



# *CAD/CAM/CAE tools for virtual prototyping.*

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- **Modern computer aided techniques changed the world of design towards a world in which virtual prototypes can be used to check and improve the design. These design methods aim to eliminate the use of many physical prototypes.**
- **In a short overview we will explore the different techniques and see how they can be used in teaching engineering students .**



# Engineering design: the design triangle.

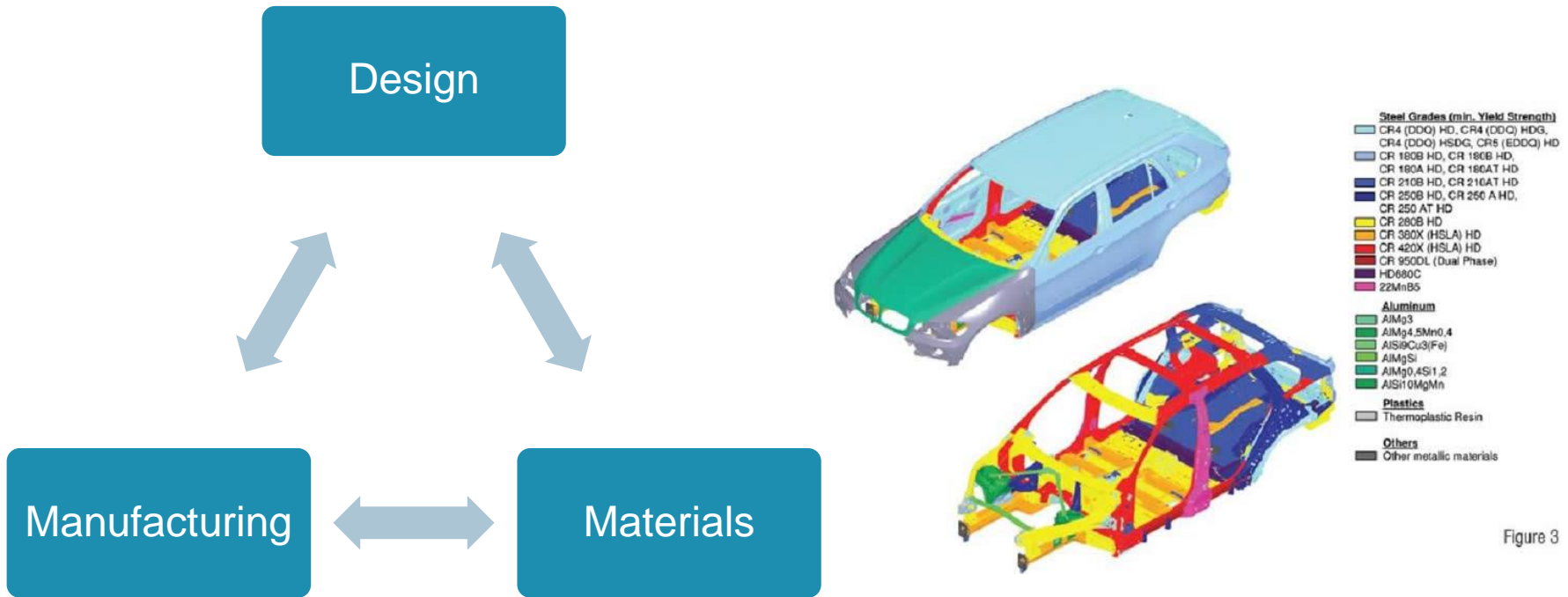
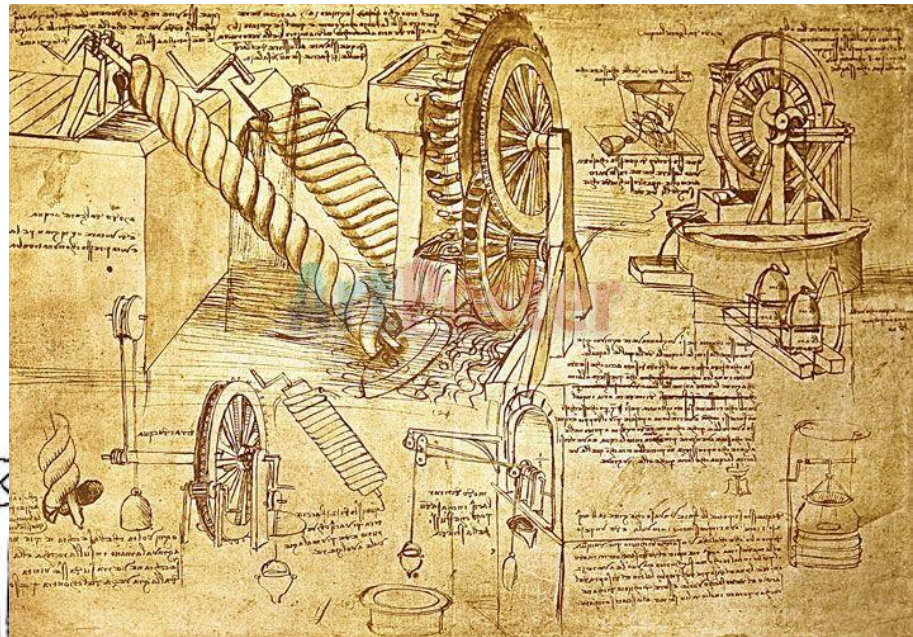
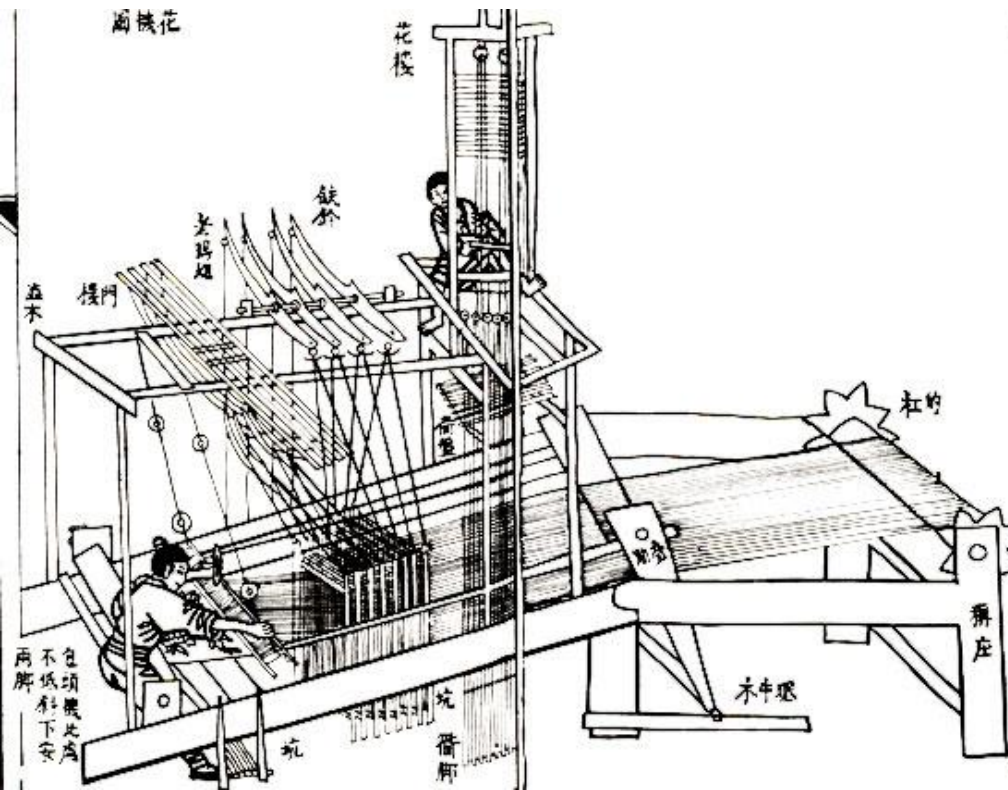


Figure 3



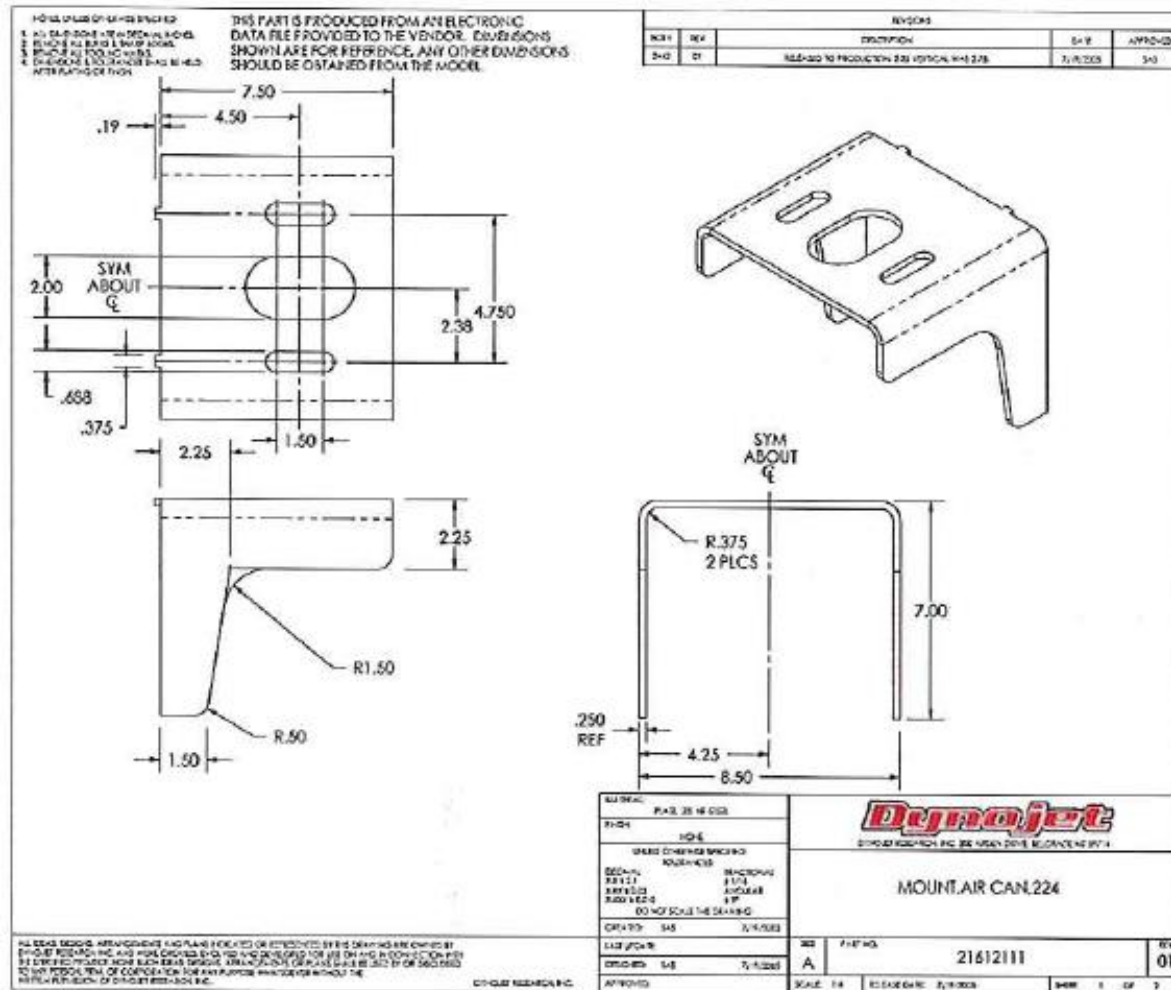
# History of design.

- Drawing is method of communication.



# Drawing containing a lot of information:

- Calculate
  - Manufacture
  - Document
  - .....
- > many documents, many possible errors

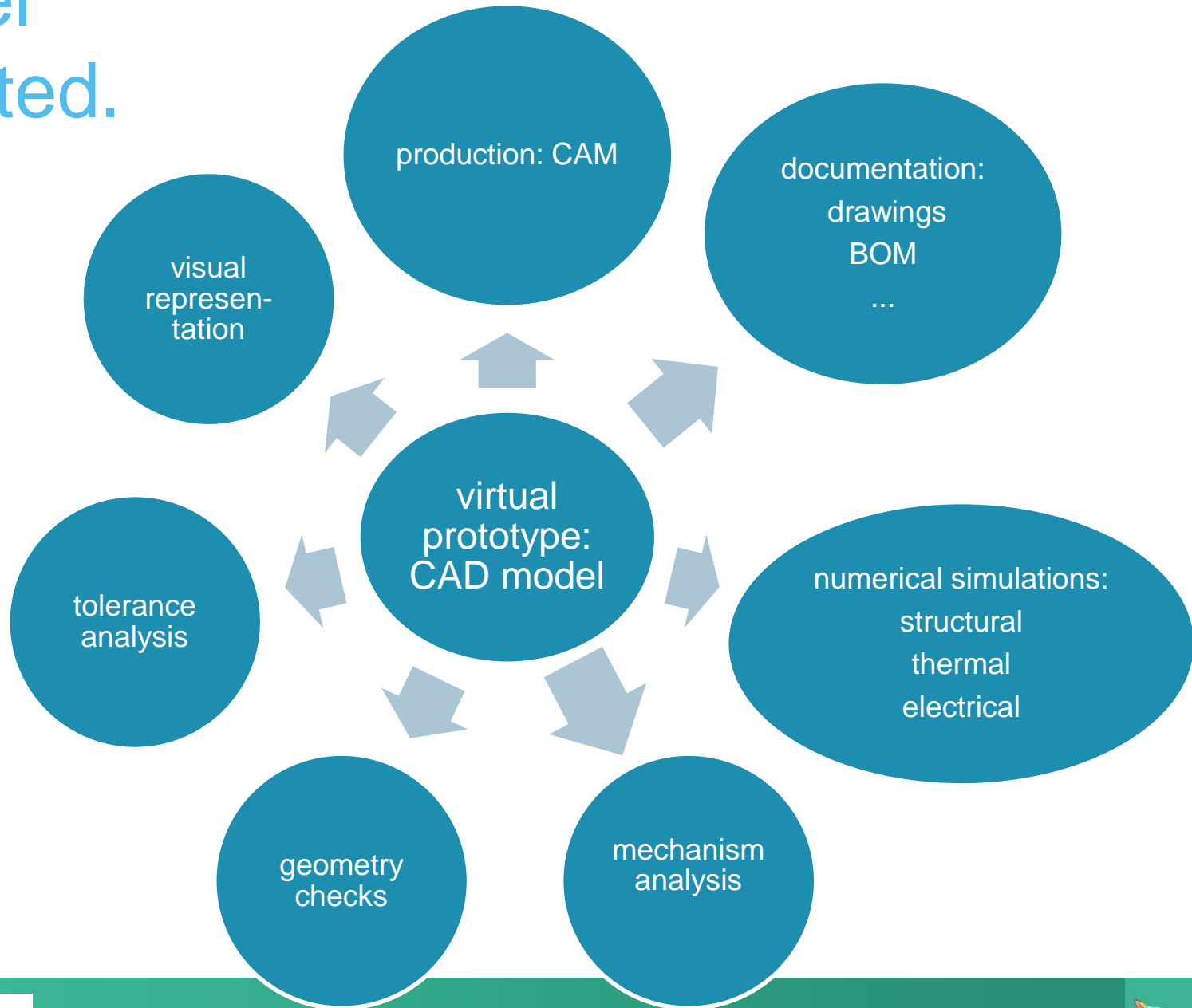


# From drawing oriented to model oriented design.

- Drawing oriented:
  - Paper model
  - Only on paper
  - Multiplication of data
- Model oriented:
  - CAD-model
  - Virtual prototype
  - 1 source of data



# Model oriented.



# Virtual prototype.



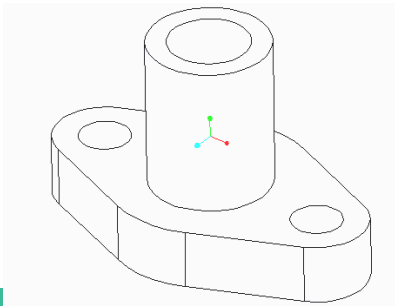
appearance

physical and mechanical properties

geometry

dynamic behavior

virtual prototype:  
CAD Model



**Material Definition**

Name: CU

Description:

Density: 8.21395e-09 tonne/mm<sup>3</sup>

Appearance: User Defined

Structural: Thermal: Isotropic

Miscellaneous: Symmetry: Isotropic

Stress-Strain Response: Linear

Poisson's Ratio: 0.35

Young's Modulus: 131000 MPa

Coeff. of Thermal Expansion: 1.674e-05 /C

Mechanisms Damping: sec/mm

Material Limits:

Tensile Yield Stress: MPa

Tensile Ultimate Stress: MPa

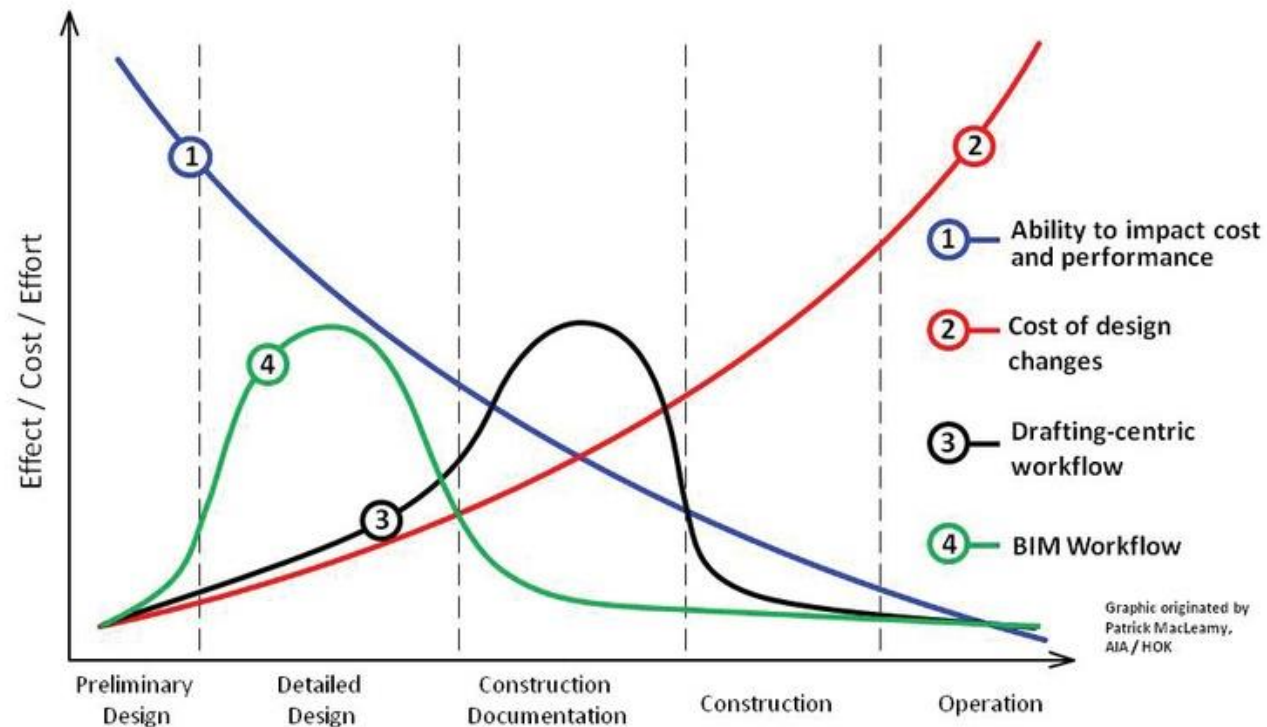
Compressive Ultimate Stress: MPa

Ok Cancel

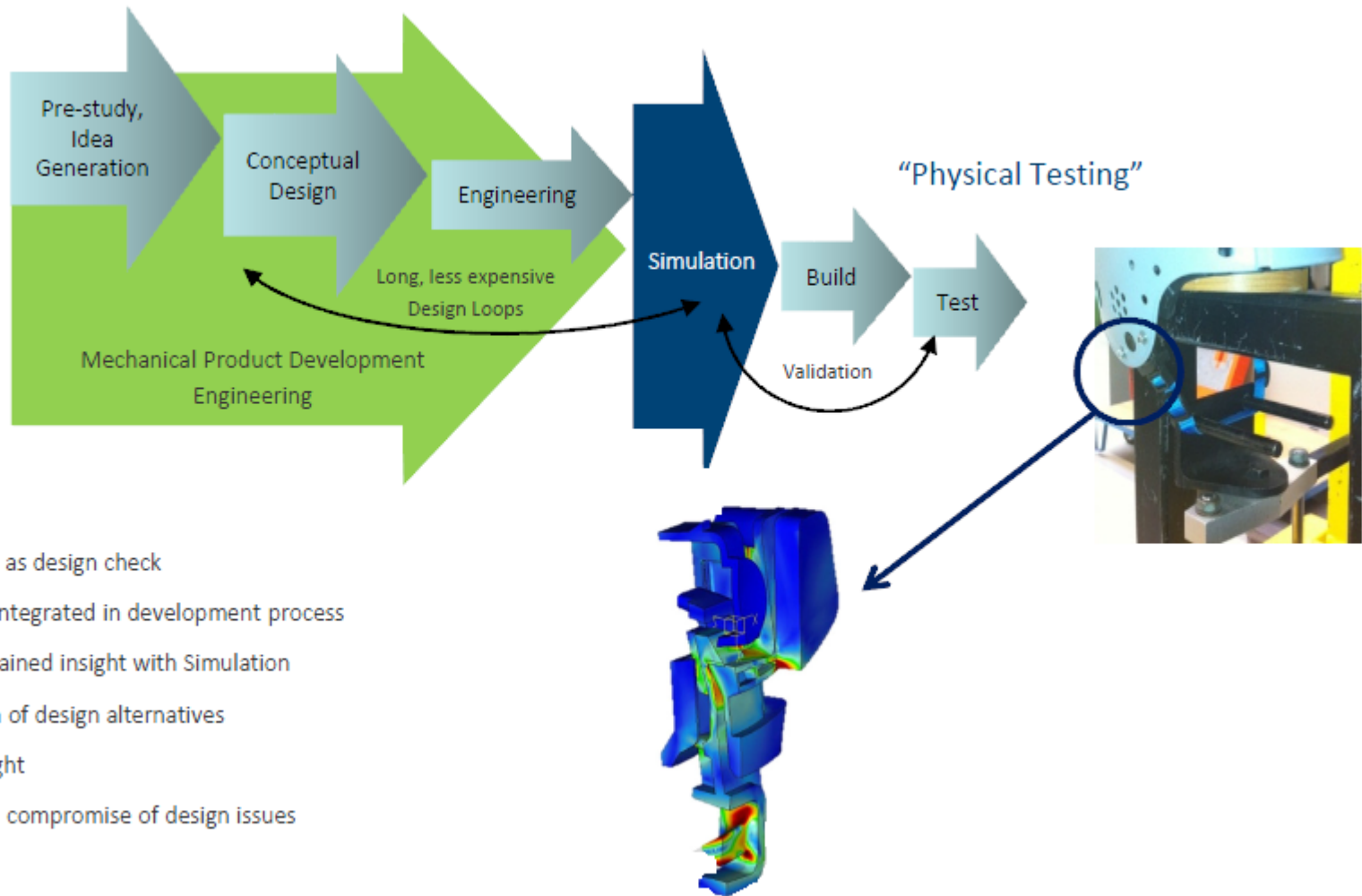


# Virtual prototyping: aims.

- Use an electronic model to test and predict behavior
- Increase knowledge on the design
- Limit the number of physical prototypes
- Limit the costs
- Limit the efforts
- Shorten the time to production/market



# Product design: Virtual testing.

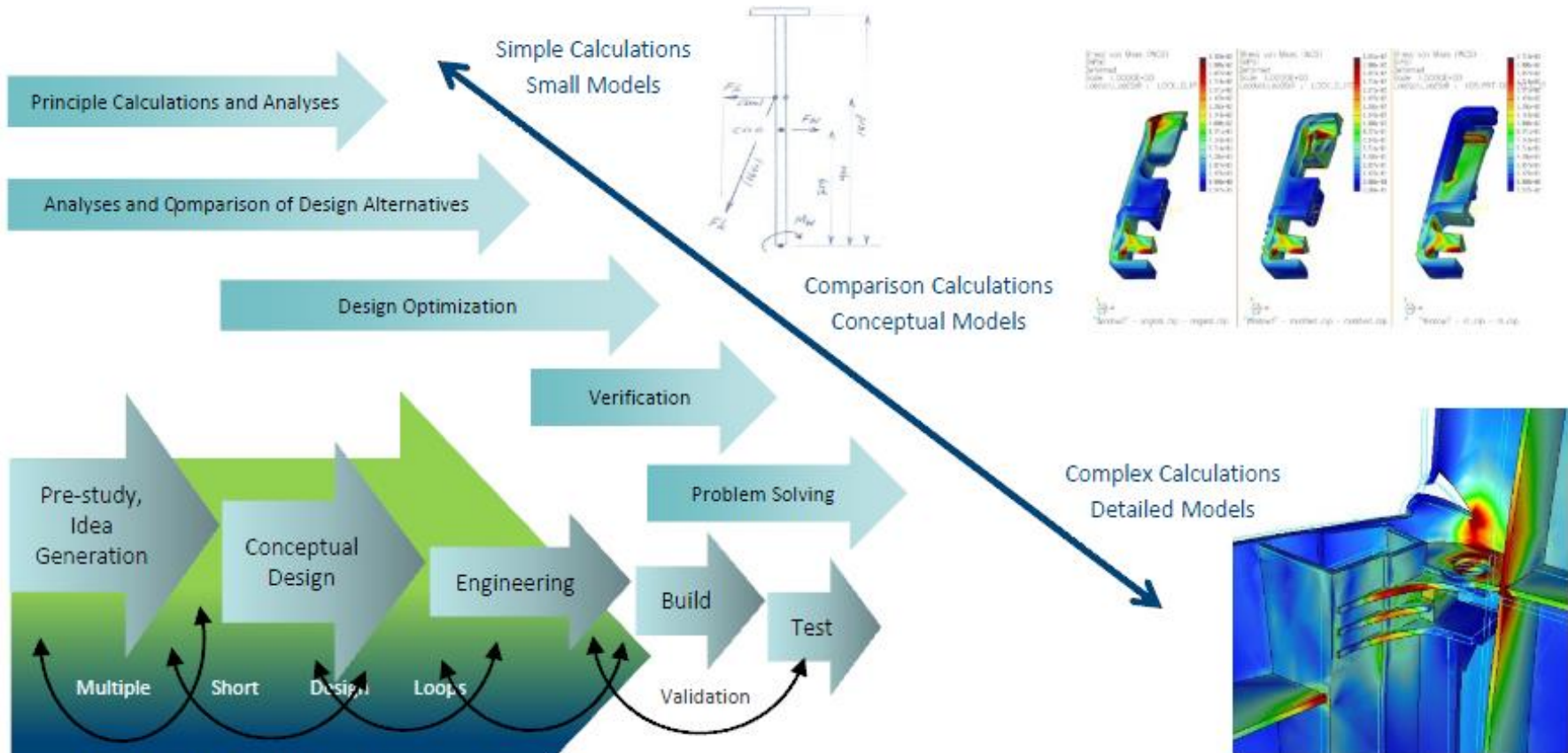


## Characteristics:

- Simulation used as design check
- Simulation not integrated in development process
- Limited use of gained insight with Simulation
- No investigation of design alternatives
- Not first time right
- End result is still compromise of design issues



# Product design: "Insight driven engineering"

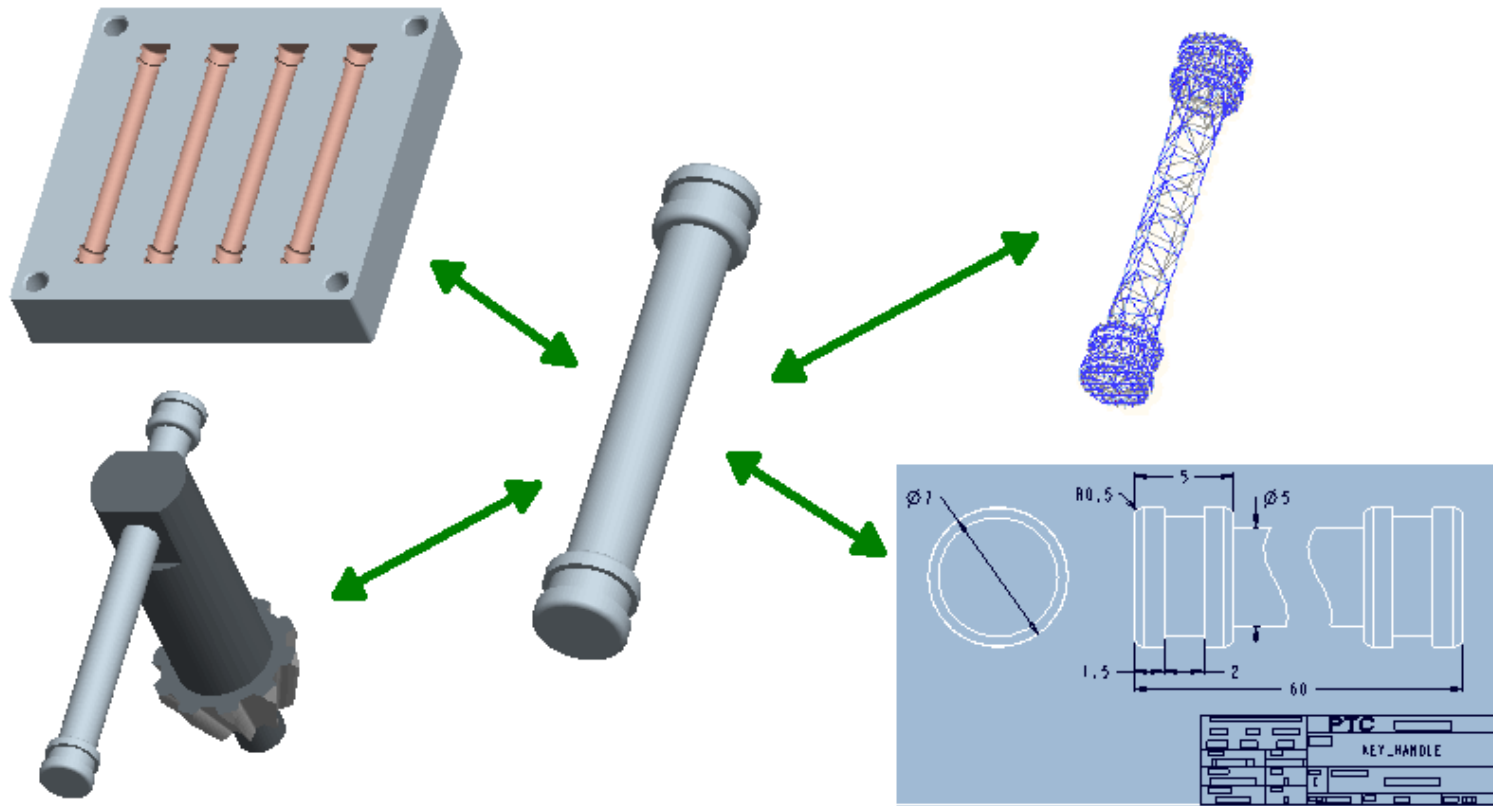


- Early insight in product behavior
- Ability to compare many design alternatives
- Short and low cost design loops
- Less physical prototypes
- First Time Right approach
- Concept optimized and based on insight

- Short Time to Market
- High Quality
- Low Costs

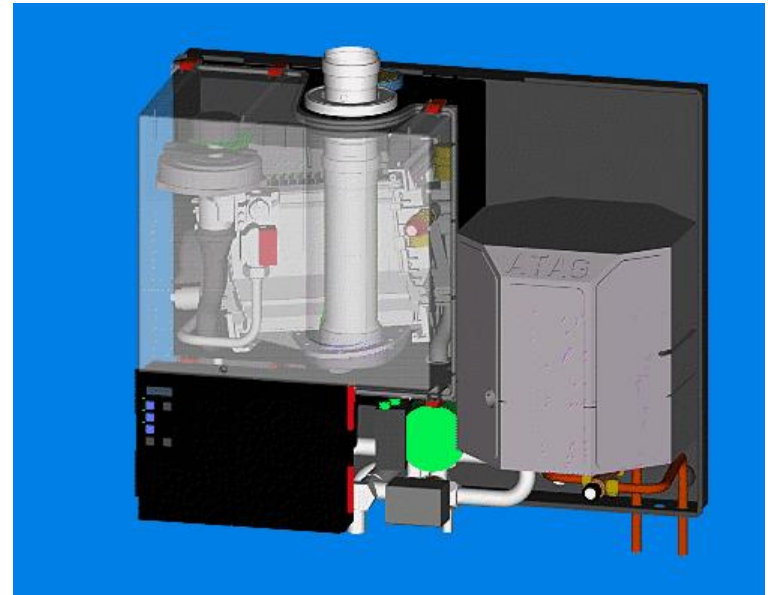


# MCAD (Mechanical CAD): Model oriented.

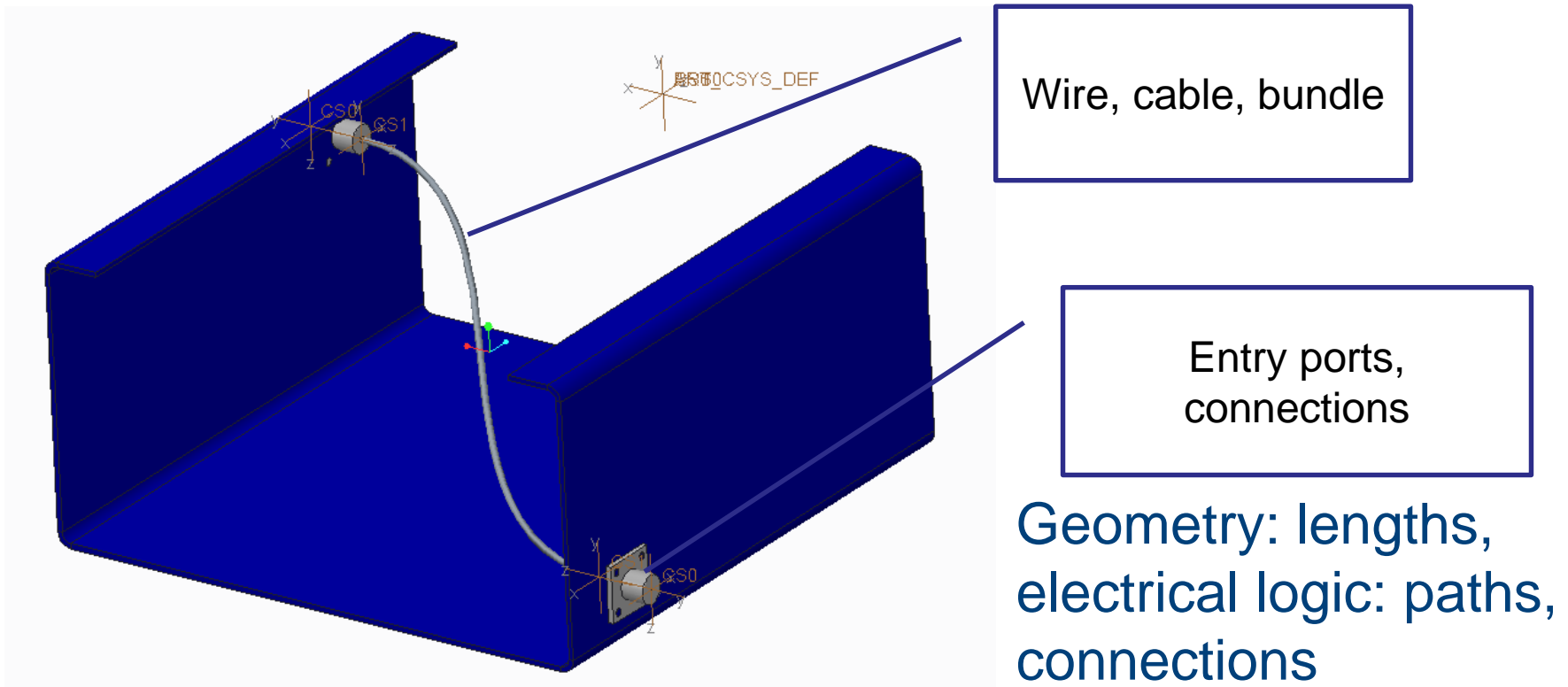


# MCAD (Mechanical CAD): CREO/ProEngineer

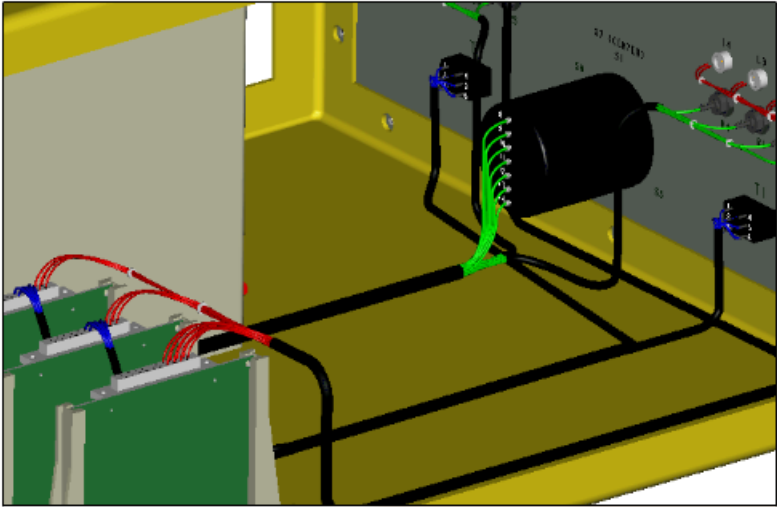
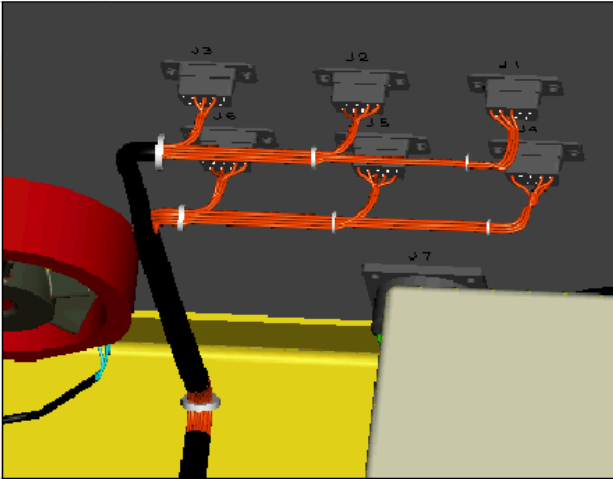
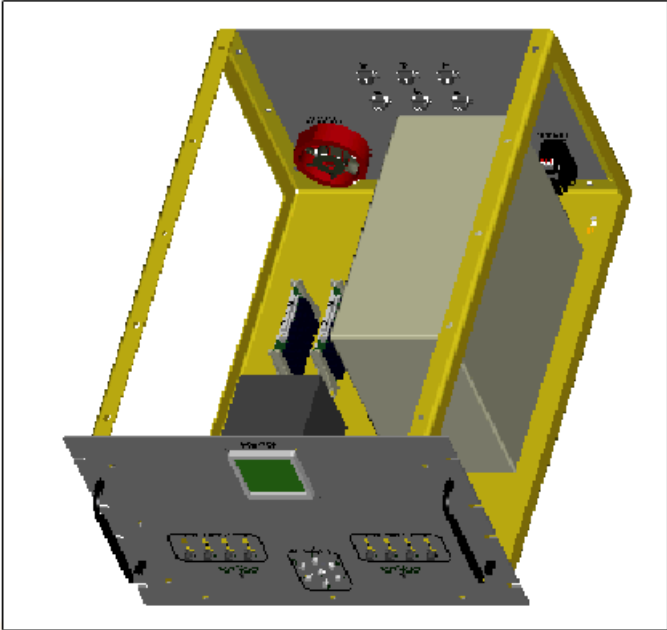
- No compromise on design
- From simple to complex design



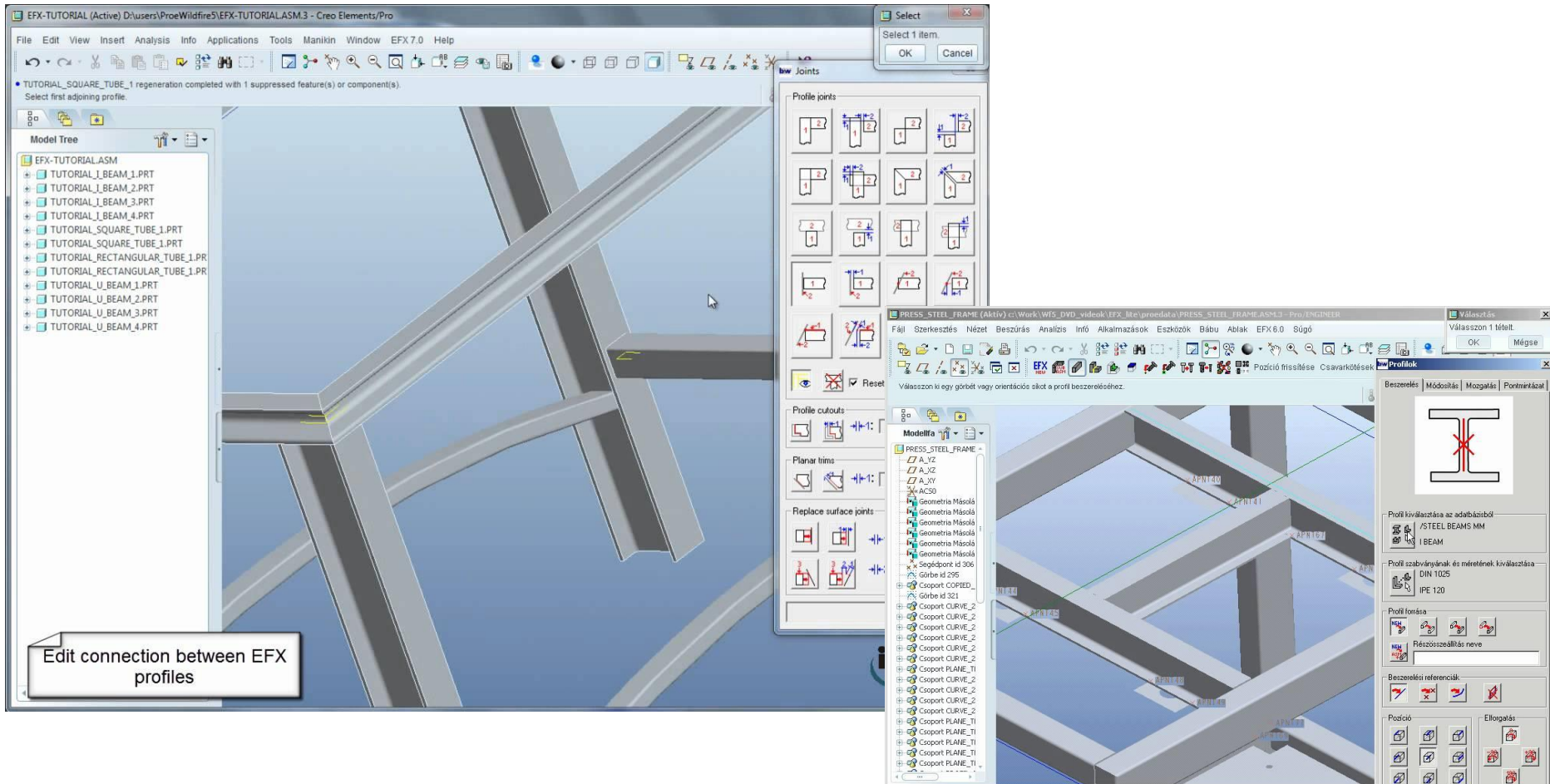
# Cable harness: cabling.



# Cabling: interfacing hardware



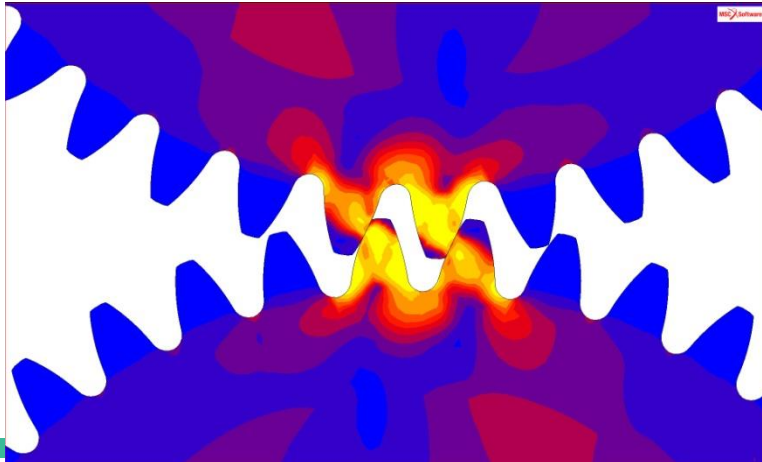
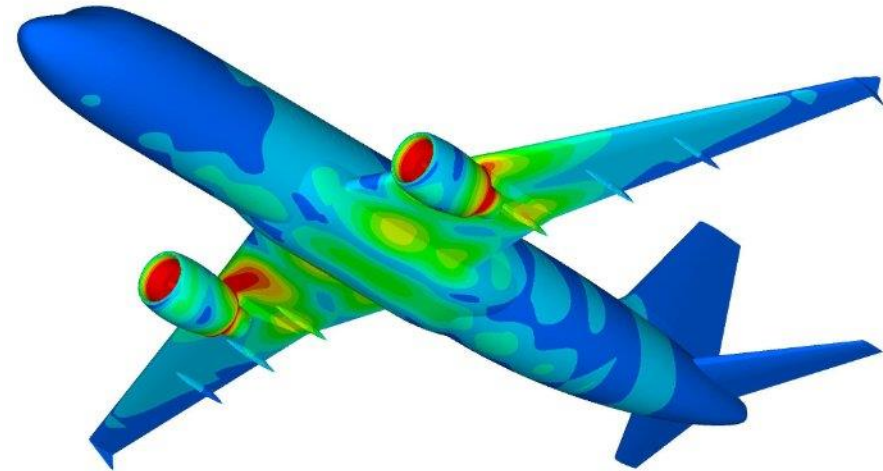
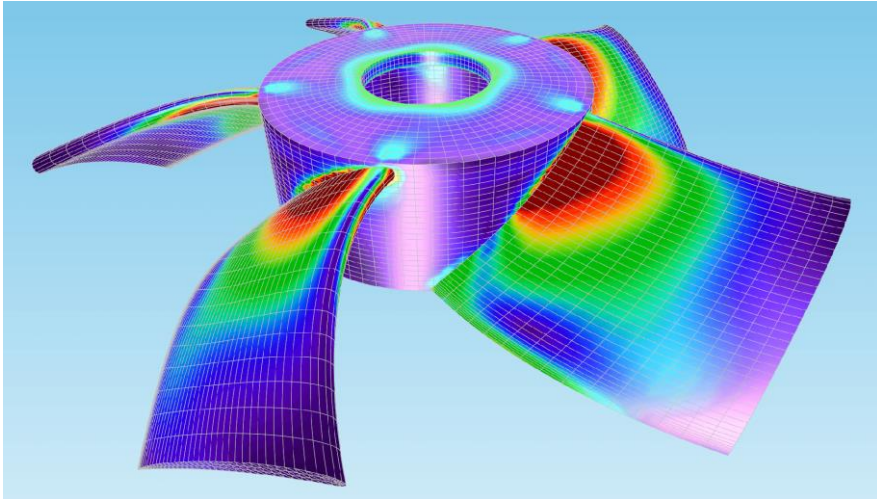
# Framework extension:



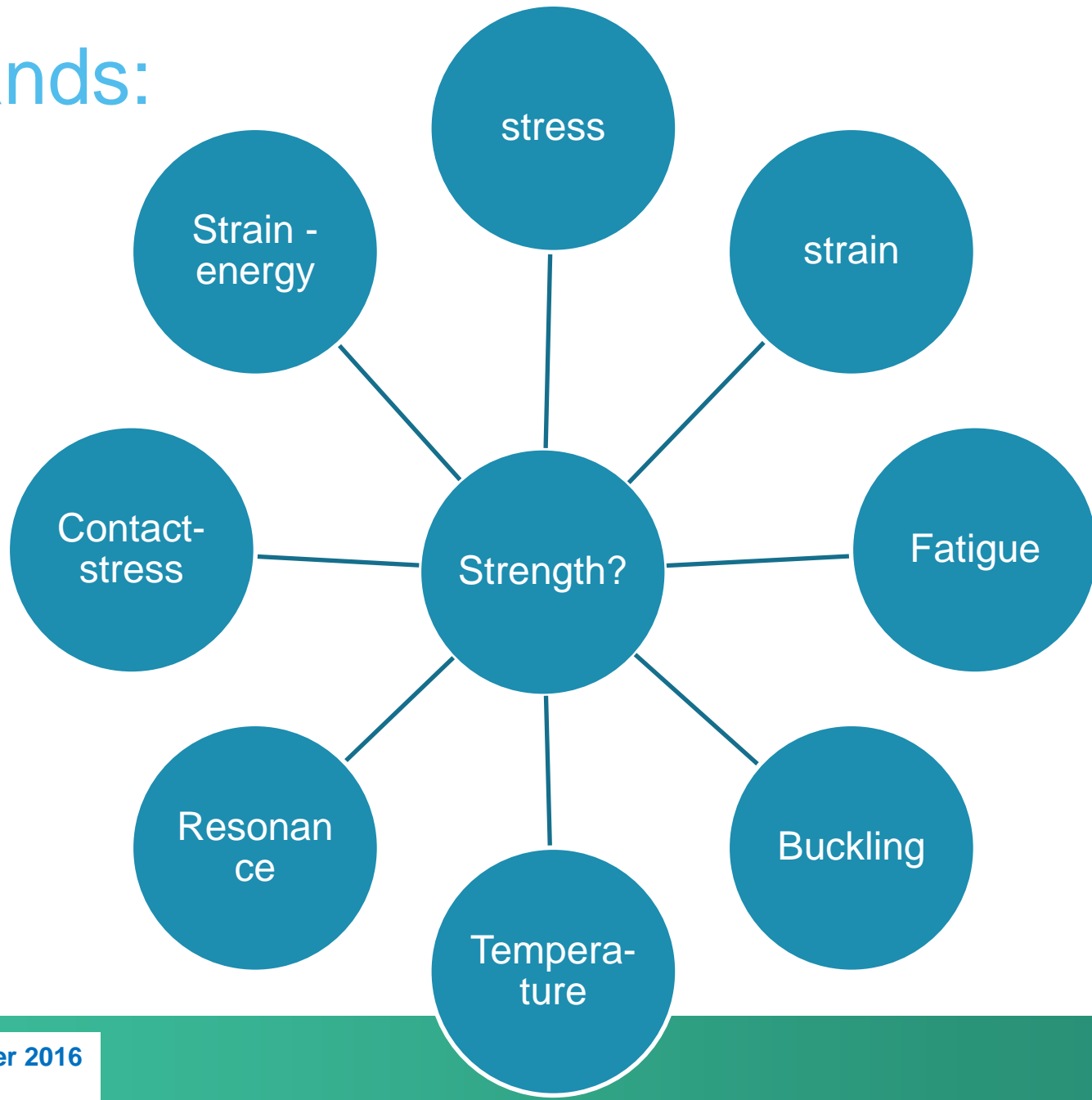
Edit connection between EFX profiles



# FEA (Finite Element Analysis)



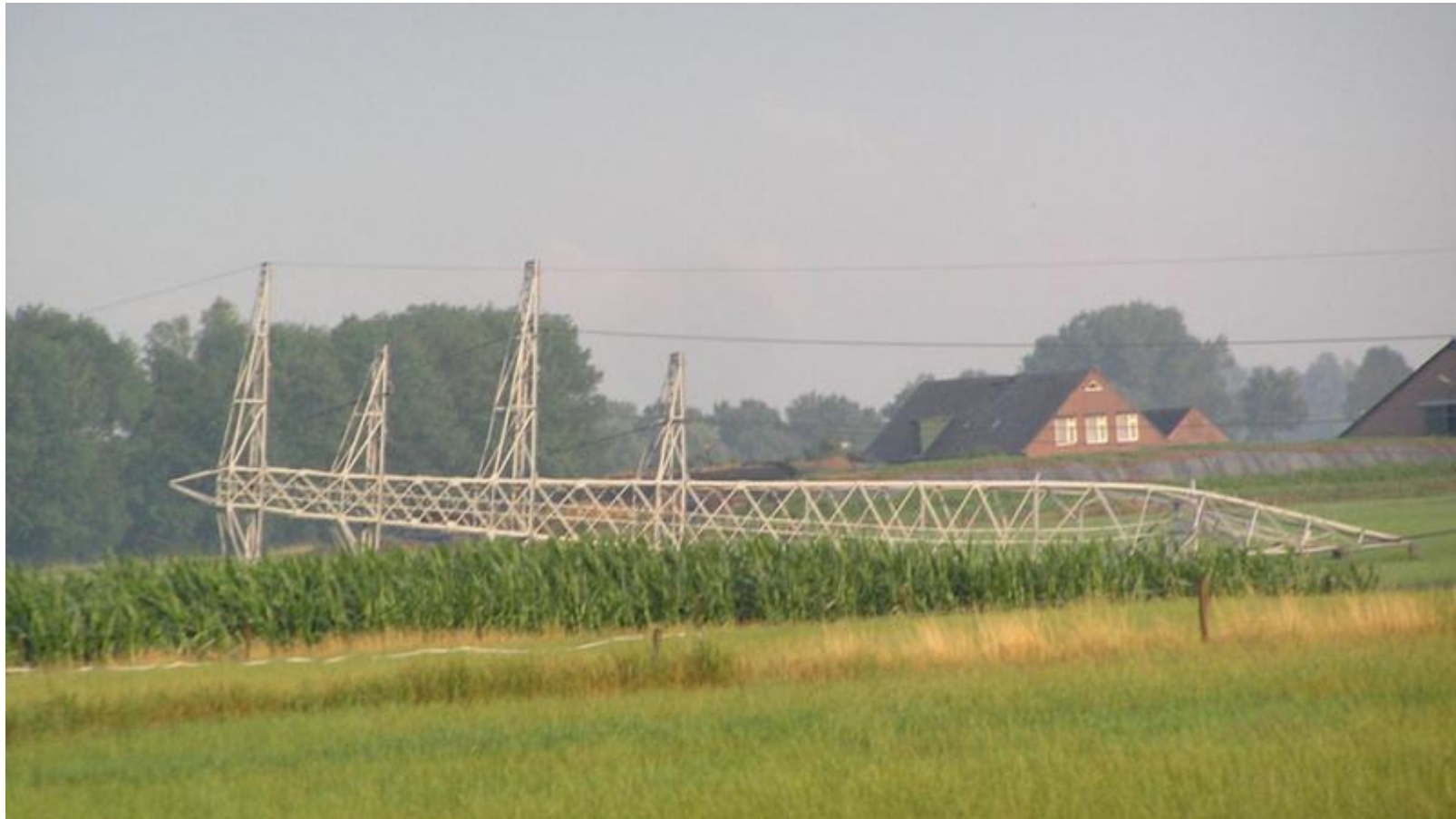
# Demands:



# Strain energy.

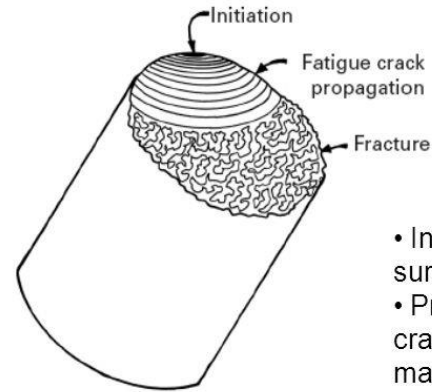


# Intolerable deformation/plasticity.



# Fatigue

## Fatigue Fracture Surface



- Initiation region (usually at the surface)
- Propagation of fatigue crack (evidenced by beach markings)
- Catastrophic rupture when crack length exceeds a critical value at the applied stress.



# Fatigue and stress-concentrations



Edda 2/7C and Alexander L. Kielland (right)

## History

Name: *Alexander L. Kielland*  
Owner: A. Gowart-Olsen A/S  
Operator: Stavanger Drilling II  
Builder: Compagnie Francaise d'Entreprises  
Métalliques (CFEM), Dunkerque, France  
Launched: 5 June 1976  
Fate: capsized / sunk at  56.464839°N  
3.104464°E

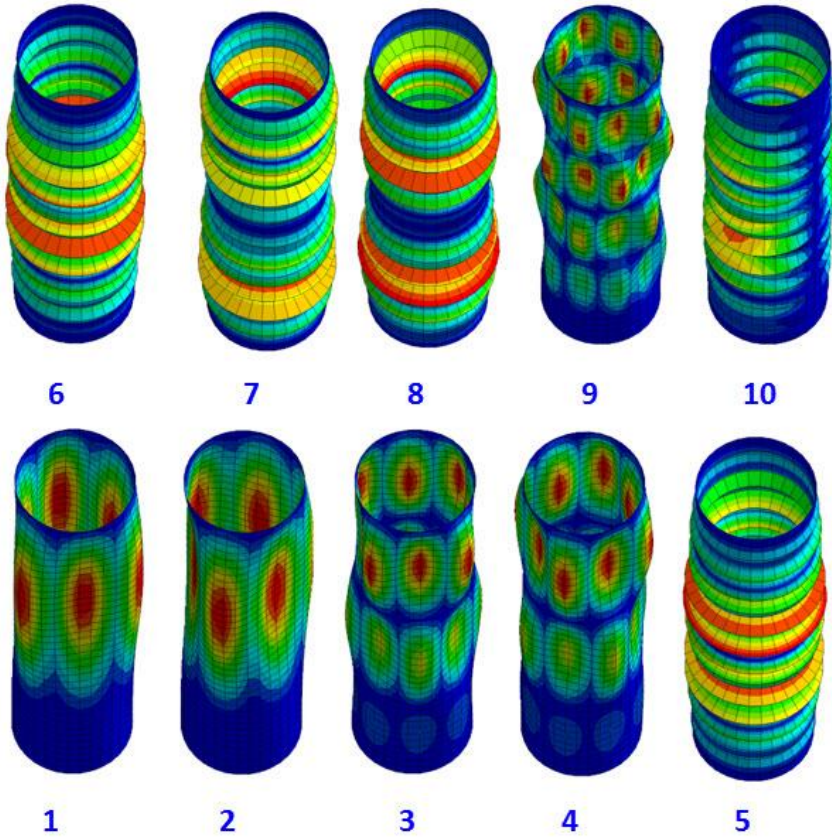
## General characteristics

Length: 103 m (338 ft)  
Beam: 99 m (325 ft)

- Alexander Kielland oilrig.

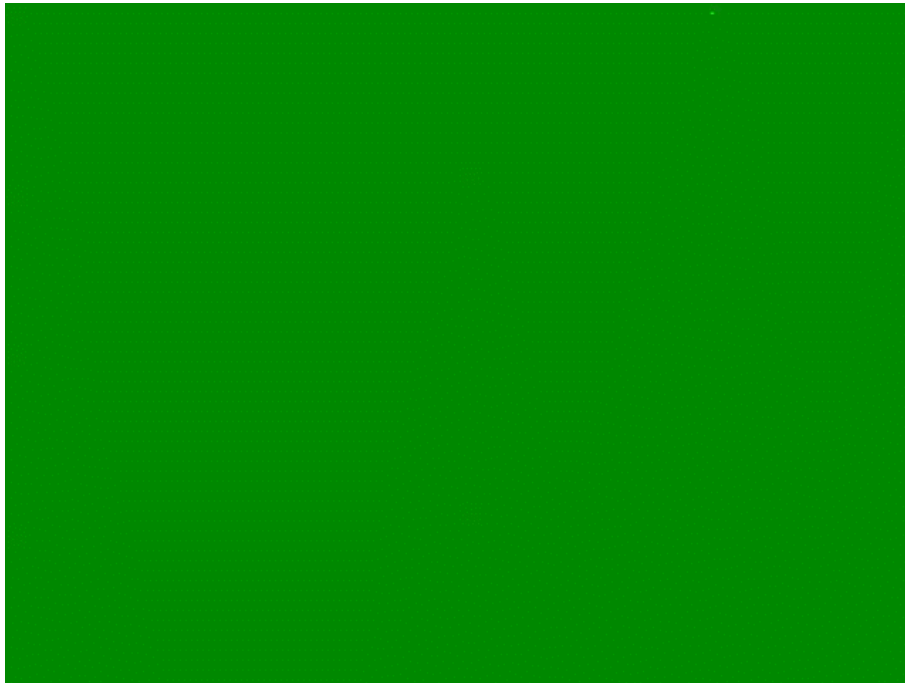


# Buckling.

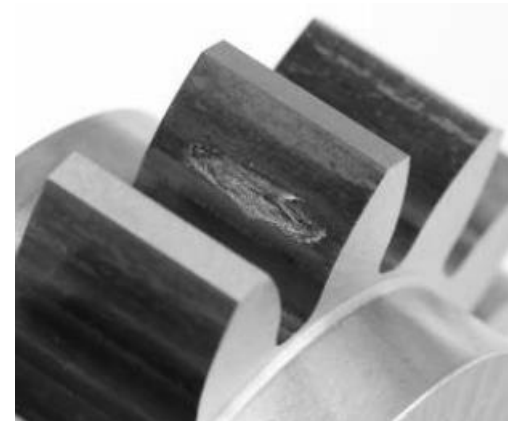
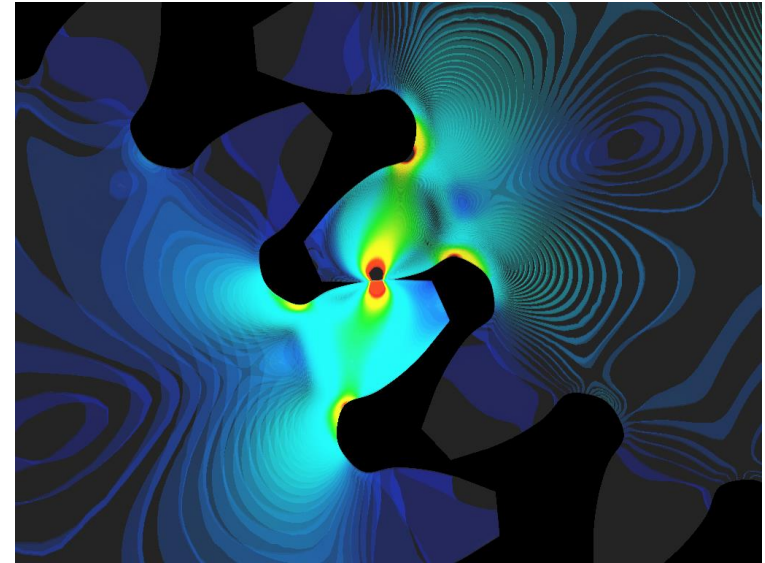
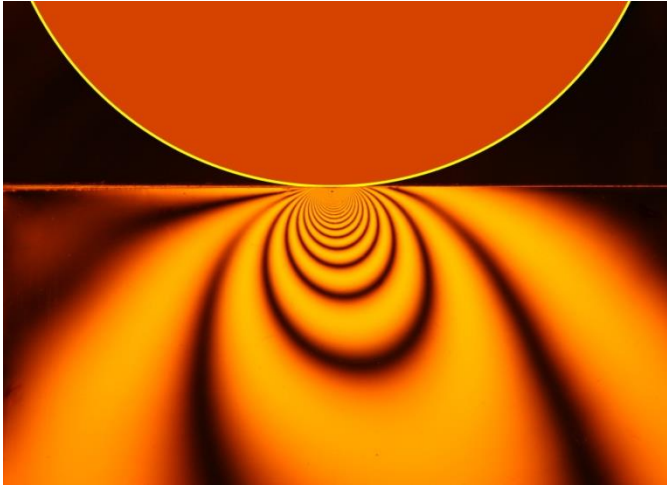


# Resonance.

- Tacoma Narrows bridge.

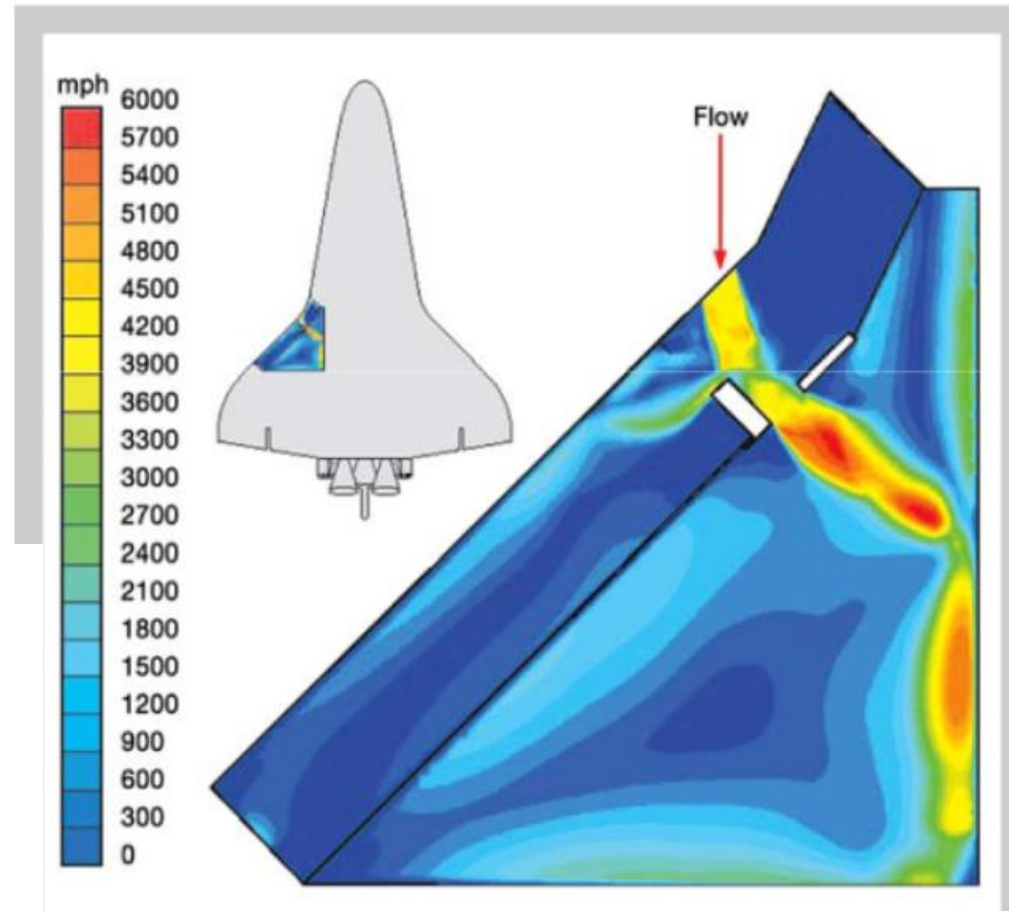
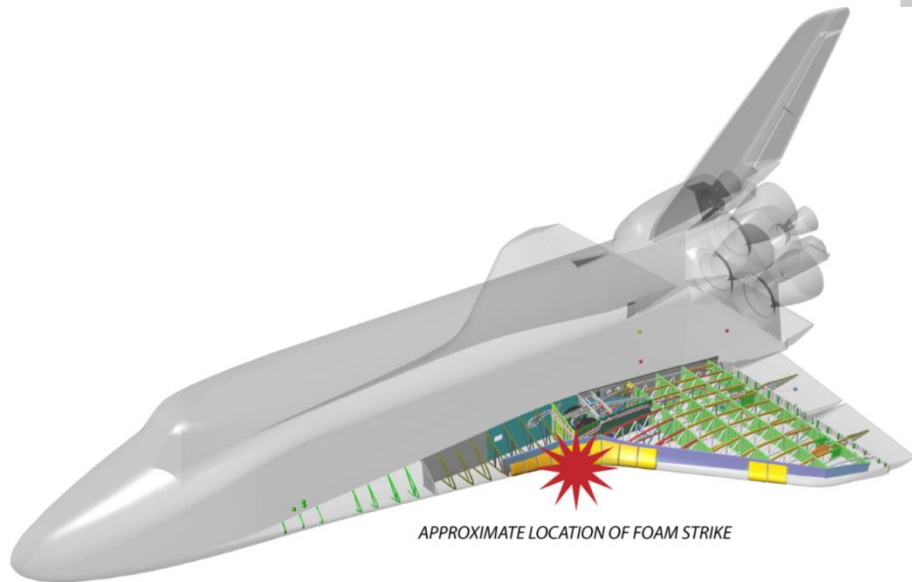
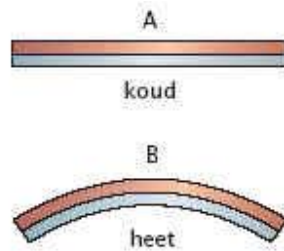


# Contact stress.



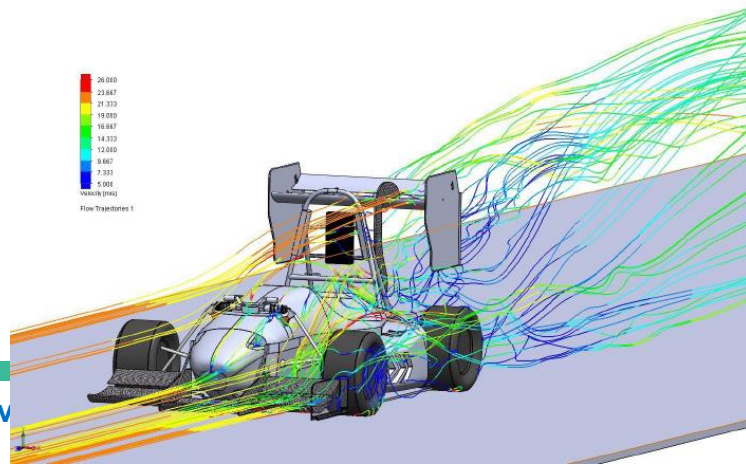
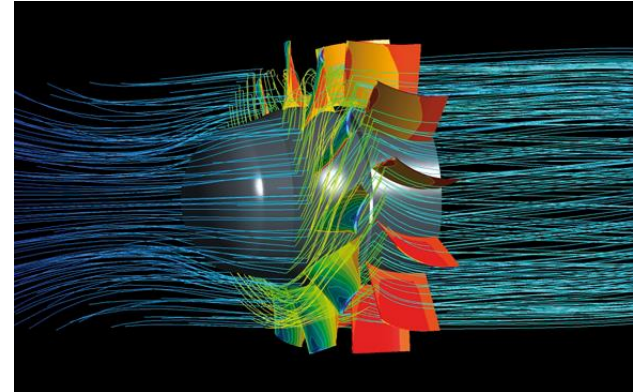
# Temperature

- Bimetal



The accident inquiry concluded that the damage to the heat shield material on the leading edge of the left wing allowed hot gas to penetrate the wing, causing significant internal damage. Both the crew and mission control were unaware of this at the time.

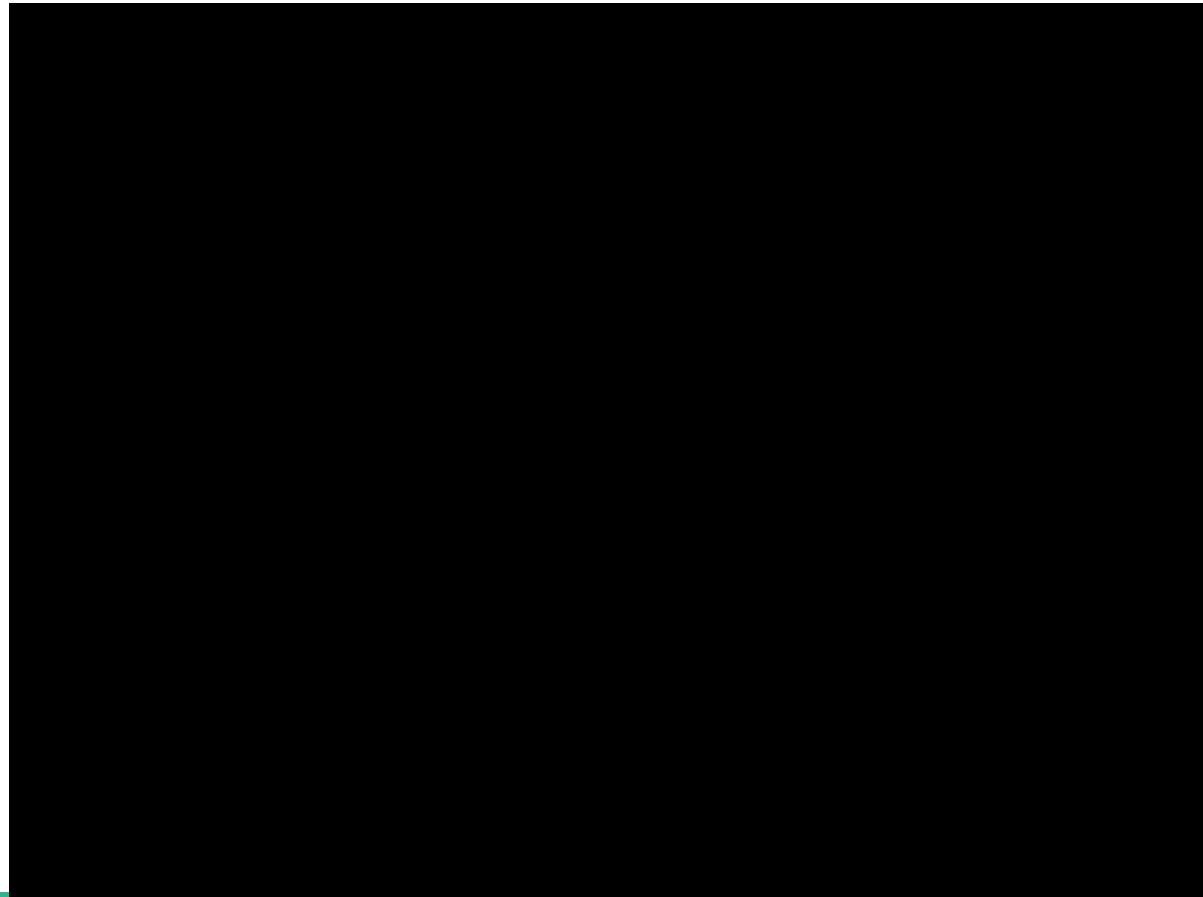
# CFD: Computational Fluid Dynamics\*



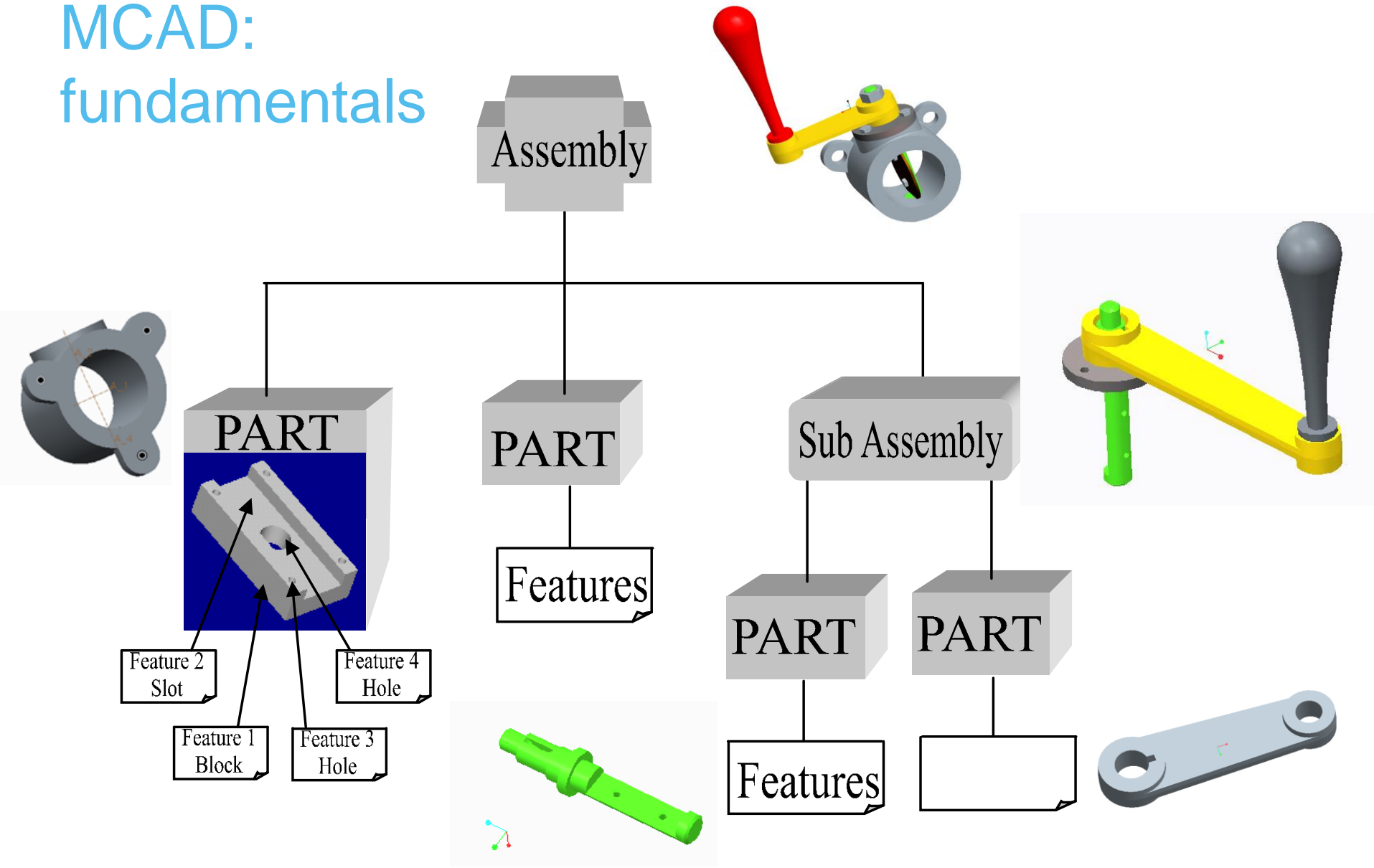


# Manufacturing.

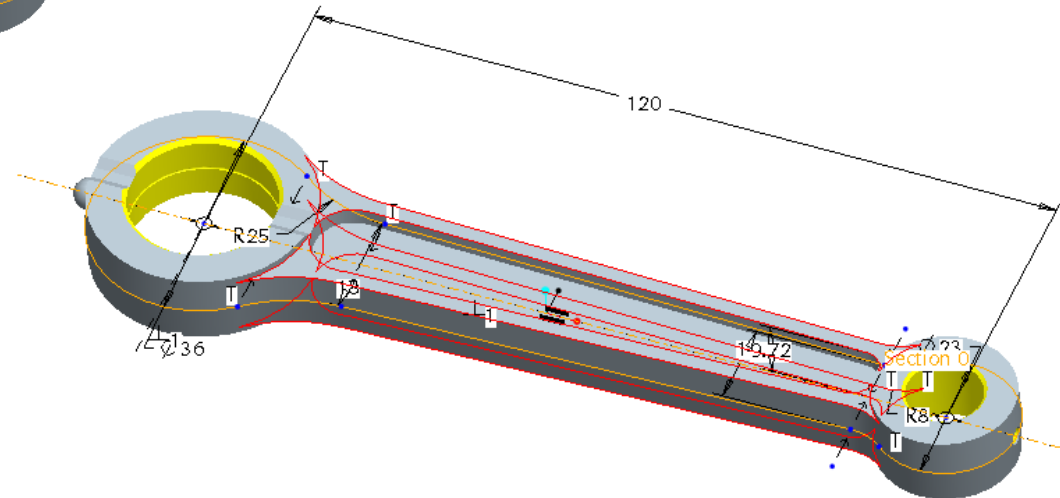
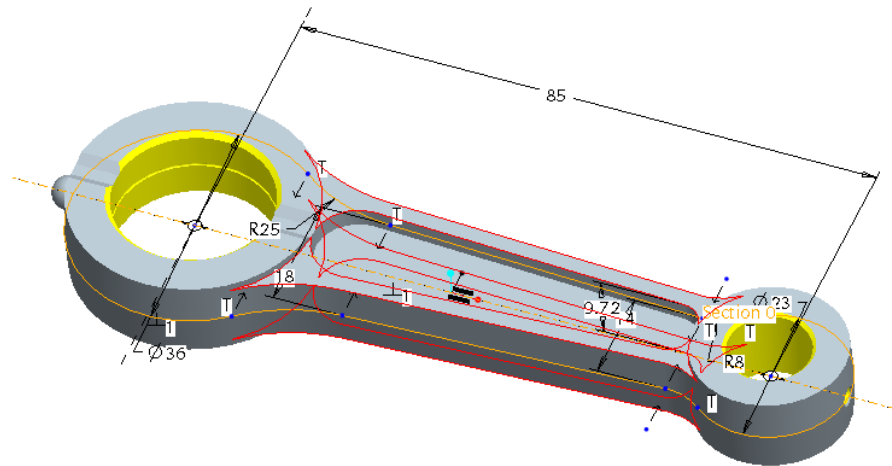
- Creating toolpaths
- Simulation
- First-time right



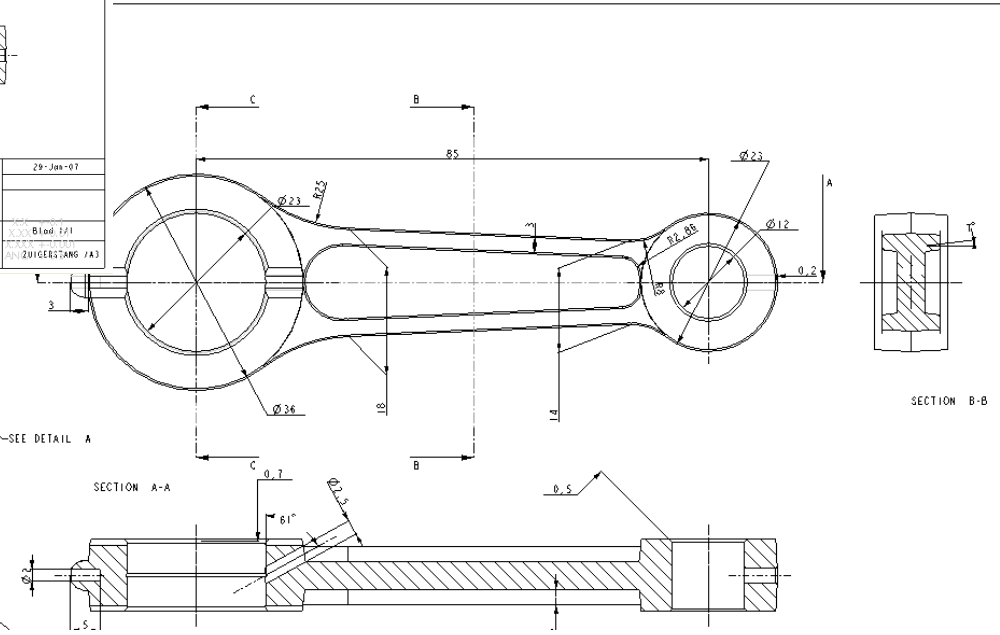
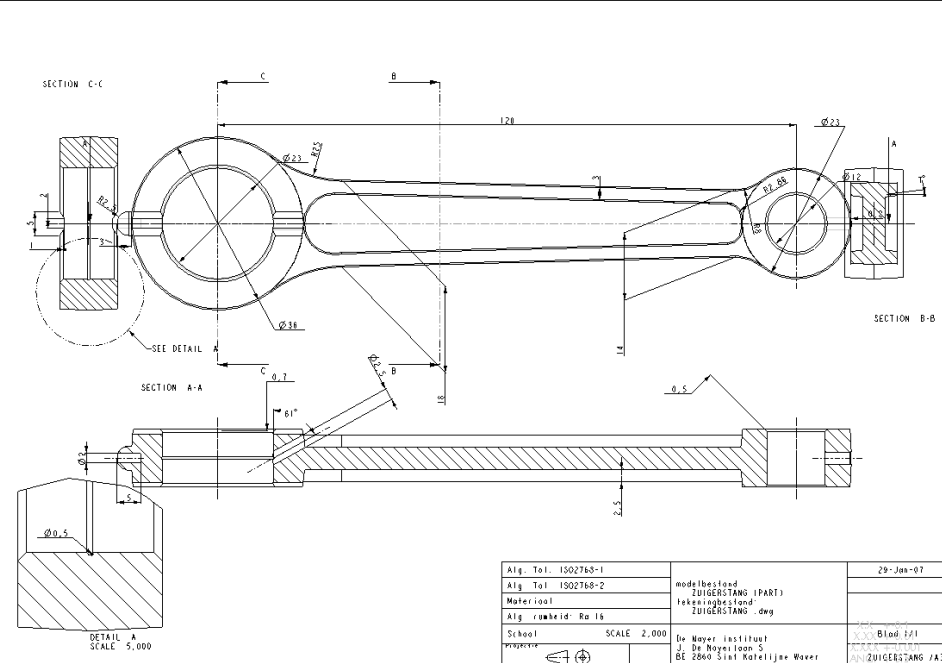
# MCAD: fundamentals



# Parametric: dimensions drive the design



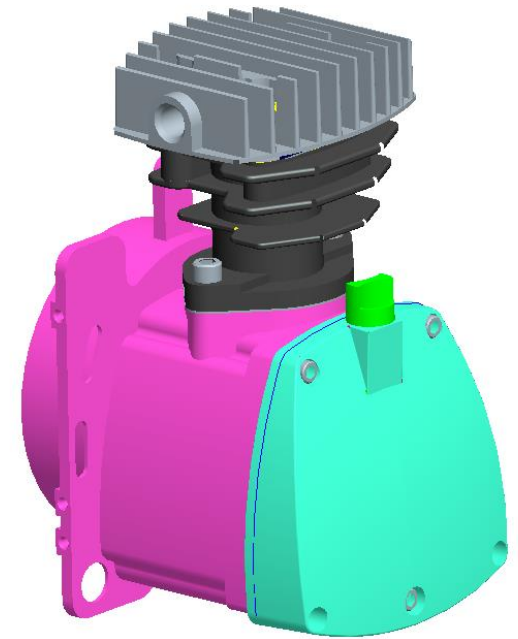
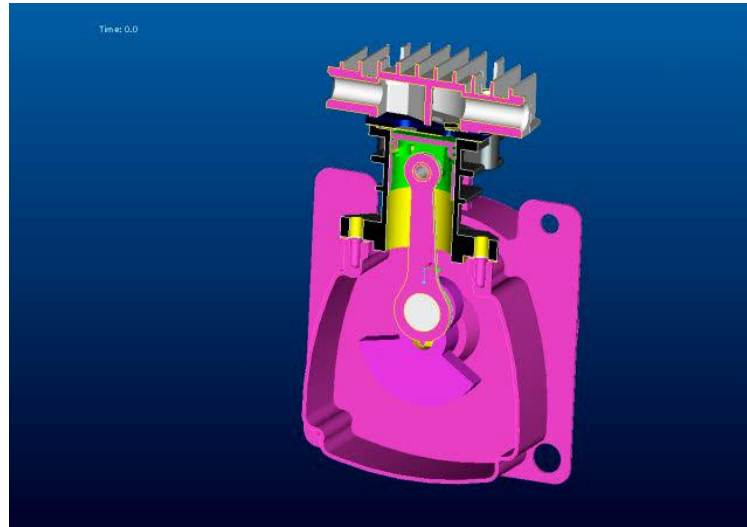
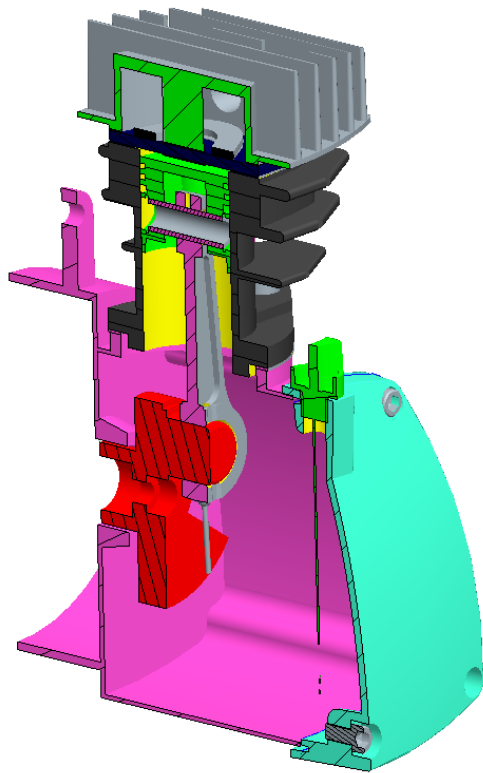
# Associative

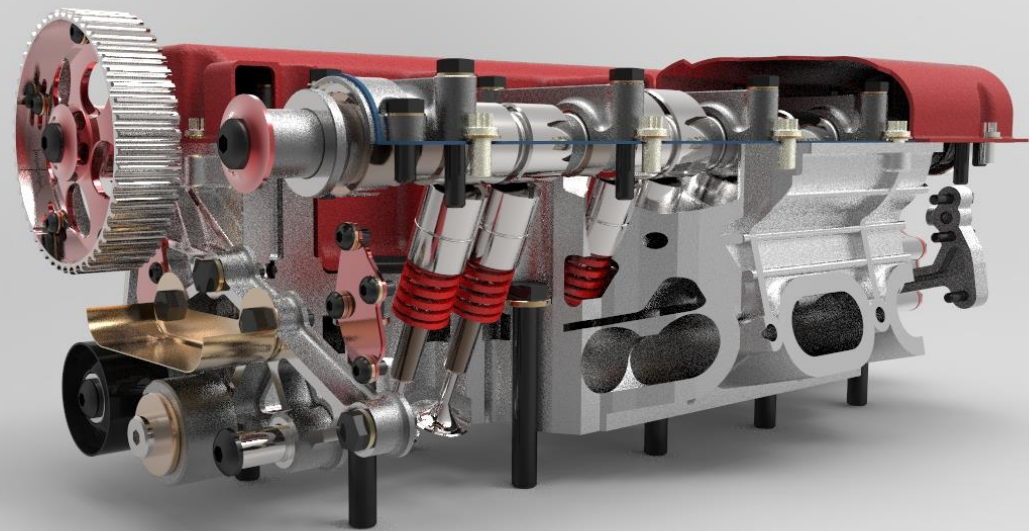


# Some student examples:



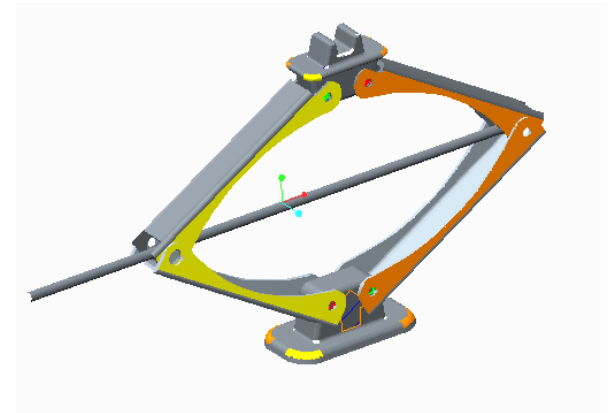
# Air compressor



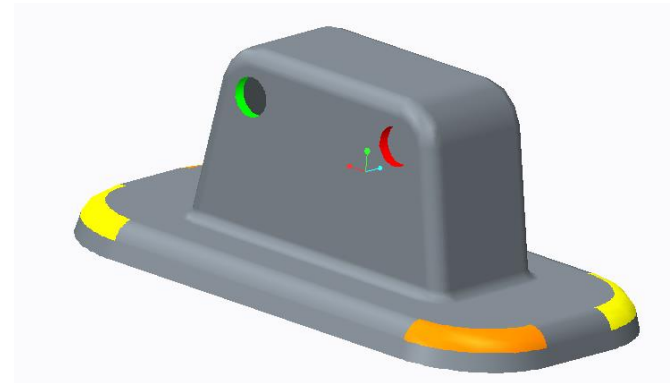
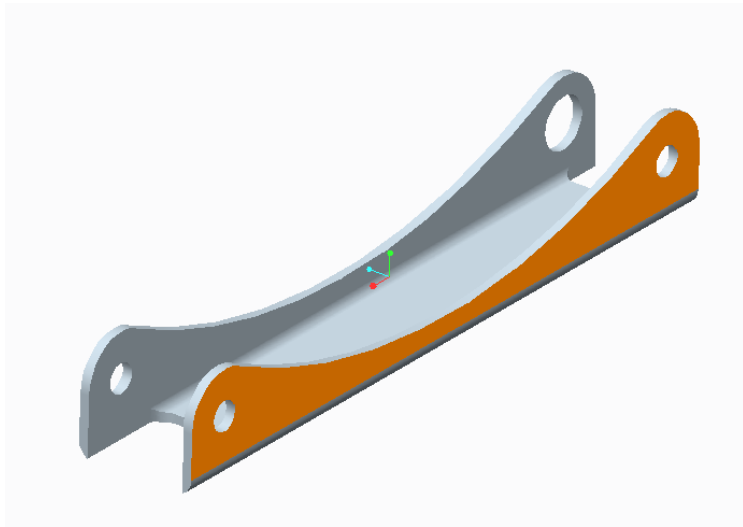


# Case study: car jack.

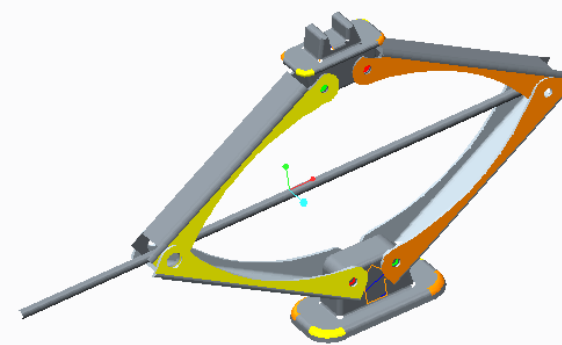
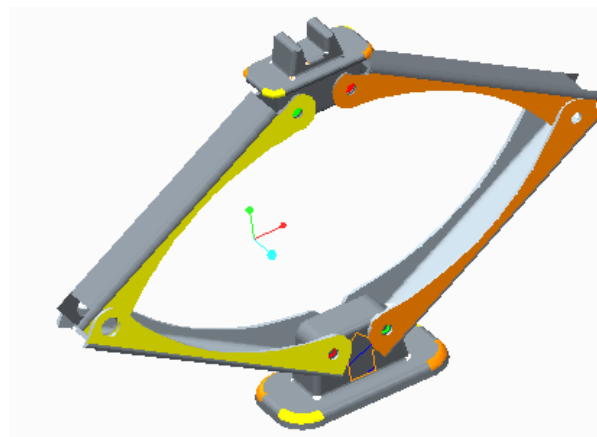
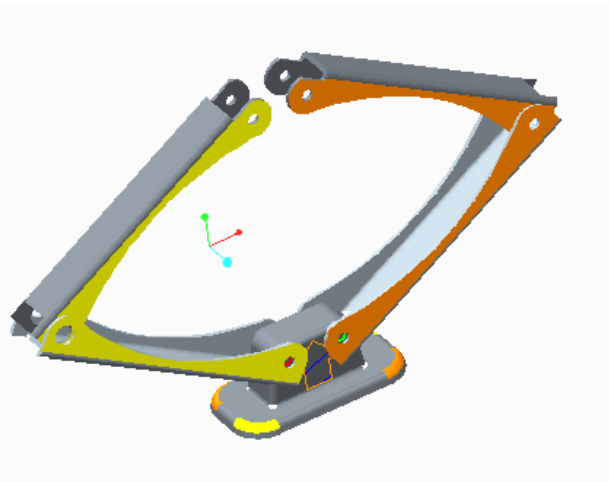
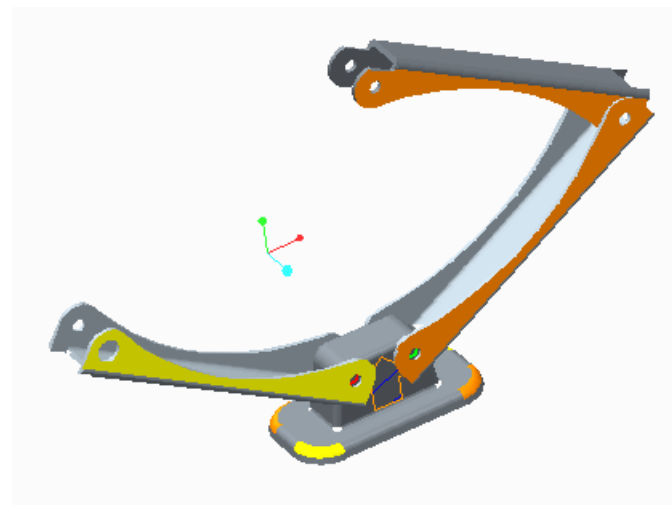
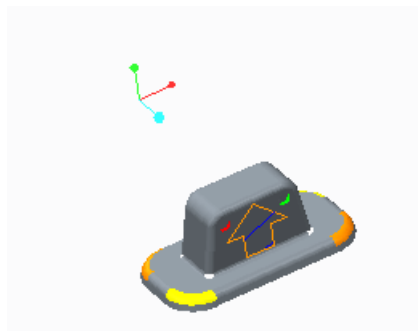
- Aim: make a car jack, able to lift the car.
  - Force to operate not too big
  - Light weight (cost, maneuverability)
  - Strong enough to withstand operation



# Design parts

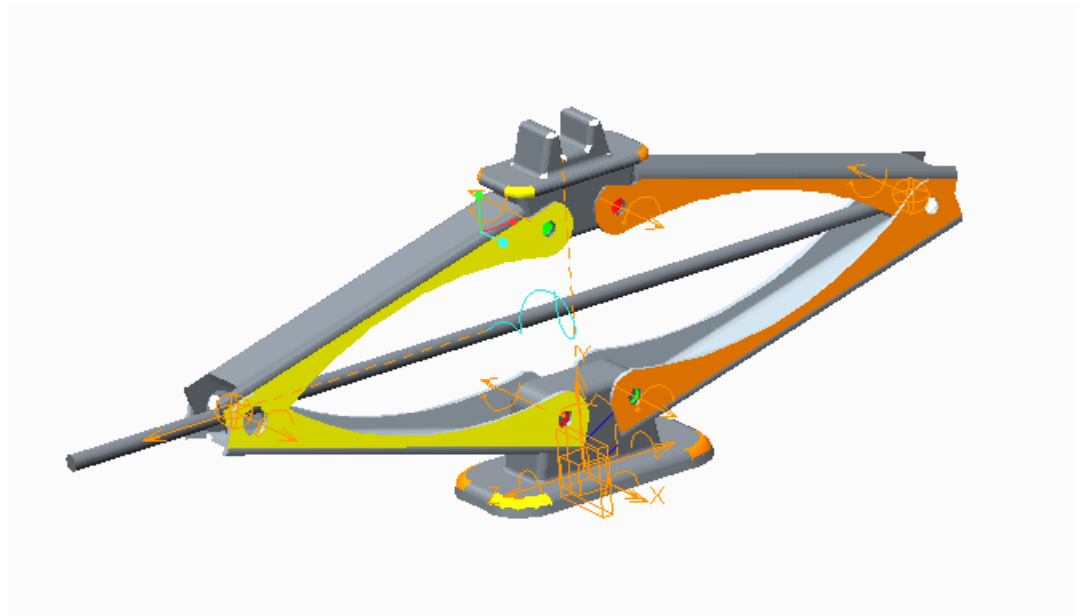


# Make assembly

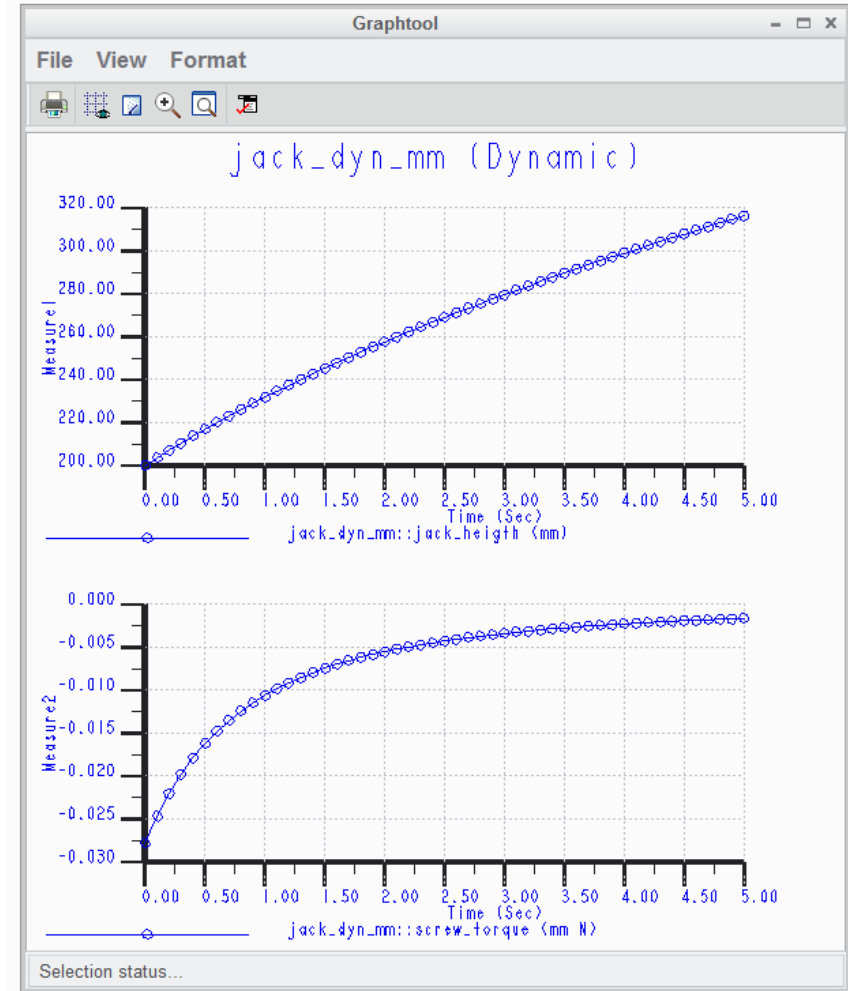
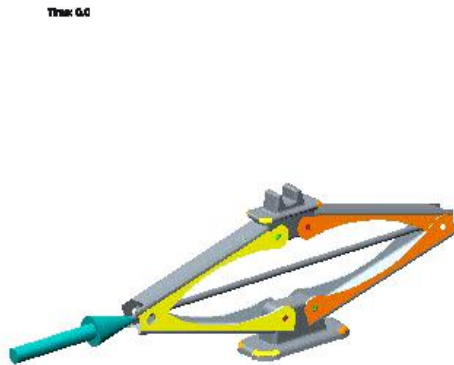


# Make mechanism

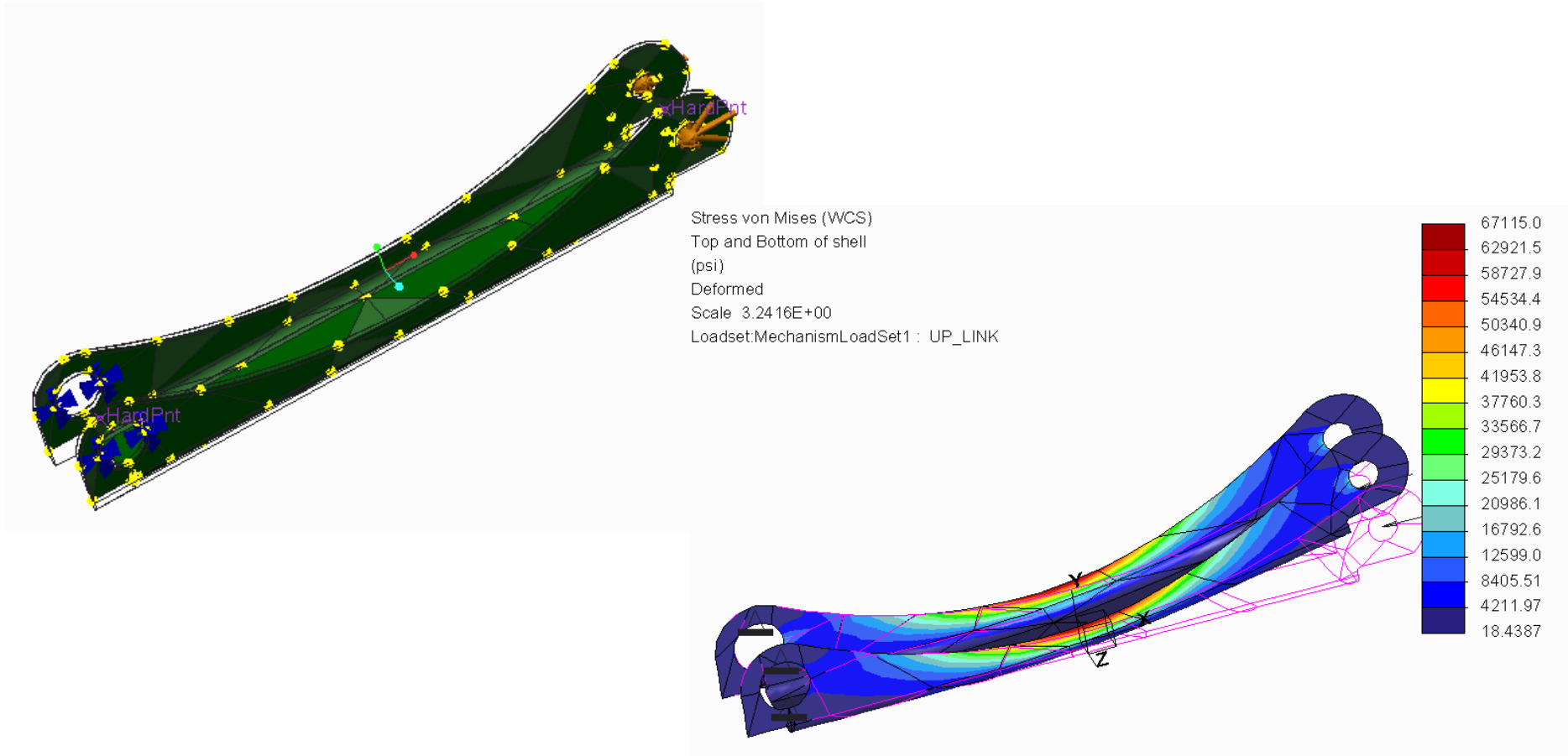
- Include:
  - Motors
  - Measures
  - Conditions
  - ...



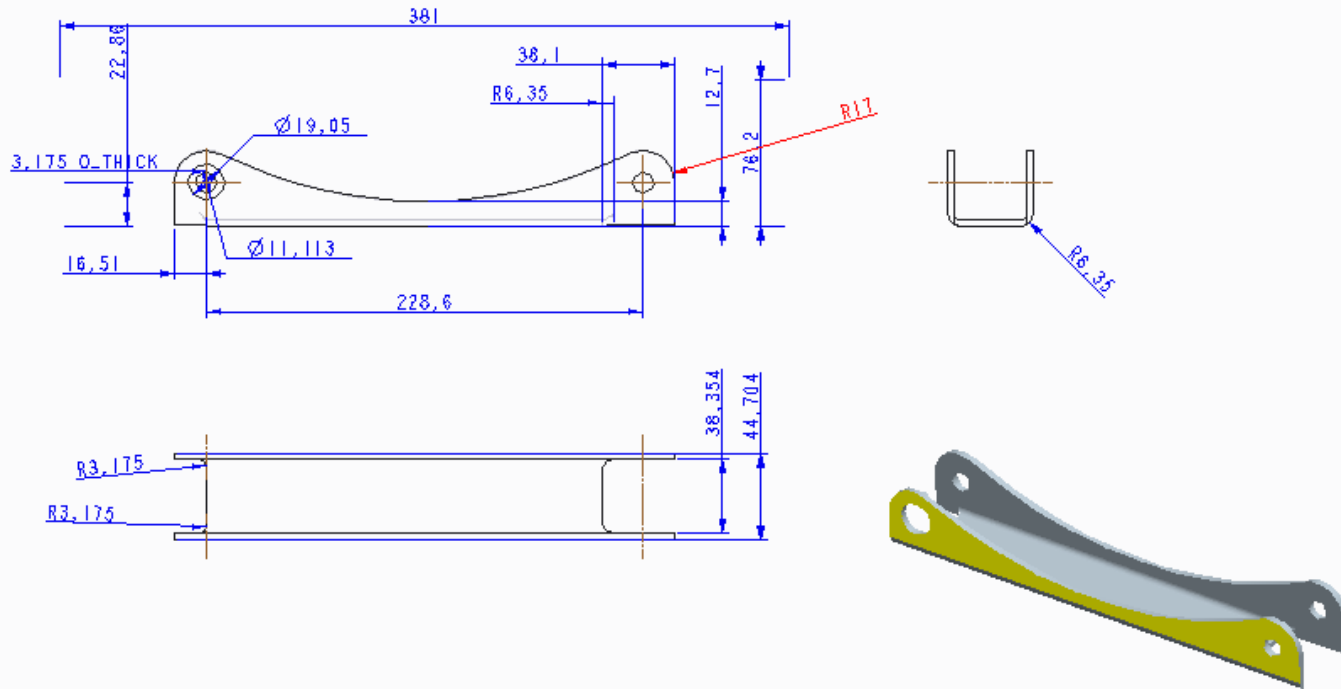
# Mechanism analysis.



# Strength analysis



# Make documentation



|                       |  |                |
|-----------------------|--|----------------|
| Alg. Tel. ISO2768-1 m | Lower link   | Oct-13-15      |
| Alg. Tel. ISO2768-2 K | modelbestand:<br>LW.LINK.MM (PART)   | DESIRE         |
| Materiaal: AL6061     | tekeningbestand:<br>LW.LINK .dwm   | Peter          |
| Alg. ruwheid: Ra 16   |  |                |
| Schaal: 0,500         | KU Leuven - campus De Nayer<br>J.P. De Nayerlaan 5<br>BE 2860 Sint Katelijne Waver | Blad 1/1       |
|                       |  | LW.LINK.NN /A3 |



# Questions?



# Contact

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