The Synthesizer Tool:
hybrids and other models

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- Cellular structures
- Composites
- Sandwich structures
- Multi-layers
- Part cost estimator
- Battery Designer

Learning objectives for this lecture unit

Ansys software mentioned	• Ansys Granta EduPack™, a teaching software for materials education

Intended Learning Outcomes	
Knowledge and Understanding	Understanding of the potential of hybrid materials
Skills and Abilities	Ability to use the synthesizer to explore material combinations
Values and Attitudes	Inspiration to combine properties to create new materials

Resources

- Text: *"Materials Selection in Mechanical Design",* 5th edition by M.F. Ashby, Butterworth Heinemann, Oxford, 2016, Chapters 12 - 13.
- *Ansys Granta EduPack software synthesizer tool,* available in advanced subject databases
- The Synthesizer Tool Model Writes Guide, available from the Ansys Education Resources Website

Outline of lecture unit

Cellular structures

Composites

Sandwich structures

Multi-layers

Part cost estimator

Battery Designer

- **Holes** in material-property space
- **Hybrids materials** – expanding the filled space
- Example 1 – **cellular materials**
- Example 2 – **sandwich structures**
- New developments – **Part cost estimator**
- Add your own **Synthesizer model**

Advanced systems use hybrid materials

Sails – Kevlar + Nylon mixed weave
With thermally bonded PET skin

Mast and boom –
CFRP, filament wound

Hull – sandwich construction,
carbon fibre/PMAA foam core

Accelerating new material development

Current internationally:

ICME - *Integrated Computational Materials Engineering*

MGI - *The Materials Genome Initiative*

AMD - *Accelerated Material Development*………… more

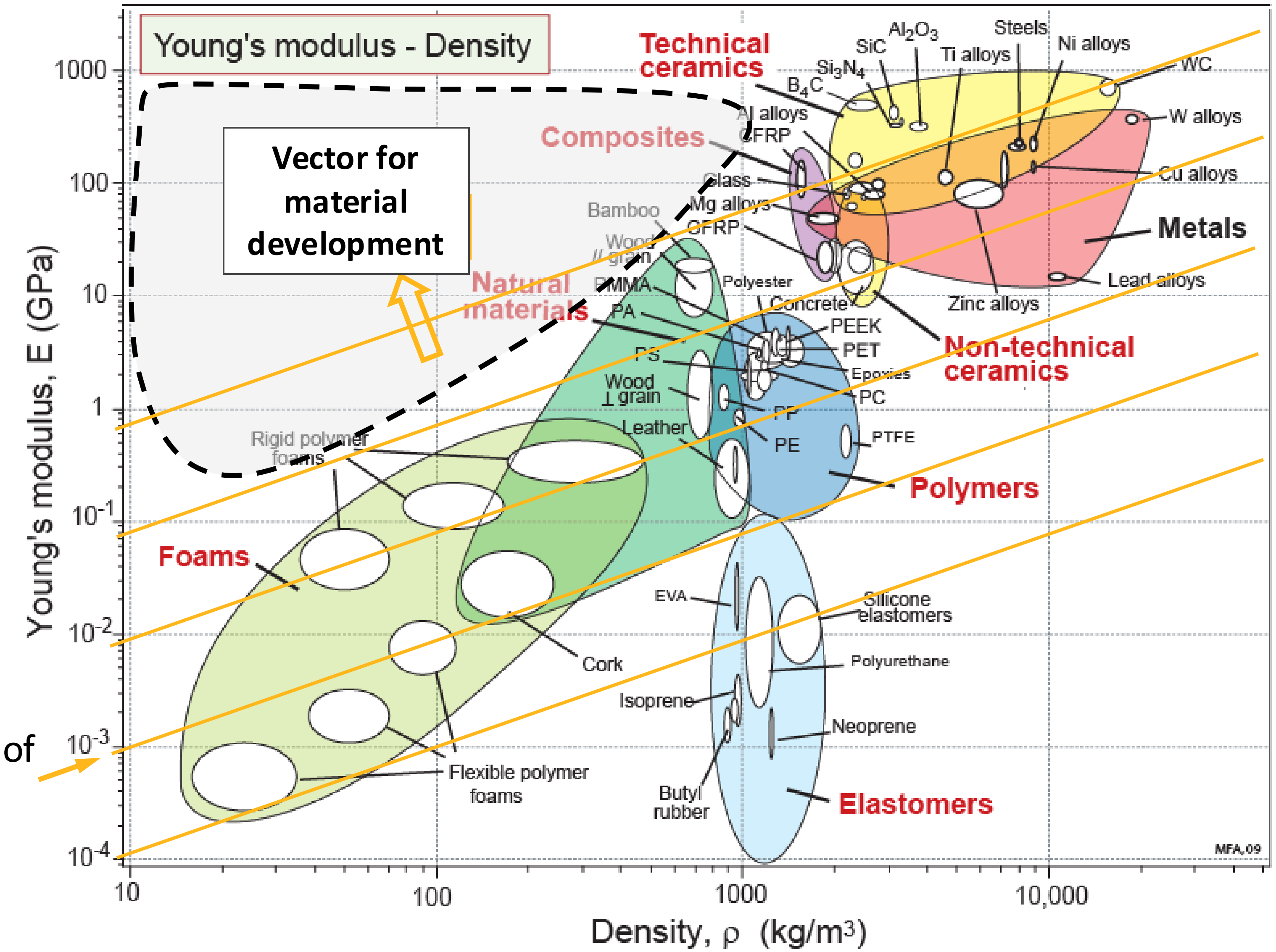
Vision: Materials Informatics

Use today's ability to store, process and retrieve information to accelerate material development

Almost all "bottom-up": *sub-atomic* → *nano* → *micron* → *mm scale*

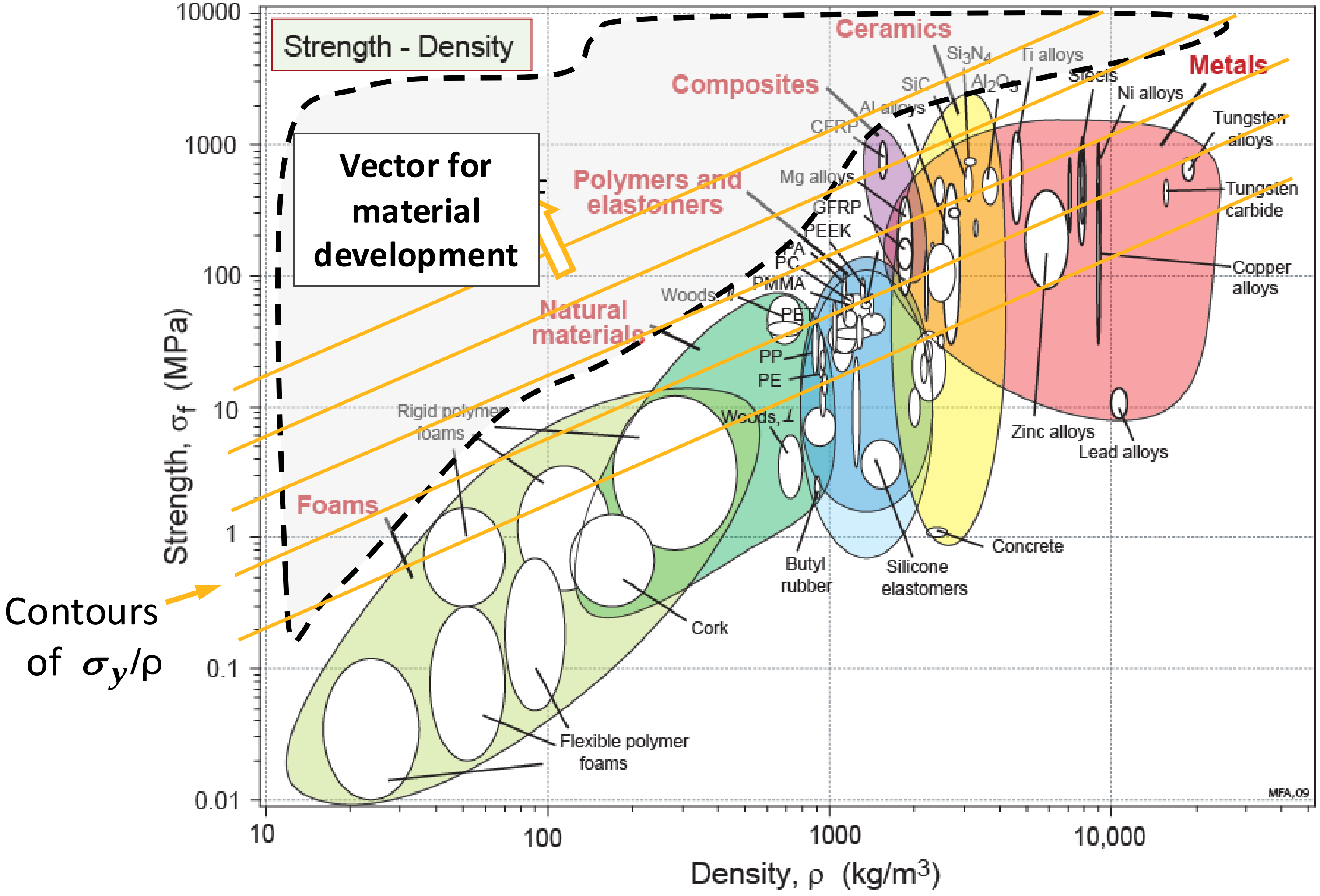
Can envisage "top-down": *Design requirements* → *Architecture*?

Modulus and density



Contours of E/ρ

Strength - Density



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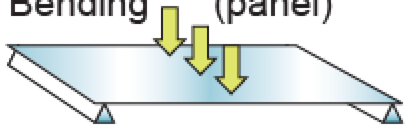
Criteria of excellence: material indices

- **Material index** = combination of material properties that limit performance

Objective minimise **mass**	**Constraints** Stiffness	 Strength
Tension (tie) 	E/ρ	σ_y/ρ
Bending (beam) 	$E^{1/2}/\rho$	$\sigma_y^{2/3}/\rho$
Bending (panel) 	$E^{1/3}/\rho$	$\sigma_y^{1/2}/\rho$

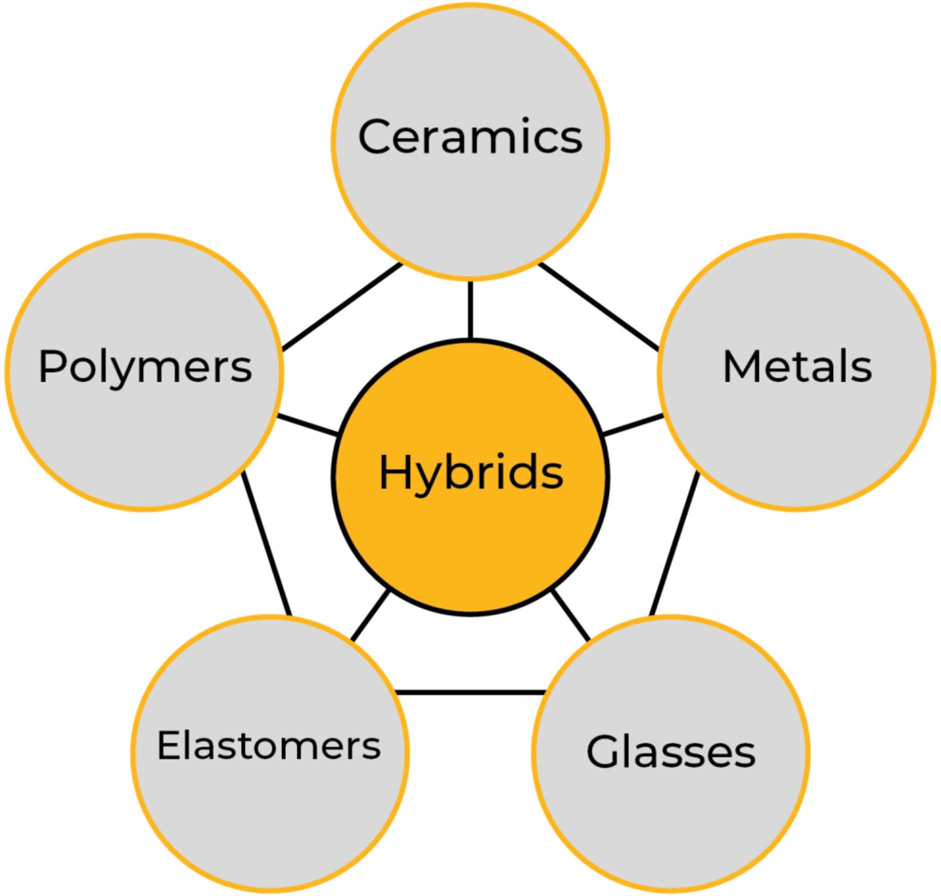
Hybrid materials

Cellular structures

Composites

Sandwich structures

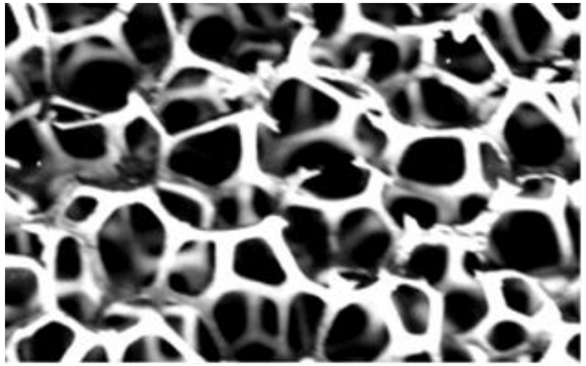
Multi-layers

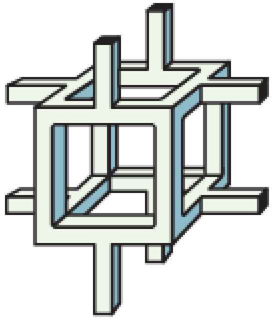


Design variables:

- Choice of materials
- Volume fractions
- Configuration
- Connectivity
- Scale

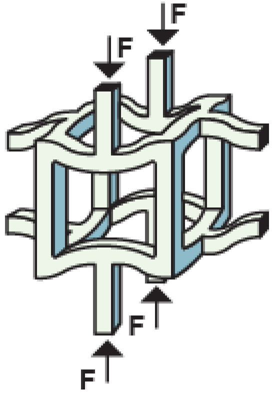
Configuration: Foam – property models



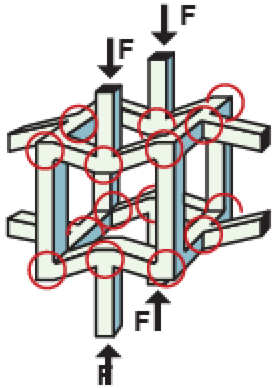


Foam cell

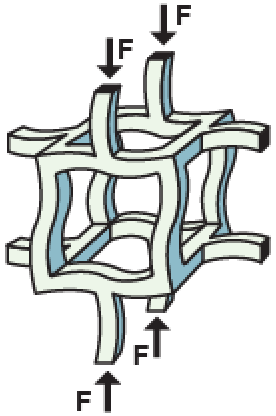
Mechanical response



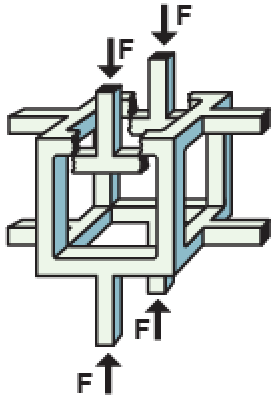
Elastic deformation



Plastic collapse



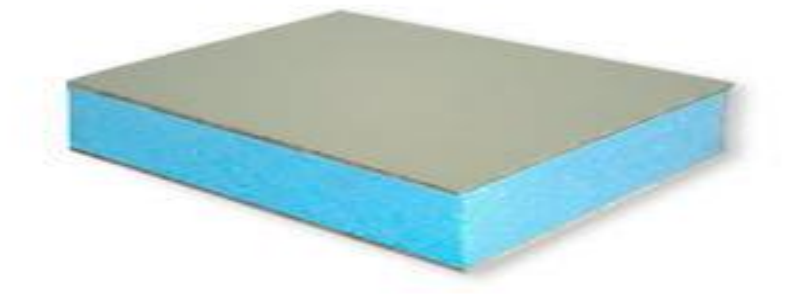
Cell edge buckling

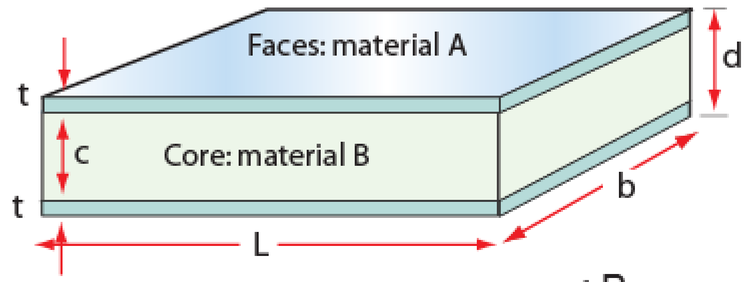


Cell edge fracture

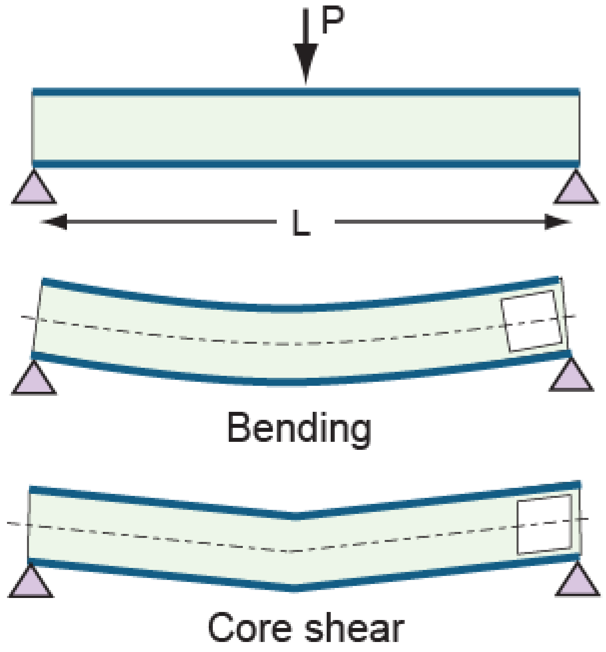
Plus **thermal and electrical properties**

Configuration: Sandwich panel – property models

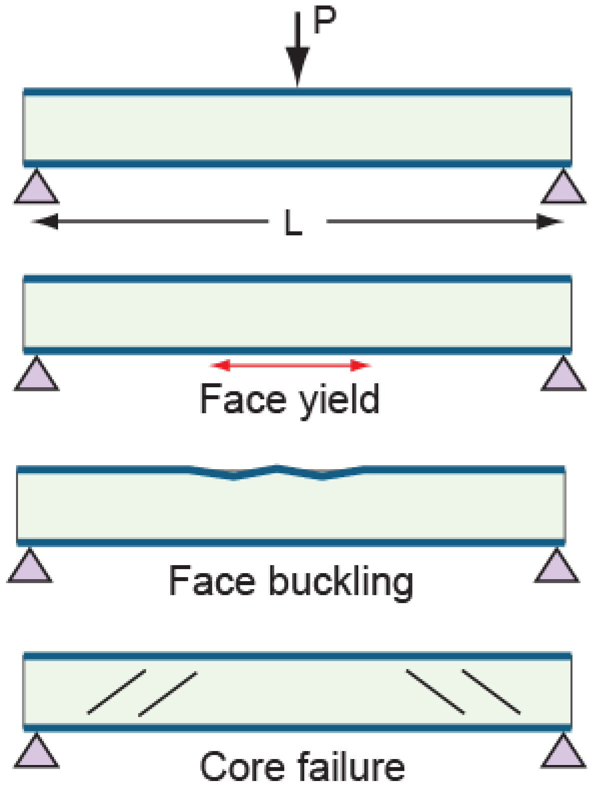




Elastic response



Collapse response



Plus **thermal** and **electrical properties**

Structure of a hybrid synthesizer

User interface

Choose:

- *Configuration*
- *Components*
- *Volume fractions*

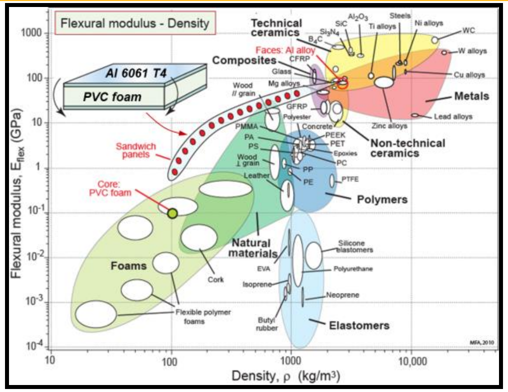
Models for configuration props.

- *Moduli*
- *Strength*
- *Thermal props*
- *Electrical props*

Data for component props.

- *Moduli*
- *Strength*
- *Thermal props*
- *Electrical props*

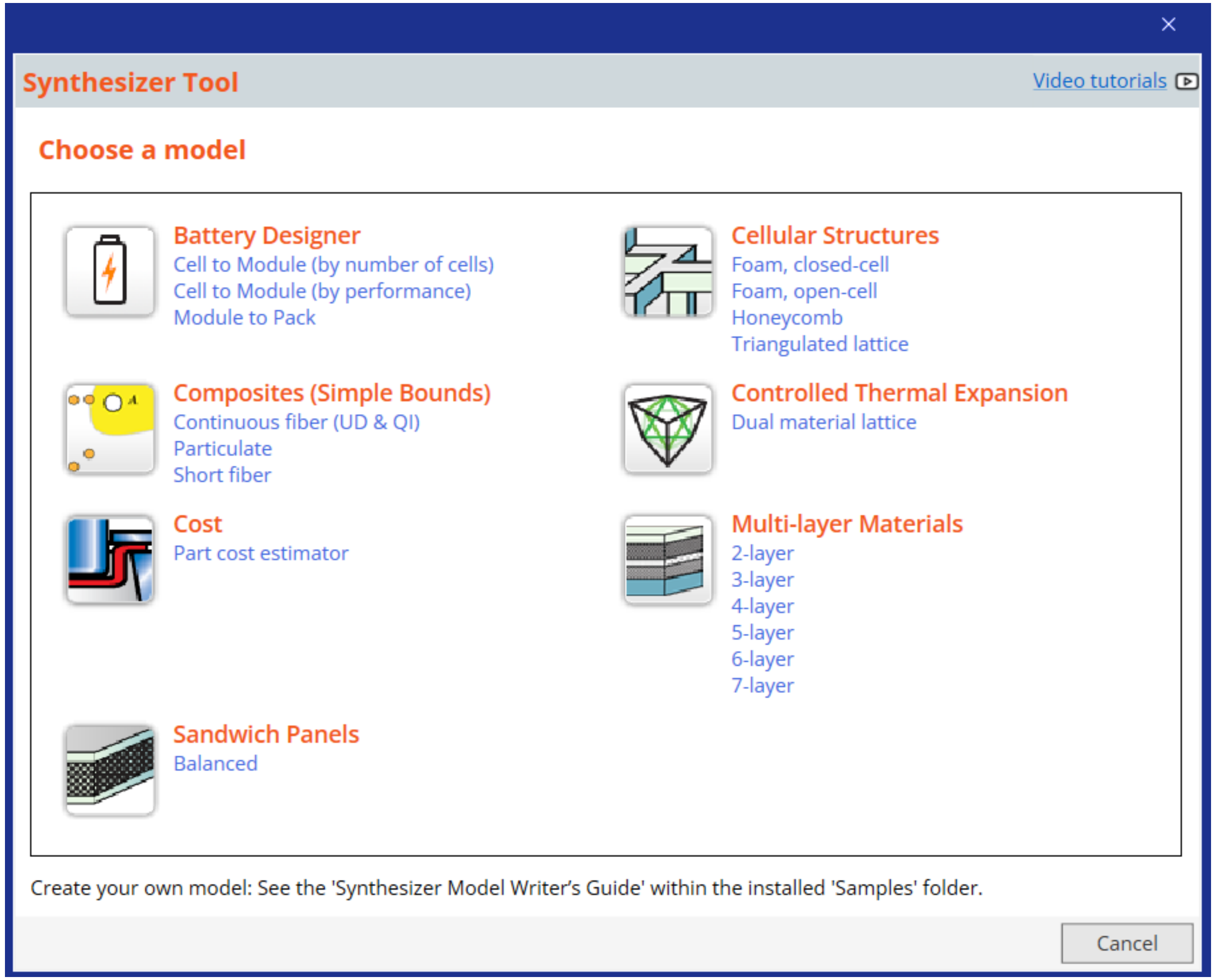
Calculate hybrid properties and scan



Data sheet for proposed hybrid

- *Moduli*
- *Strength*
- *Thermal props*
- *Electrical props*

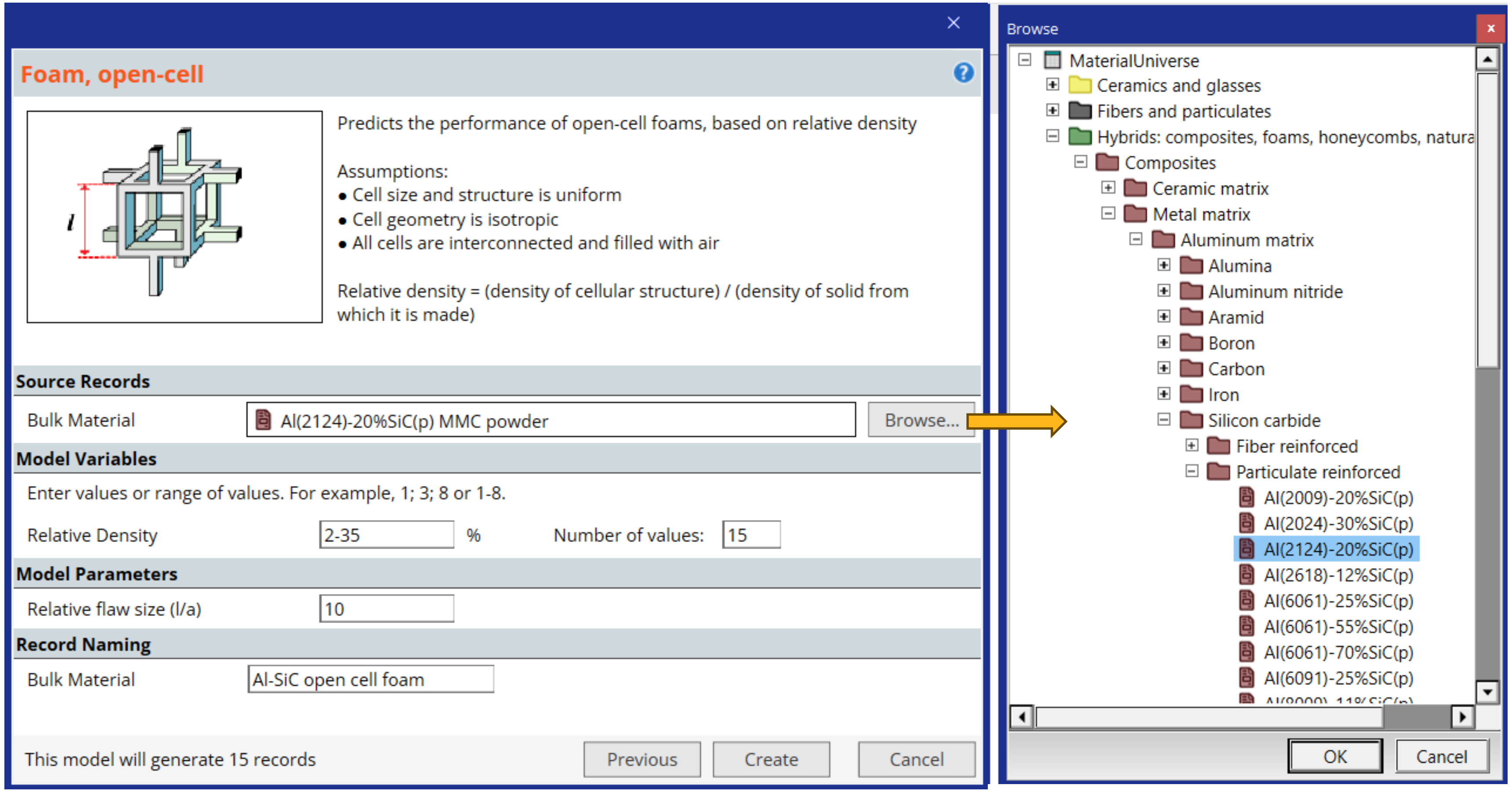
The Synthesizer tool and its models



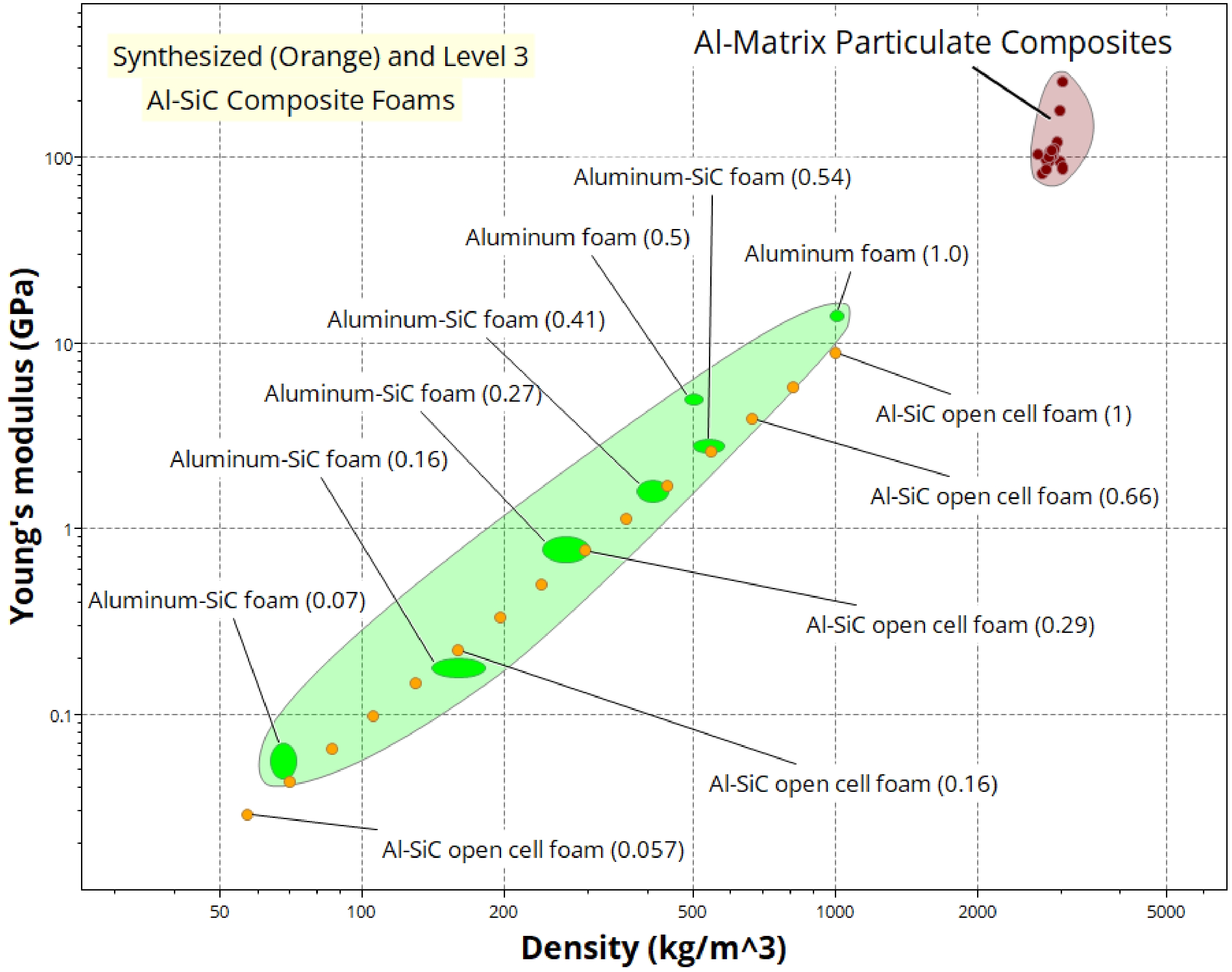
Select:

- **Configuration**
- **Materials**
- **Control parameters**
- **Click "Create"**

Exploring metal foams - inputs



Aluminum SiC composite foams



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Sandwich panels - inputs

Sandwich Panel

Source material

Face sheet Aluminum 606

Core PVC cross-link

Model variables

Face-sheet thickness

Core thickness -

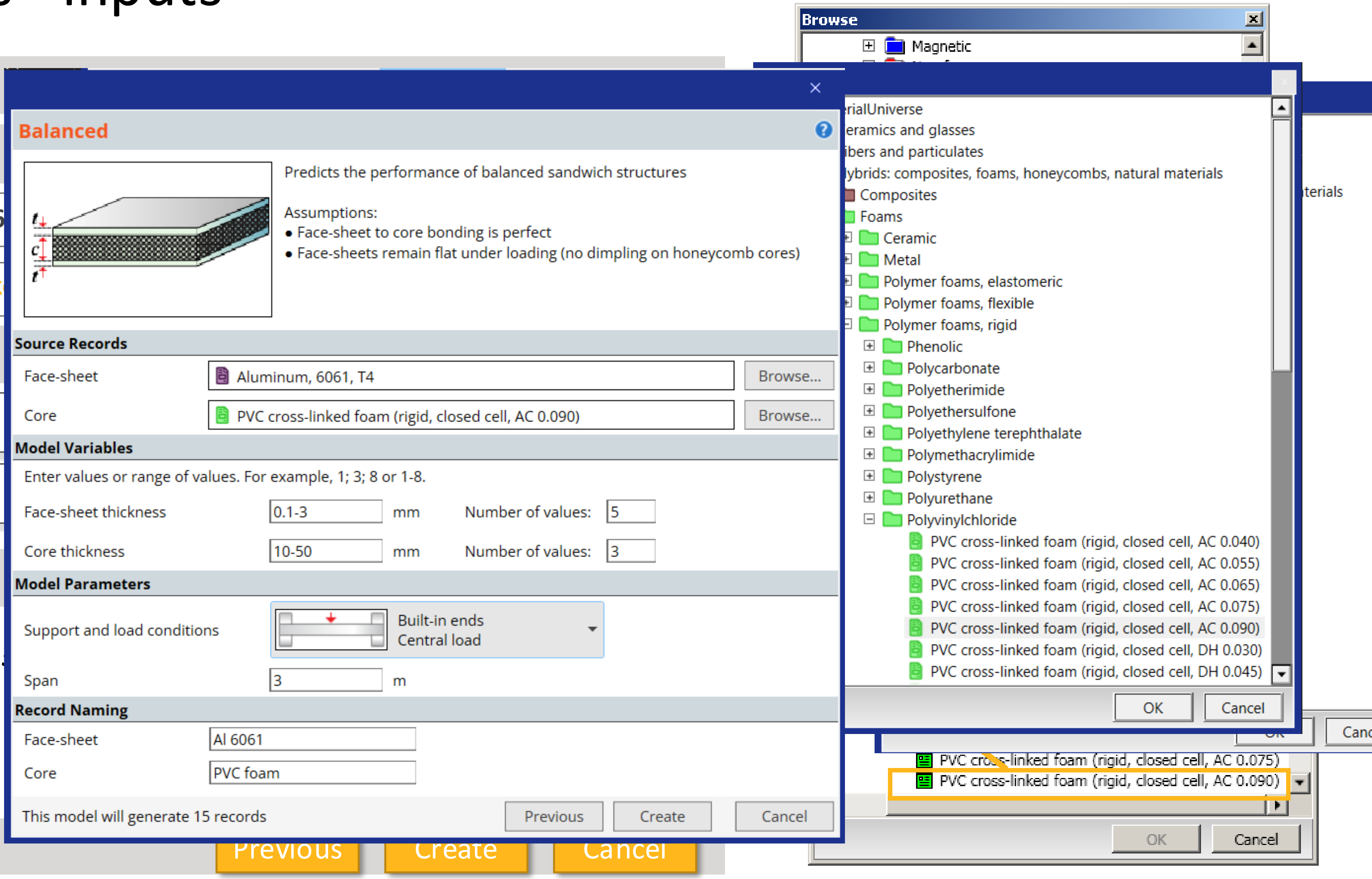
Model parameters

Support and load condition

Span 3 *m*

Model

Previous Create Cancel



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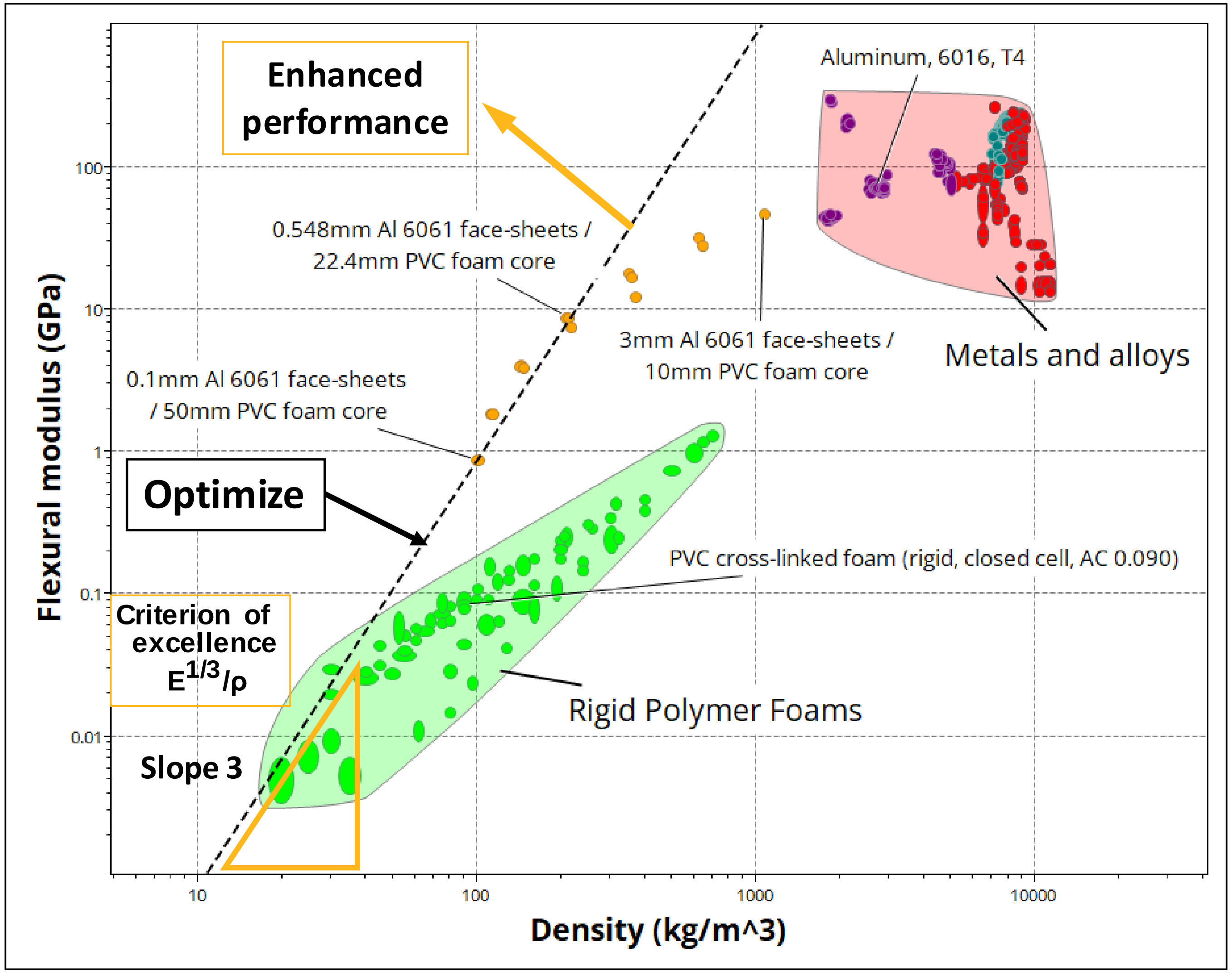
Stiff sandwich panels



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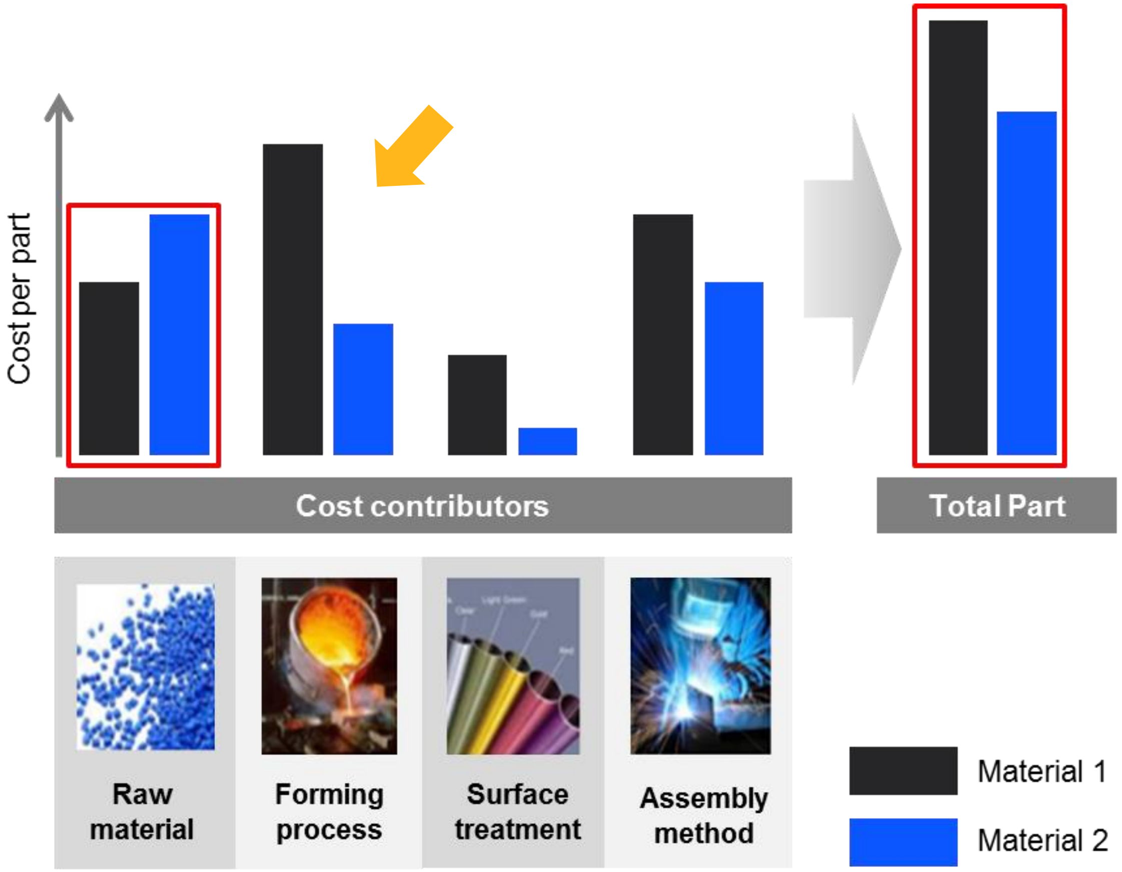
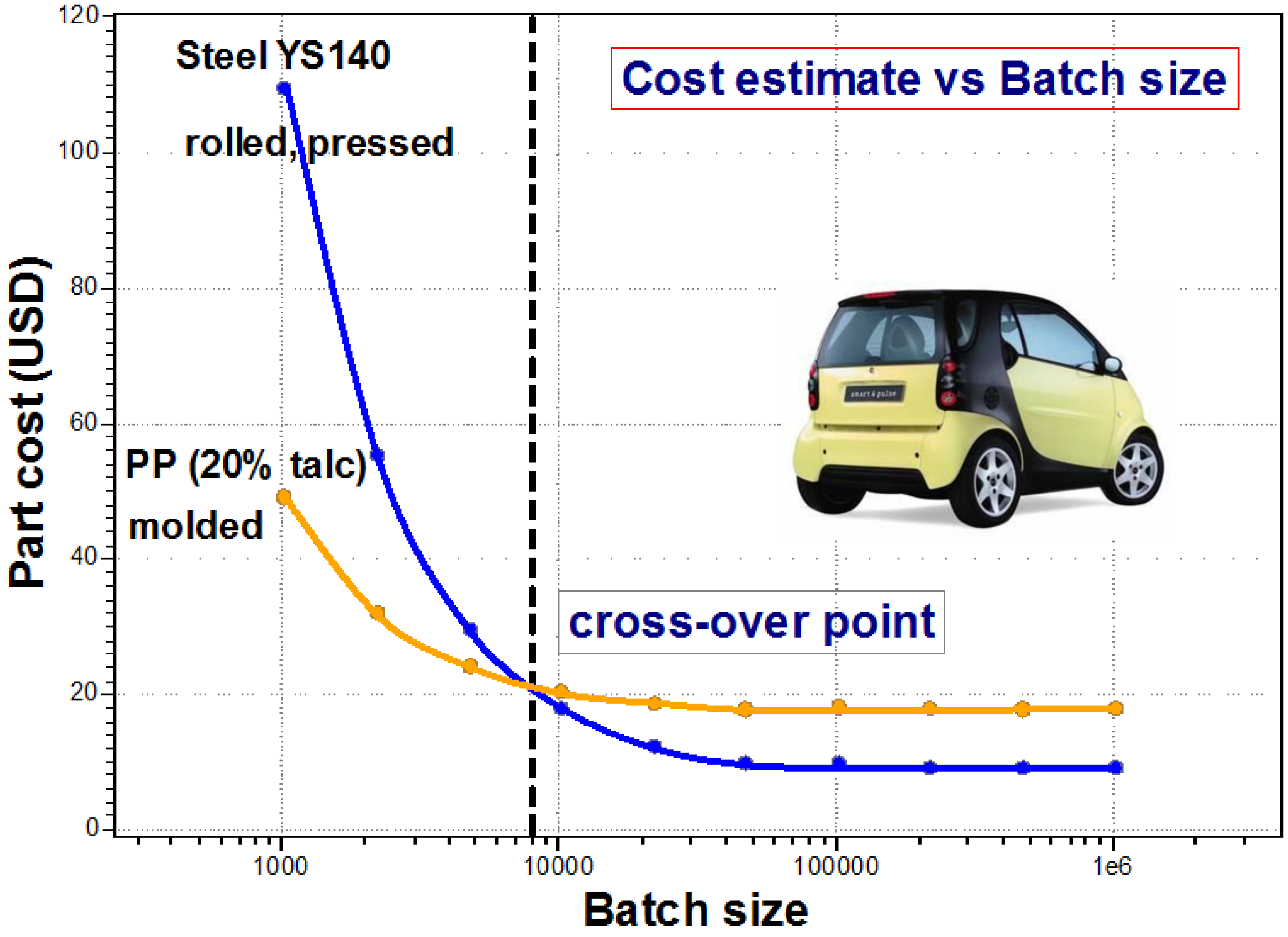
Synthesizer model for part cost



PP-20% mineral filled door panel
15% saving in door weight, but what about cost?

- Quickly estimate the **cost to manufacture a component**
- **Compare different classes** of materials *and* processing routes

Part cost comparison: Door panel



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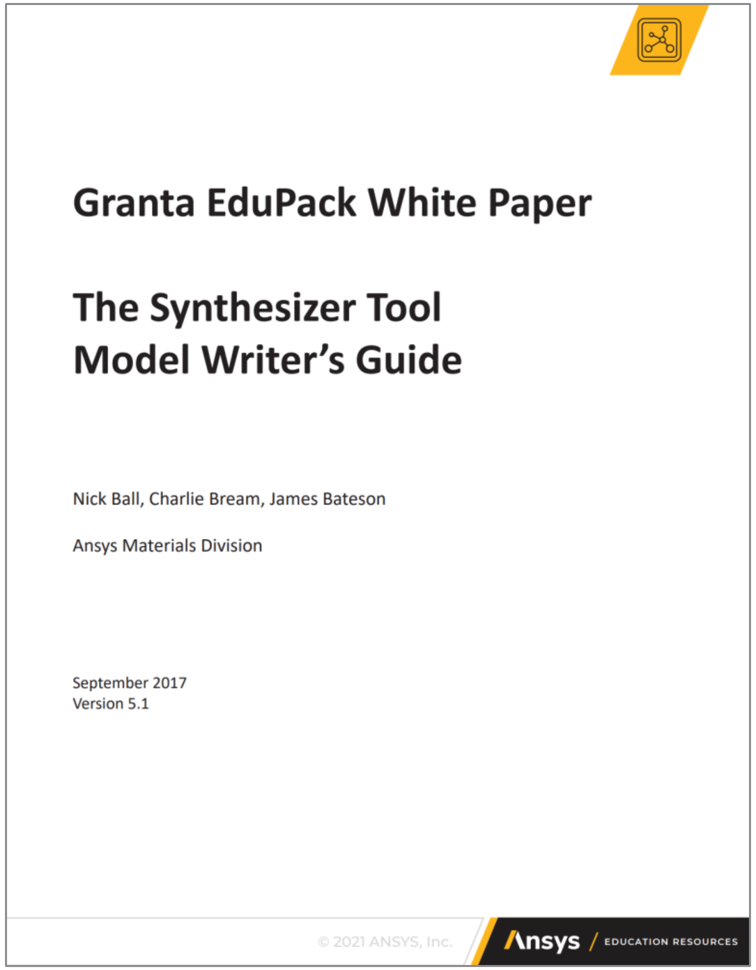
Enter your own models



Granta EduPack White Paper

The Synthesizer Tool
Model Writer's Guide

Nick Ball, Charlie Bream, James Bateson

Ansys Materials Division

September 2017
Version 5.1

Ansys / EDUCATION RESOURCES

Outline of a model in code (C#)

- You need: Microsoft Visual Studio (the community edition is free)
- Administrator rights on your PC in order to copy your model
- Details of your model calculations.

```
[Export("Granta.HybridModel")]
[BindableDisplay(Name = "Simple Model (C#)",
                 Description = "A simple example model.",
                 GroupName = "Examples")]
public class ExampleModel
{
}
```

Summary

The synthesizer stimulates

- Imaginative exploration of novel material combinations
- Interest in materials modelling
- Direct comparison of hybrids with the standard materials of engineering
- Exploration of structured-structures
- Does ***not*** advise on manufacture of hybrids, but…
- Can be used to estimate part manufacturing costs
- Enables you to enter your own materials-based models

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