

# 92<sup>nd</sup> ESGI

EUROPEAN STUDY  
GROUPS WITH INDUSTRY  
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Instituto Superior de Engenharia de Coimbra  
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PT  
MATHS  
IN

rede portuguesa  
de matemática  
para a indústria  
e inovação

## working groups

### CHALLENGE 1

**Modelling percolation and fractal structure in aerogels**

industry\_ **Active Space Technologies**  
sector\_ **Aeronautic**



Aerogels are synthetic porous ultralight materials derived from gels, in which the liquid component has been replaced with a gas. The first aerogels were synthesized from silica, but many types of aerogels have been studied. Because of their properties, including low thermal conductivity and density, and occasionally hydrophobicity, aerogels are extraordinary insulating materials with applications in the aeronautics, construction, cryogenics, oil and gas, pharmacy, and space sectors. Although substantial developments have been made, the processes by which aerogels are produced remain poorly understood. Developments of chemical, physical, and mathematical models are therefore crucial to characterize the processes that lead to unique aerogel properties.

The problem is to develop macroscopic and microscopic mathematical models that provide a better understanding of the physical and chemical processes involved. In particular, the company would like to model the percolation in aerogel and to compute the aerogel fractal dimension. For the percolation problem, the study shall consider equations used to model percolation in porous media, identifying strengths and weaknesses that would lead to definition of more elaborate models for the investigation of aerogel drying processes. For the computation of the aerogel fractal dimension, the aim is to develop algorithms suitable to compute the fractal dimension of silica aerogel from microscopy images. Images of different resolution taken with microscopes at various depths are used for a 3D reconstruction of the medium. In some cases, 3D rendering of microscope images may be also available. In some cases, the fractal dimension can be related with aerogel porosity, providing a link between microscopic and macroscopic properties from mathematical descriptions.

### CHALLENGE 2

**Model to Estimate and Monitor the progress of System Testing Phase**

industry\_ **Critical Software**  
sector\_ **IT and Software**



Critical Software – as a highly-specialized SW development company – performs Validation or System Testing activities for the developed software. System Tests are executed by testers, which cover and trace to SW requirements of the application, and usually take weeks or months to perform. There are projects with 50 tests, whilst there might be projects with +400 tests (with durations ranging from 2 weeks in time to over 9 months).

In summary, Critical Software would like to know in real-time, in every instant, what is the expected finish date, what is the remaining estimated effort, what is the expected number of defects, all based on on-going execution and project reality. This information would be most useful for the Project Management Team to monitor and control the System Testing phase and take appropriate corrective action.

### CHALLENGE 3

**Customer's expected energy consumption**

industry\_ **Tula**  
sector\_ **Engineering consultant**



The mission of the electric power utilities is to service the customer's needs of electric energy at optimal costs. In the energy business, the pricing of electricity is determined by the customer's energy consumption at different times as well as the demand on the amount of incremental power. In fact, customer's load variation causes the energy selling company to buy energy. The planning of the time of day tariffs and seasonal tariffs requires knowledge of the energy shares for different time/price categories, which values depend on the customer's load variation. In fact, the most important thing characterizing the service is the customer's load as it influences planning, dimensioning of electricity production, transmission and distribution. With this said, electric energy consumption forecast becomes essential in making certain decisions, especially to meet the needs of consumers.

In summary, TulaES would like to know in real-time, what is the expected energy consumption. The forecast should be based on the customer's energy consumption history. The problem is to develop a mathematical model enabling energy consumption forecasting considering individual customer consumption history.

### CHALLENGE 4

**Picking optimization**

industry\_ **Sonae MC**  
sector\_ **Retail and Distribution**



Continente's grocery e-commerce teams prepares 300k orders/year. Each operator steer the trolley on the shopfloor to select items to multiple clients. Each order picking can involve more than 2500m distance. SONAE MC's Grocery e-commerce is below international best practice efficiencies in picking. Picking inefficiencies to be addressed include improving picking tasks to minimize distances. There's a very high level of ambition within SONAE MC's e-commerce to boost growth and profitability.

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