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Alloys by design

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Alloys – where are they used?

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- Potential energy in elastic band:

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- Kinetic energy in handgun bullet: $E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 400^2 = 400\,\mathrm{J}$

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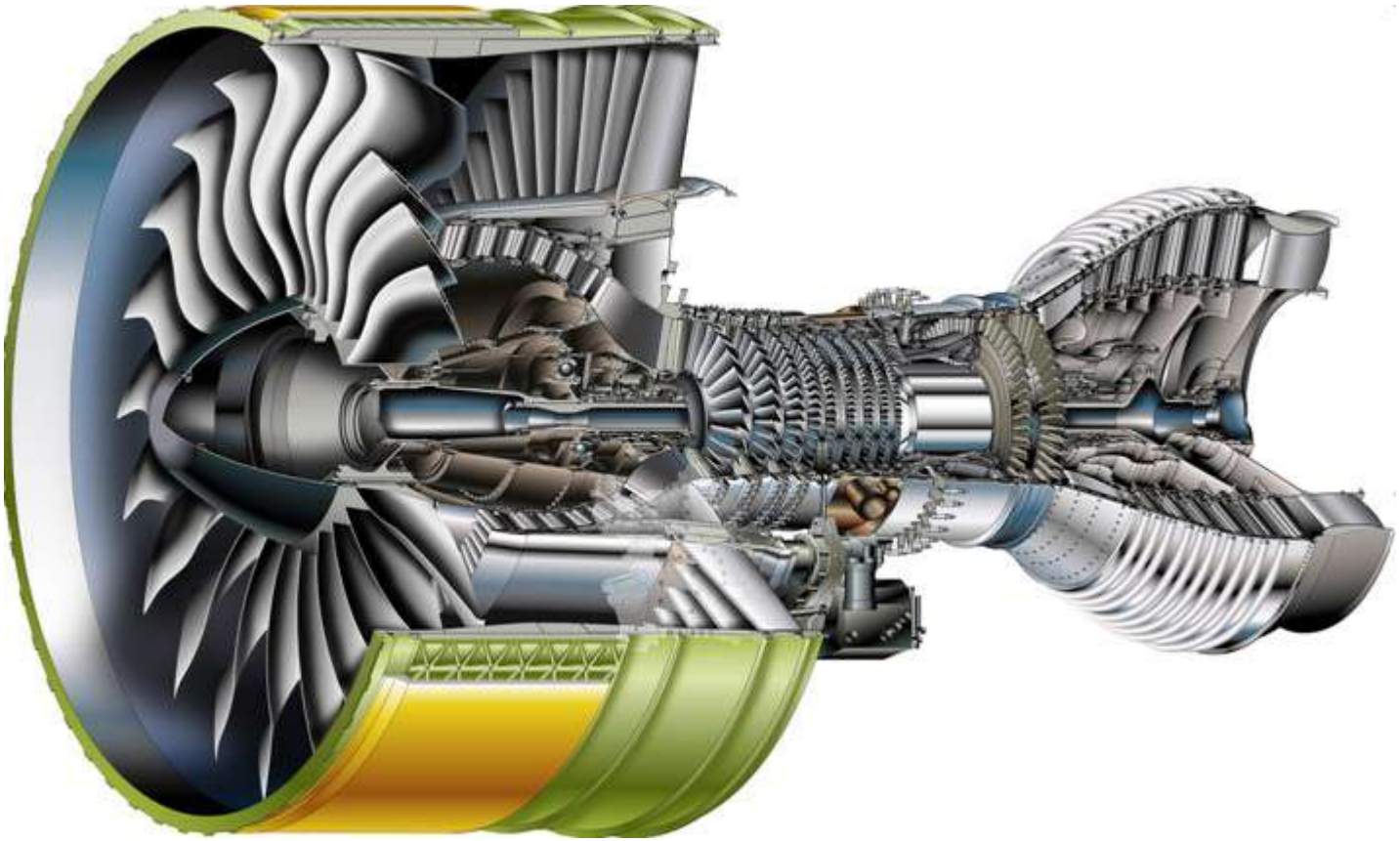
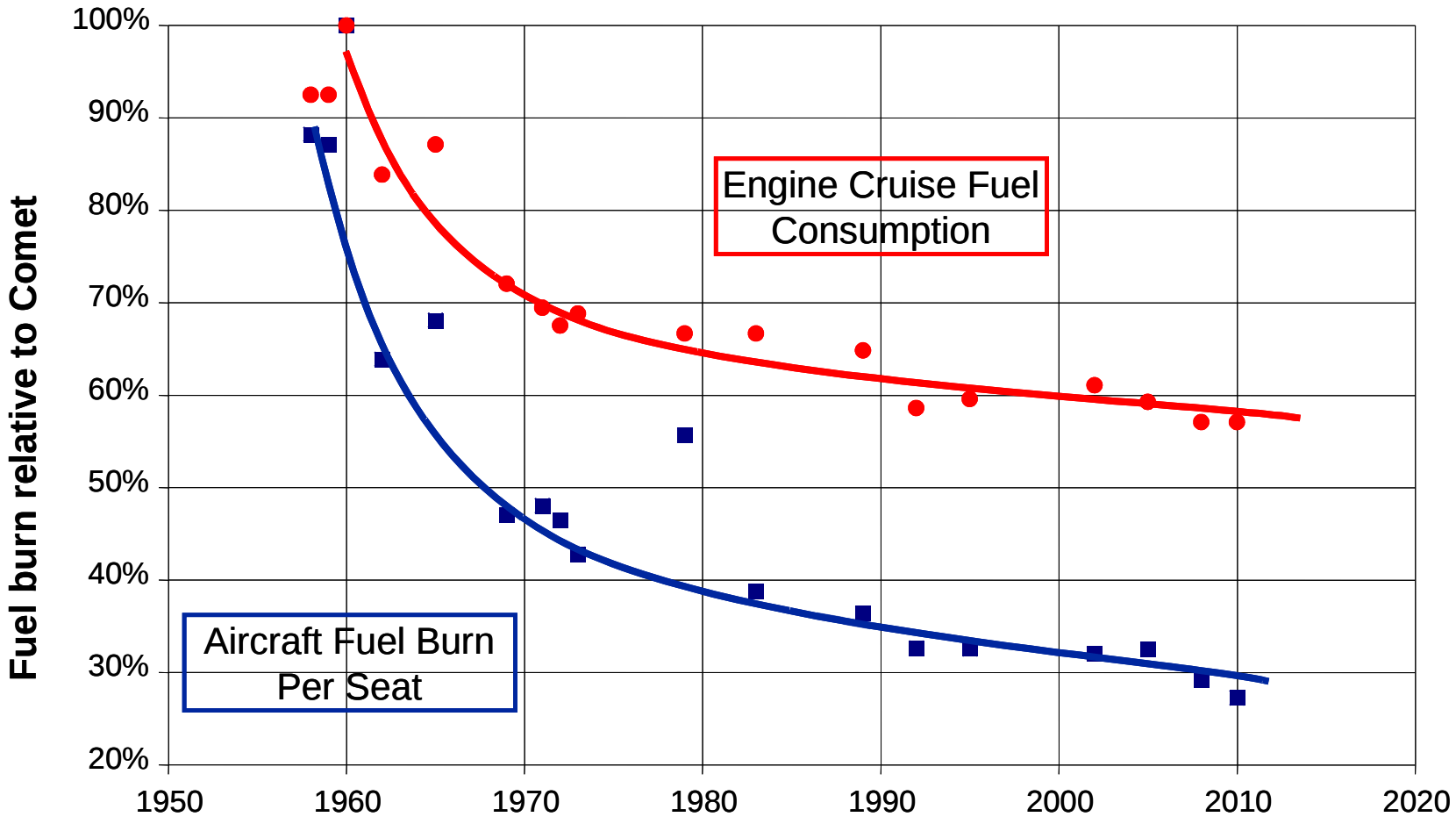
- Kinetic energy in handgun bullet: $E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 400^2 = 400\,\mathrm{J}$
- Potential energy in enormous band: $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}100 \times 10 = 500\,\mathrm{J}$

Alloys – where are they used?

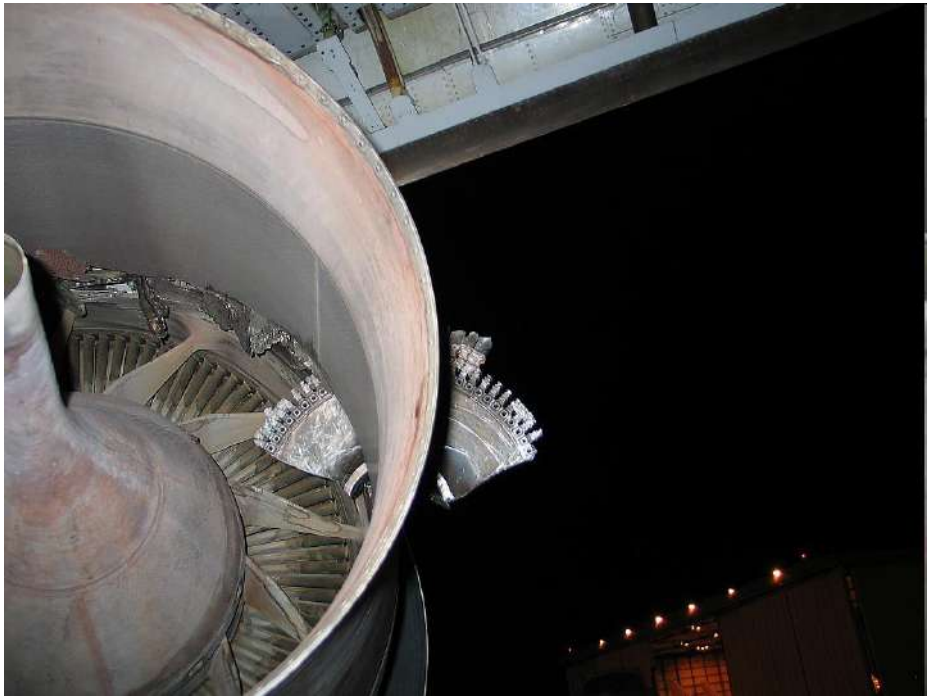
Jet engine: commercial jet



Aircraft fuel efficiency over the past 50 years

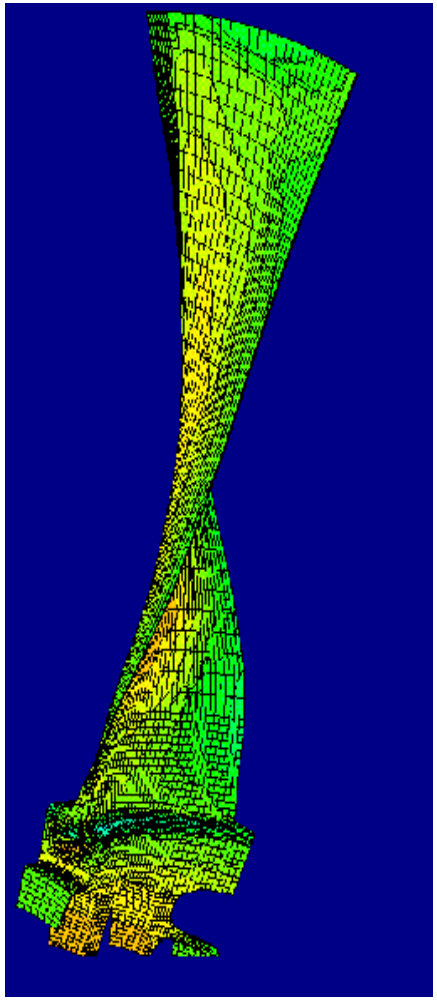


Jet engine: turbine discs

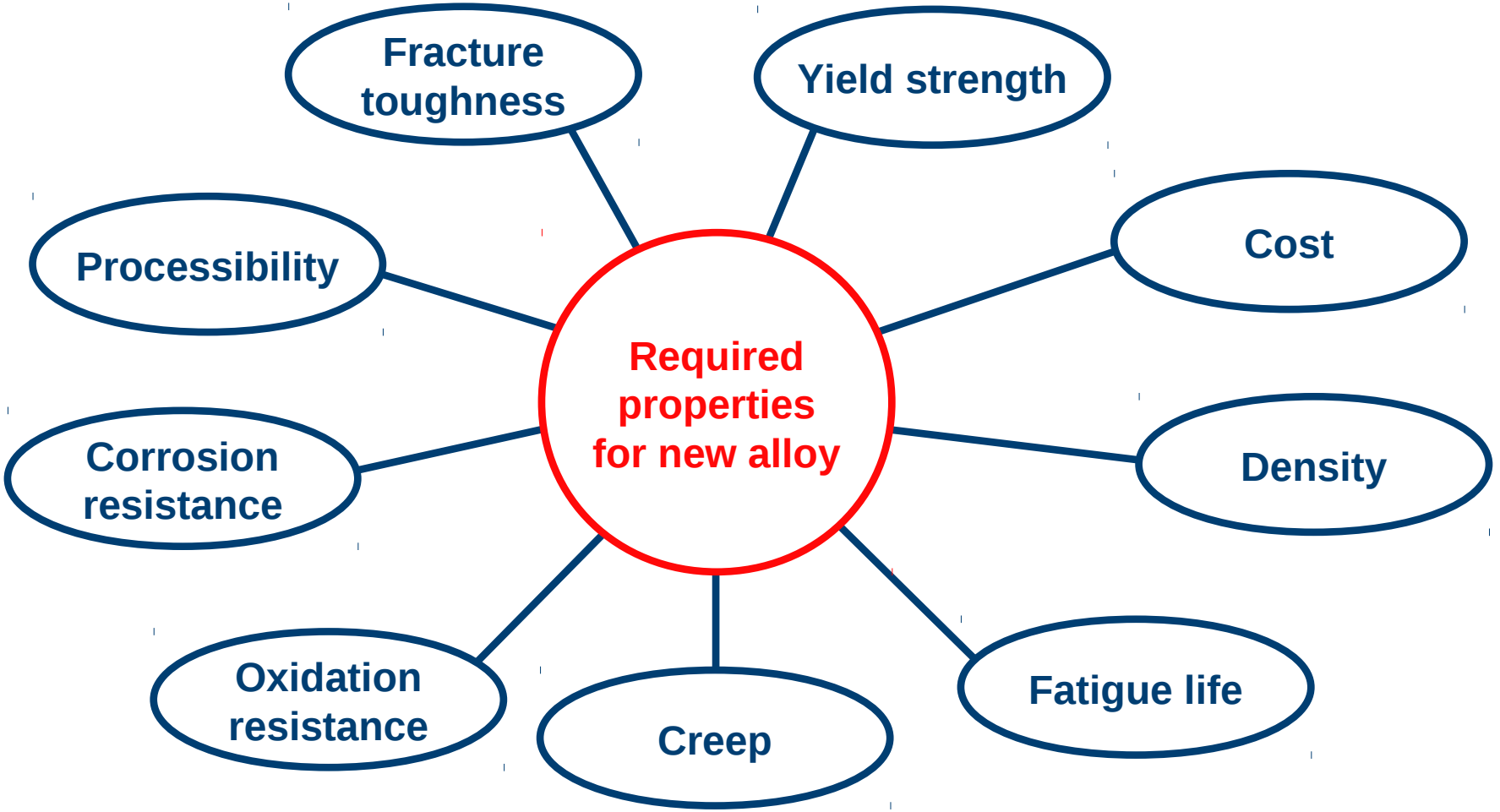


Certification – fan blades & birds!

- Small bird: Number based on area of front of engine, maximum 16, mass 55 - 110g (e.g. starlings)
- Medium bird: Number based on area of front of engine, maximum 10, mass 0.7 kg (e.g. seagull)
- Large bird: 1 bird, mass at least 1.8 kg at speeds up to 2500ms^{-1}



Designing a new alloy – what is required ?



Types of property models

- **For efficient development, predictions must take seconds or less**
  - ✘ Experimental data (weeks/months)
  - ✓ Neural networks (nano/micro seconds)
- **Combine estimates of individual properties to give overall probability of success**

Multidimensional design space

Cr Co Mo W Ta Nb Al







Ti Fe Mn Si C B Zr







Cu N P V Hf Mg Ni

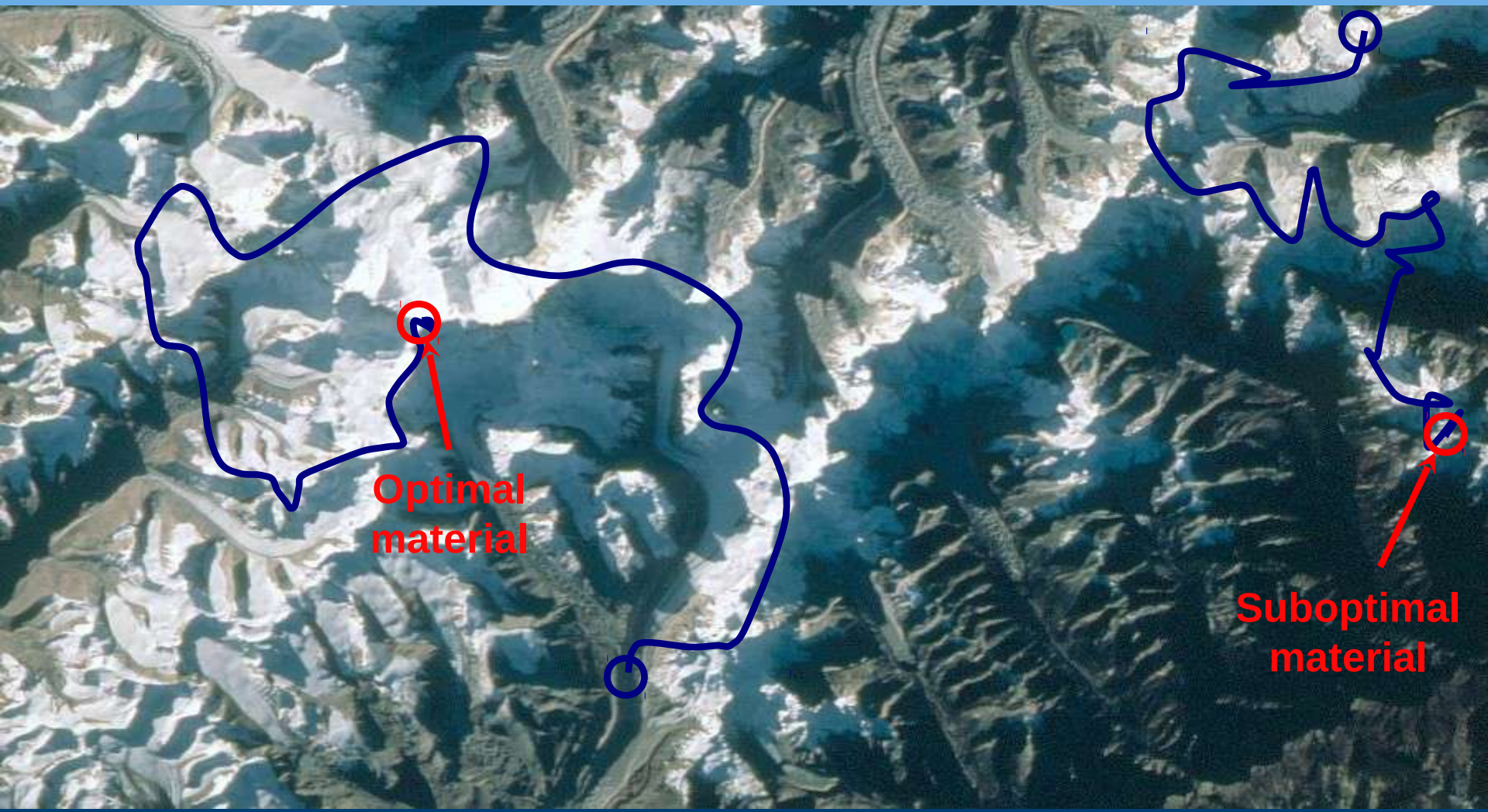






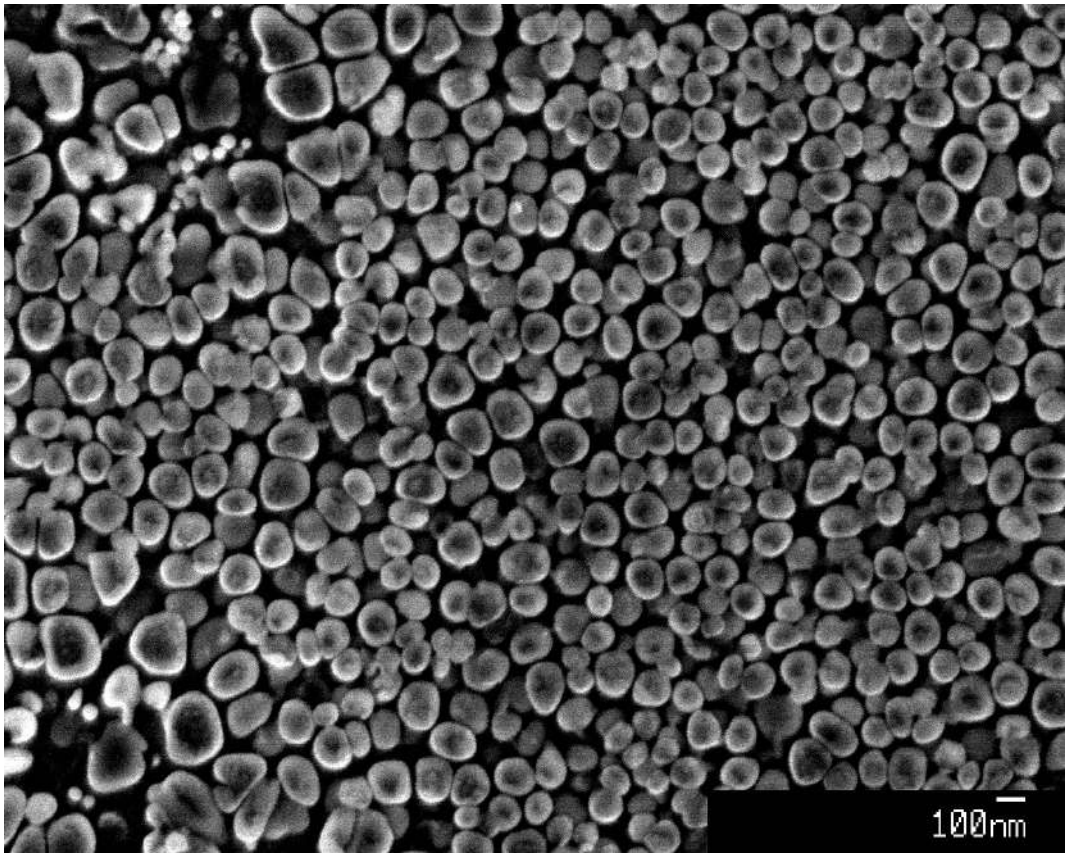
and 4 different manufacturing processes

Automated sampling - parallel optimization



Predicted material

- Processed according to model predictions
- Property assessment underway



Conclusions: why natural sciences & materials?

- Union of different sciences that encourages analysis with a variety of techniques – analytical, numerics, and experiments
- Close connection to real-world problems
- Strong academic funding and well-paid industrial jobs