UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

Prototipazione Virtuale

LECTURE 1

Product Development Process and Cax

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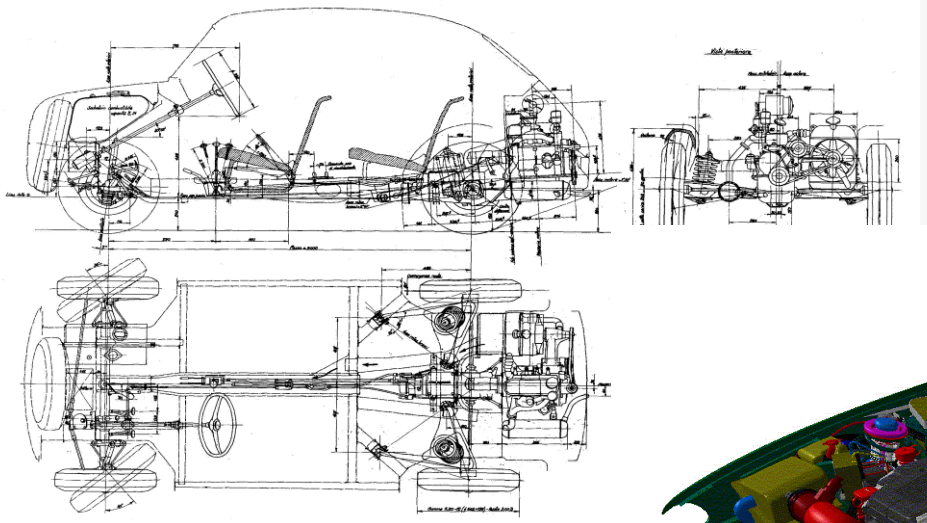
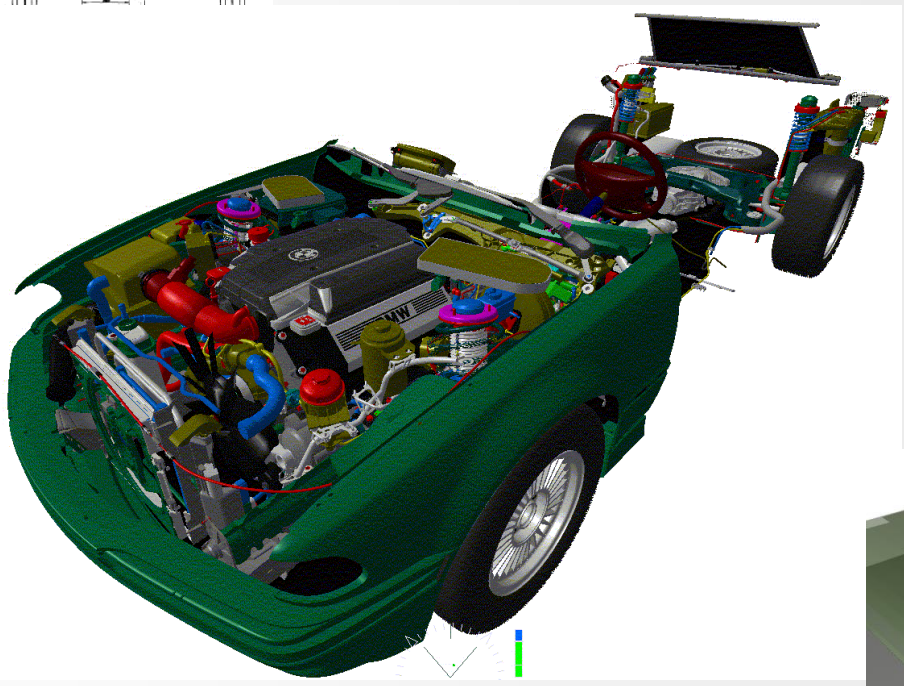
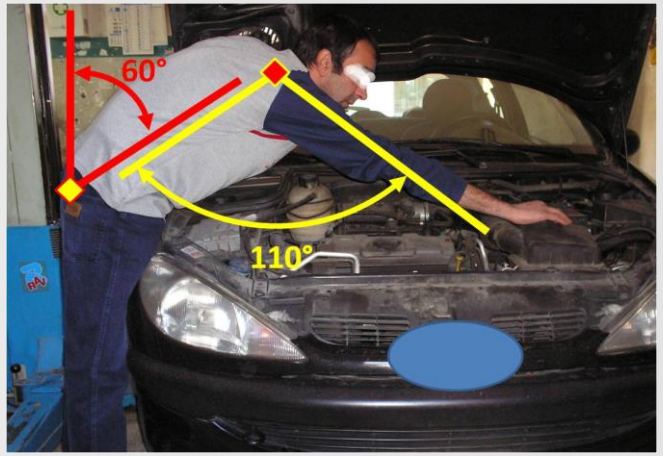
Raggruppamento Scientifico disciplinare ING- IND/15

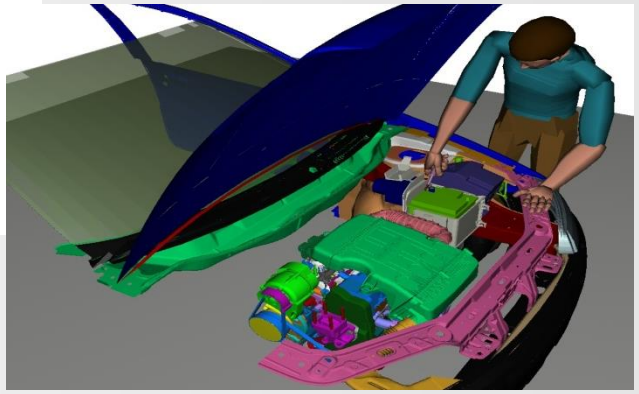
Evoluzione del disegno







Modelli 3D



Modelli virtuali

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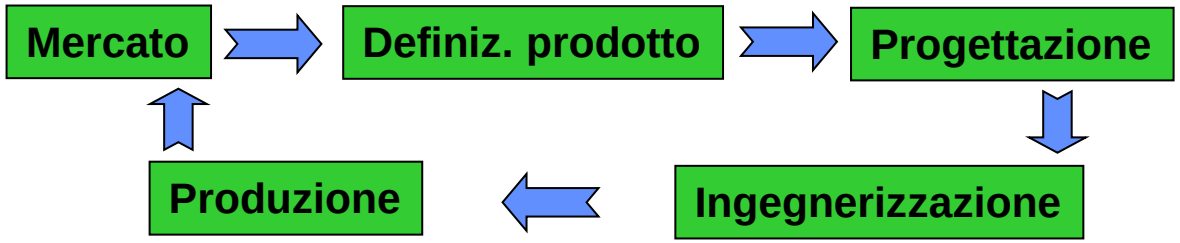
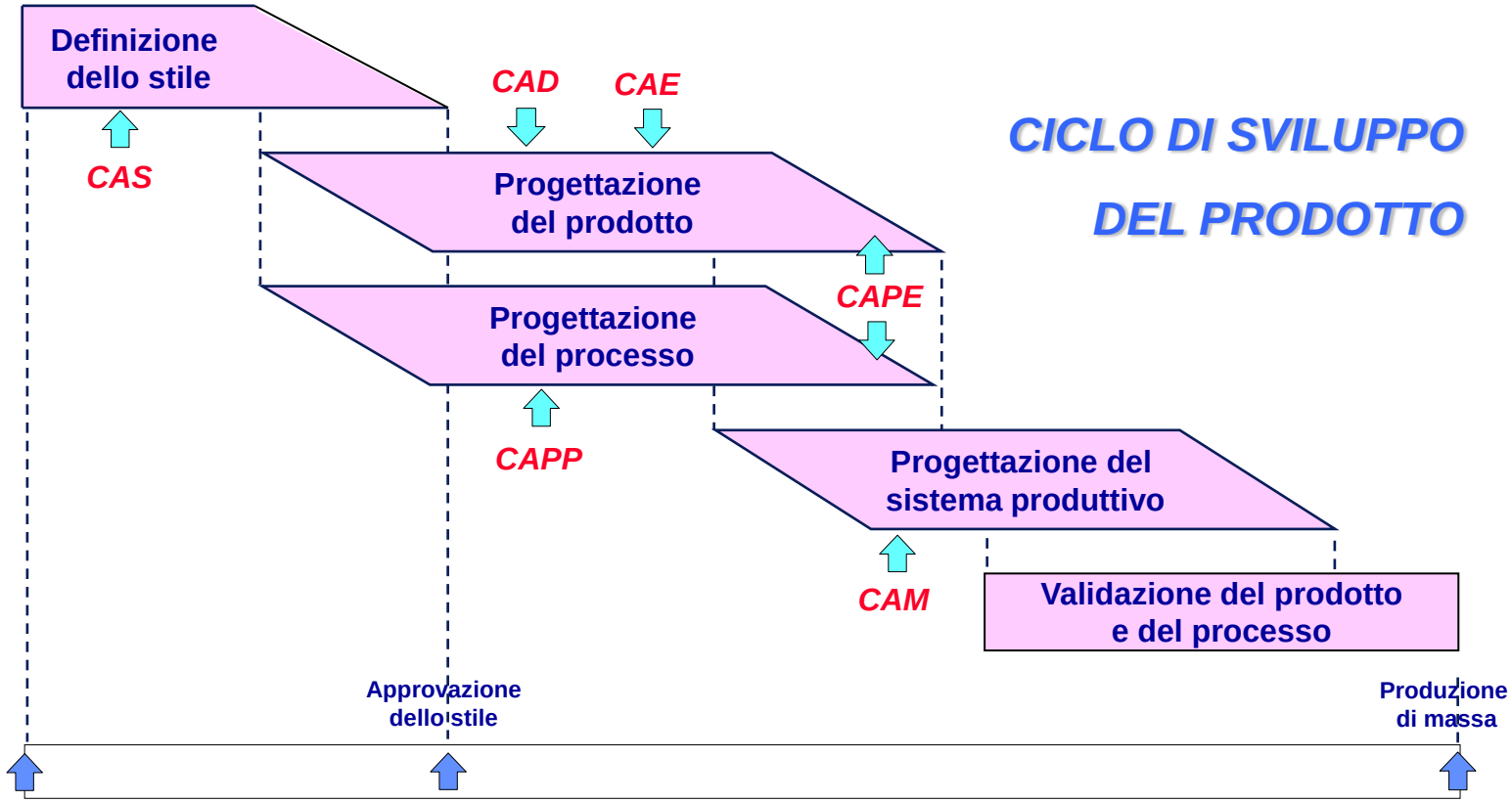
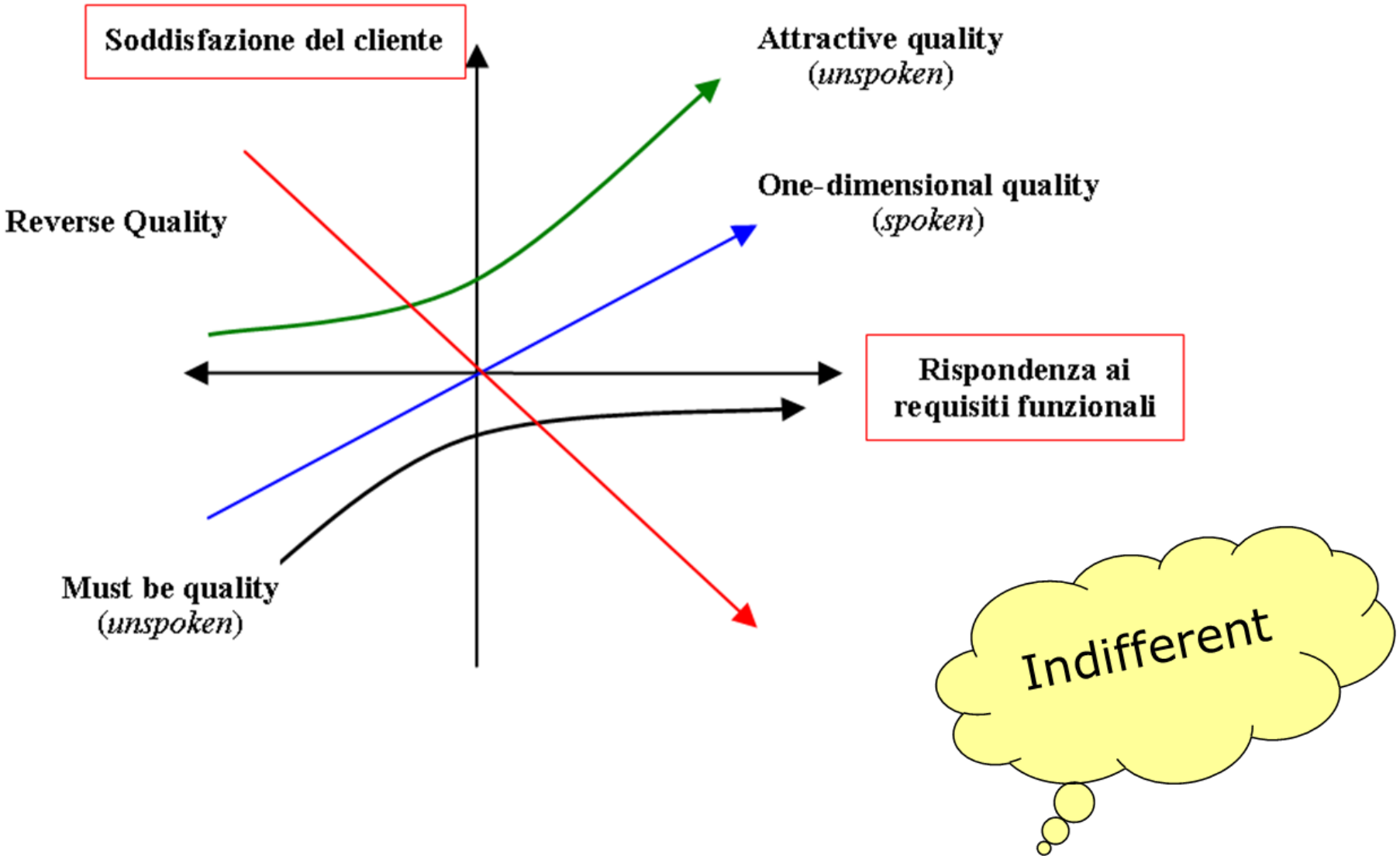
Product Development Process and CAx



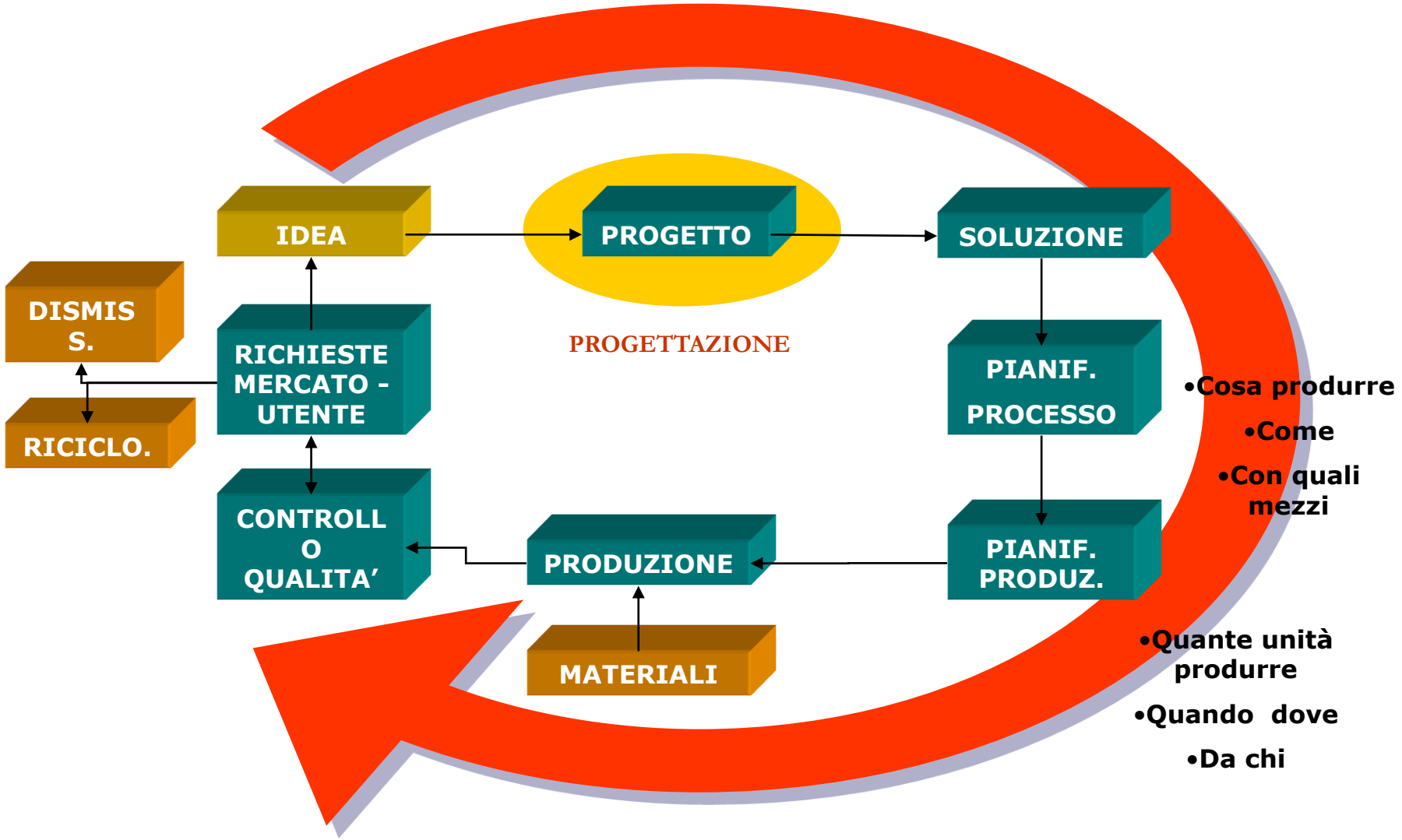


CICLO DI SVILUPPO DEL PRODOTTO

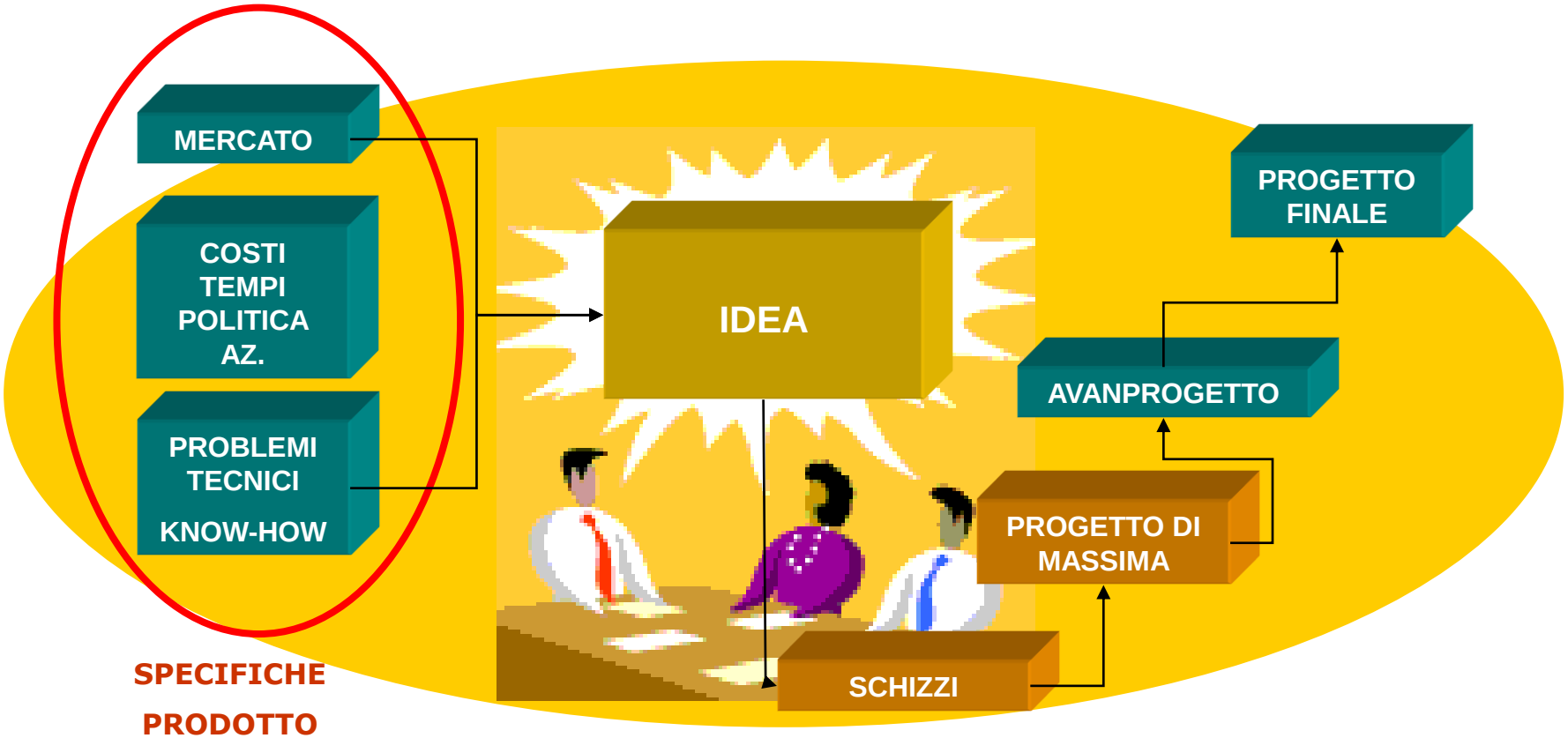
Classificazione degli elementi di qualità (KANO)



Ciclo di vita del prodotto



La progettazione



- Massima semplicità degli organi
- Minimo numero di componenti
- Facilità di produzione, montaggio, riciclo
- Costo
- Reperibilità sul mercato dei componenti esterni

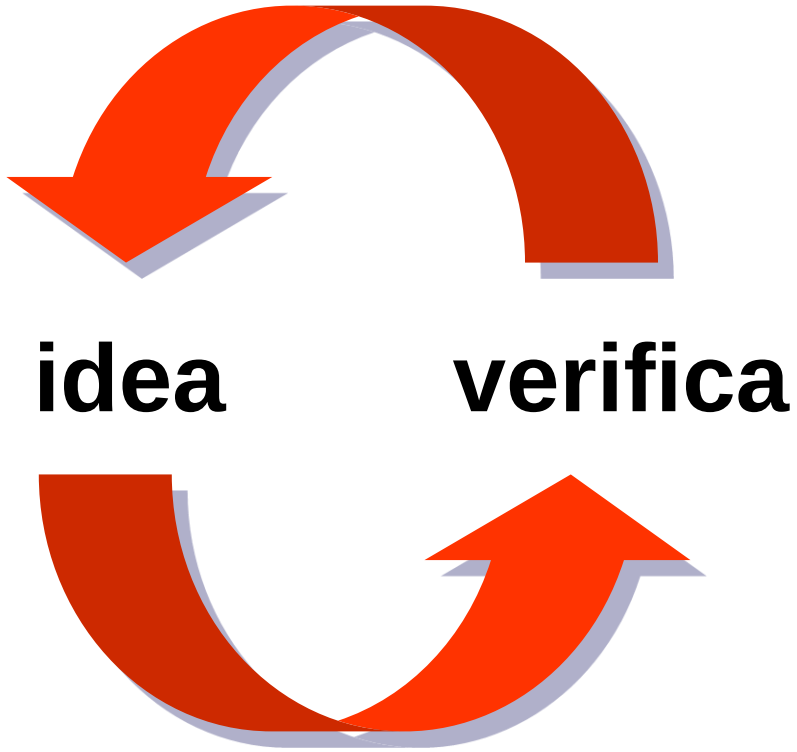
La progettazione

Progettare significa concepire e comunicare una idea\prodotto rispondente a precisi requisiti (vincoli economici, estetici, funzionali, geometrici e tecnologici).

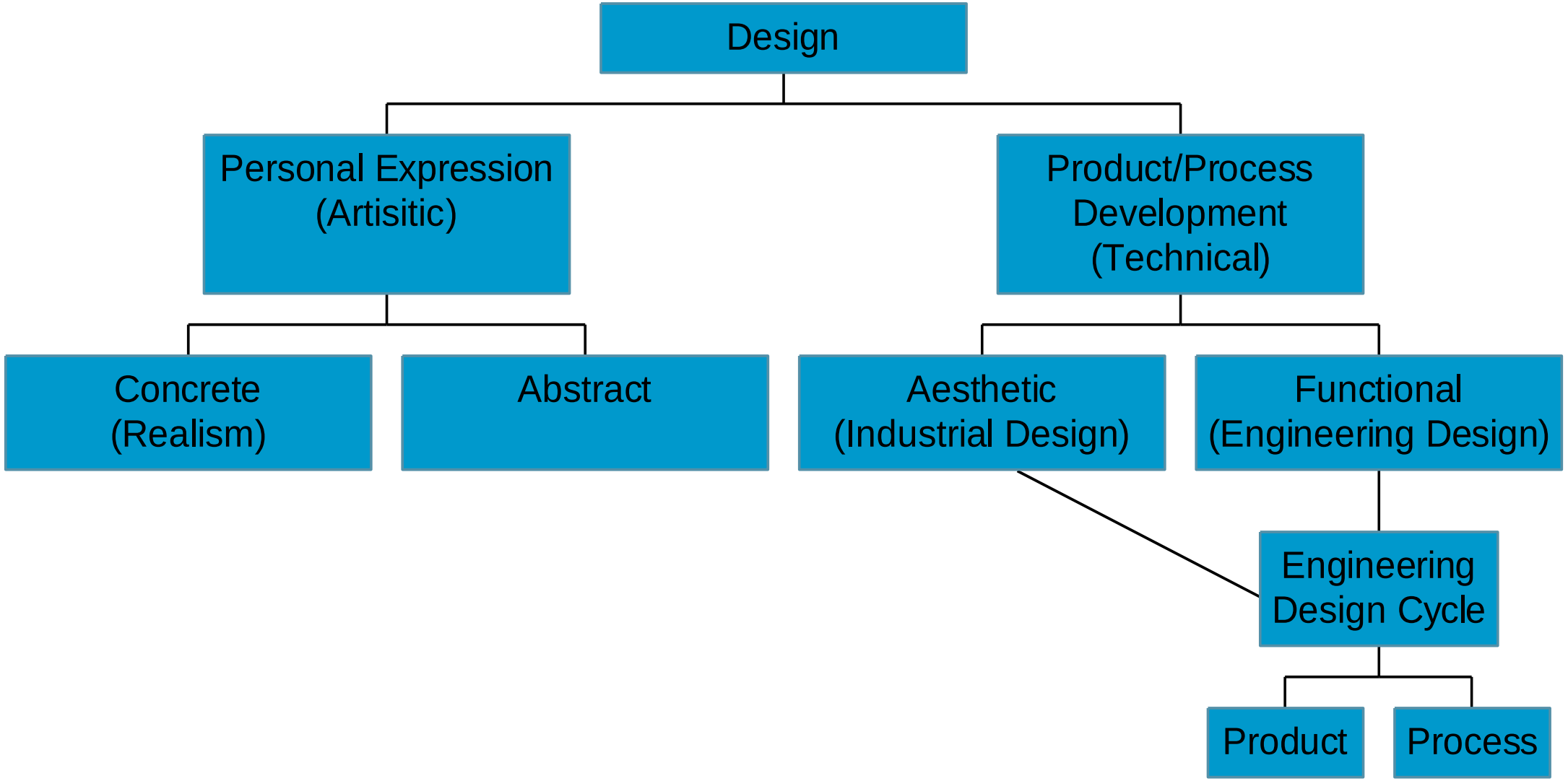
*Il risultato è il **Progetto**: schizzi, schemi, rappresentazioni, modelli matematici, analisi di resistenza, di costi, di fabbricazione, ecc.*

E' costituito da 2 fasi:

- Creativa
  - Risposta alle specifiche e vincoli progettuali
- Analisi e ottimizzazione
  - Forma, dimensioni, materiali, etc.



Declination of «Design»

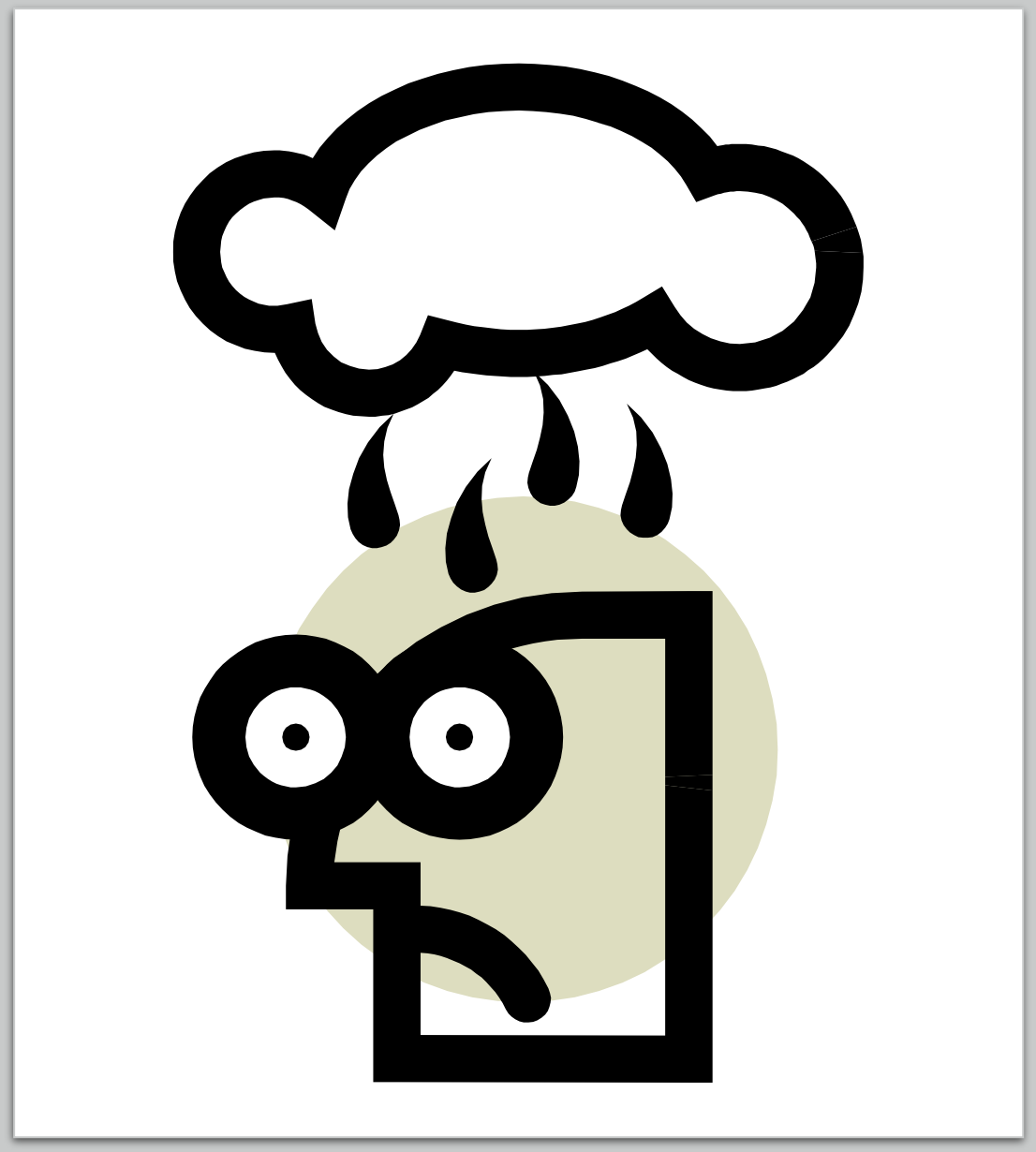


Design phases

- Problem identification and formalization
- Preliminary design
- Conceptual design
- Engineering Analysis
- Optimization
- Implementation and documentation

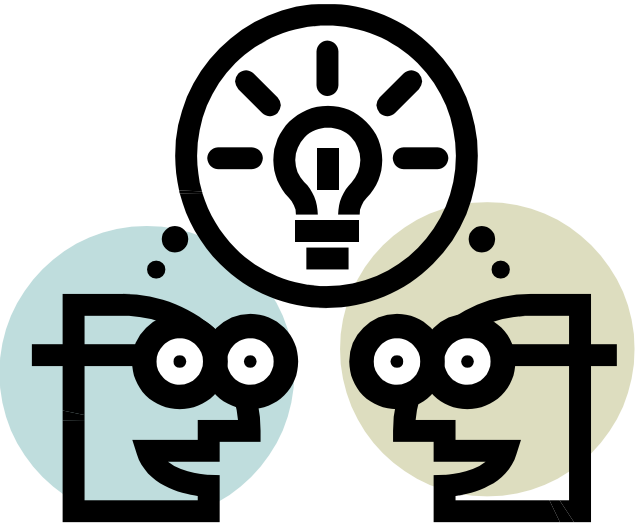
1) Problem identification and formalization

- Description of the problem
- Requirements
- Conditions that must be met
- Create a priority list
- Limitations
- Determine the constraints (of cost, space, weight, environment, etc.)
- Has the problem already been addressed in the past?
- Are there already solutions to similar problems?



2) Preliminary design

- *BRAINSTORMING*
- Groups of 4-8 people
- Everyone provides their own ideas without evaluating them too much
- Even the most imaginative ideas are encouraged
- Highly creative stage
- Paper support through sketches



3) Conceptual design

- *Select the best preliminary ideas*
- *Evaluate the merits of each idea*
- *Combining ideas*
- *Refine the sketches*
- *Develop a single digital model on the computer*

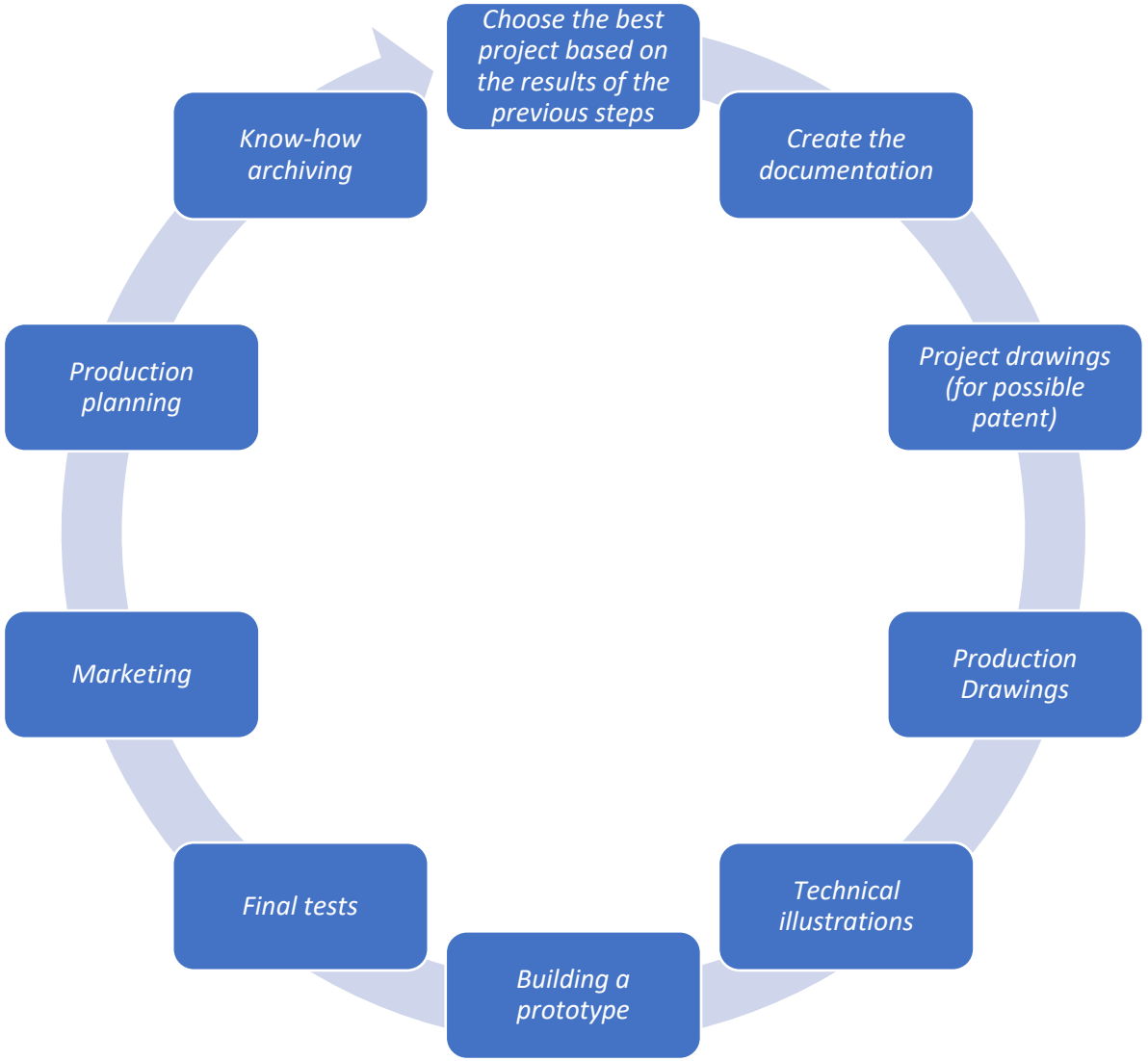
4) Engineering analysis

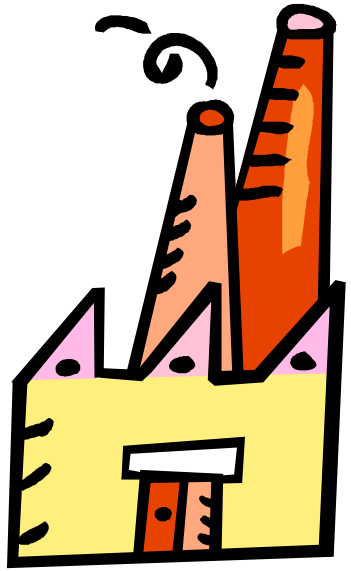
- *Apply engineering and scientific principles to evaluate the design*
- *FEM, Fatigue, Wear analysis*
- *Thermal analysis, etc.*
- *Using CAE software*
- *Ergonomic analysis*
- *Assemblability or assembly compatibility analysis*
- *Maintainability analysis*

5) Optimization

- *Look at the best ideas from the previous step*
- *Improve the details of the project*
- *More sophisticated computer model (project view)*
- *How will the proposed solution integrate with the other systems?*
- *How will the parts be made?*
- *What materials will be used?*
- *Additive manufacturing*

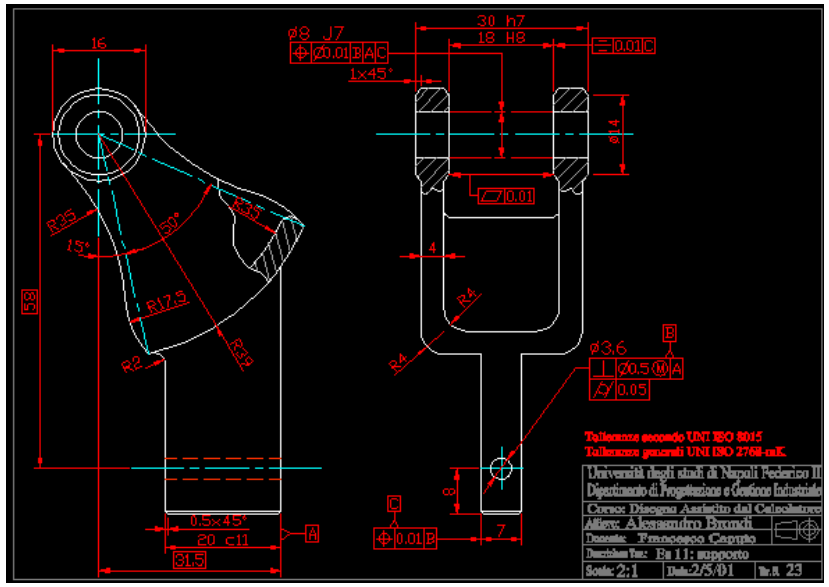
6) Implementation and documentation



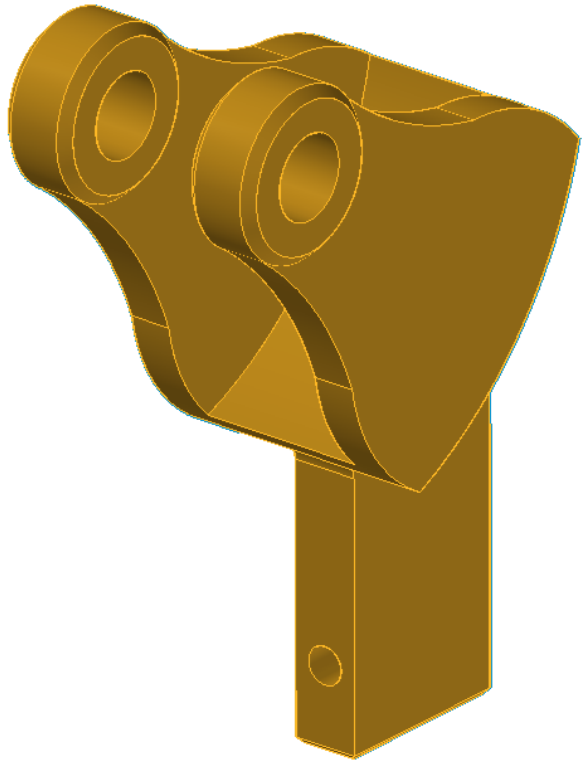


Possibili Approcci

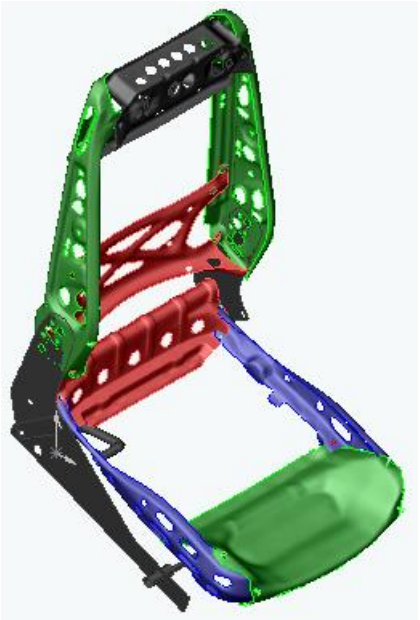
Technical drawings



3D models



Physical prototype



Virtual prototype

SYSTEMS ENGINEERING

What is a System?

A system is an assembly of components, connected together in an organised way to form a whole, this showing properties of the whole, rather than properties of the components.

SYSTEMS ENGINEERING

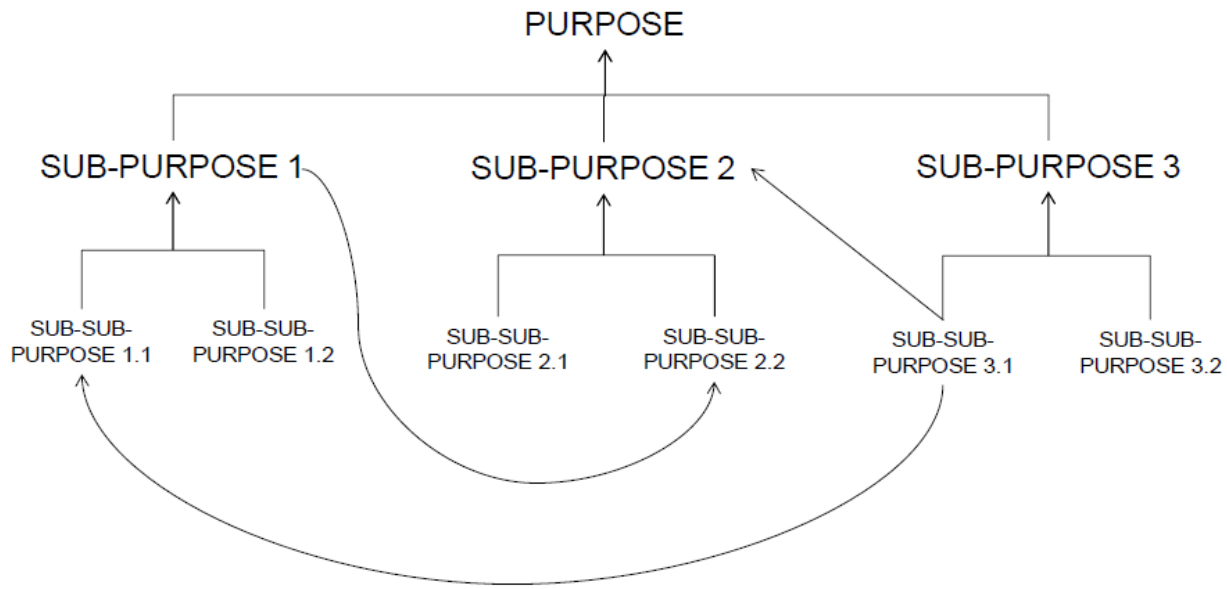
System Purpose

All systems seek to achieve a purpose

The purpose is property of the whole and not in any of the components – **the purpose is the fundamental emergent behaviour we desire**

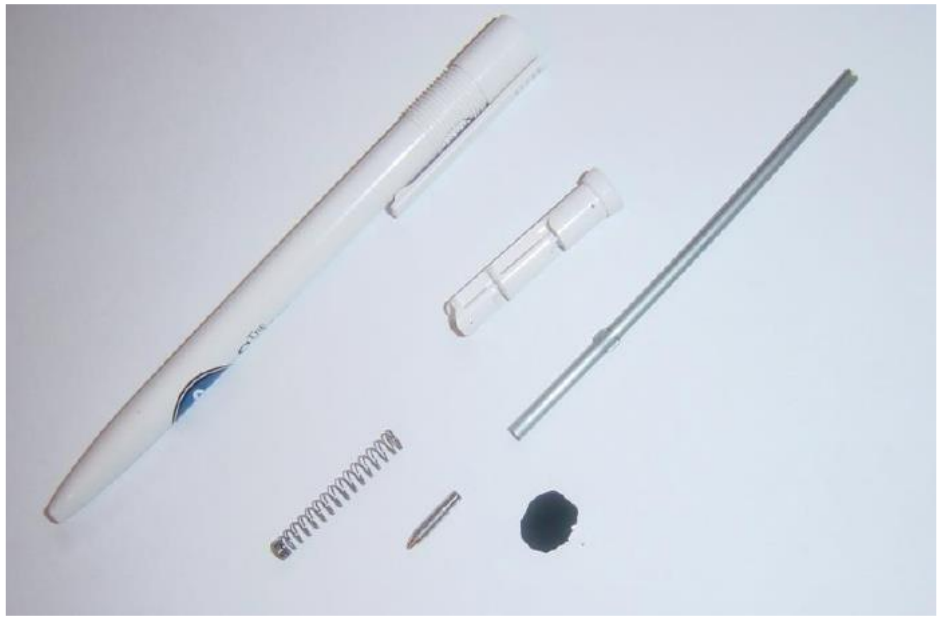
Some systems have more than one purpose

The purpose often requires the achievement of lower level purposes which in turn requires even lower level purposes which .... BUT it is rarely a simple hierarchy



SYSTEMS ENGINEERING

System Purpose



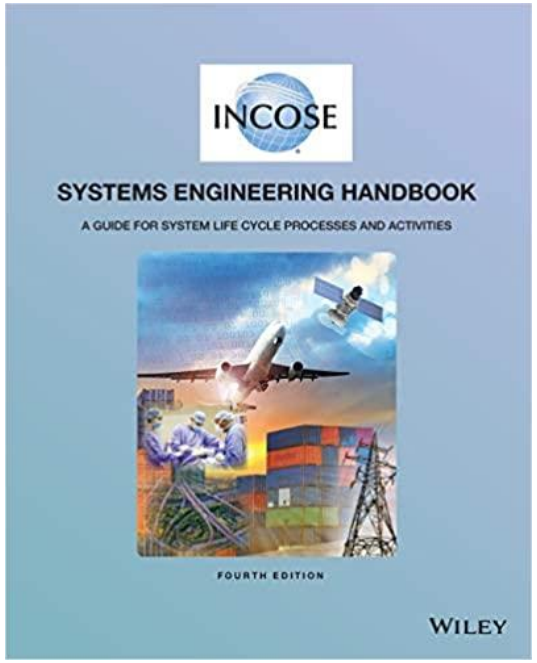
Components are affected by being in the system and the behaviour of the system is changed when a component is added to the system or when one leaves it

The properties of the pen as a whole are not found in any of the individual components – they emerge when the pen components are integrated

SYSTEMS ENGINEERING

"Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs. (INCOSE)"

The International Council on Systems Engineering (INCOSE)



SYSTEMS ENGINEERING

STEPS

- **Expression of the need**: the *identification of a need* based on the project approach.
- **Scope statement**: a document that *expresses the demand (request) of the customer* to the supplier. This document must be precise to ensure that the product is made in compliance with the expectations (waits).
- **Specification**: a *consumer need analysis made by the supplier*. It helps reduce complexity and define the limits.
- **Conception (design):** the process of *inventing, creating and developing a product by using the knowledge*, techniques, tools and methods of both Sciences and Techniques of the Industry (STI) and sustainable development.
- **Production**: the *manufacturing of the elements* which constitute the product.

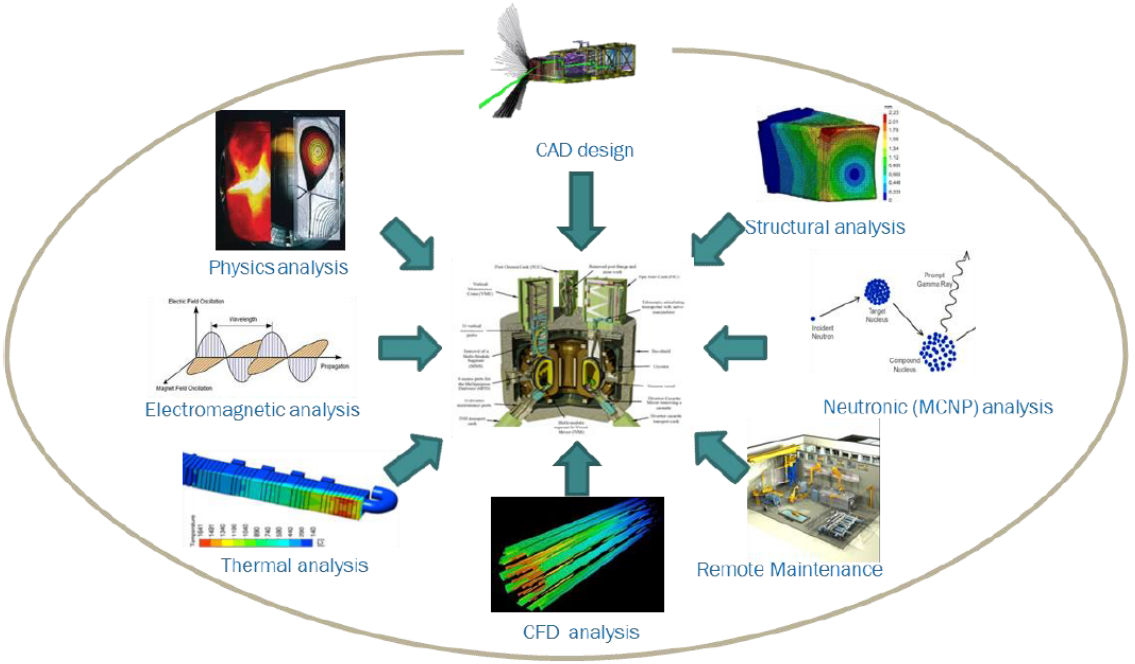
SYSTEMS ENGINEERING

A multidisciplinary project

- Multidisciplinary system requires skills in various disciplines: Mechanics, Electronics, Computing and many other fields.
- During the design, these disciplines interact with one another. It is important to manage the process of multidisciplinary engineering to make sure that the conceived product meets the customer needs.

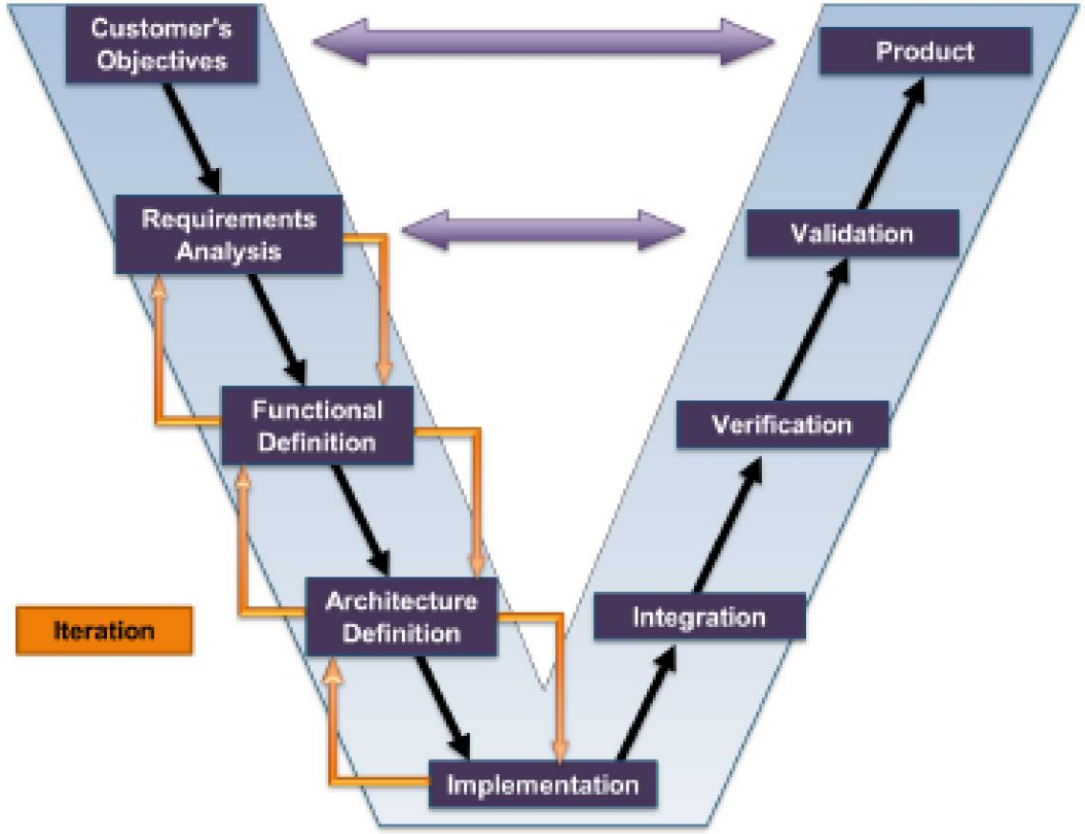
It is necessary to have:

- A common vision to share the Same understanding.
- A structured process of development to integrate all the disciplines and the specialists in the same team.



SYSTEMS ENGINEERING

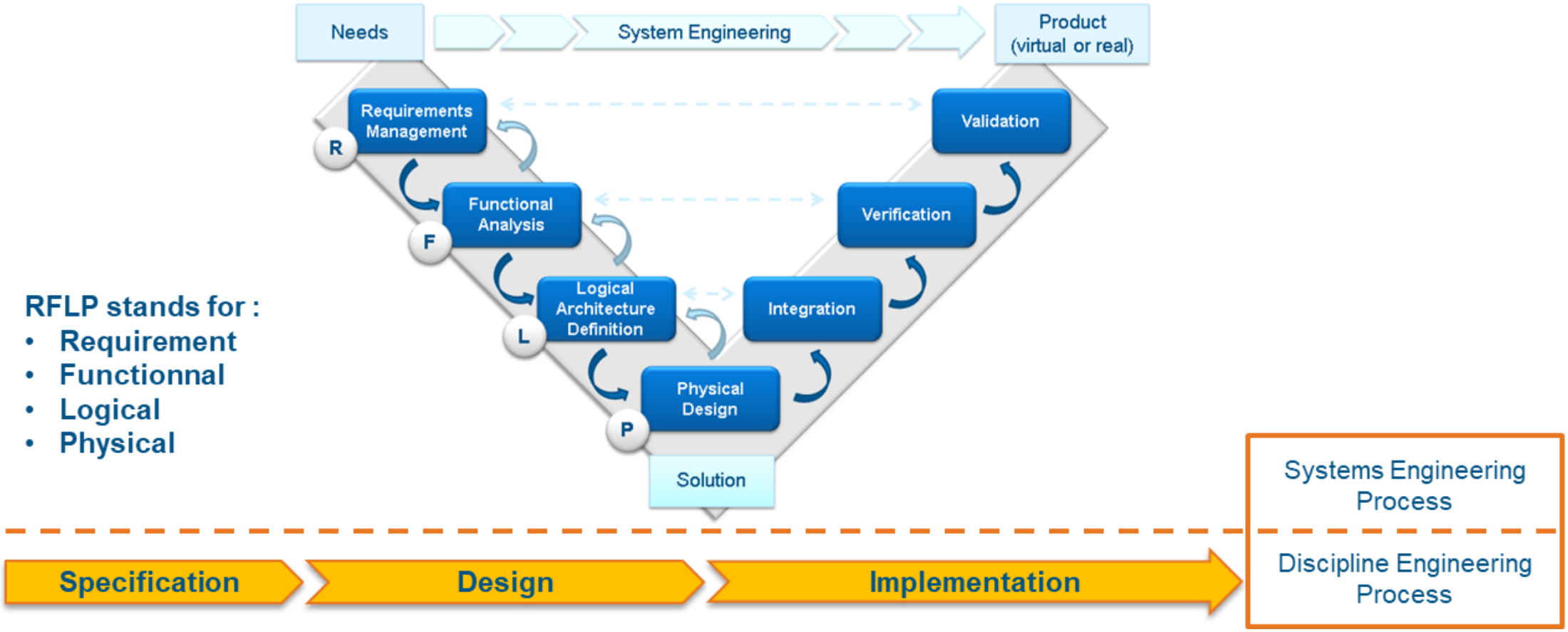
V-MODEL



Sottolinea la necessità di definire piani di verifica durante lo sviluppo dei requisiti, la necessità di una convalida continua con i clienti e l'importanza della valutazione continua dei rischi e delle opportunità

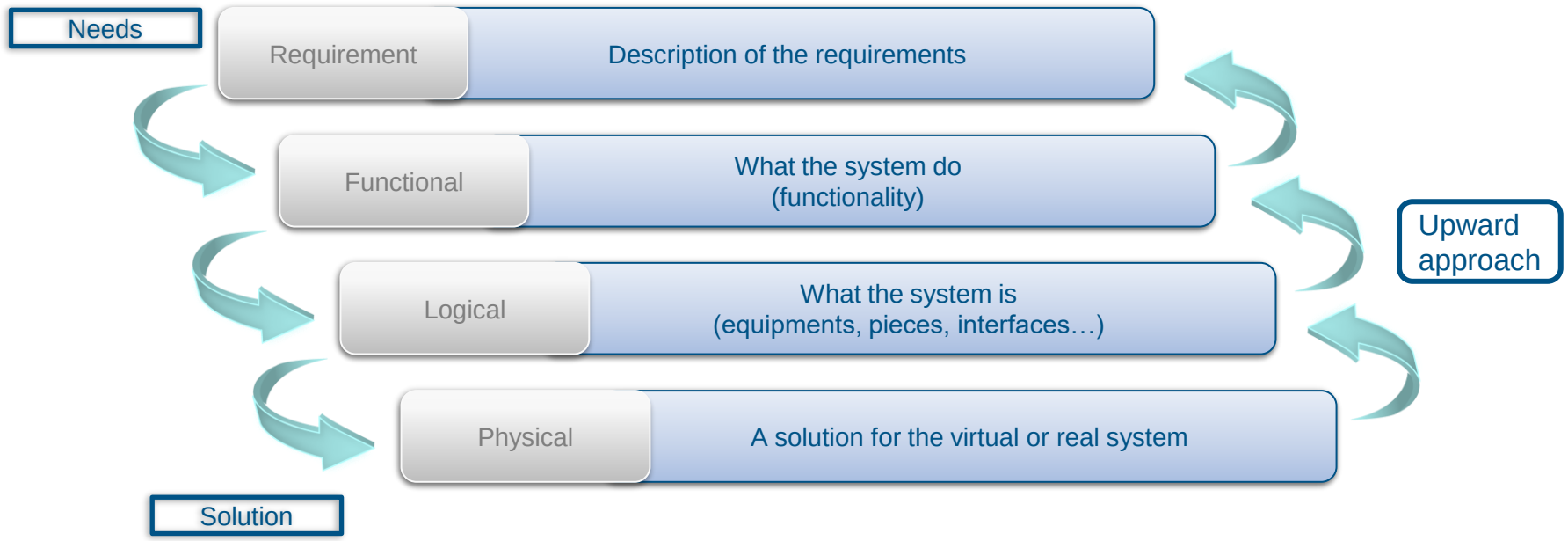
SYSTEMS ENGINEERING

The RFLP is a Systems Engineering process based on the V cycle design process.



SYSTEMS ENGINEERING

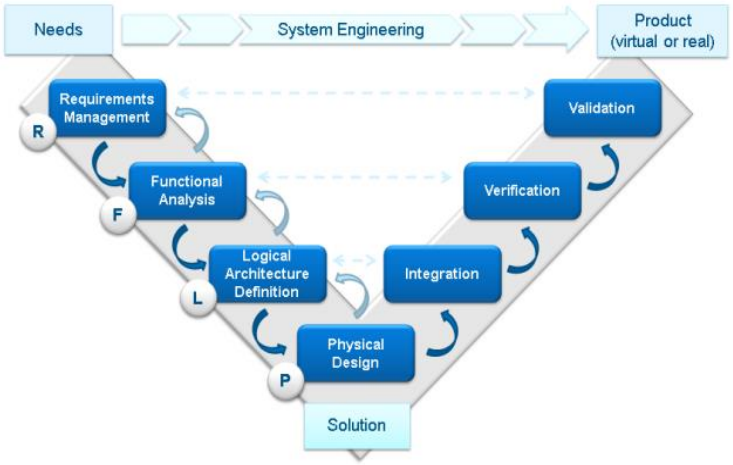
The RFLP is a Systems Engineering process based on the V cycle design process.

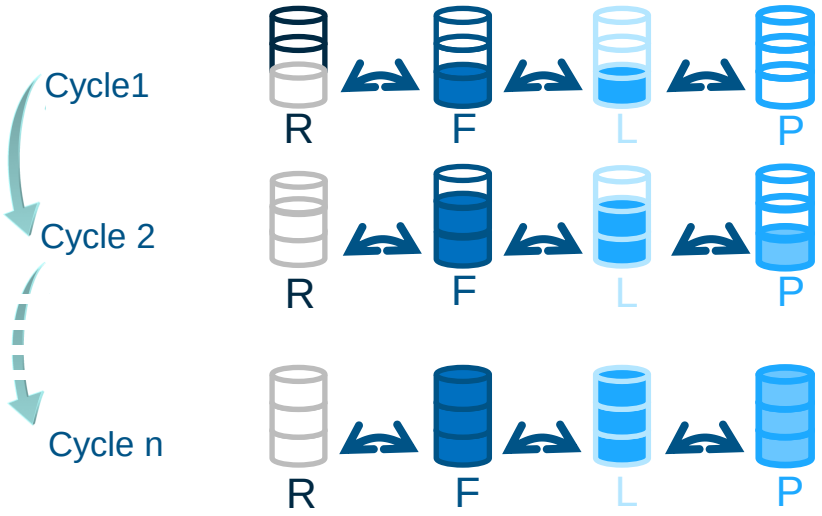


SYSTEMS ENGINEERING

The RFLP is a Systems Engineering process based on the V cycle design process.

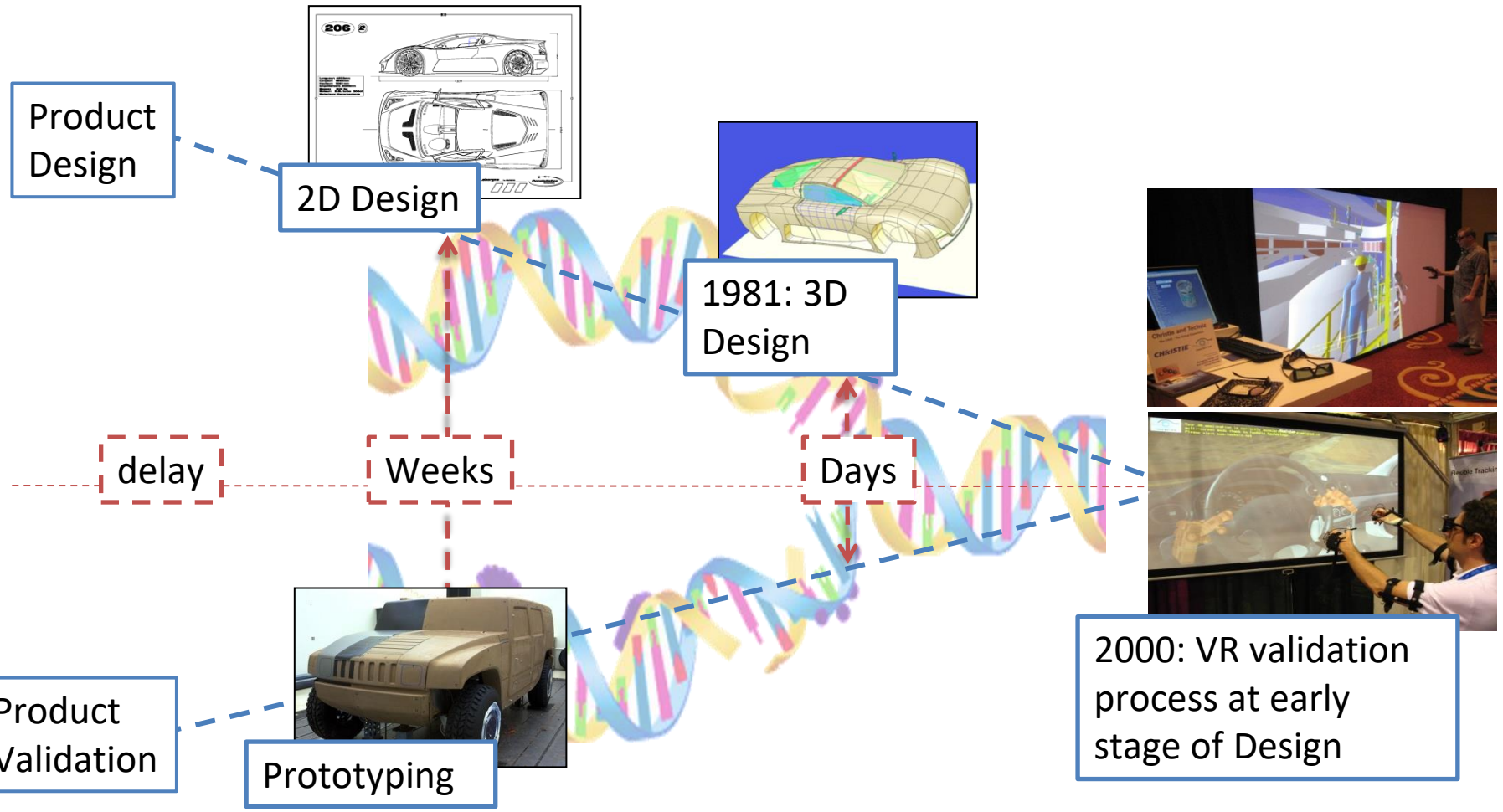
- Some interaction are necessary to complete the various steps of a project. The approach is not sequential but simultaneous.





To a final product

Evolution of Design vs. Validation



Physical vs Virtual Prototype

Physical prototype

Virtual Prototype

Sketchpad
Ivan Sutherland
MIT 1963

Computer
MIT Lincoln Labs TX-2


CORNING

Model

- The model is a substitute for an object:
- Really existing
- That will be realized
- That will never be realized
  - *Ex: Representation of a product that we only want to display*

Modeling is the process of describing an object or scene so that we can eventually draw it.

Modeling

Each model contains two descriptions:

1. ***The structural*** description is basically the *geometry* of the model

2. ***The appearance*** describes how the surface of the model interacts with light: color, shininess, and transparency

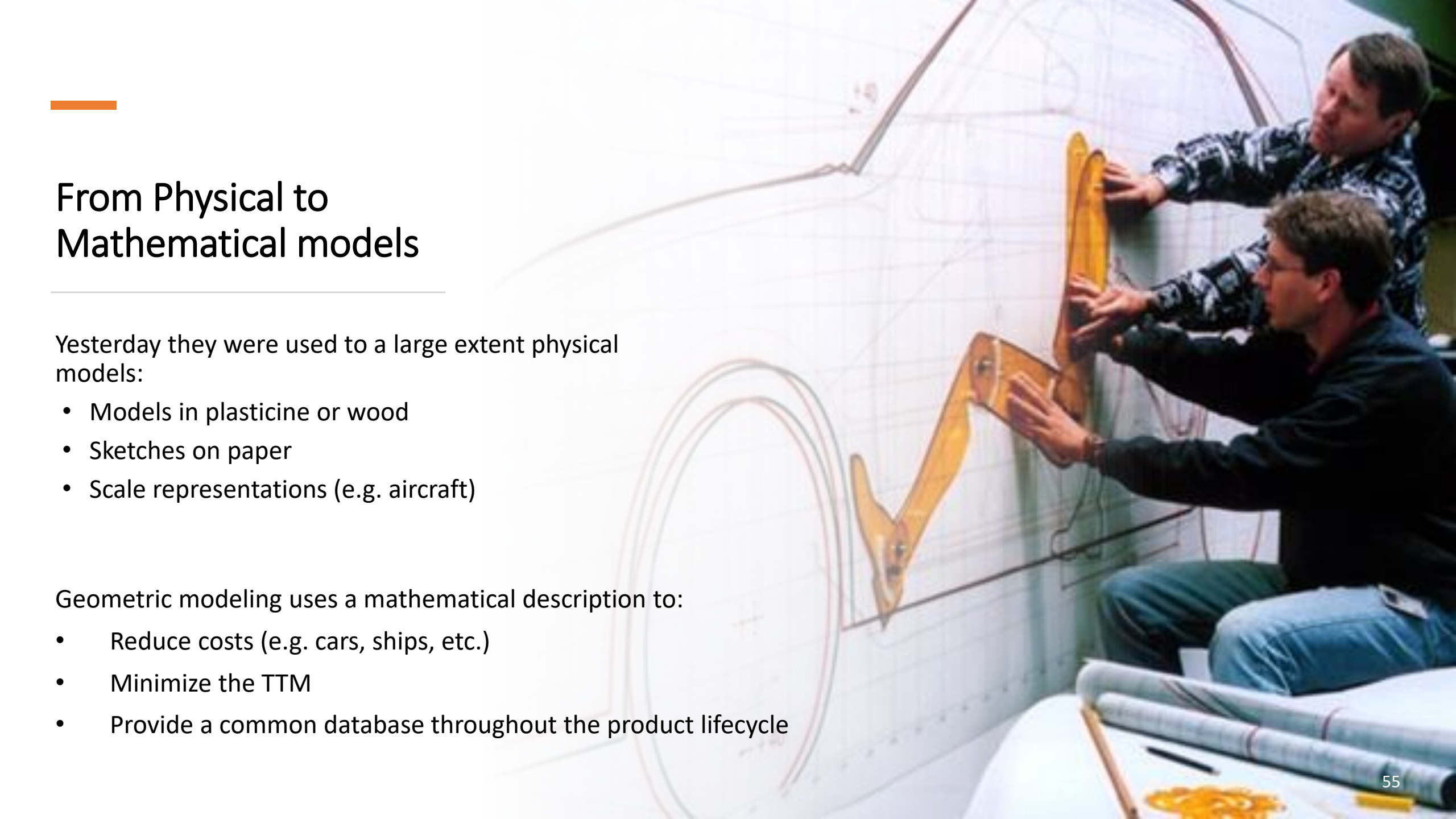
From Physical to Mathematical models

Yesterday they were used to a large extent physical models:

- Models in plasticine or wood
- Sketches on paper
- Scale representations (e.g. aircraft)

Geometric modeling uses a mathematical description to:

- Reduce costs (e.g. cars, ships, etc.)
- Minimize the TTM
- Provide a common database throughout the product lifecycle

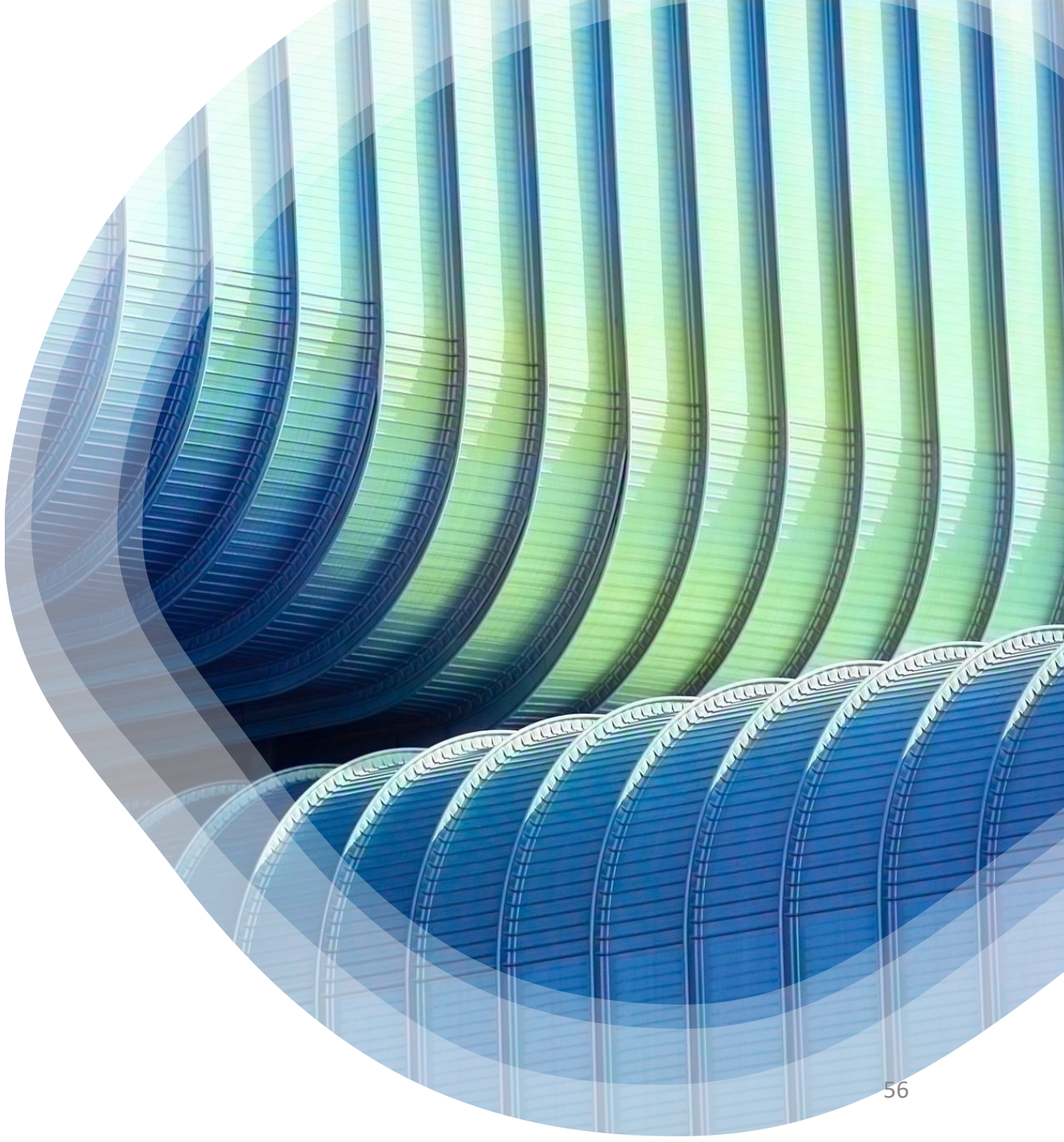


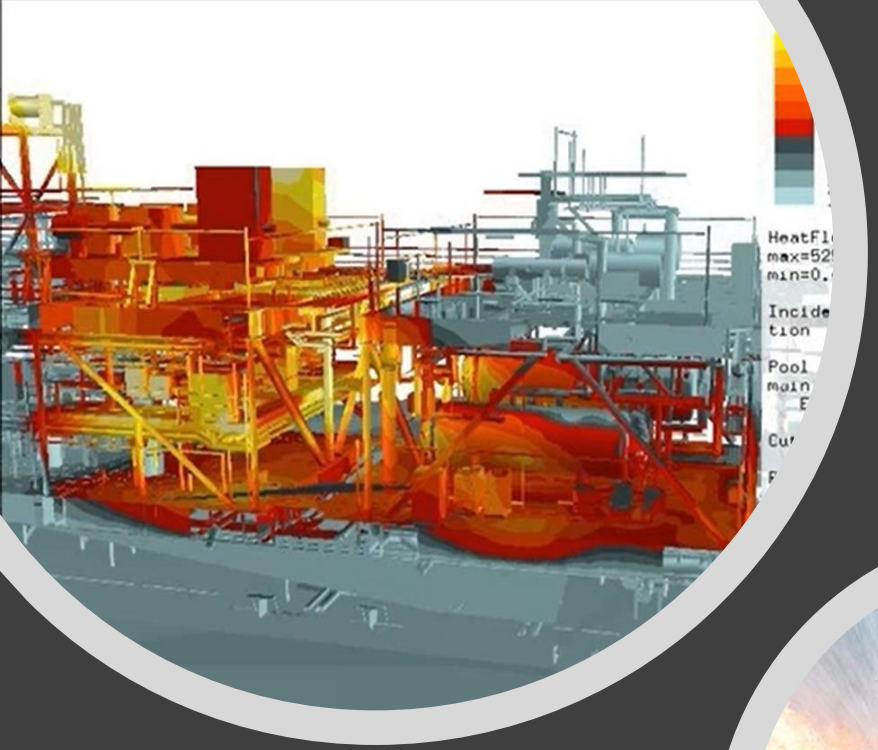
Virtual model

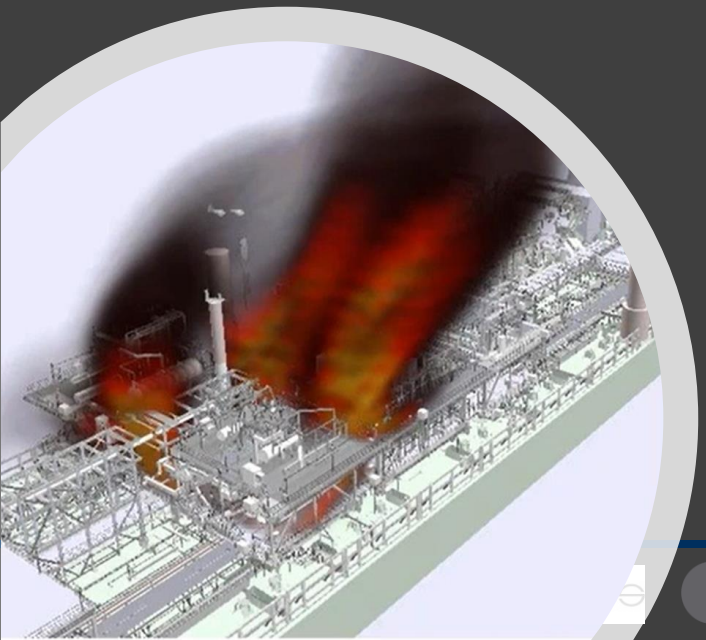
A computer representation of an object or system with the required level of detail.

Virtual simulation

Use of a mathematical and / or computerized model for the description of its behavior (kinematic, thermal, etc.) based on a set of initial parameters (boundary conditions).



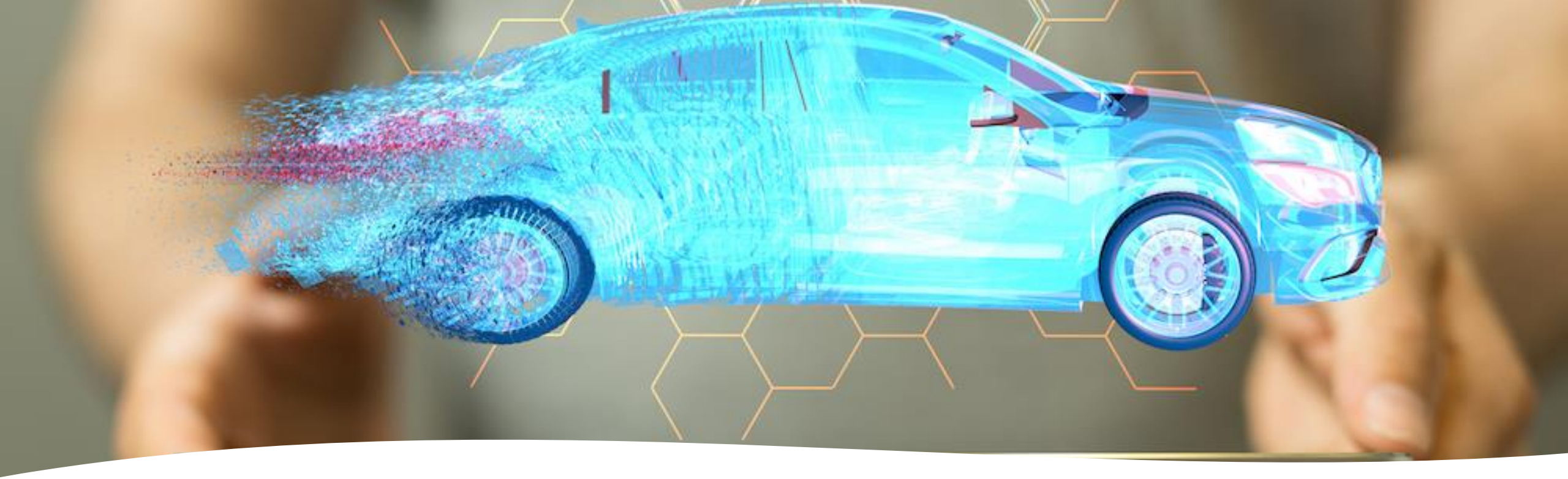




Simulation… why?

Experimentation is not always possible:

- Inaccessible input and output data
- The experiment is too dangerous
- The cost of the experiment is too high
- The time needed may not be compatible with man
- The experiment can be disturbed or perturbed in an uncontrolled manner.



Geometric modeling… …what is?

Geometric modeling is the technique for representing (in digital format) the geometry of real or imaginary components.

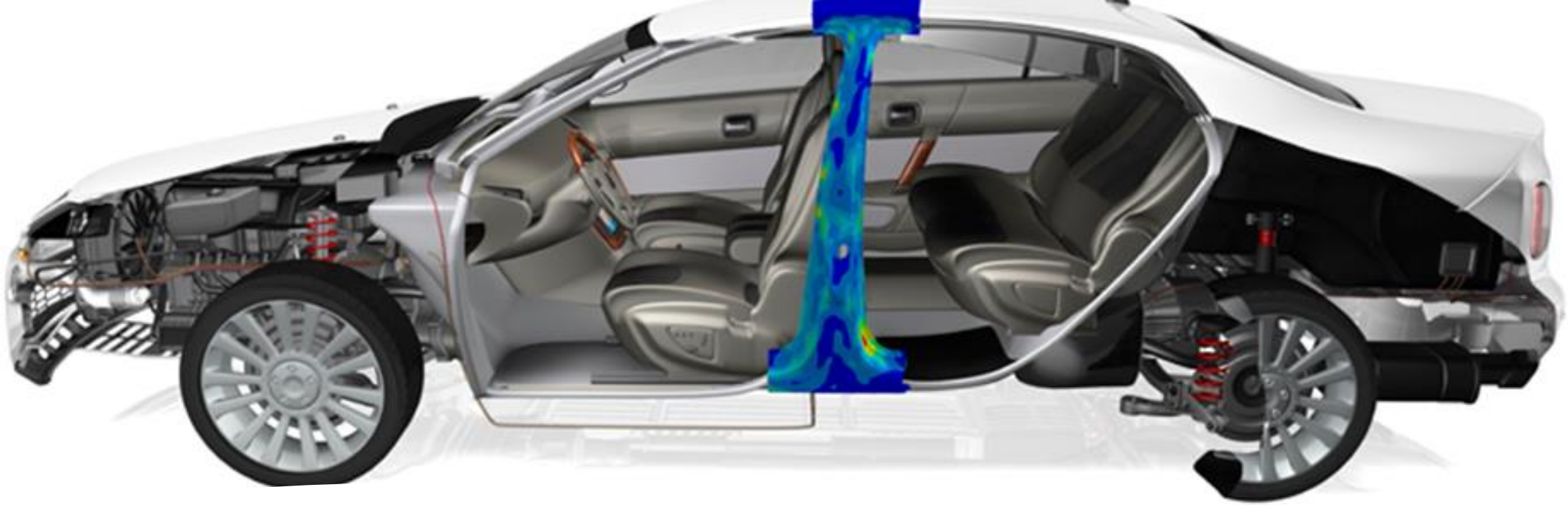
- It was born at the end of 1960, with the electronic computer, to drive the numerically controlled machines.
- It is a multidisciplinary activity involving:

Mathematics

- Differential geometry, Linear and Boolean algebra, Topology
- Numerical methods, vectors and matrices, set theory

Information technology

- Data structures
- Algorithms
- Programming



Virtual prototyping … …what is?

Geometric modeling will be "supplanted by ***virtual prototyping*** or product modeling, which not only includes the geometry of the object, but any information or data that is needed to design, develop, produce and support the product through its entire life cycle."

Ault, Holly K. (1999). 3-D Geometric Modeling for the 21st Century. The Engineering Design Graphics Journal, 63 (2), p.38.

Virtual Reality

- …methods and techniques that allow the design team to simulate human-product interaction when the product is still “immaterial”.

CAD model +

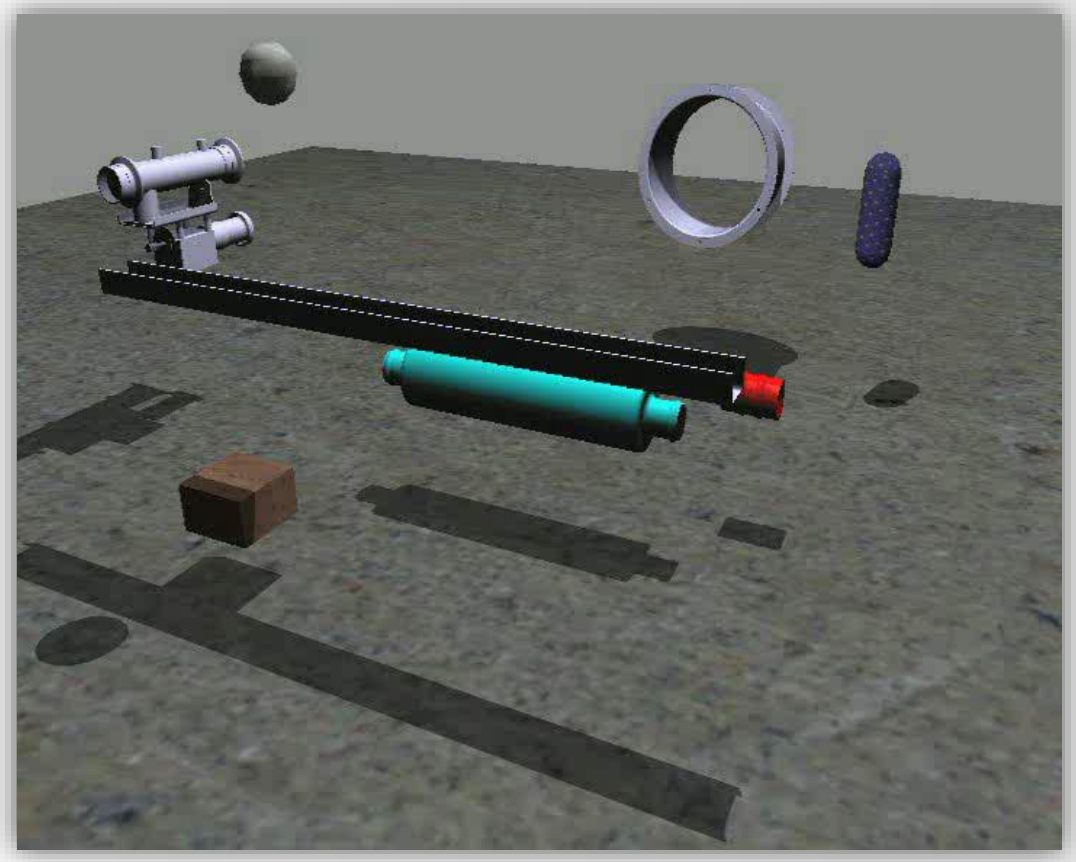
- ***Material, textures, shaders and lights***

CAD model +

- *Material, textures, shaders and lights*
- ***Kinematic behaviors***
  - ***Direct***
  - ***Inverse***

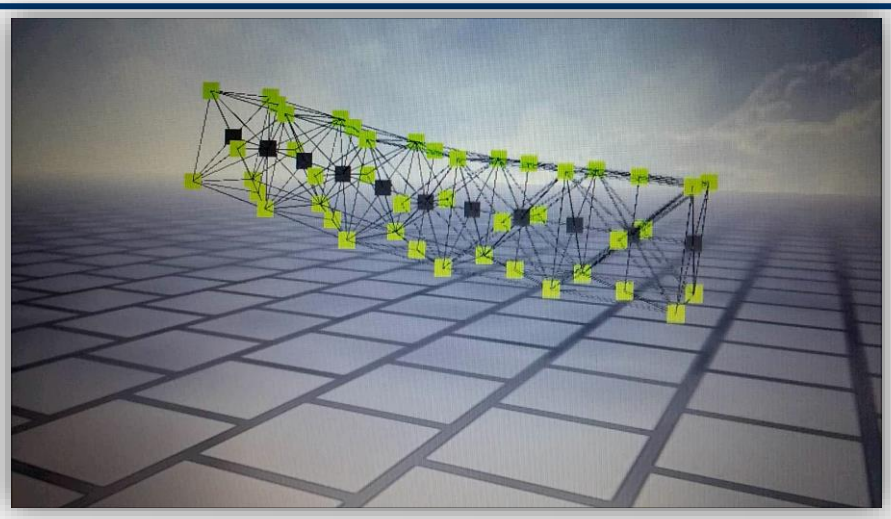
CAD model +

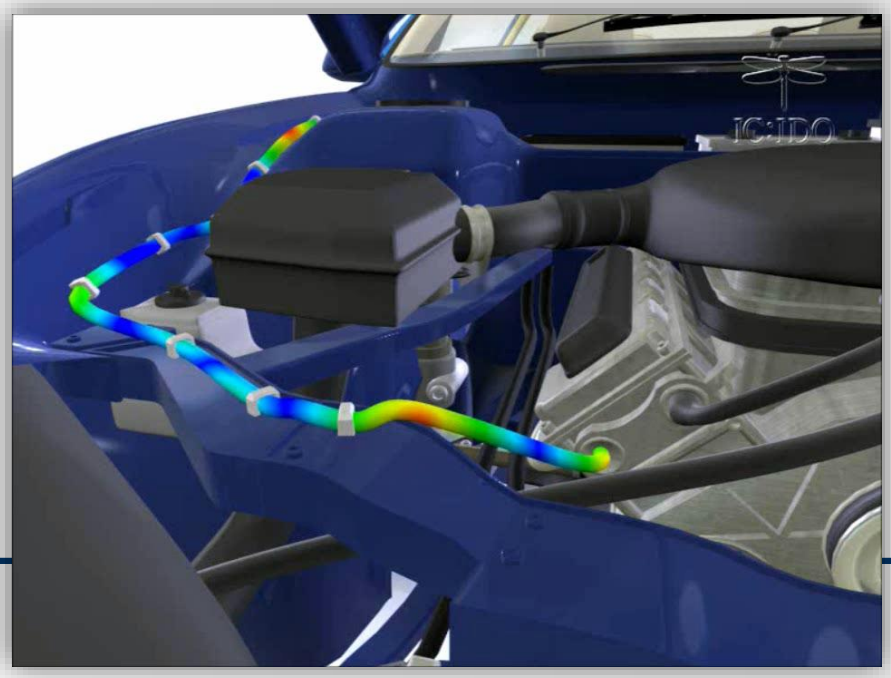
- *Material, textures, shaders and lights*
- *Kinematic behaviors*
  - *Direct*
  - *Inverse*
- ***Dynamic behaviors***
  - ***Rigid body***



CAD model +

- *Material, textures, shaders and lights*
- *Kinematic behaviors*
  - *Direct*
  - *Inverse*
- ***Dynamic behaviors***
  - *Rigid body*
  - ***Deformable body***





CAD model +

- *Material, textures, shaders and lights*
- *Kinematic behaviors*
  - *Direct*
  - *Inverse*
- *Dynamic behaviors*
  - *Rigid body*
  - *Deformable body*
- ***Sensitivity to collisions***
  - ***Detection***
  - ***Gliding***
  - *Avoiding*

CAD model +

- *Material, textures, shaders and lights*
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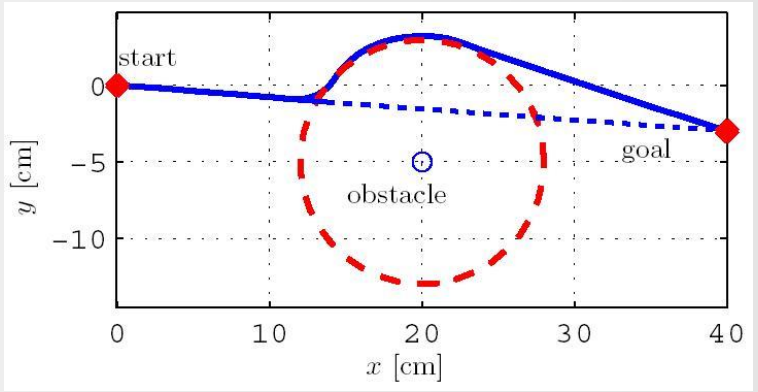
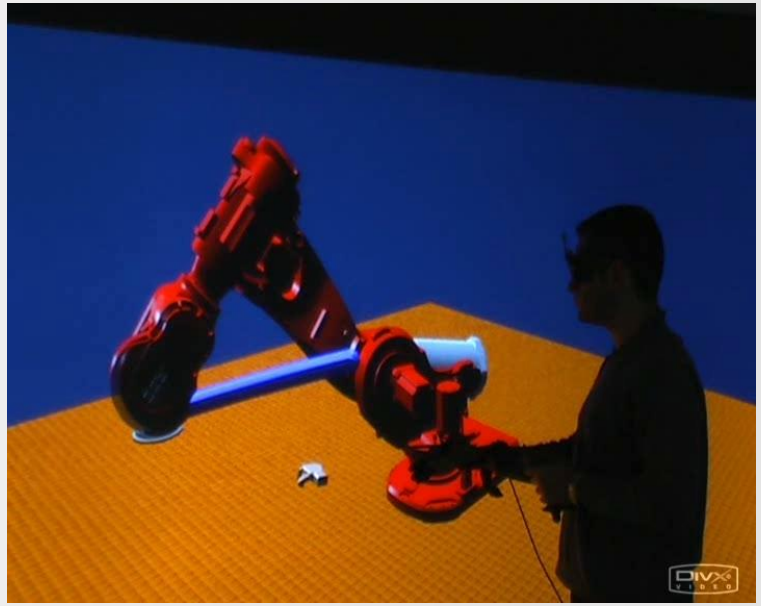




Modellazione geometrica al calcolatore

La descrizione matematica di un oggetto reale è molto complessa.

Solo con l'ausilio di un calcolatore è possibile gestire tale complessità.

La modellazione geometrica, è strettamente connessa con la visualizzazione e quindi la disciplina chiamata computer grafica.

Utilizzi principali della modellazione

- Rappresentazione degli oggetti fisici e reali
- Sviluppo di prodotto che soddisfi le specifiche tecniche e i vincoli estetici e funzionali.
- Visualizzazione dell’oggetto per valutarlo, interpretarlo, svilupparlo e produrlo (es. disegni tecnici, disegni di produzione, manuali, etc…)

Applicazioni

La **Modellazione geometrica** è utilizzata specialmente nelle seguenti applicazioni

- CAD, CAM
- Realtà virtuale
- Visualizzazione scientifica
- Analisi cinematica
- Robotica, computer vision

Altre…

- Videogiochi, video-produzione, modelli 3D via web, etc..

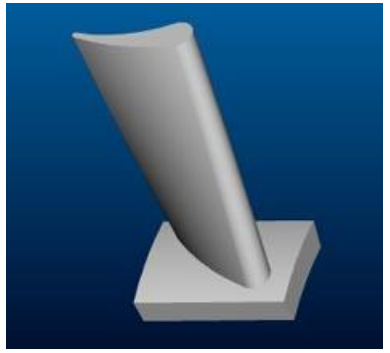
Come vengono generati i modelli?

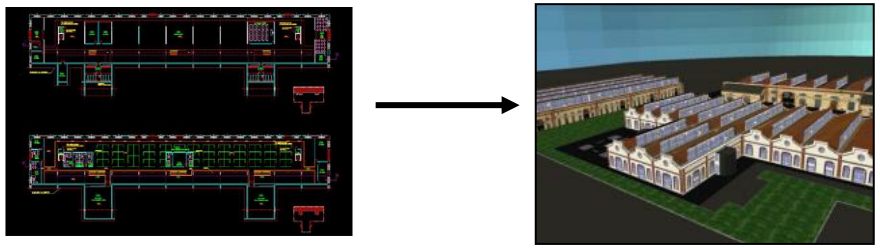
Geometric Model o Modello geometrico: la rappresentazione della forma 3D

Geometric Modeling o Modellazione: la tecnica di costruire il modello 3D

Metodi di generazione:

- Modellazione 3D
- 3D scan (reverse engineering)
- Simulazione e\o ottimizzazione
- Da rilievi cartografici e\o satellitari





Quale è il modello da utilizzare ?

Il modello digitale è sempre una rappresentazione approssimata. E' un compromesso:

- **Complessità di calcolo\archiviazione**
  - Tempo di modellazione
  - Visualizzazione
  - Dimensione del file
- **Complessità**
  - Numero di elementi
  - Geometria
  - Regole e vincoli

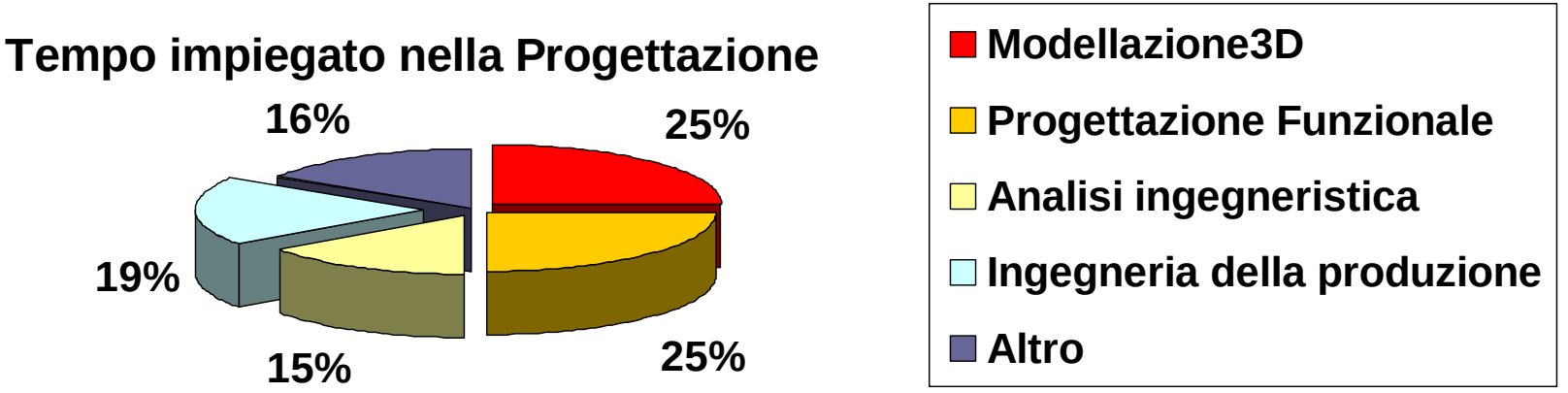
- **Efficacia**

  Il modello rappresenta l'oggetto ai fini che ci interessano?

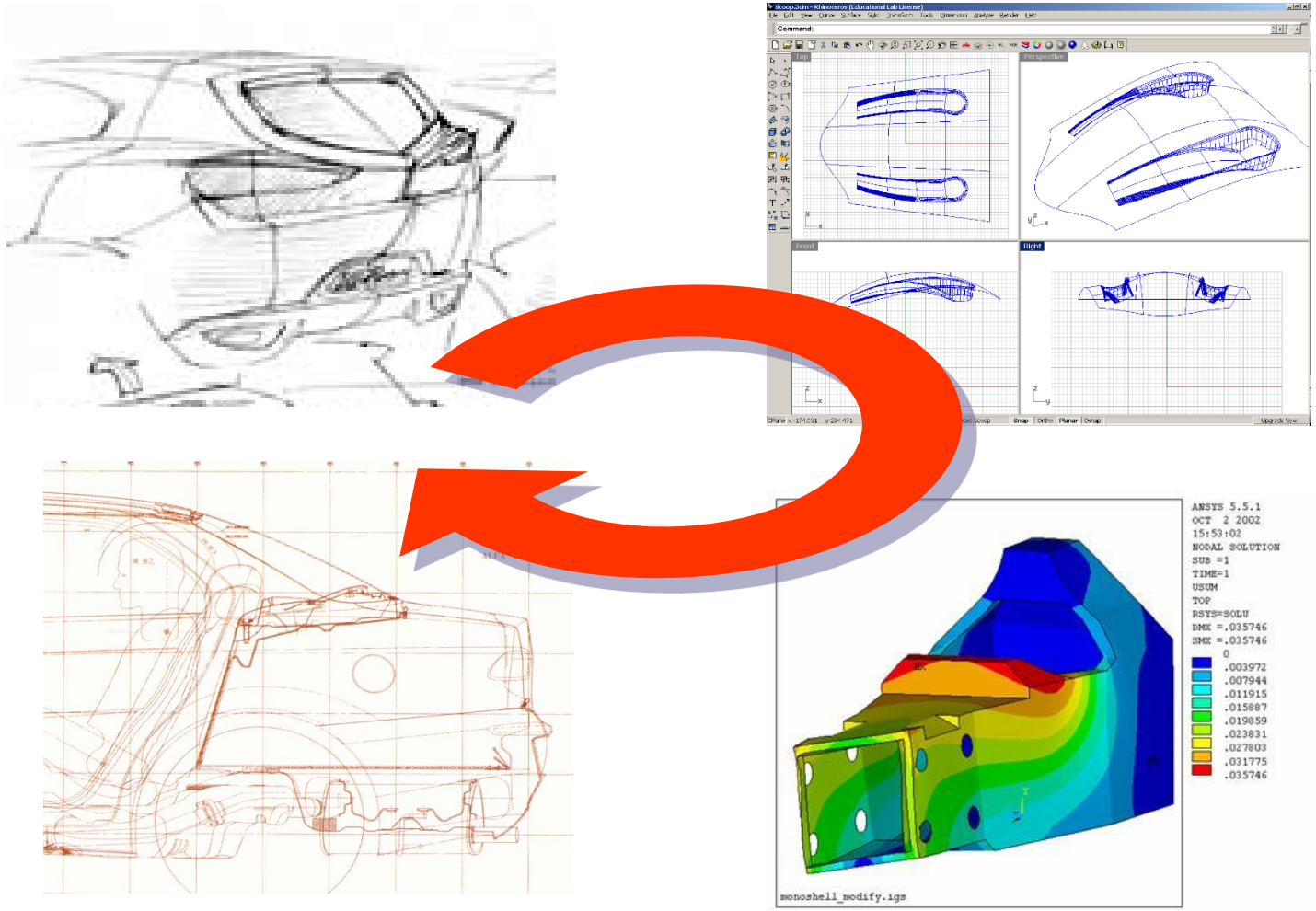
La comunicazione grafica tecnica

Circa il 92% del processo di progettazione usa la Comunicazione grafica per sviluppare e comunicare le soluzioni tecniche ai problemi .

La CG usa diversi strumenti (schizzi, disegni tecnici, modelli CAD, regole, schemi, documenti, etc.) ed è un linguaggio con regole ben precise.



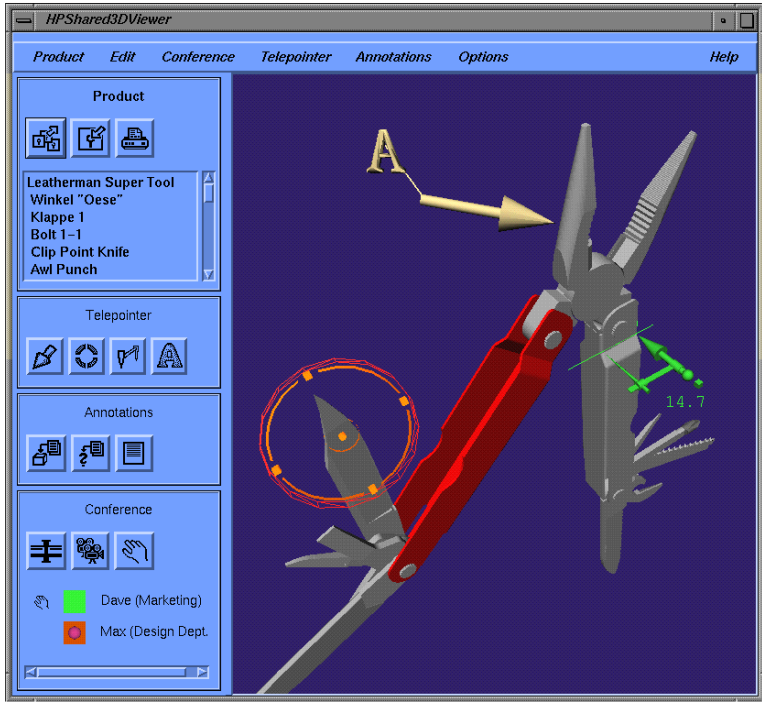
La grafica tecnica nel ciclo di vita del prodotto



Tipi di simulazione

Simulazione estetica

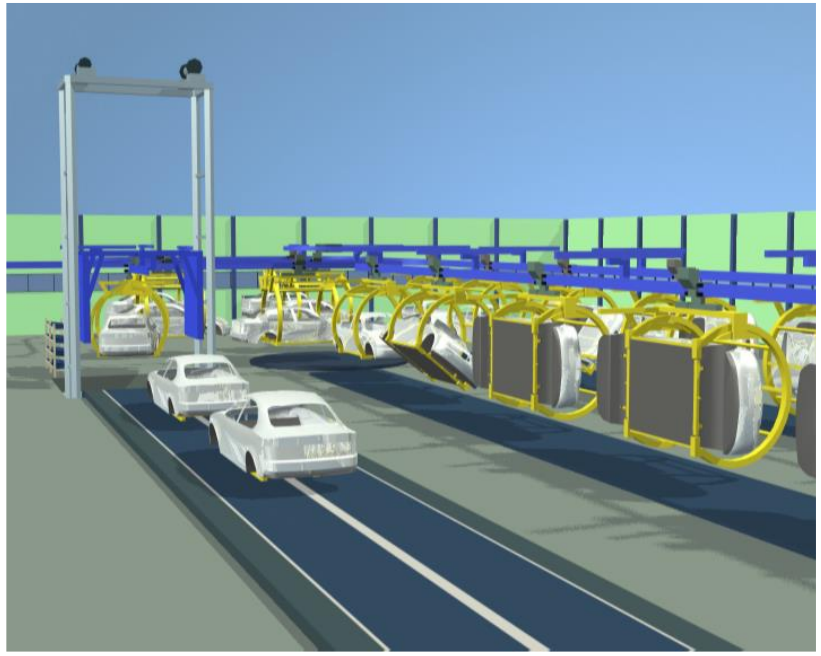
Simulazione funzionale



Altri tipi di simulazione

Ergonomia di un abitacolo auto durante la guida notturna(BMW-Fraunhofer)

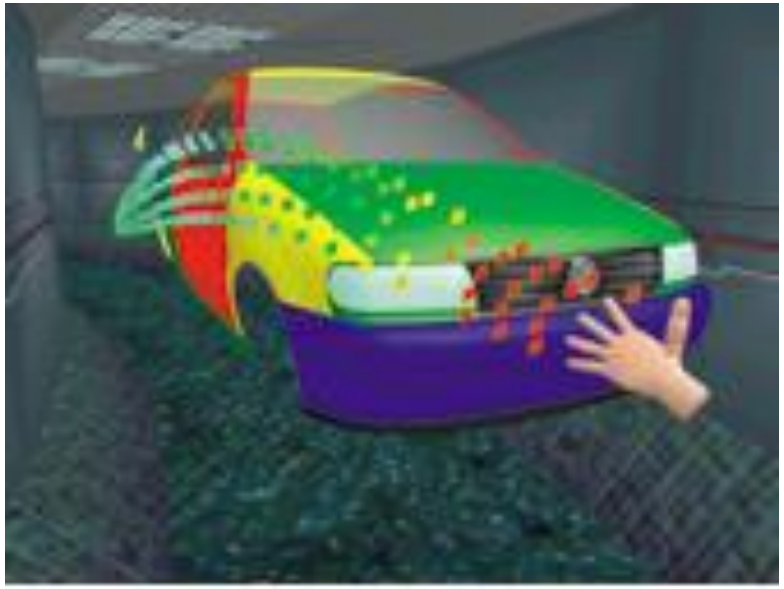
Simulazione di un impianto produttivo



Realtà virtuale

Studio dell’assemblaggio portiera in VR(VW)

Galleria del vento Virtuale



Il Progetto

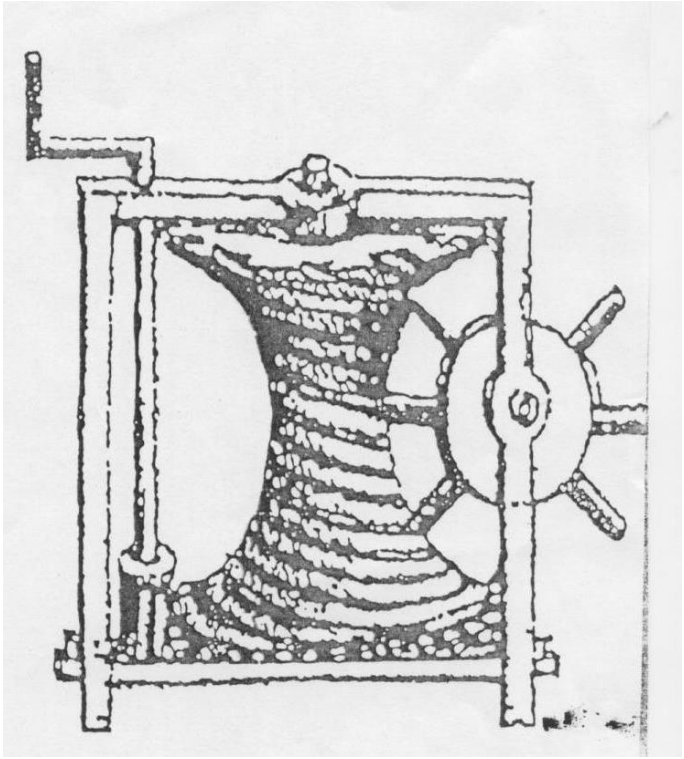
Il risultato della Progettazione è il Progetto.

E’ il frutto della collaborazione di più persone non può avere dei codici di linguaggio personale ma formale affinché tutti lo comprendano

Il metodo più spontaneo di rappresentazione è quello **grafico**: Il disegno tecnico.

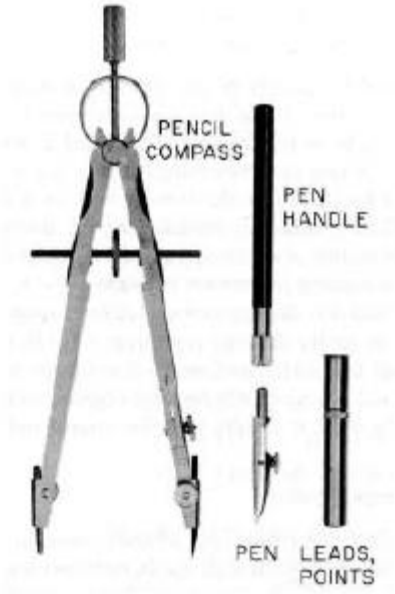
L’evoluzione storica del disegno

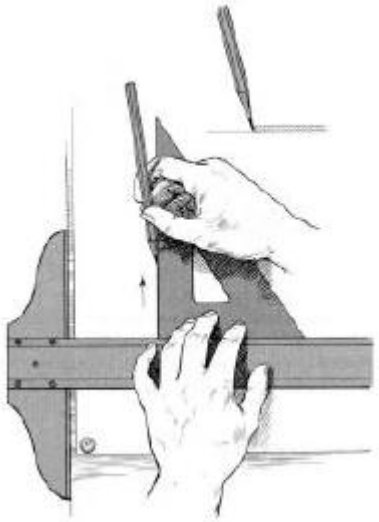
- ~ 1700 Nasce con la rivoluzione industriale
  - Disegni fatti a mano con i tradizionali strumenti di disegno (tecnigrafi, squadre, matite, compassi, ecc).
- ~ 1800 nasce l’indicazione delle quote in modo esplicito (quotatura)
- ~ 1900 tolleranze dimensionali e più tardi le tolleranze geometriche
- ~ 1970 Avvento del CAD, ma l’output cartaceo rimane, lo strumento di comunicazione principale.

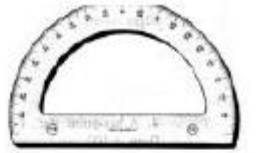


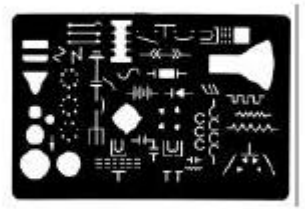
Leonardo da Vinci: “vite senza fine”

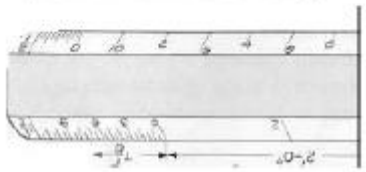
Gli strumenti tradizionali

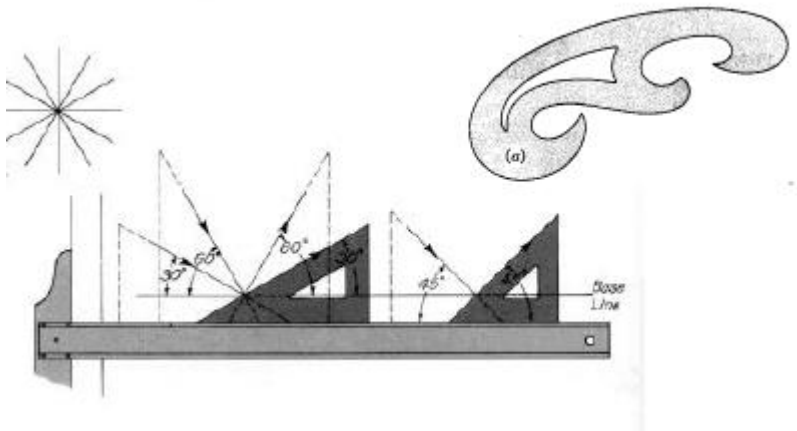




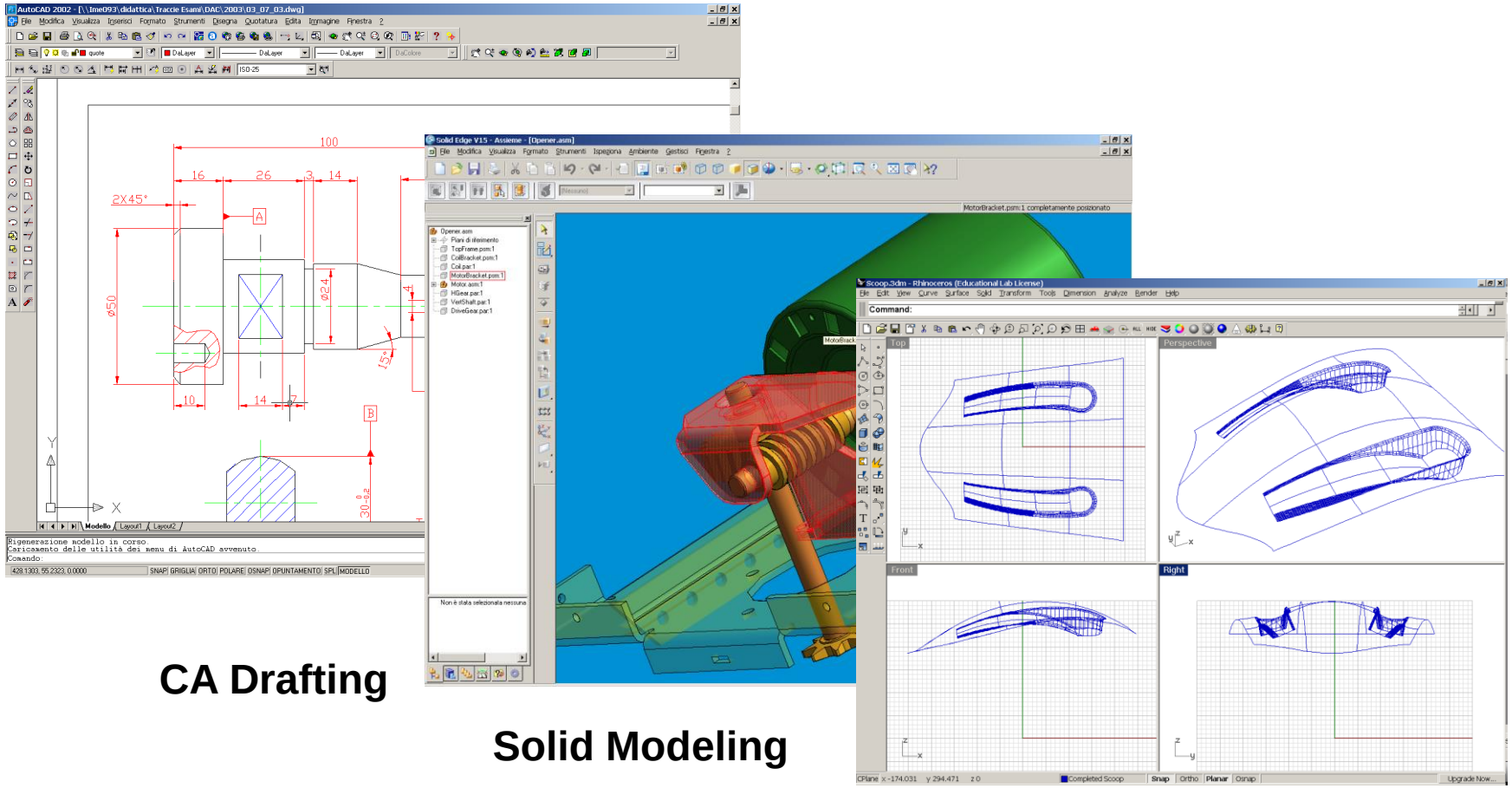








I nuovi strumenti CAX



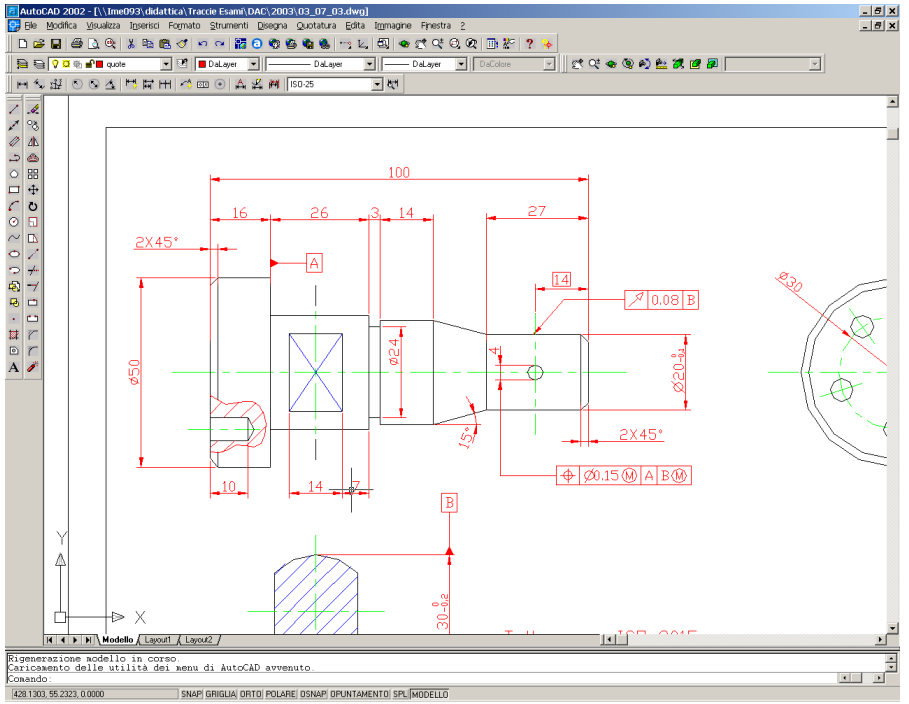
CA Drafting

Solid Modeling

Free Form Modeling

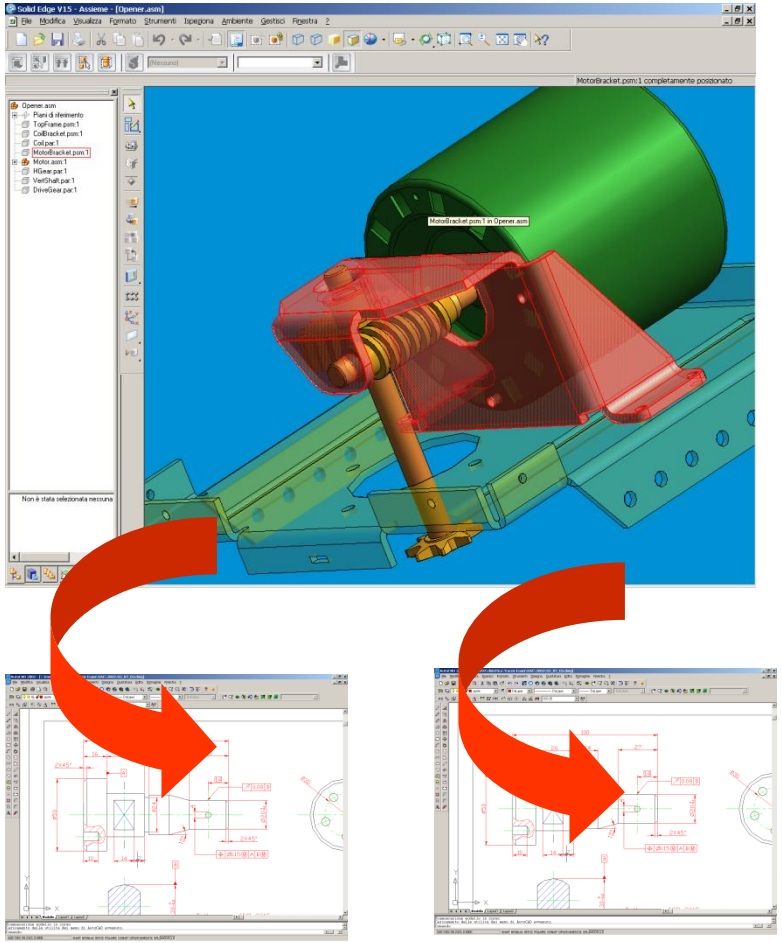
Il Computer Aided Drafting (2D)

- Editing del Documento (non del modello)
- Aumenta la produttività con l'automazione di attività ripetitive
- La sola geometria catturata è quella del contorno
- L'oggetto è implicito e va interpretato
- Un word-processing di documenti grafici per la comunicazione in linguaggio tecnico



Il Modello 3D\Solido

- Es. Solid Modelling (ProEngineer, CATIA, SolidWorks, SolidEdge, etc.)
- Modellazione del prodotto invece che del documento
- La forma è il riferimento per definire le caratteristiche funzionali e tecnologiche
- Associativo, Parametrico e feature based



Il processo di progettazione

Definizione: *Il processo di mettere insieme principi ingegneristici, risorse materiali,umane e creatività per industrializzare un nuovo prodotto.*

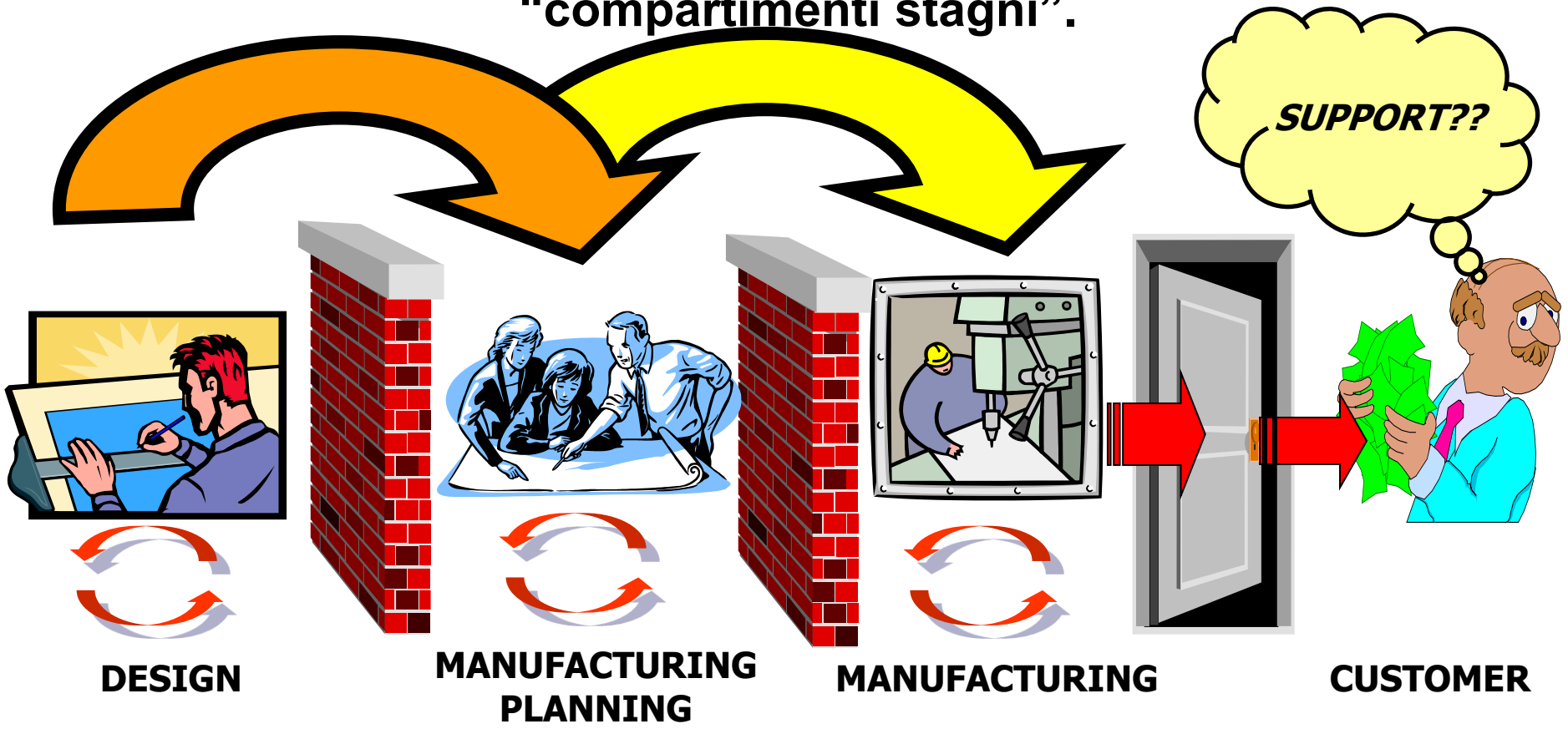
In altre parole è come si integra la progettazione nel ciclo di vita di un prodotto.

Due modelli:

- Sequenziale
- Parallelo

Modello sequenziale a “comparti”

Un modello iniziale viene ripetutamente analizzato e modificato fino a passare alla fase successiva “compartimenti stagni”.



Il modello sequenziale

- Functions Separated
- Functions Serially Executed
- No Interaction
- Maintenance Usually an Afterthought
- Time Consuming
- Costly
- Product a Series of Suboptimal reconsiderations

Il modello parallelo: CE

Definizione: *"Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception to disposal, including quality, cost, schedule, and user requirements."*

(Institute for Defense Analysis (IDA) R-338, 1986)

Sinonimi di Concurrent Engineering

A rose by another names:

- **Simultaneous Engineering**
- **Integrated Product Delivery**
- **Integrated Product and Process Development**
- **Team Design**

is still concurrent engineering.

Modello Parallelo (CE)

L'Ingegneria Simultanea (Concurrent Engineering) sovrappone temporalmente tre fasi principali:

- ideazione del prodotto
- perfezionamento
- Implementazione

tutti gli addetti ai lavori intervengono in ogni fase o per quelle fasi di competenza al fine di ridurre tempi e costi (interdisciplinarietà).

Quindi le fasi vengono sviluppate in parallelo in modo da non avere più il processo iterativo della progettazione sequenziale.

Keys to Concurrent Engineering

- Systematic approach
- Technical Competence/Experiences
- Use of multidiscipline teams
- Technical Tool Availability (CAx Tools)
- environment to provide information
- for rapid intelligent decision-making
- Communication
- Information Tool Availability

Obiettivo primario della CE

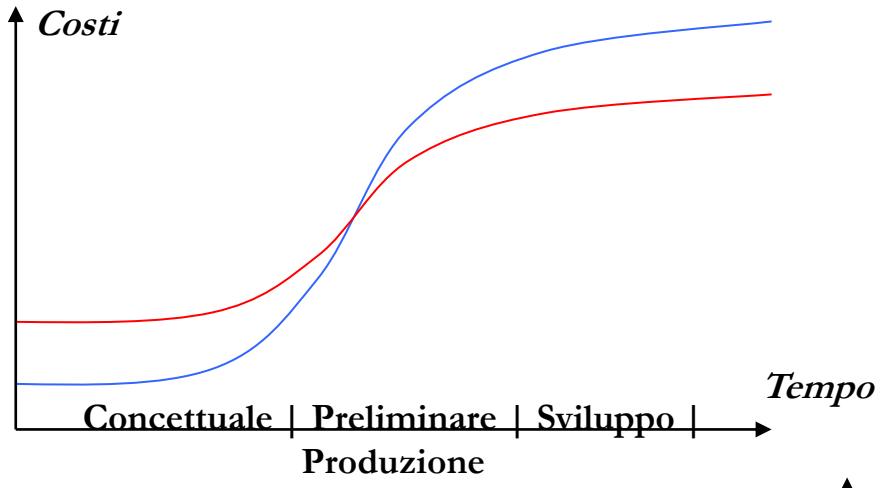
Razionalizzare e ottimizzare nelle prime fasi di sviluppo di prodotto

- La rispondenza ai requisiti di progetto
- La funzionalità
- La realizzabilità
- La manutenibilità
- Il riciclo

Con il fine di

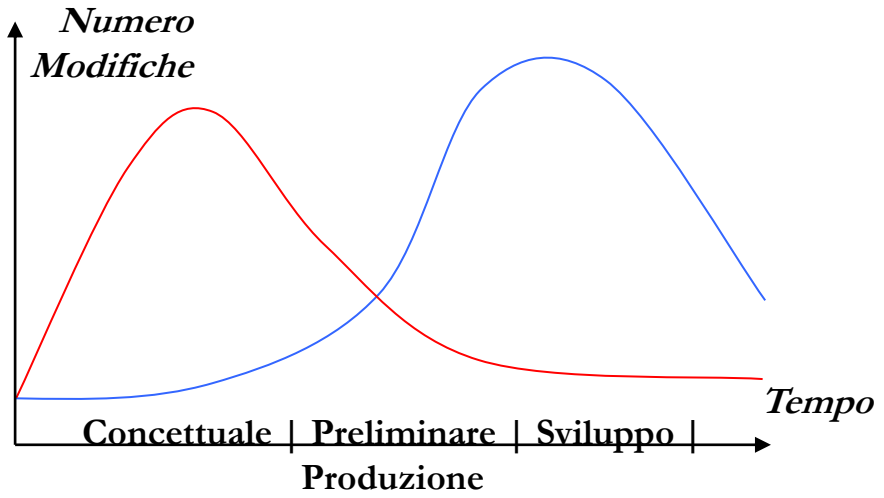
- Ridurre i costi e tempi
- Migliorare la qualità del prodotto

Diagramma dei costi



- Proceso seriale
- Processo parallelo

La CE aumenta i costi e le modifiche iniziali ma riduce i costi finali



Concurrent vs. Serial Engineering

- All Viewpoints Solicited
- Interdisciplinary Teams
- Life Cycle Cost Considered
- Attempt to Embody Concept Early - Before Committing to Detail Design
- Data/Information/Knowledge Exchange Planned and Encouraged
- Cycle Time and Cost Reduced

Virtual Concurrent Engineering

In un ottica di aziende multinazionali

- I gruppi sono distribuiti geograficamente e culturalmente
  - Cosa significa la distanza fisica?
- Le informazioni sono generate e memorizzate in vari formati e località
  - Single Plant + Customers
  - Multiple Plants (Same Organization) + Customers
  - Multiple Organizations + Customers

Massive & diverse types of information

Modello Parallelo (CE) nel dettaglio