

Progettazione di Materiali e Processi

Università degli Studi di Trieste

Dipartimento di Ingegneria e Architettura

Corso di Laurea in Ingegneria di Processo e dei Materiali

A.A. 2021-2022

Progettazione di materiali e processi

- Corso sviluppato in tre moduli tenuti dai Proff. Posocco, Lughì e Cortesi
- Ogni modulo avrà una valutazione finale, che dovrà essere positiva, da parte del singolo docente
- Il voto finale del corso verrà registrato dal Prof. Lughì e calcolato
 - Per il 50% dalla valutazione pesata, in funzione dei crediti forniti, dei risultati ottenuti in ognuno dei tre moduli (3 CFU per la Prof. Posocco, 4 per il Prof. Lughì, 2 per il Prof. Cortesi)
 - Per l'altro 50% attraverso una tesina su argomenti proposti dallo stesso studente, dal singolo docente o da realtà industriali (nell'ultimo caso si potranno organizzare anche gruppi di max 3 studenti per la soluzione di possibili mini progetti)

PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

Design process

- Example
- Fundamentals
- Identification of needs (market; coevolution; true need)
- Types of design
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

Previous classes

+

This course

simulazione di processo, fluidodinamica, impianti; reattori; termodinamica chimica; simulazione molecolare; ceramici e nanostrutturati; polimeri; TFC; Dinamica e controllo dei processi chimici; Chimica industriale; sistemi complessi; reologia; disegno di macchine; gestione industriale; meccanica applicata; metallurgia e corrosione; scienza delle costruzioni; tecnologia meccanica; ...

- **Selection and design of materials and processes**
 - Tools for optimal systematic selection
 - Design of materials: case studies (nano, meso, microstructures; hybrid materials; composites)
- **Design of thermal exchange processes**
- **Advanced tools and methods** (ad-hoc lectures and seminars: FEM, product/process economics, Life Cycle Assessment, ...)
- **Special topic seminars** (Intellectual Property, product evaluation, materials in industrial design, theory of scenarios, rapid plant assessment, material selection in engines, design for recycle, refurbish, reuse)

Programma del modulo (1)

Selezione e Progettazione di Materiali (4 crediti)

Introduzione: Materiali come opportunità nel progetto; dati e strumenti per la progettazione; sommario delle principali famiglie di proprietà dei materiali.

Selezione dei materiali: Indici dei materiali e indici strutturali; uso dei diagrammi di Ashby; selezione con obiettivi e vincoli multipli; selezione di materiali e forme; materiali ibridi; casi di studio. Utilizzo del programma CES.

Cenni alla selezione di processi.

Introduzione alla selezione dei materiali con vincoli ambientali.

Esempi di design avanzato: metamateriali; bandgap engineering; materiali ibridi

Analisi economica di processi. Stime costi capitale e operativi. Analisi di profittabilità, ritorno di investimento.

Seminari

Module 1 – Selection and Design of Materials (Lughi)

CALENDAR:

Module 1 (Lughi) - September 21st – November 3rd

Module 2 (Cortesi) – November 10th – end of semester

Module 3 (Posocco) – Second semester

TEXTBOOKS (Module 1):

Ashby - Materials Selection in Mechanical Design

Ashby – Materials and the Environment

Ashby, Johnson – Materials e Design

Basic materials science and engineering textbooks (Smith, Callister, Shackelford,...)

CONTACTS:

Vanni Lughi

Building B, Room 48

Office: 040 558 3769

vanni.lughi@dia.units.it

MODULE TEST:

Solve a real-world problem of materials selection (24 hours)

PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

Design process

- Example
- Fundamentals
- Identification of needs (market; coevolution; true need)
- Types of design
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

Previous classes

+

This course

simulazione di processo, fluidodinamica, impianti; reattori; termodinamica chimica; simulazione molecolare; ceramici e nanostrutturati; polimeri; TFC; Dinamica e controllo dei processi chimici; Chimica industriale; sistemi complessi; reologia; disegno di macchine; gestione industriale; meccanica applicata; metallurgia e corrosione; scienza delle costruzioni; tecnologia meccanica; ...

- **Selection and design of materials and processes**
 - Tools for optimal systematic selection
 - Design of materials: case studies (nano, meso, microstructures; hybrid materials; composites)
- **Design of thermal exchange processes**
- **Advanced tools and methods** (ad-hoc lectures and seminars: FEM, product/process economics, Life Cycle Assessment, ...)
- **Special topic seminars** (Intellectual Property, product evaluation, materials in industrial design, theory of scenarios, rapid plant assessment, material selection in engines, design for recycle, refurbish, reuse)

PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

Design process

- Example
- Fundamentals
- Identification of needs (market; coevolution; true need)
- Types of design
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- **Design, Product, Process**
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

Design

- The art or action of conceiving of and producing a plan or drawing of something before it is made
- A plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made
- Decide upon the look and functioning of (a building, garment, or other object), by making a detailed drawing of it
- Do or plan (something) with a specific purpose in mind

Product

- An article or substance that is manufactured or refined for sale
- A substance produced during a natural, chemical, or manufacturing process

Process

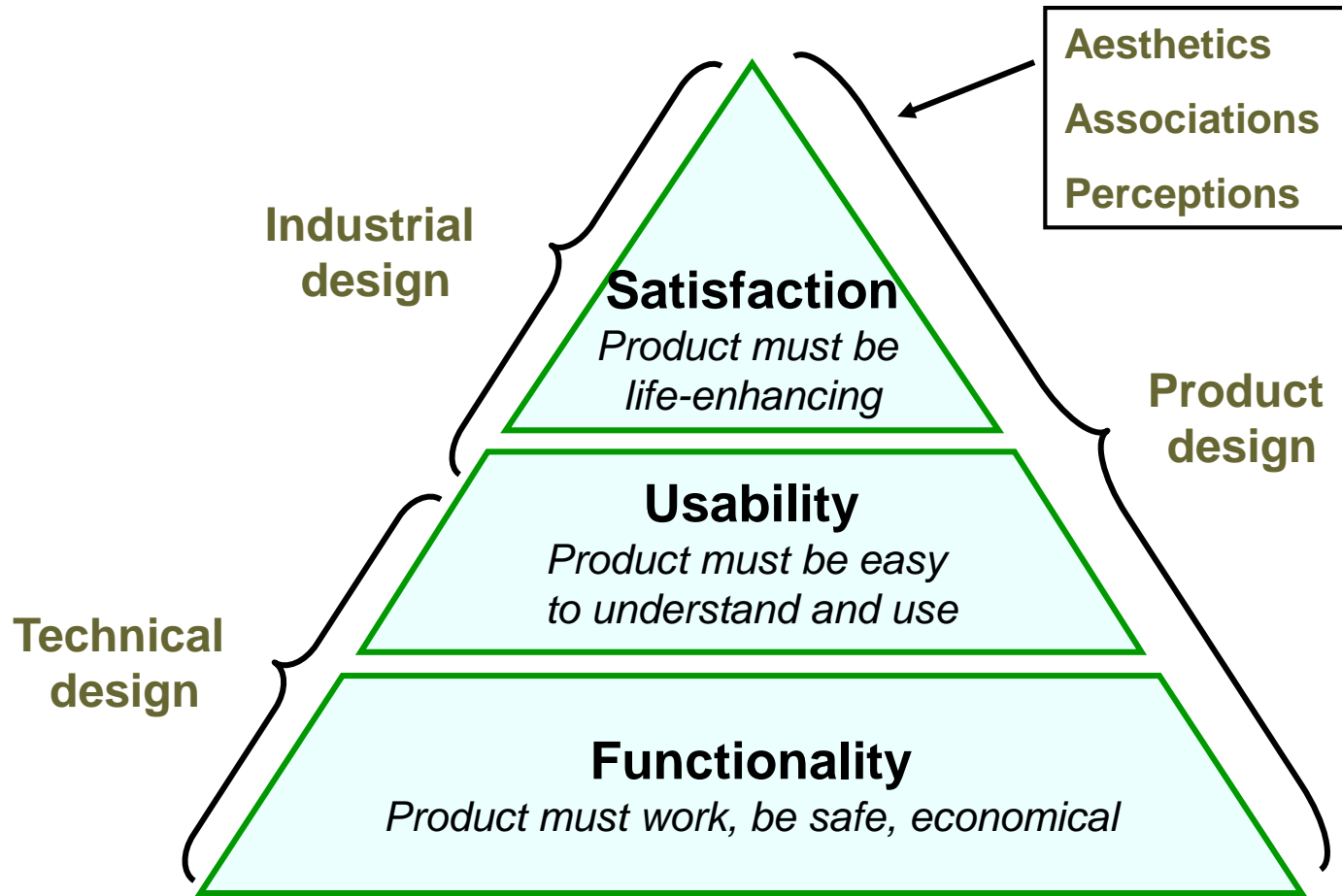
- A systematic series of mechanized or chemical operations that are performed in order to produce something

Product Design

(...as seen by an engineer...)



Technical, Industrial, and Product Design



What gives a product its *character*?



Establishing the context

Context

Who?

Men / Women
Children / Elderly
Sportsmen / Disabled
...

What ?

Functionality?
...

Where ?

Home / Office
Europe / Africa...

When ?

Day / Night
Occasionally / All the time...

Why?

To fill a basic need
To meet an aspiration
...

«Intentions»:
design according to...

User

Design for public use
Design for women/men
Design for elders/children
...

Economic factors

Design for minimum cost
Design for easy assembly
Design for mass production
...

Sustainability

Design for the environment
Design for recycling
Design for biodegradability
...

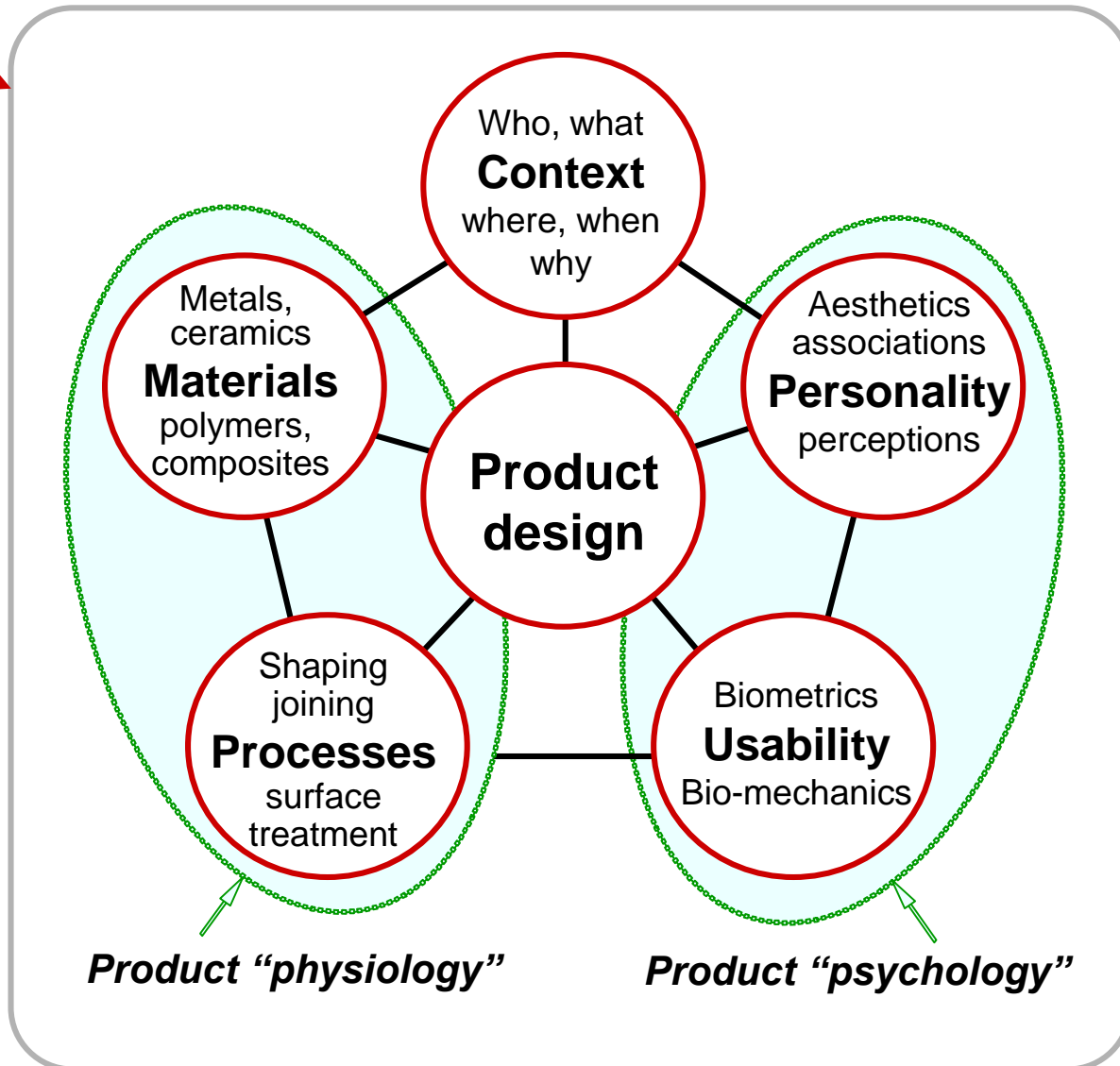
Performance

Design for minimum mass
Design for max. insulation
...

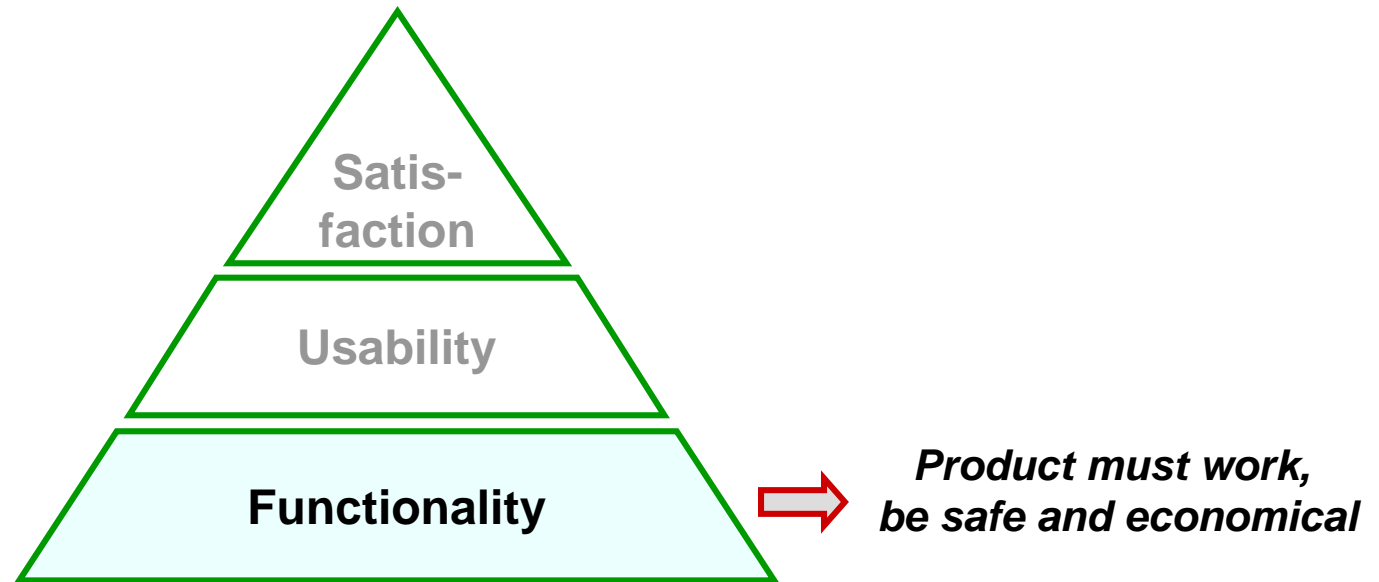
These steer all decisions that follow -- they set the **MOOD**

What gives a product its *character*?

Product
“character”



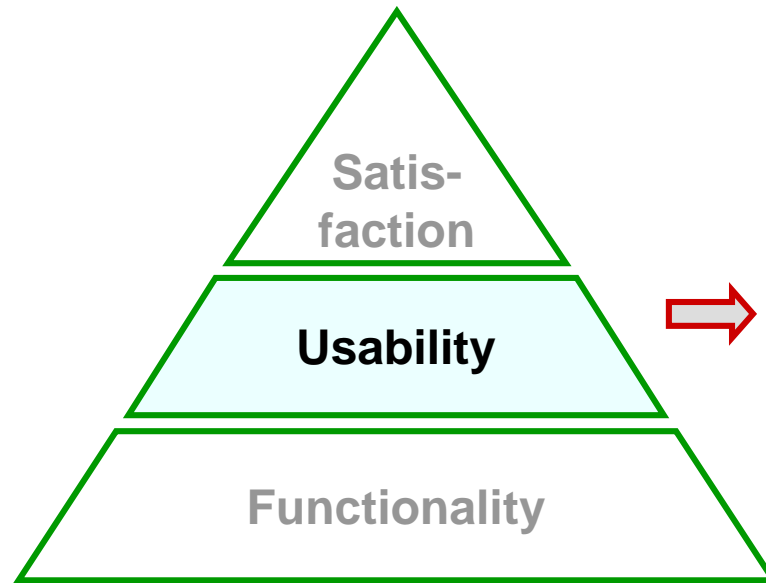
Technical and industrial design



- Sound technical design
- Proper choice of materials
- Proper choice of manufacturing process

Plenty of tools to do this

Usability («ergonomics»)



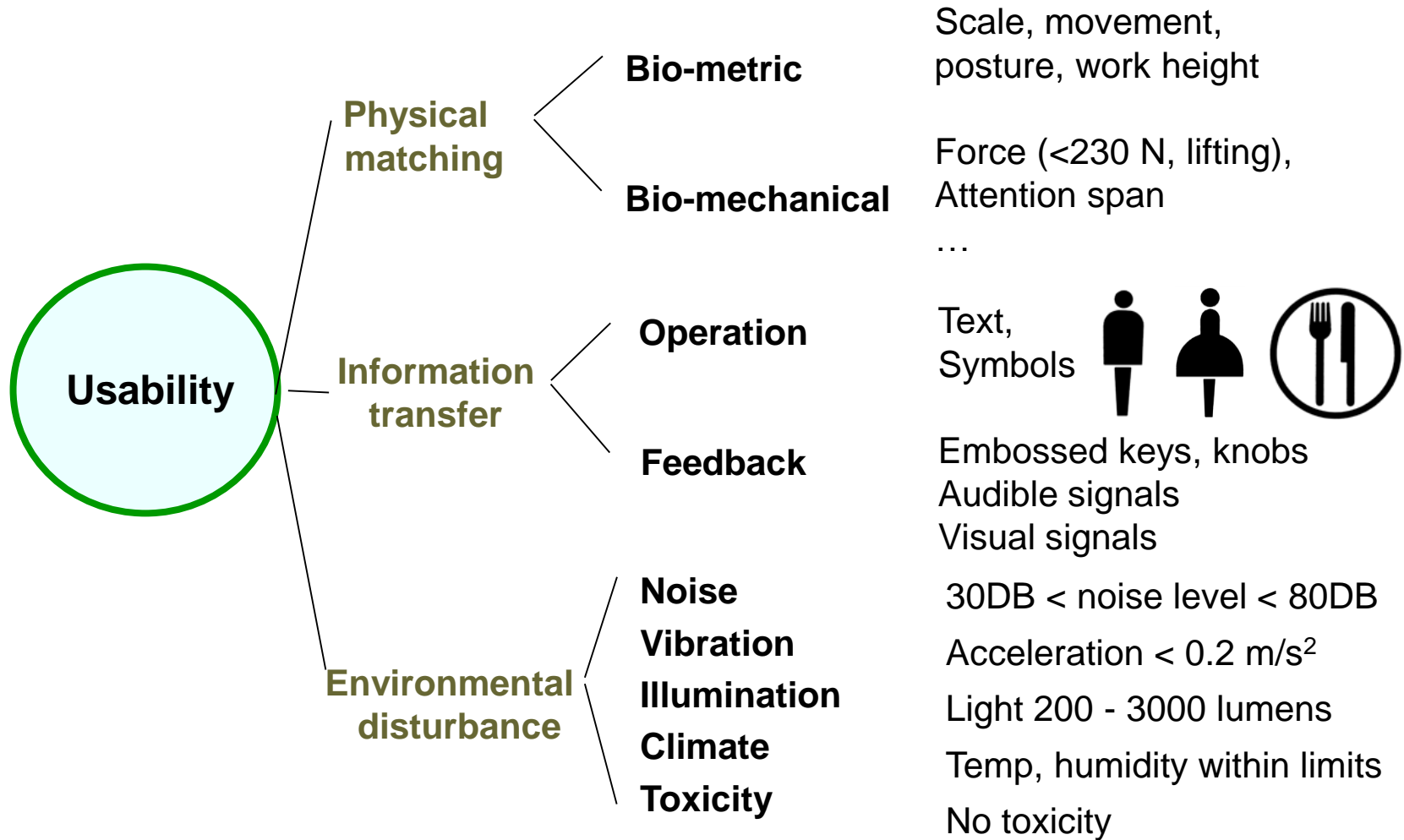
Product must be easy to understand and use

Three aspects

- Interaction with the **human body** -- biometrics
- Interaction with the **mind** -- intelligibility
- Interaction with the human **environment**

} Now much researched

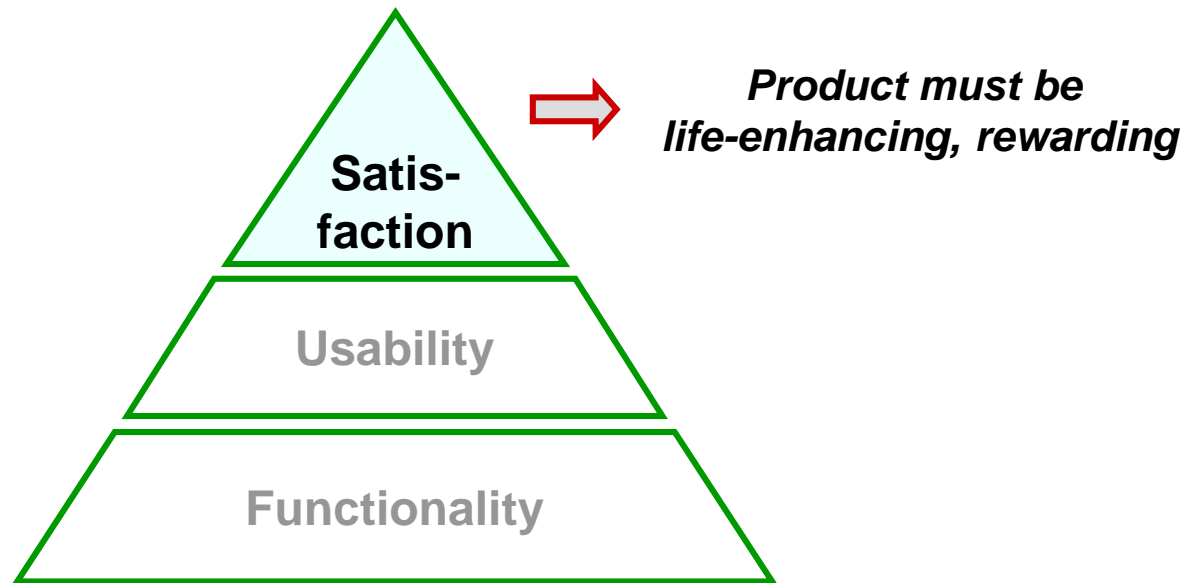
Usability («ergonomics»)



Examples of bio-mechanical matching



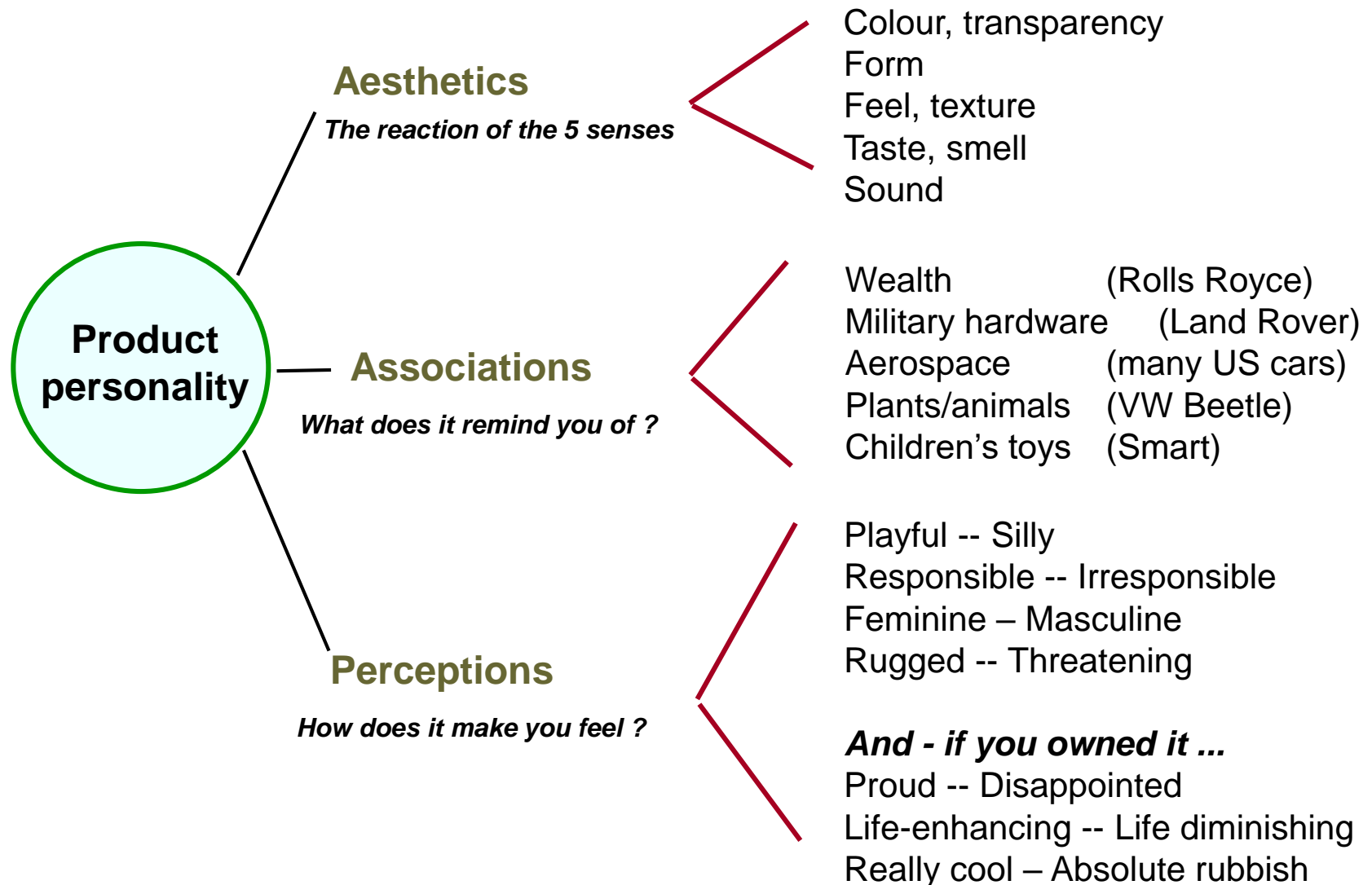
Industrial Design and *satisfaction*



Three facets

- **Aesthetics** -- appealing to the senses -- sight, hearing, feel, taste, smell
- **Associations** -- what does it remind you of ? What does it suggest ?
- **Perceptions** -- what is your reaction to it ? How does it make you feel ?

Product *personality*



Product Value

A product has
a **cost C**
a **price P**
a **value V**

*the true **cost** of manufacture, marketing etc.
the **price** at which it is offered to the consumer
what the consumer thinks it is **worth***

*My Parker pens,
8 euros each*



*Parker special
edition 3000 euros*



*Do they write 375
times better?*

Product success requires that
 $C < P < V$

What determines **cost**?

Technical design, materials, processes, labour

What determines **price**?

Cost plus margin

What determines **value**?

*Both technical and industrial design;
-- **aesthetics, associations, perceptions***

Why is Industrial Design important?

Product maturity and market saturation

- Products tend to converge in performance and price
- ID allows differentiation, enhanced value

Corporate identity

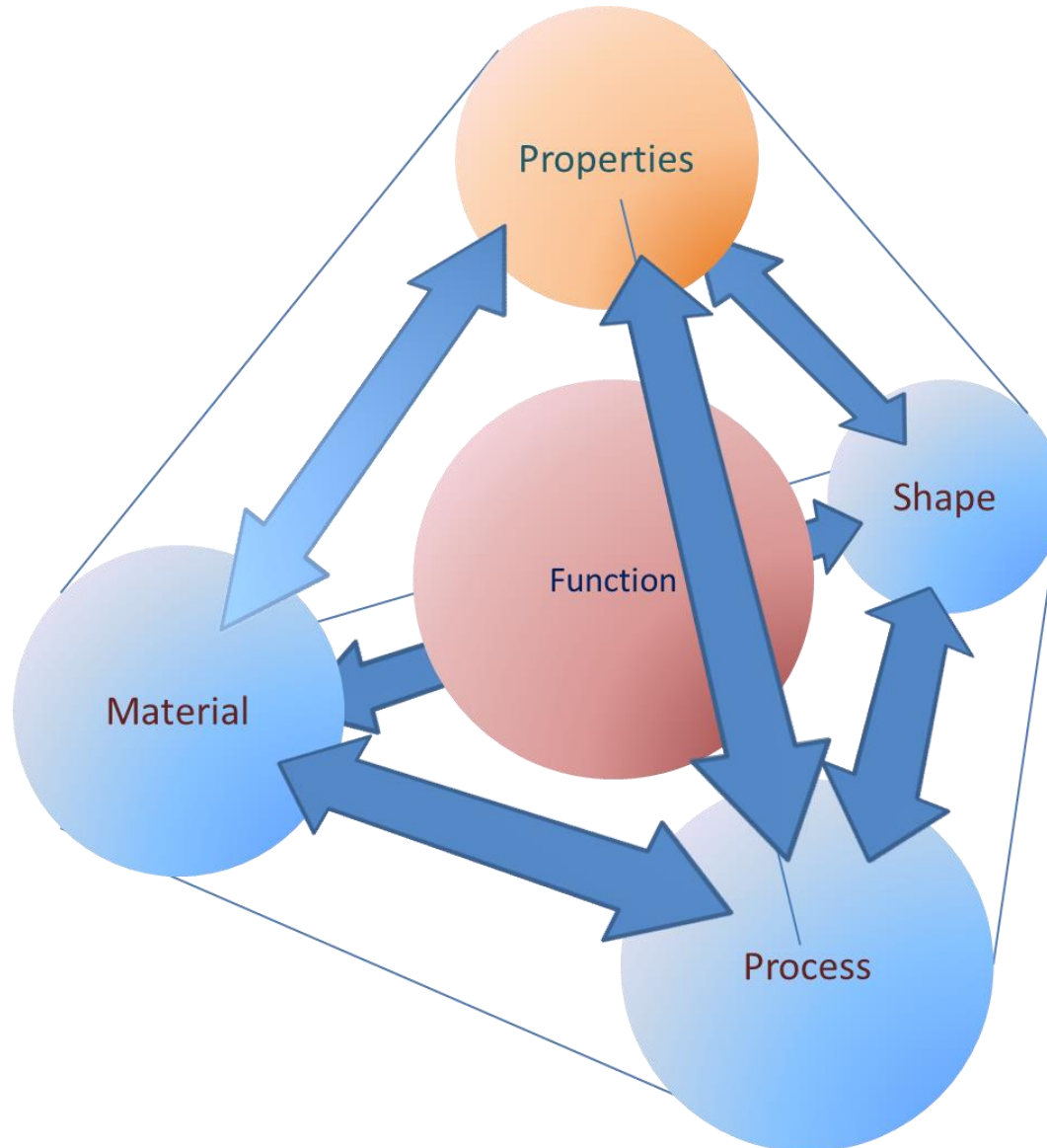
- ID creates corporate image
- ID creates brand loyalty

The environment, in the broadest sense

- ID contributes to quality of life

Intro

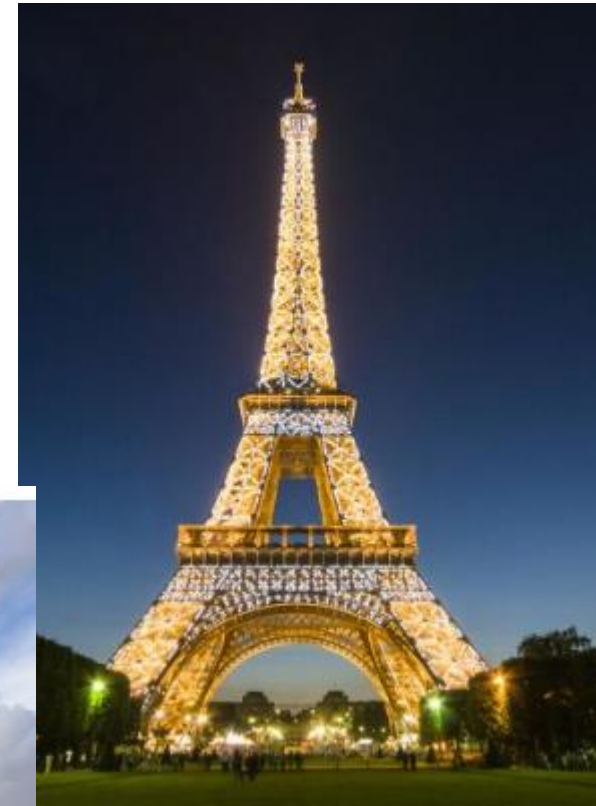
- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- **Material, process, shape, properties, function**



Function – Material – Shape - Process

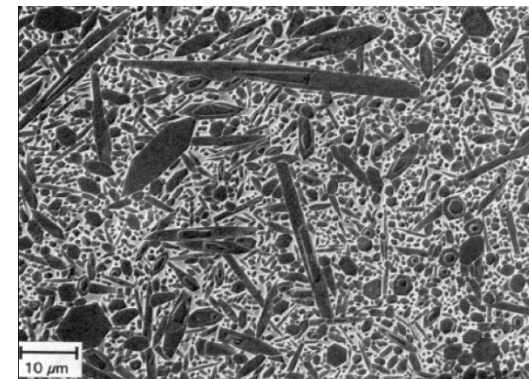
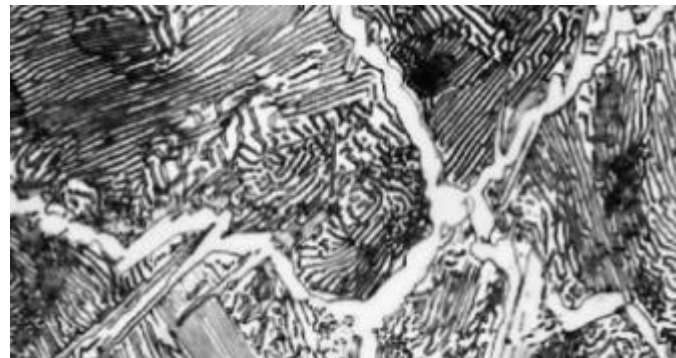
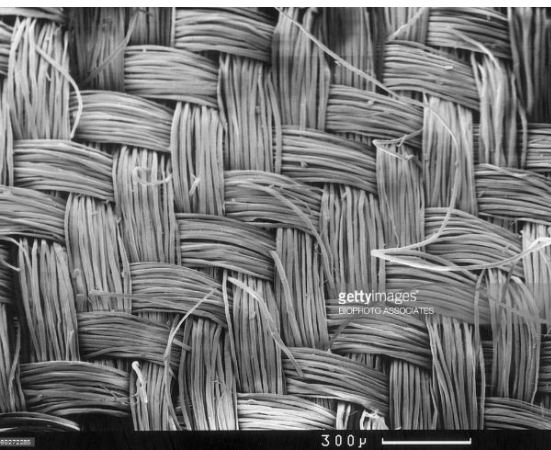
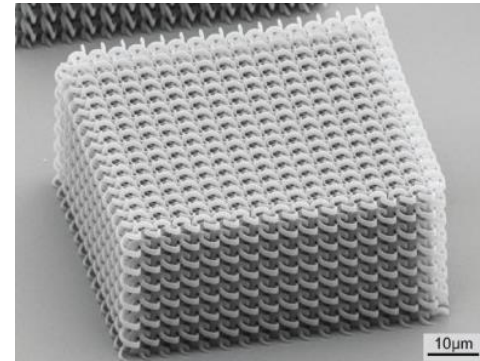
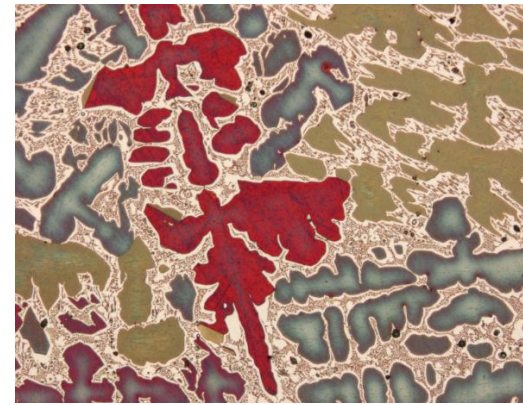
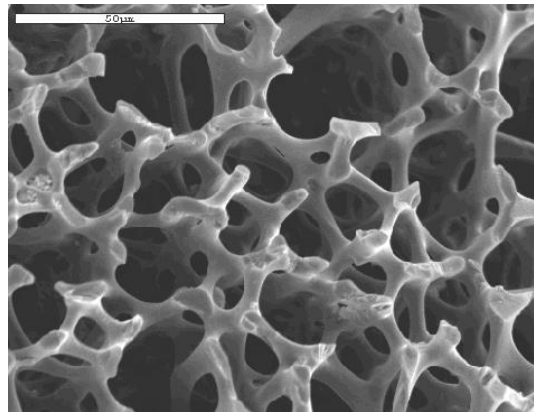
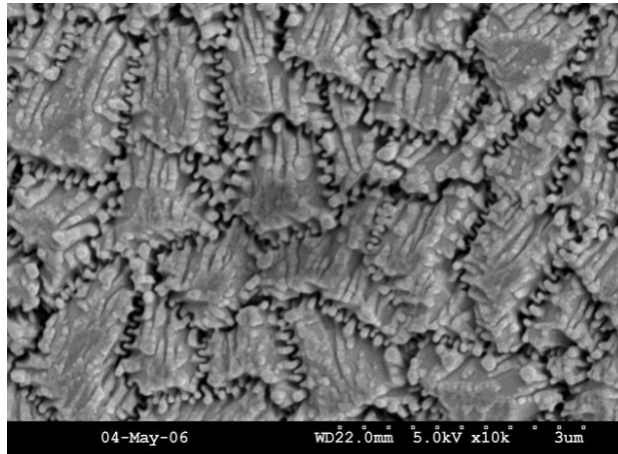


Function – Material – Shape - Process



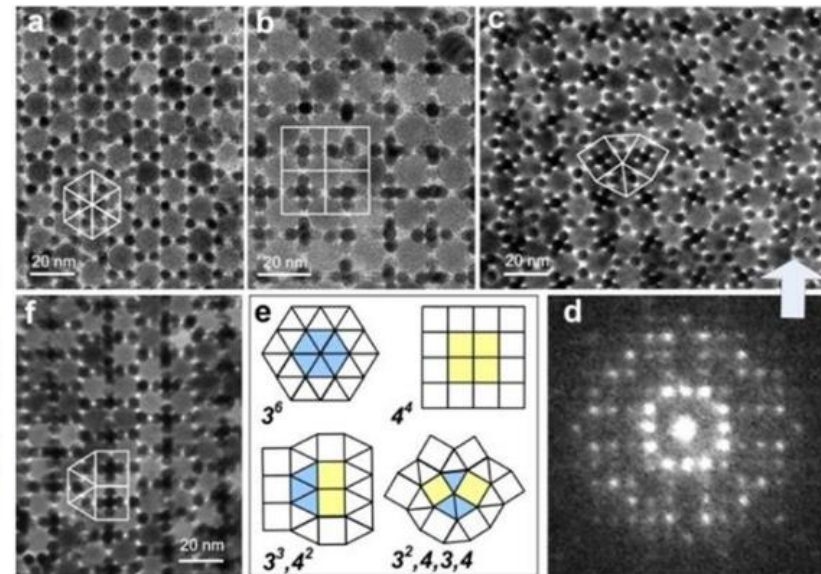
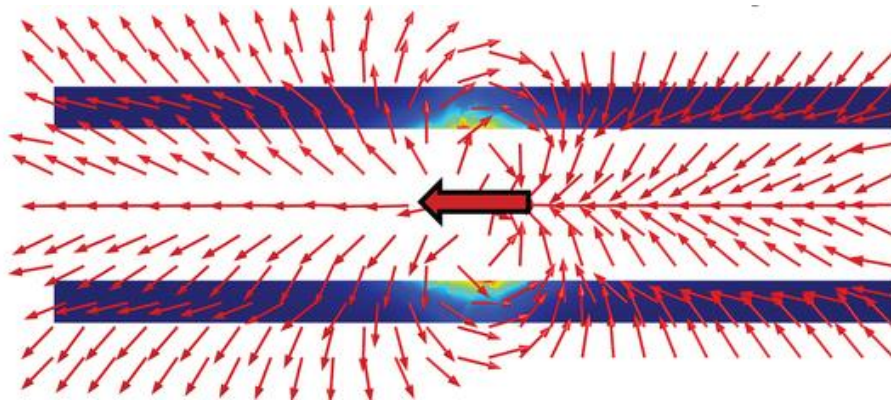
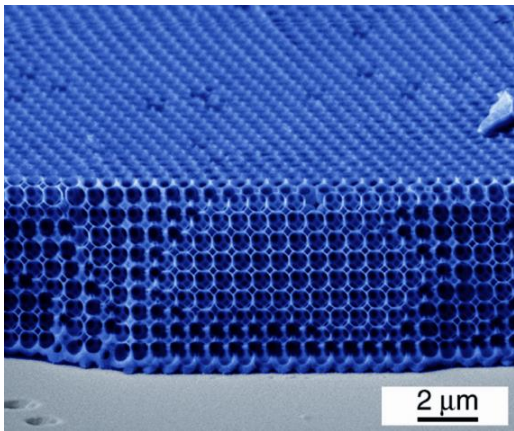
Function – Material – Shape - Process

MICROSTRUCTURE



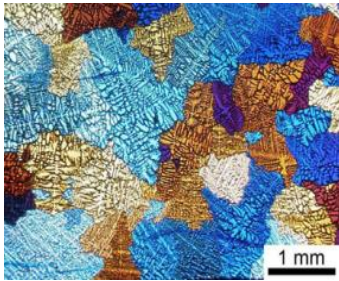
Function – Material – Shape - Process

NANOSTRUCTURE



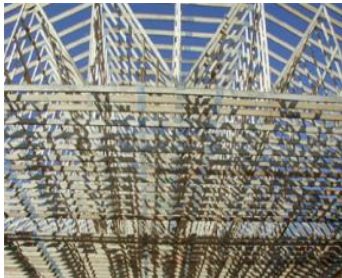
Function – Material – Shape - Process

HYBRID MATERIALS



Combining:

- **Materials** – relate properties to microstructure: controlled nature, scale through alloy design and processing.



- **Mechanics** – accept properties as “given”, optimise the geometry

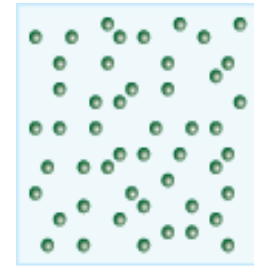
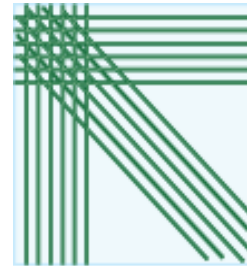


- **Textile technology** – exploit unique strength and blending properties of fibers

Function – Material – Shape - Process

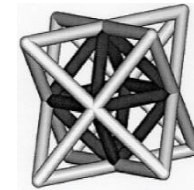
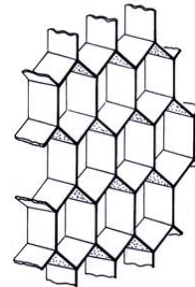
Composites

- *Unidirectional*
- *Quasi-isotropic*
- *Particulate*



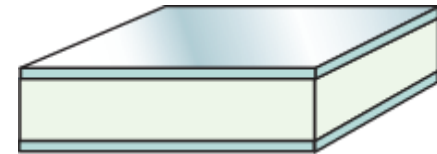
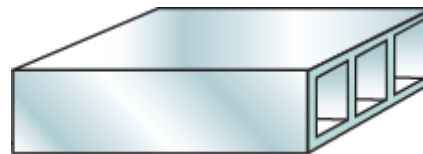
Cellular structures

- *Foams*
- *Honeycombs*
- *Triangulated lattices*



Sandwich structures

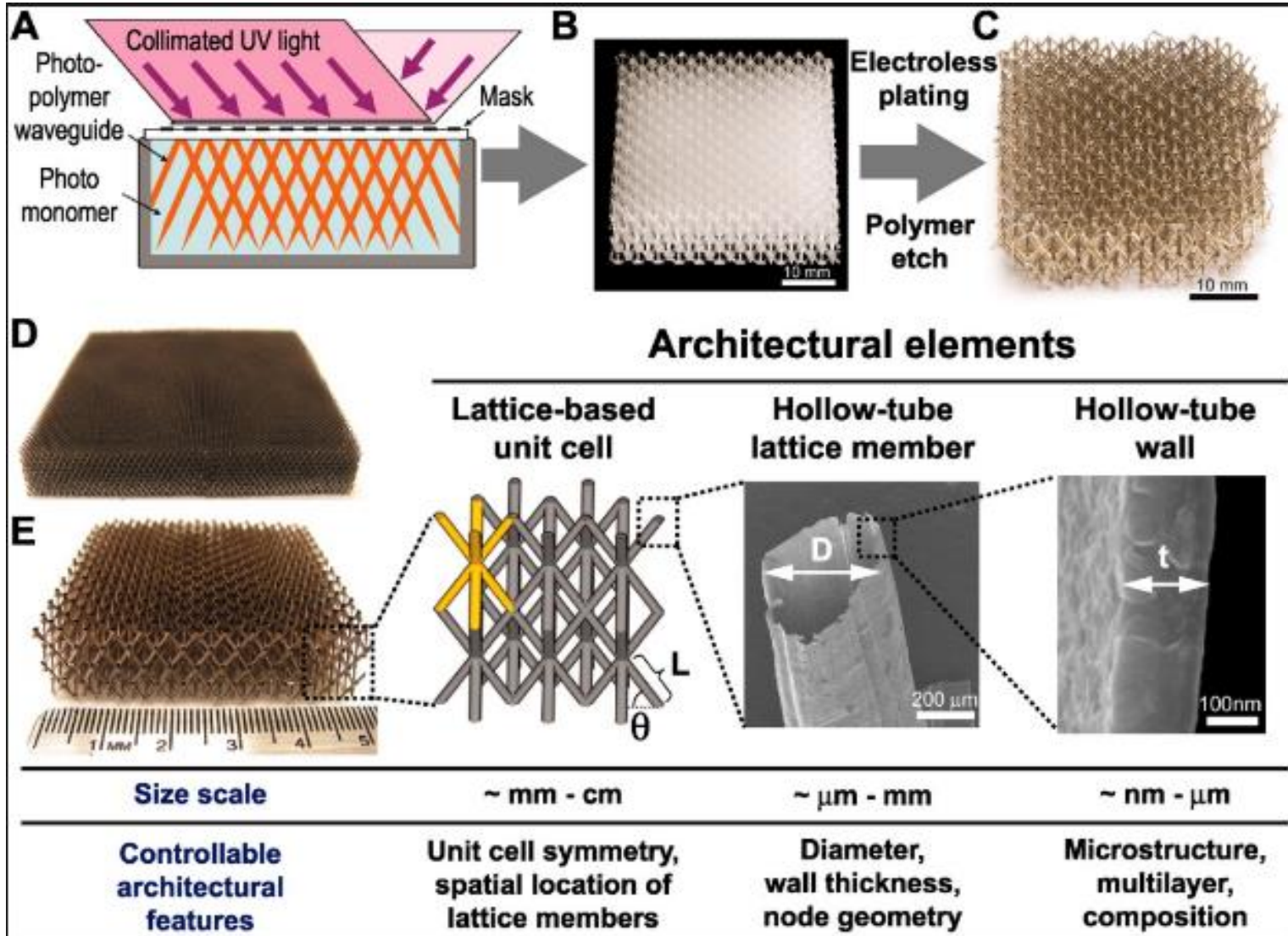
- *Symmetric sandwiches*



Many more

Function – Material – Shape - Process

MULTISCALE



PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

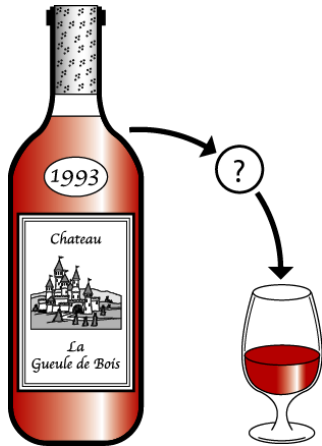
Design process

- **Example**
- Fundamentals
- Identification of needs (market; coevolution; true need)
- Types of design
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

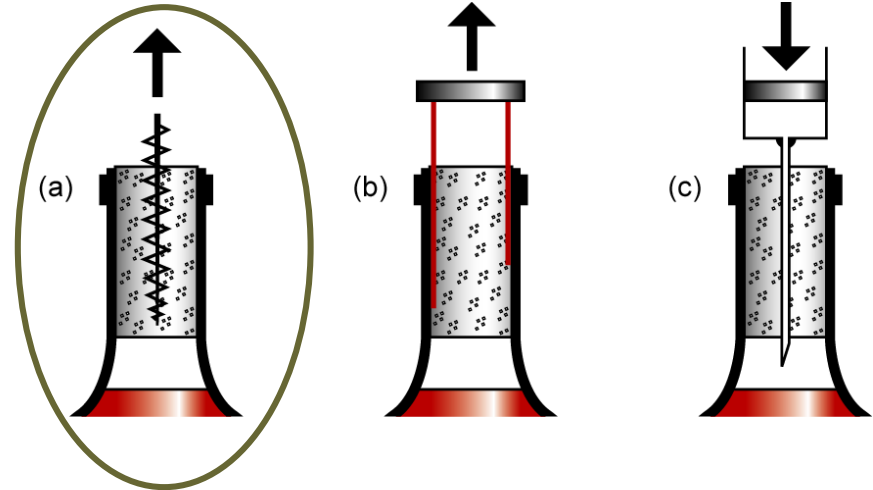


Need – Concept – Embodiment - Detail

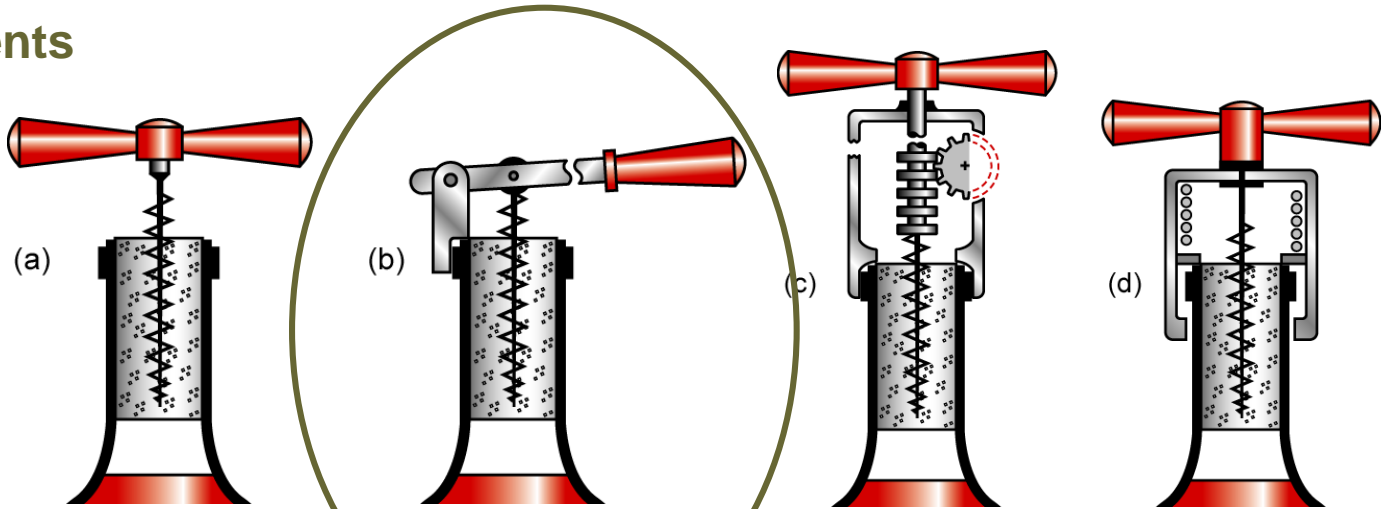
Need



Concepts



Embodiments



Direct pull

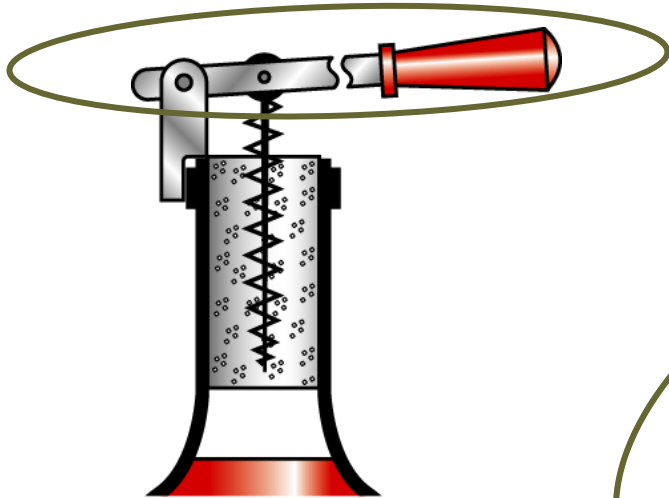
Levered pull

Geared pull

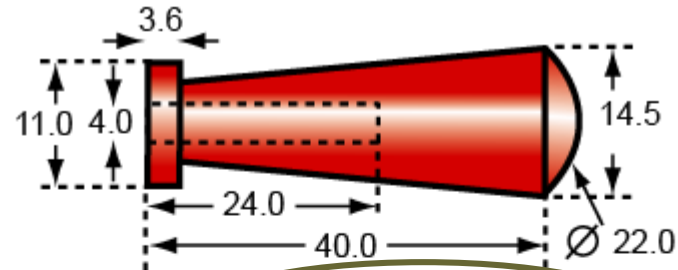
Spring-assisted pull

Need – Concept – Embodiment - Detail

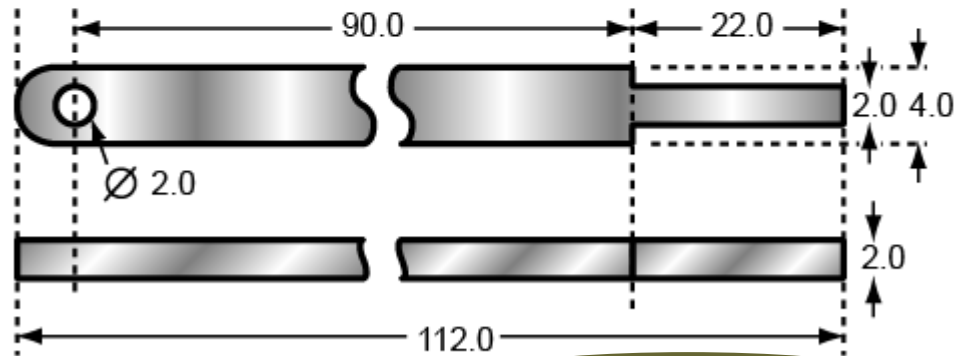
Embodiment



Detail



GRIP Cast phenolic through colored



All dimensions mm

ARM Stainless steel type 302 machined from bar stock

How are those choices made?



thehomestoreonline

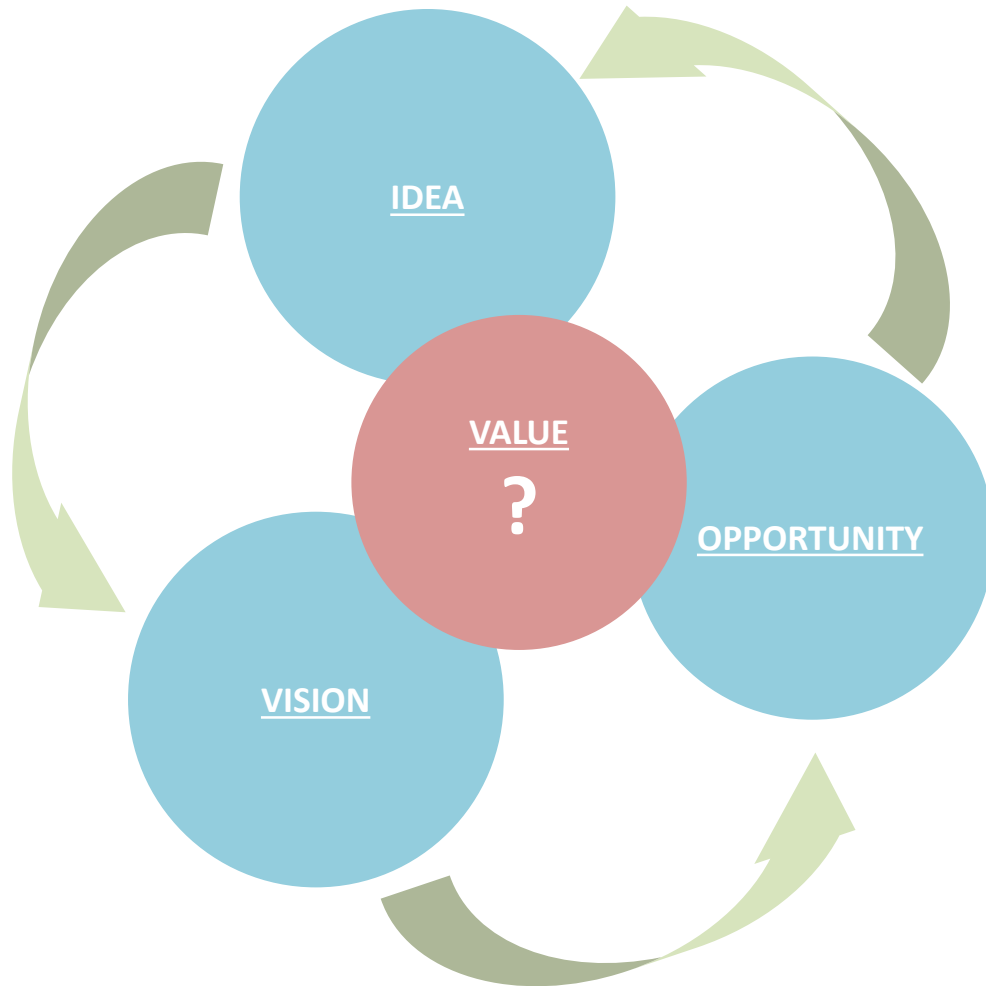
PRODUCT (MATERIALS) AND PROCESS DESIGN

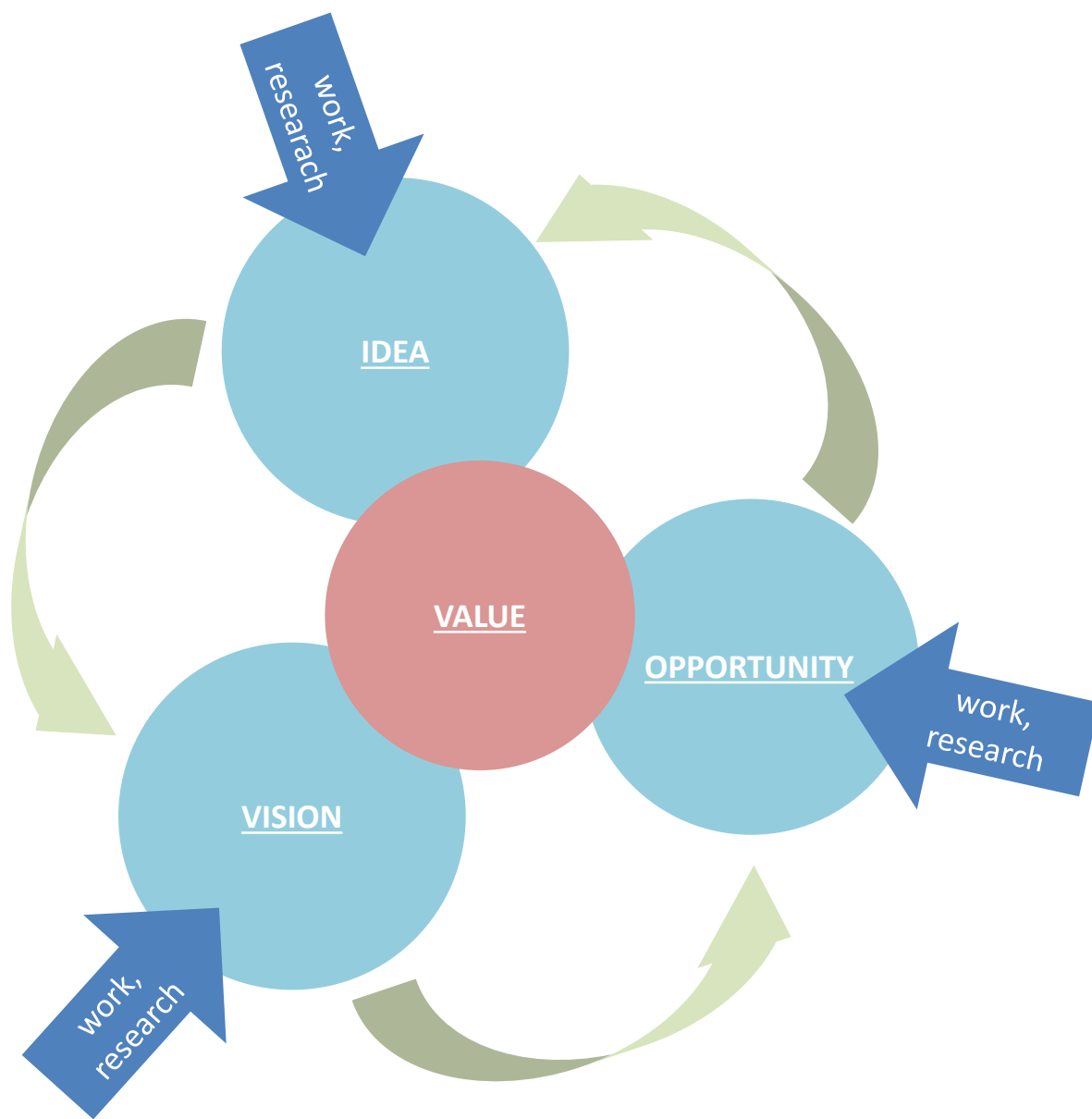
Intro

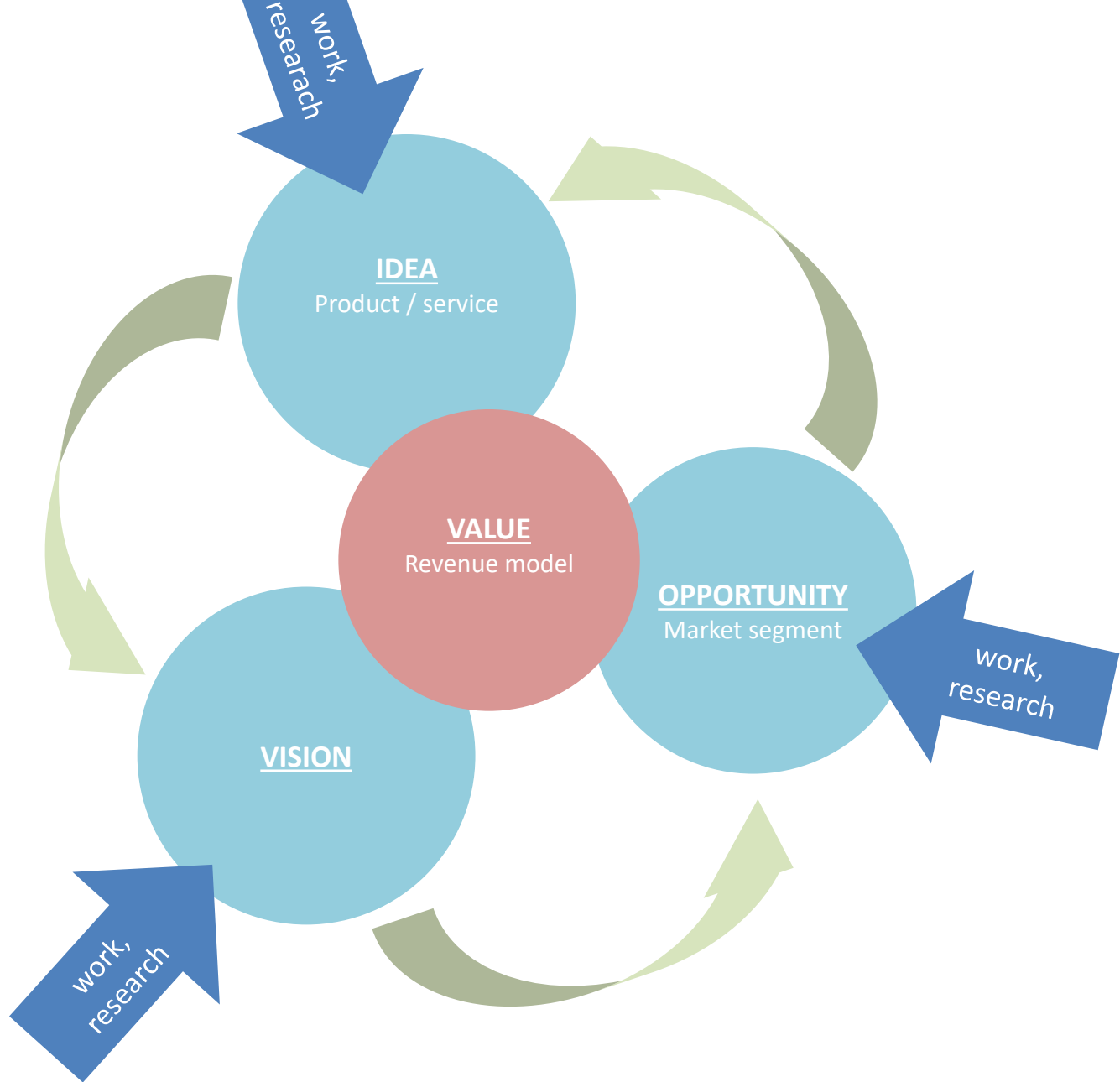
- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

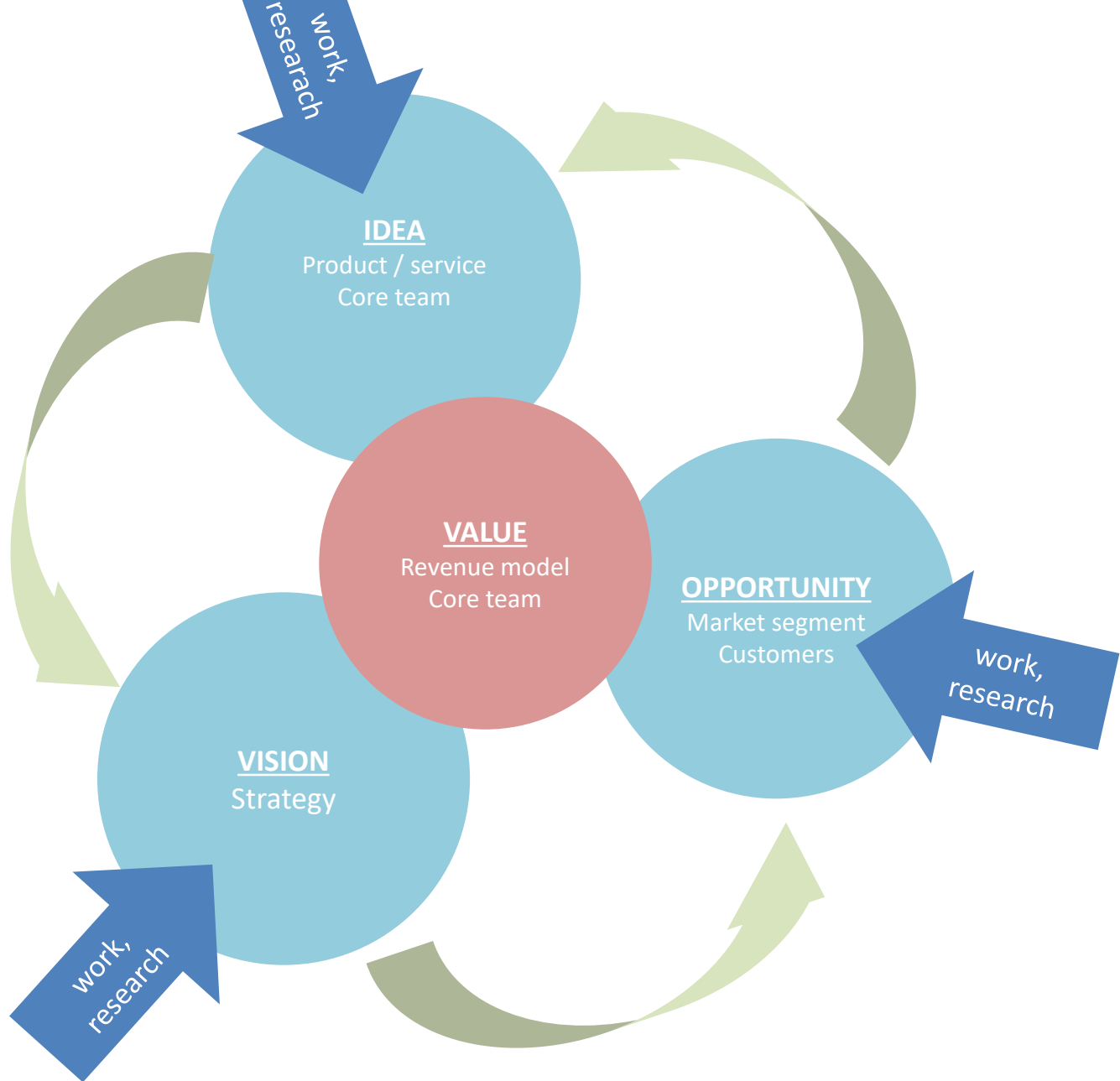
Design process

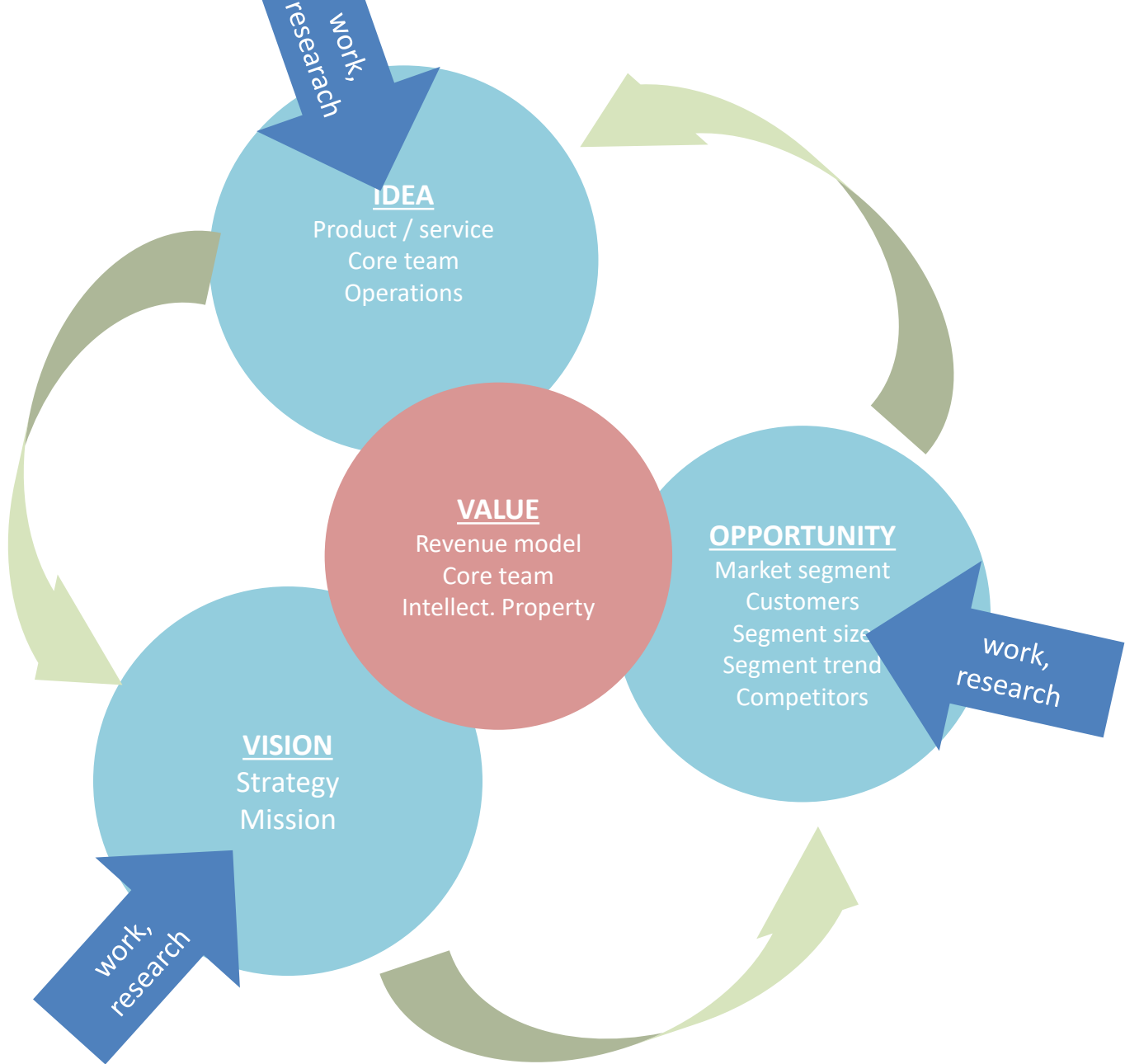
- Example
- Fundamentals
- **Identification of needs (market; coevolution; true need)**
- Types of design
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

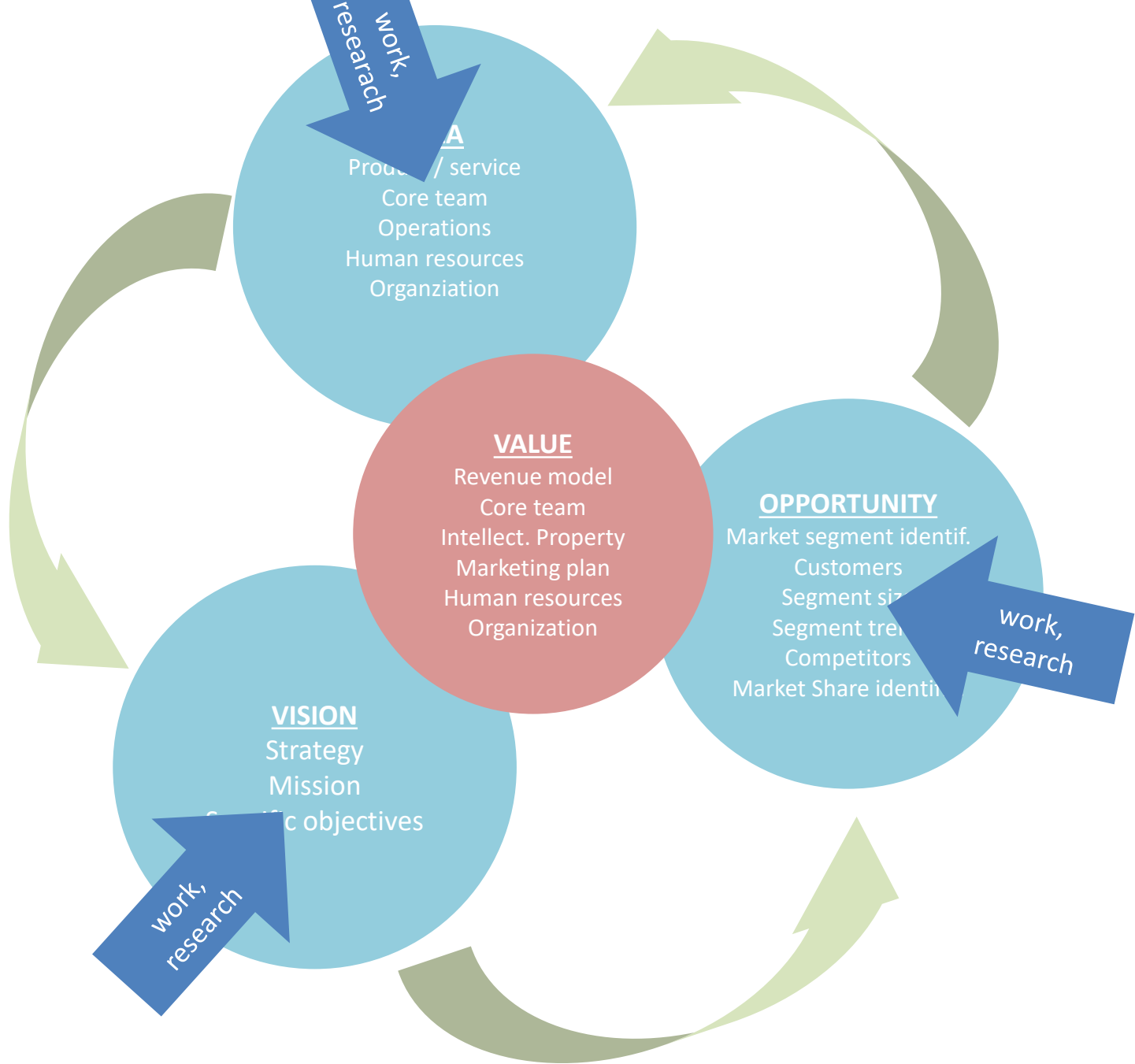












PRODUCT (MATERIALS) AND PROCESS DESIGN

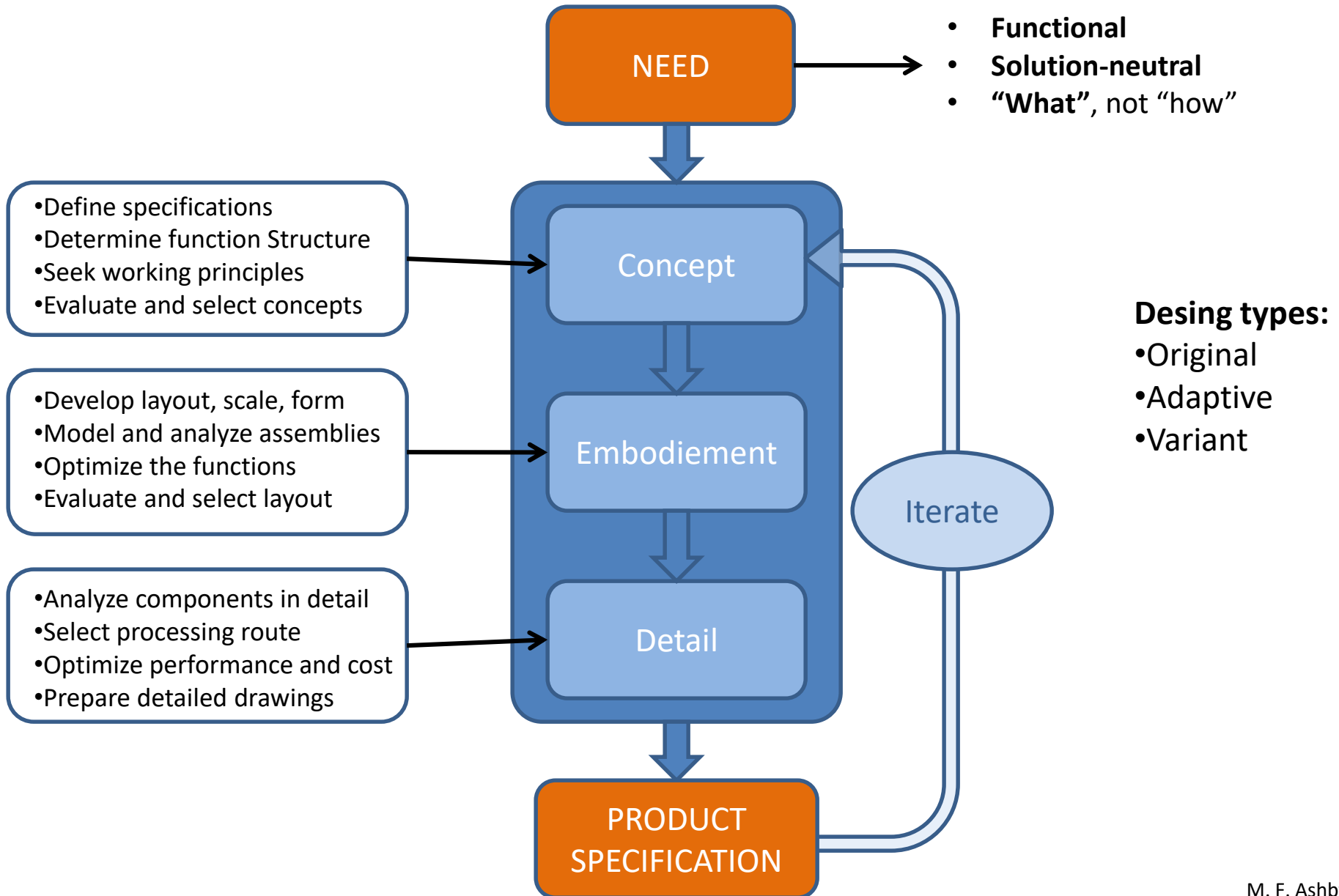
Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

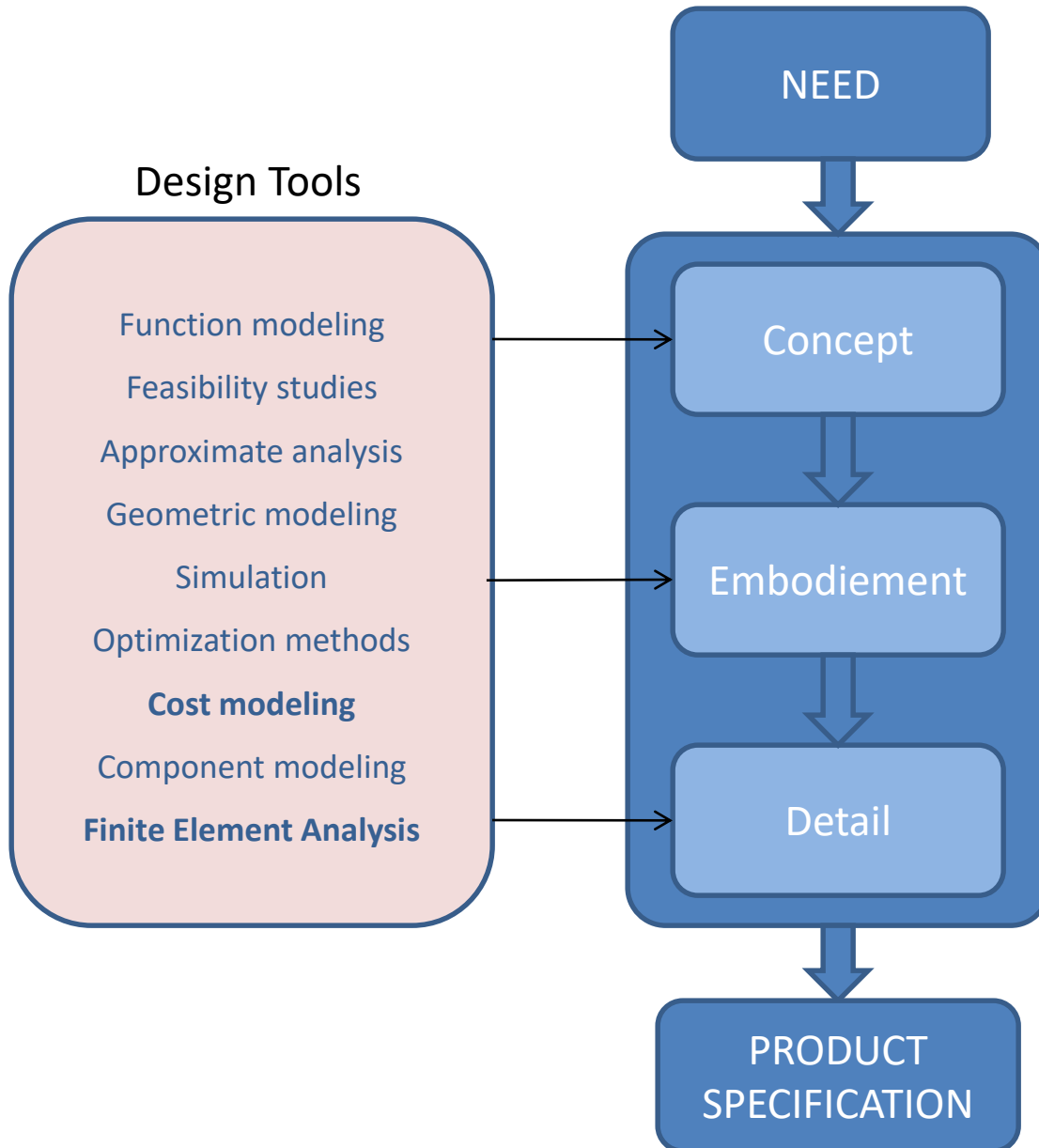
Design process

- Example
- **Fundamentals**
- Identification of needs (market; coevolution; true need)
- **Types of design**
- Design tools
 - Databases
 - Analytical tools
 - Simulation tools

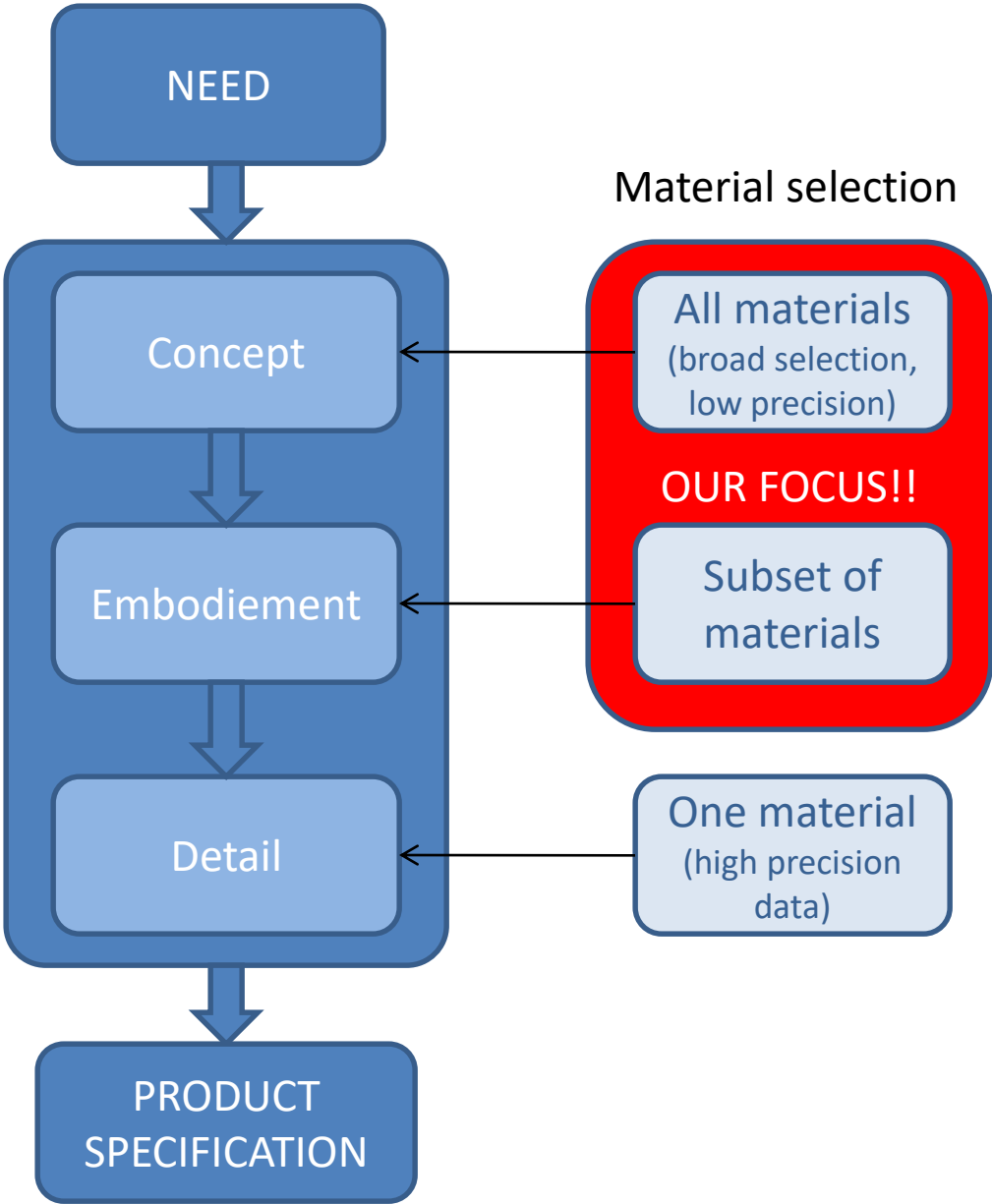
Design Process



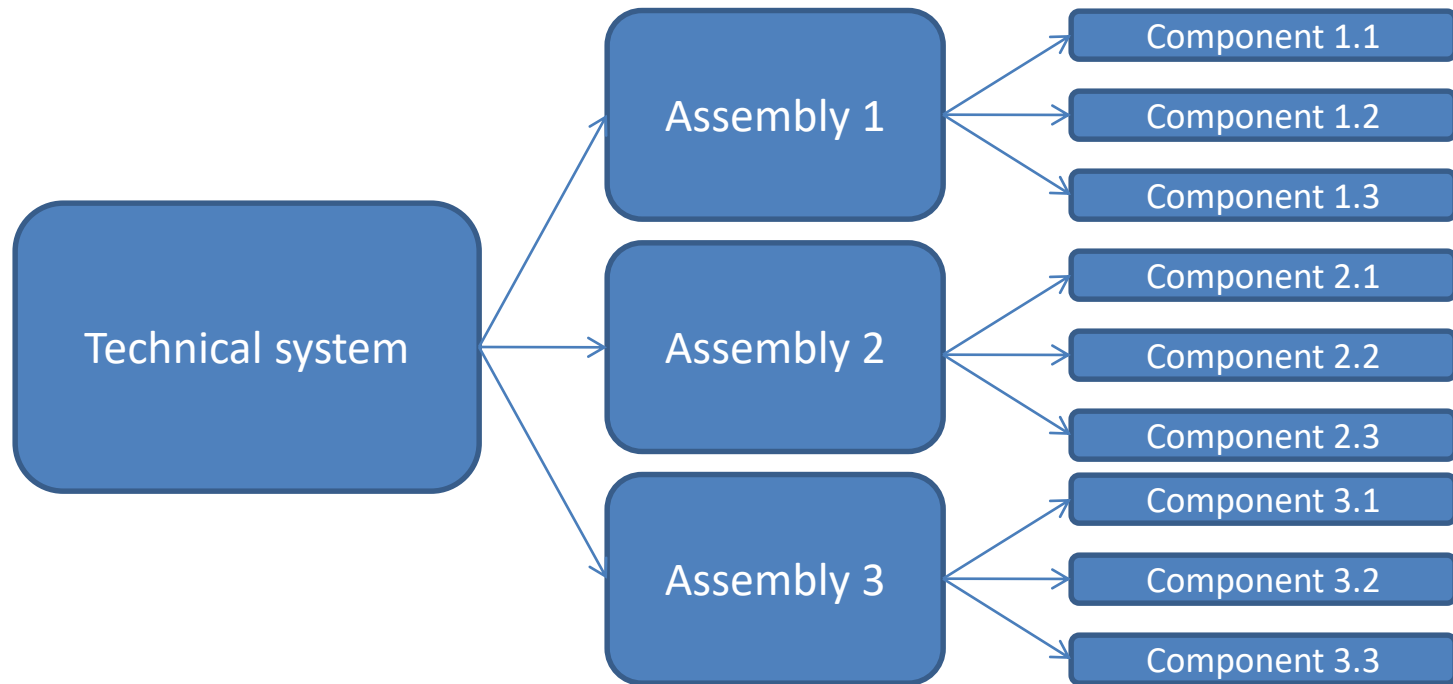
Design Process: Available Tools



Design Process: The materials selection point of view

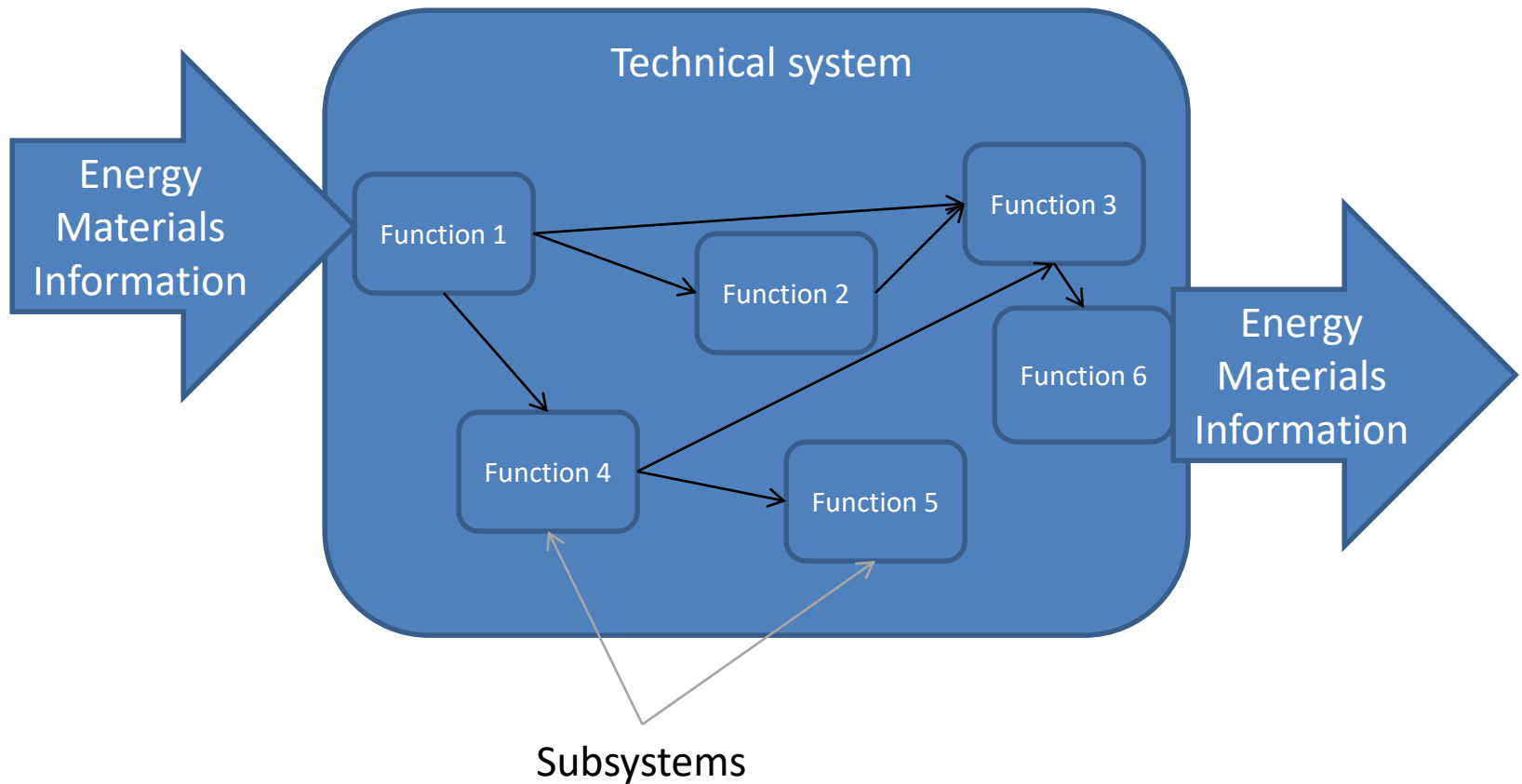


Product as a technical system



Technical system's analysis

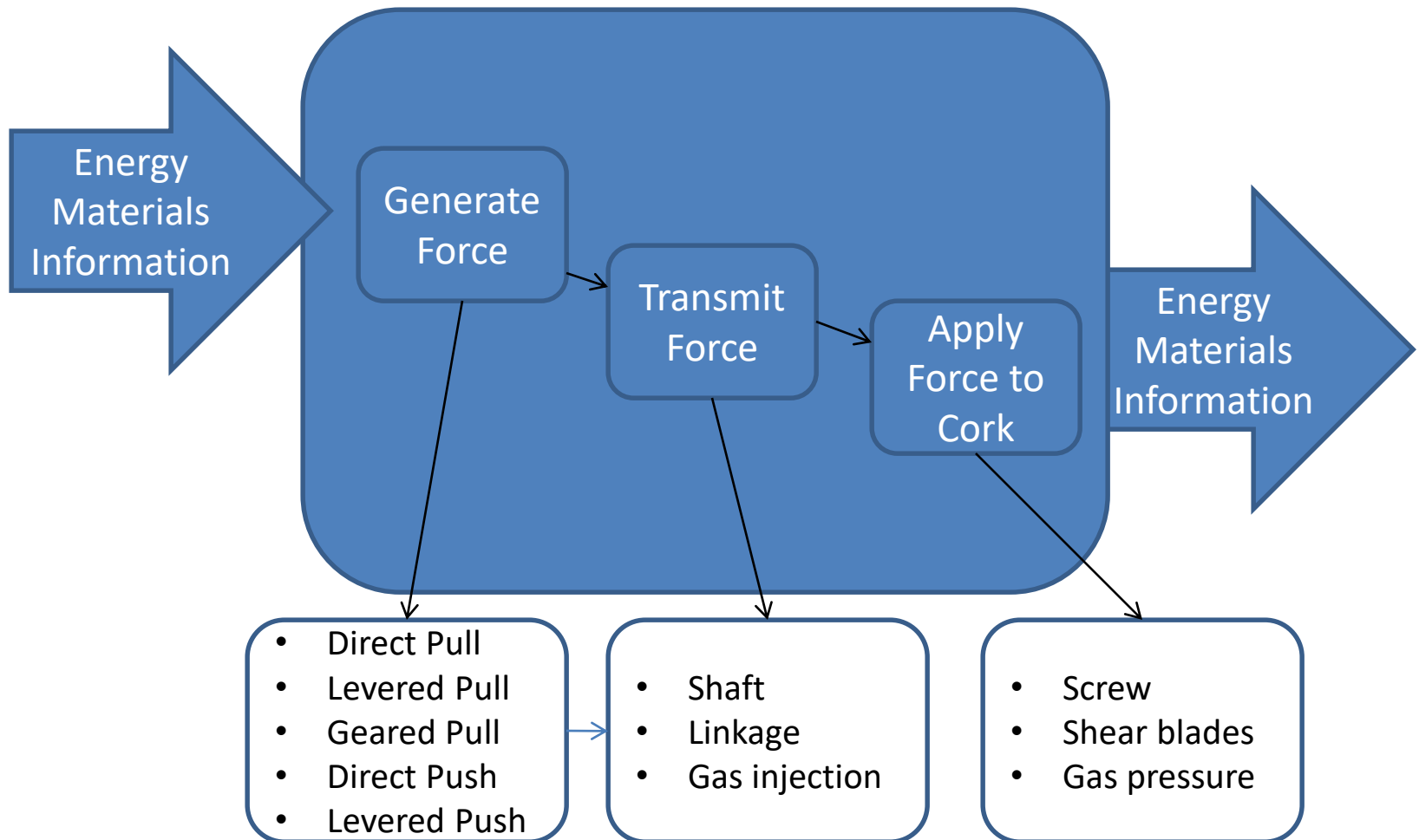
- Systems approach: the concept of function -



Technical system's analysis

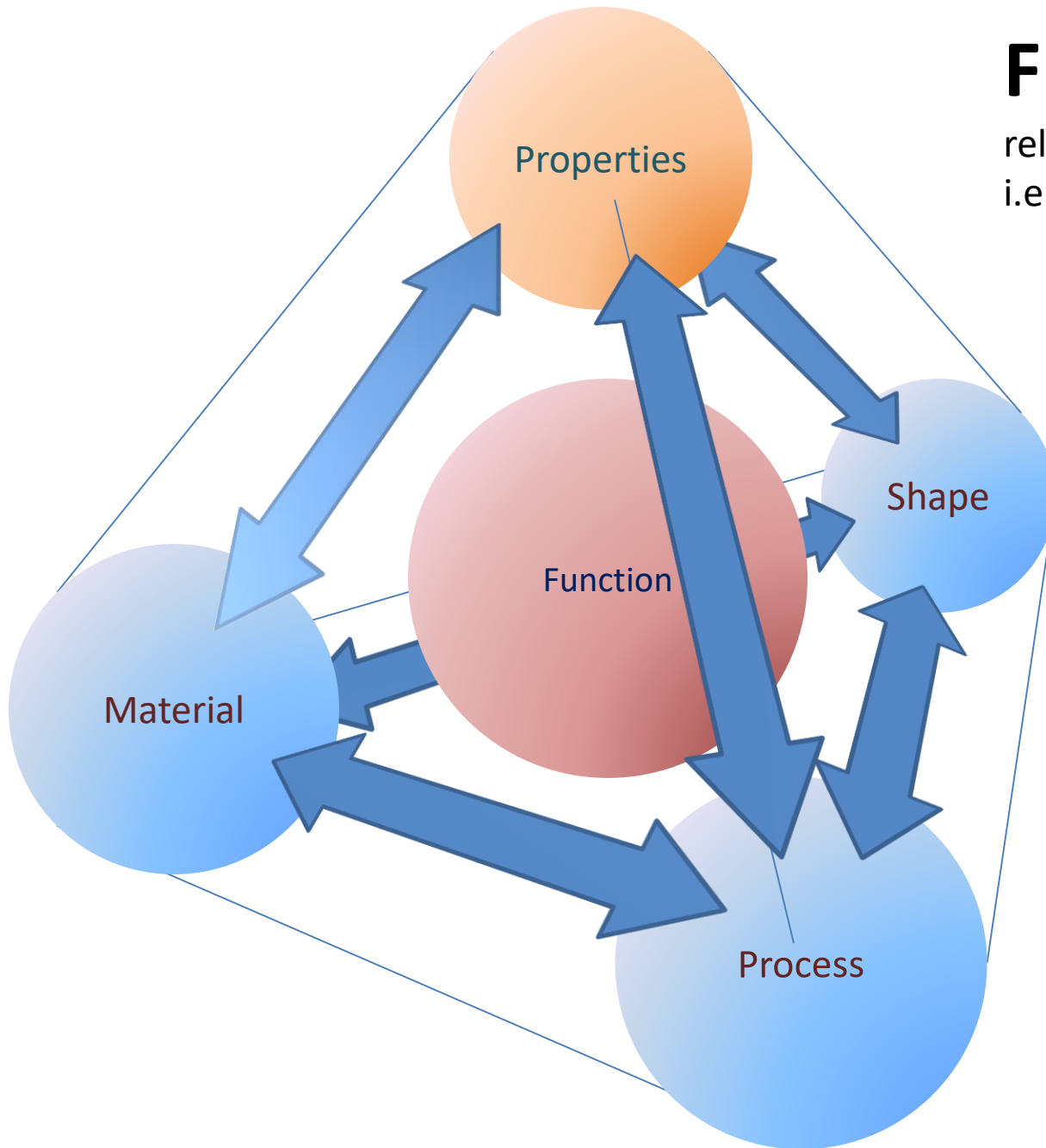
- Systems approach: the concept of function –

The bottle opener example



FUNCTION

relation with properties
i.e. material, process, shape



EXAMPLES OF FUNCTIONS IN MECHANICAL DESIGN:

- Carry load
- Transmit load
- Transmit heat
- Transmit current
- Store energy
- ...

PRODUCT (MATERIALS) AND PROCESS DESIGN

Intro

- Design, Product, Process
- Product Design; Process Design; Product and Process Design
- Material, process, shape, properties, function

Design process

- Example
- Fundamentals
- Identification of needs (market; coevolution; true need)
- Types of design
- **Design tools**
 - **Databases**
 - **Analytical tools**
 - Simulation tools

- **Selection and design of materials and processes**
 - **Tools for optimal systematic selection**
 - Design of materials: case studies (nano, meso, microstructures; hybrid materials; composites)
- **Design of thermal exchange processes**
- **Advanced tools and methods** (ad-hoc lectures and seminars: FEM, product/process economics, Life Cycle Assessment, ...)
- **Special topic seminars** (Intellectual Property, product evaluation, materials in industrial design, theory of scenarios, rapid plant assessment, material selection in engines, design for recycle, refurbish, reuse)