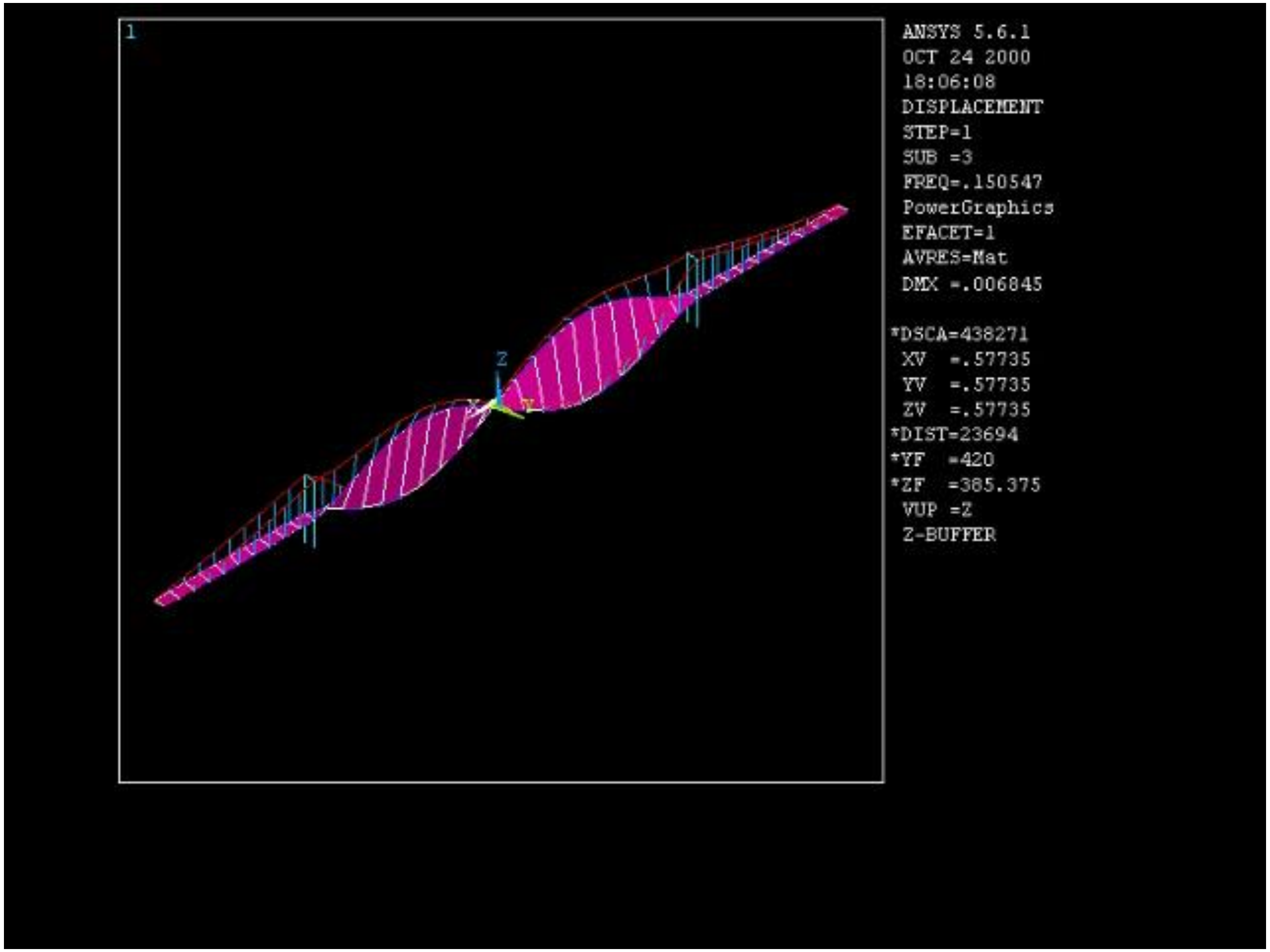
More on computer based design analysis

Computer based design analysis – especially FEM is an excellent tool in order:

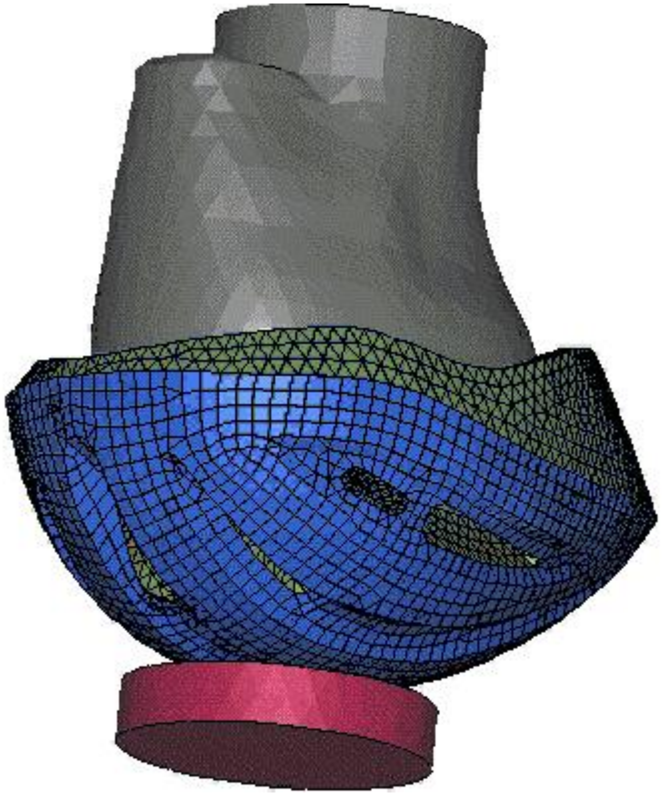
- to understand phenomena from physics
- to analyze the design results
- to verify and validate structural strength
- to avoid expensive prototypes
- to guide towards design improvements and even automatically optimize the design

Understanding phenomena from physics

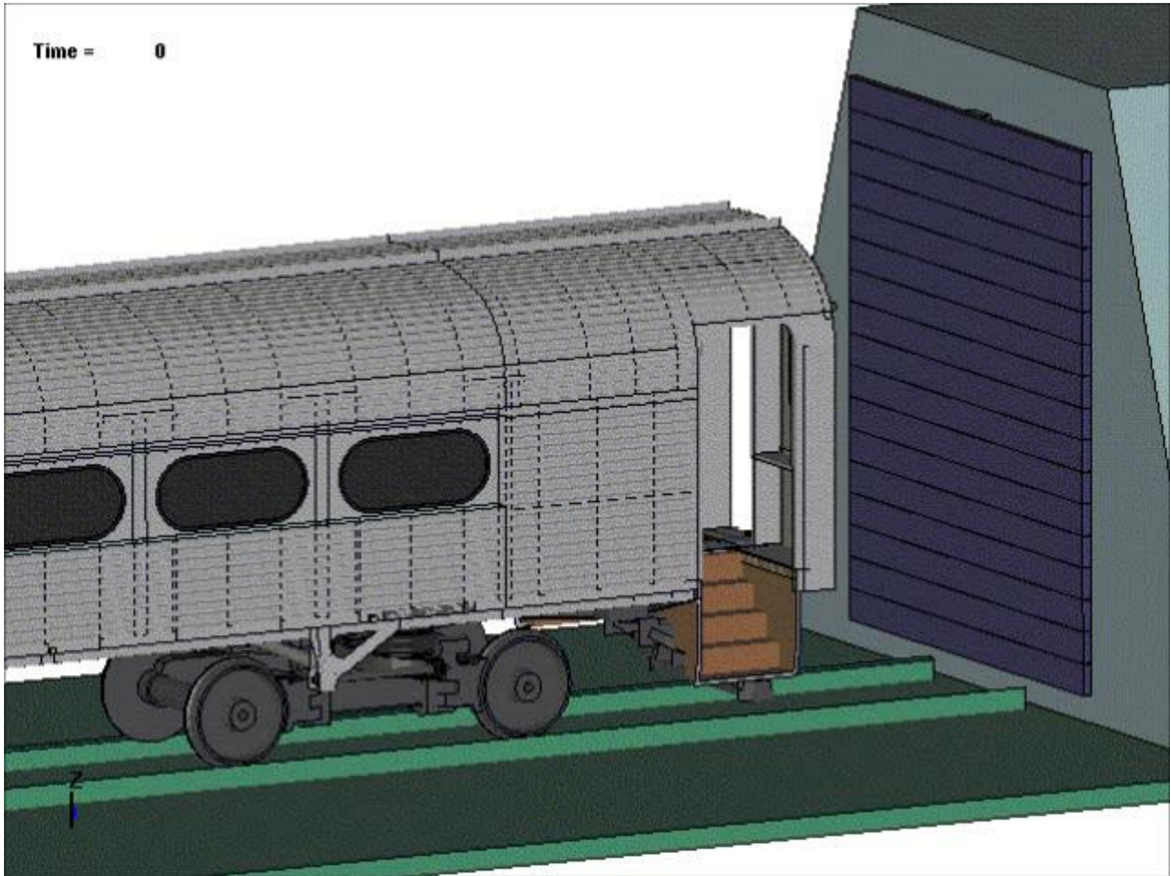
Understanding phenomena from physics



Analyzing designs



Verification and validation of a FEM-analysis

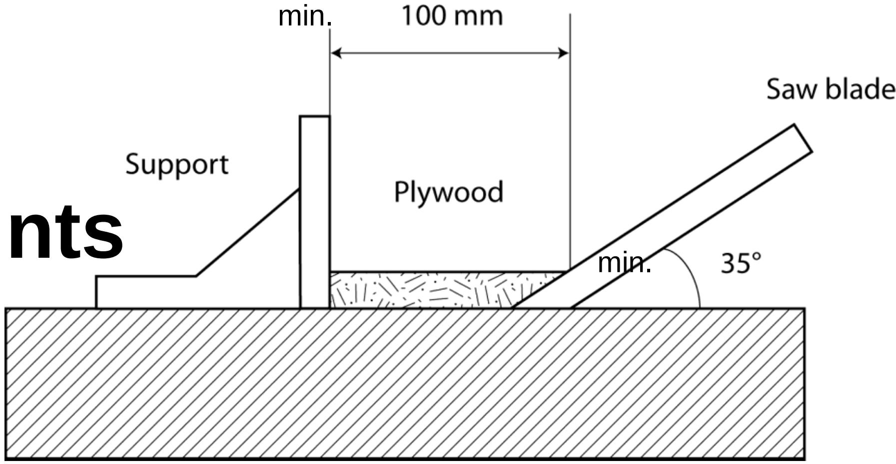


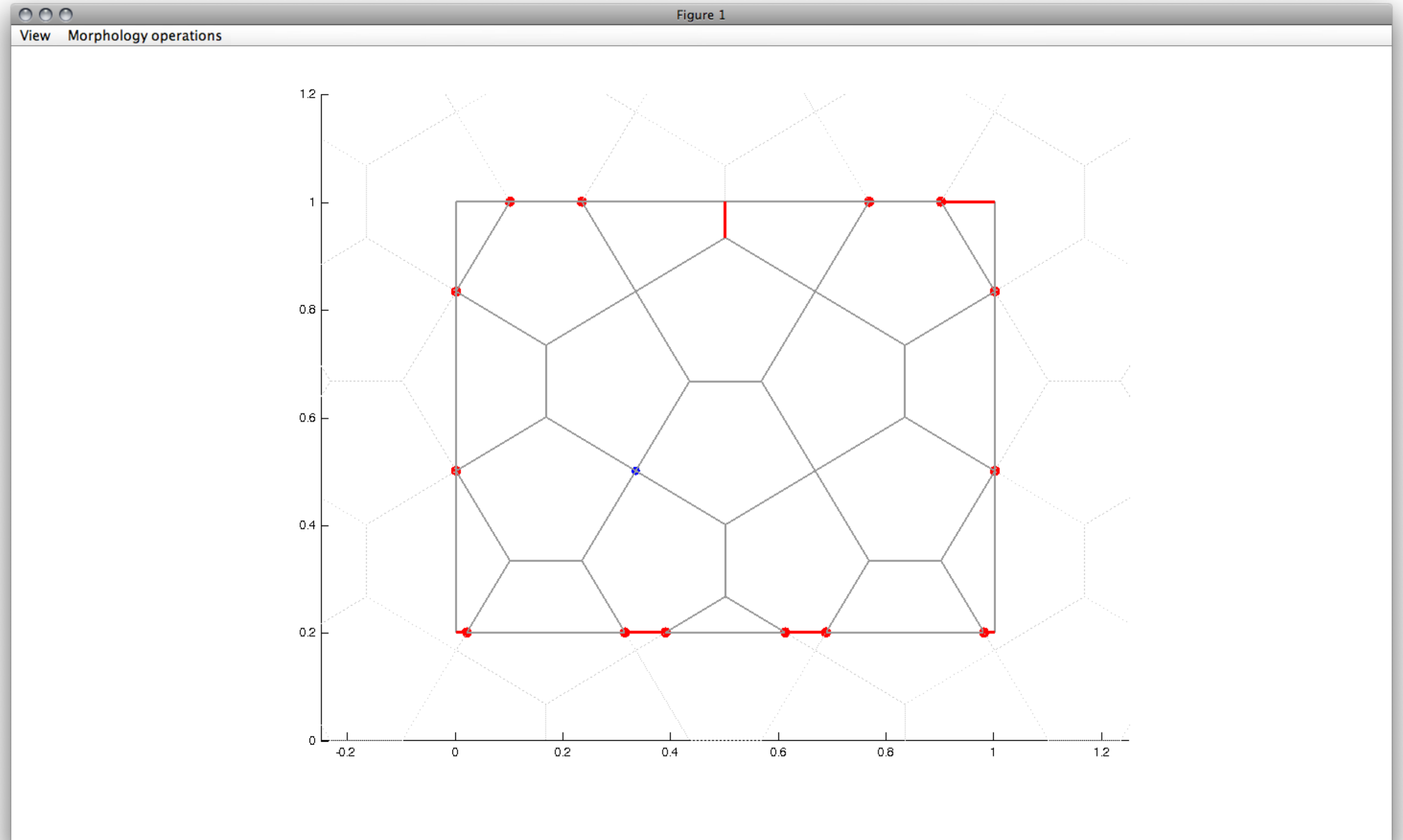
Interaction between industrial design, engineering design and production

- In an ongoing joint research project (entitled *Renaissance 2.0*) between the division of Machine Design and the division of Industrial Design at Lund University, an interactive computer-based generative design system has been developed.
- The design system facilitates the interactive generation of products with complex morphologies by integrating structural and manufacturing constraints.

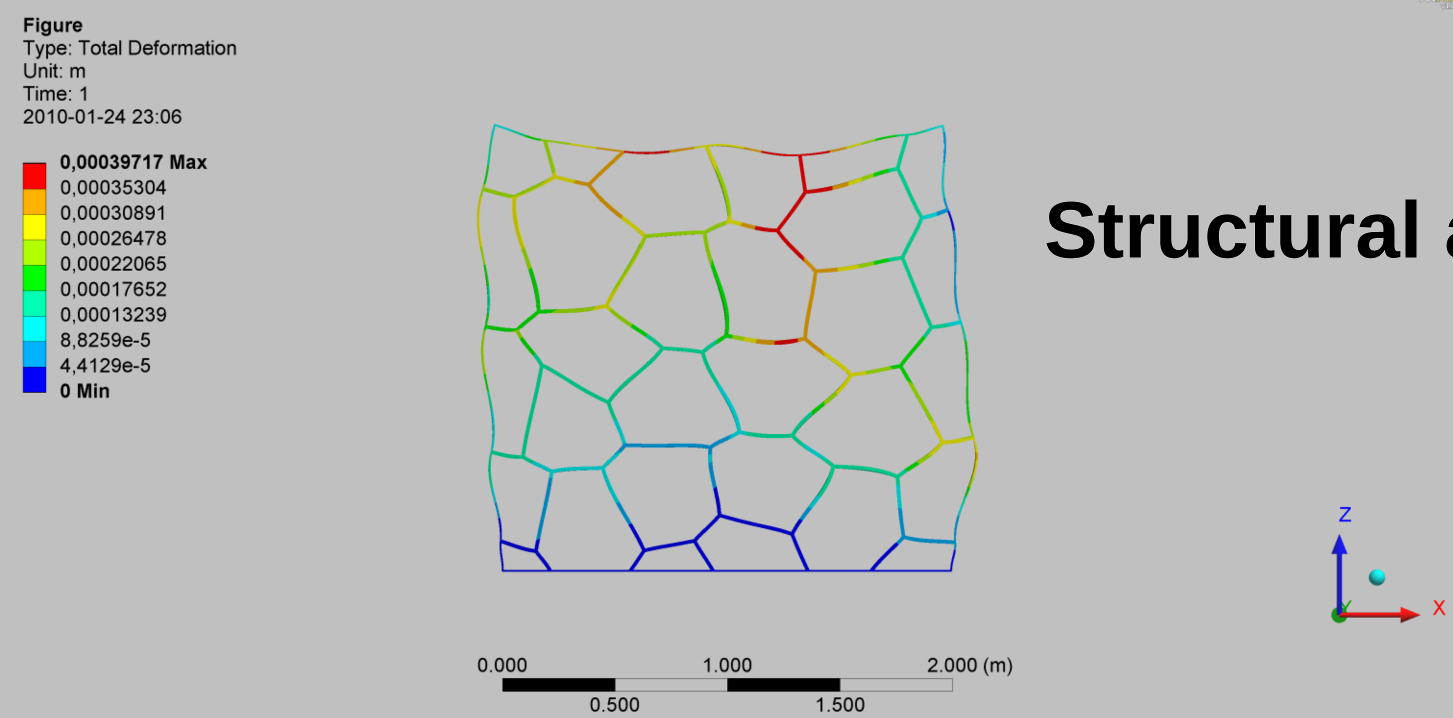
(Axel Nordin, Machine Design, and Andreas Hopf, Industrial Design, Lund University)

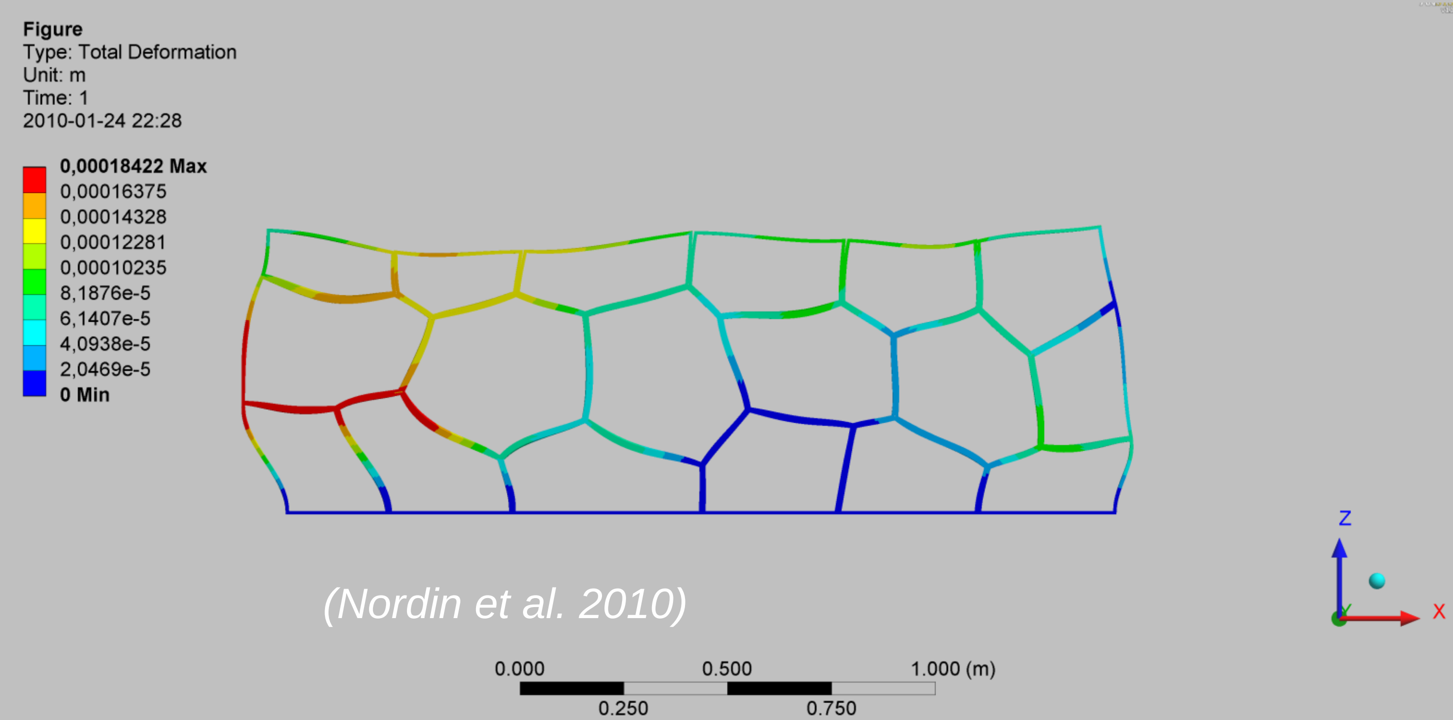
Manufacturing constraints



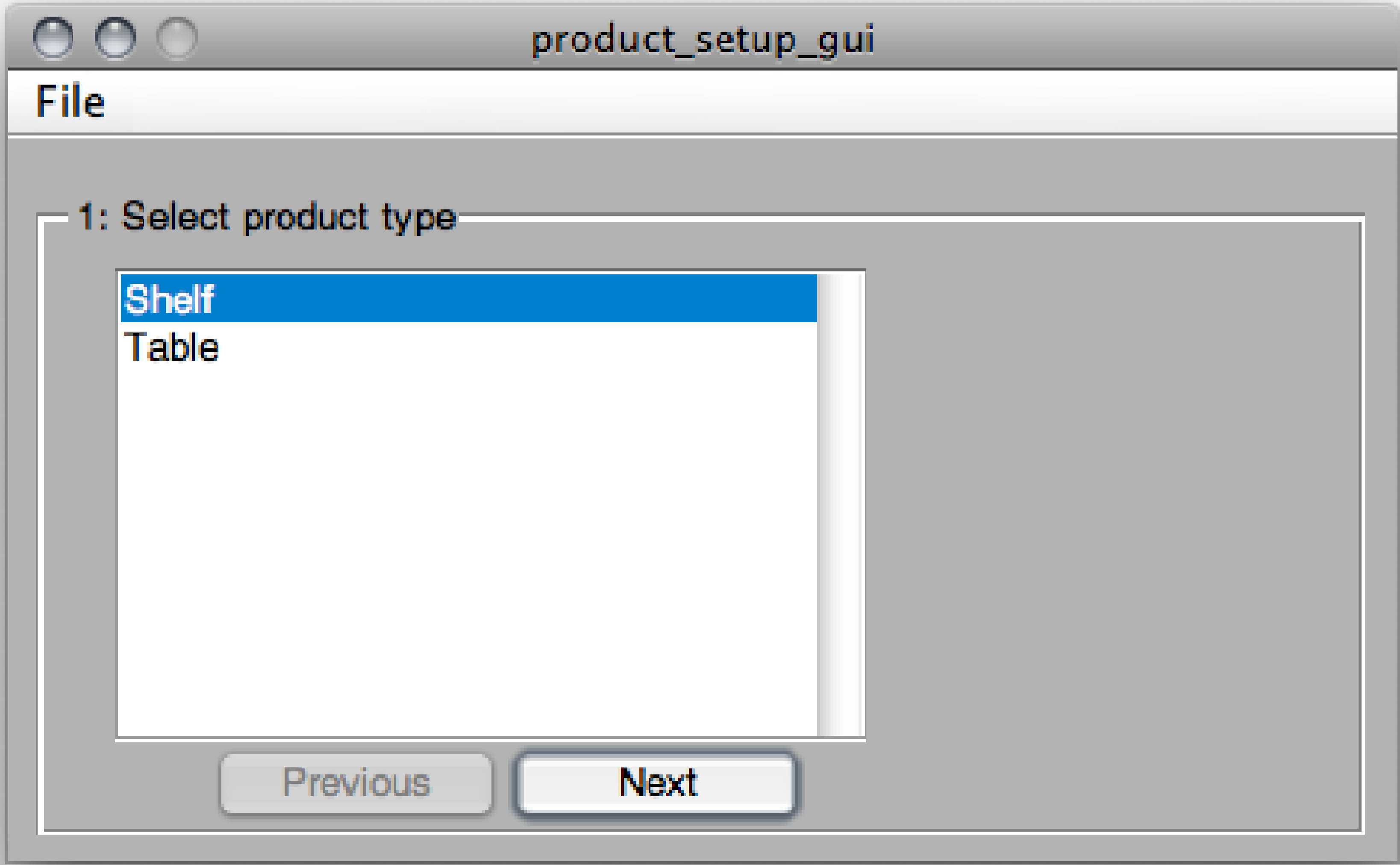


Structural analysis





(Nordin et al. 2010)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PART 3: Global Product Development - GPD

Global Product Development (GPD)

What is GPD?

GPD is a single, coordinated product development operation that includes ***distributed teams in more than one country utilizing a fully digital and connected, collaborative product development operation***. This may include third parties that provide engineering or design capacity, or it may be an entirely captive, company-owned operation.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Why is the GPD transformation happening now?

- Throughout the 1980s and 1990s many US, Western European and Japanese manufacturing companies located production operations in regions where labor cost much less than at home.
- Such organizations have today deep experience with globally distributed operations and suppliers.
- Many multinational companies have grown by acquisition of regional companies whose operations have since been integrated.
- Most manufacturing companies today have experience of global supply chains, and this experience applies directly to collaboration in GPD.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Companies are building their GPD capabilities today for any of four reasons:

Lower Costs

Many companies strive to reduce PD operating costs by redistributing activities to take advantage of labor arbitrage or to access more affordable capabilities. There is a huge pool of engineering talent in low-cost regions such as the Czech Republic, India, Malaysia and Vietnam — and in medium-cost nations including South Korea, Hungary, Poland and Taiwan.

(The authors consider "low-cost" to be 10% to 20% of the equivalent engineer's salary in the United States, and "medium-cost" to be 20% to 50% of U.S. wage rates.)

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Companies are building their GPD capabilities today for any of four reasons (cont.):

Improved Process

Many engineering managers can recall the key lesson learned from both the 1980s emphasis on design for manufacturing (DFM) and the 1990s emphasis on time to market (TTM).

This lesson was that co-locating development teams - particularly the design engineers with the manufacturing engineers - yielded both the cost benefit of DFM and the agility benefit of TTM. The prospect of moving design engineering to global manufacturing locations can be attractive again today.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Companies are building their GPD capabilities today for any of four reasons (cont.):

Global Growth

Locating some PD activities in selected international locations can give companies access to critical information about markets in those regions. By using local engineers, companies make direct connections with potential new markets.

Technology Access

Companies are using GPD to develop integrated PD processes that include engineers in regions where critical new technology has been developed and where technical experts reside. Although cost remains the primary reason that many companies initially consider GPD, it is technology, process innovation or revenue growth that drives a GPD strategy. This move from cost to growth and innovation has been a major shift in stated GPD objectives over the past two to three years.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Comparing the New Practice of GPD with the Conventional Approach

Global Product Development

Globally distributed teams

Takes advantage of engineering in multiple geographic locations, including low-, medium- and high-cost regions

Uses an entirely digital PD process to facilitate distributed, collaborative engineering

Conventional Product Development

Largely co-located teams

Uses engineering located in existing engineering centers

Uses a combination of digital PD tools and conventional paper-based processes for engineering

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

The essential elements of GPD

Outsourcing Versus Offshoring

As companies think more holistically about their product development operations and the distribution of various activities, four fundamental modes of GPD emerge. Recent discussion about ***outsourcing*** and ***offshoring*** — much of it politically charged — is relevant to GPD practice.

"Outsourced" typically means the PD resources are owned by a third party, while ***"insourced",*** or ***"captive",*** means they belong to the manufacturer. Outsourced resources can be located on-site at the company, down the road at the third party's offices or halfway around the world.

The term ***"offshore"*** refers to the location of those resources — generally meaning lower-cost regions.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Viewing the concepts of outsourcing and offshoring together allows us to envision four modes of global product development operation:

1. Centralized

This mode is the traditional one, in which all product development resources are within the company and at ***onshore*** locations. Centralized operation can include different project teams in multiple countries, such as a U.S. team and a German team. All resources are owned by the company and located in the “headquarters” countries — that is, generally in high-cost regions.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Viewing the concepts of outsourcing and offshoring together allows us to envision four modes of global product development operation:

2. Local Outsourcing

This mode has been commonly used, often in conjunction with the centralized mode. Many large manufacturers use on-site contractors to support their product development activities. Local outsourcing is used for two primary reasons: to gain access to specialized skills or to meet temporary requirements for capacity.

For example, in the concept development phase, a number of ideation activities are the distinctive competencies of specialized outsource firms, such as IDEO, Design Continuum and Smart Design.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Viewing the concepts of outsourcing and offshoring together allows us to envision four modes of global product development operation:

3. Captive Offshoring

One of two relatively recent offshore GPD modes, captive offshoring is useful when a company believes it should own a PD operation in a region in which it has not done business before.

This requires choosing a location, hiring a management team, securing a facility, establishing the operation as a legal entity, understanding the local regulatory and tax requirements, hiring and training staff, and putting in place the supporting finance, human resources and information technology processes.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Viewing the concepts of outsourcing and offshoring together allows us to envision four modes of global product development operation:

4. Global Outsourcing

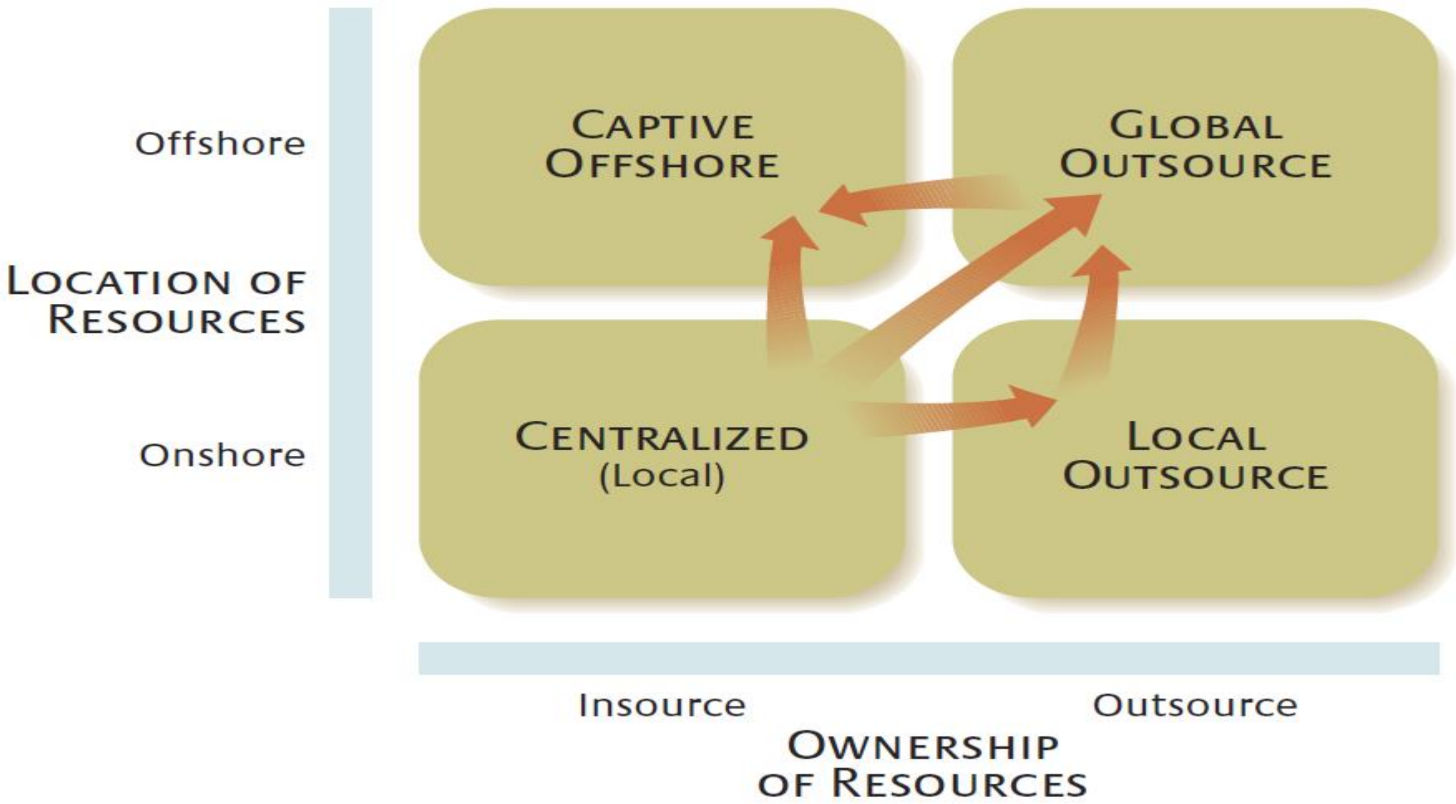
This type of arrangement — the other offshore GPD mode — gives many companies early experience with GPD without requiring the commitment to establish a captive center. Companies contract with a service provider to undertake basic engineering tasks, such as updating drawings, implementing engineering change orders or writing technical publications. This is typically done by staff augmentation on a time-and-materials basis, with an early focus on transferring knowledge and building a working relationship.

By using outsourced staff only at certain points in the process, the company keeps control of the PD process overall. However, this is an important step in moving toward a deeper integration of product development with the outsourced provider because it helps the provider understand the company's PD processes, methods and protocols, and it helps the company understand the technical capability, costs and timeliness of the outsourced provider.

(Eppinger & Chitkara 2006)

Global Product Development (GPD)

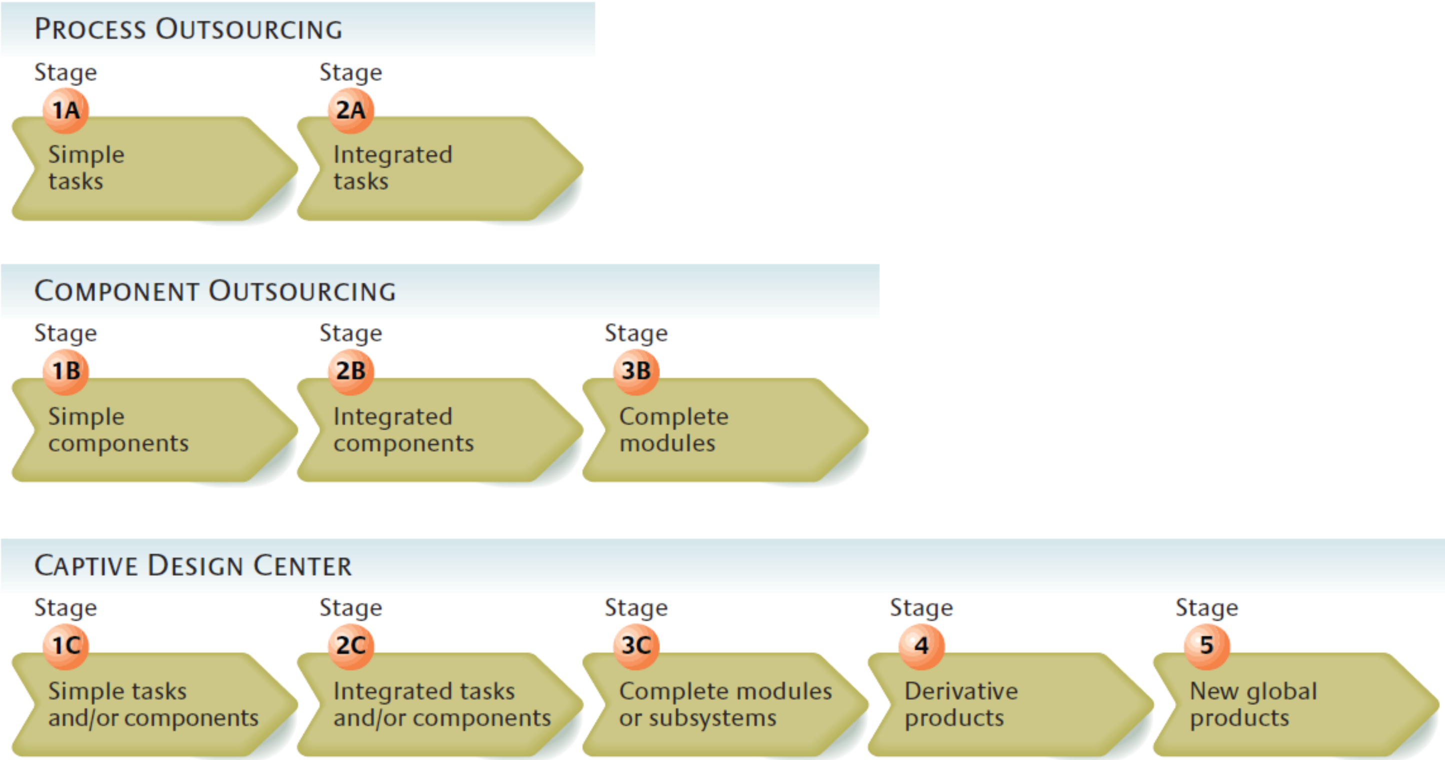
To summarize:



(Eppinger & Chitkara 2006)

Global Product Development (GPD)

Best practice leaders typically deploy a GPD strategy in stages:



(Eppinger & Chitkara 2006)

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