

# E&I Research Studentship project proposal 2019

**Project title: Understanding and Visualising Design Margins in Engineering Design**

**Supervision Team:**

**Claudia Eckert, School of Engineering & Innovation ([claudia.eckert@open.ac.uk](mailto:claudia.eckert@open.ac.uk))**

**Helen Lockett, School of Engineering & Innovation ([helen.lockett@open.ac.uk](mailto:helen.lockett@open.ac.uk))**

**Project Highlights:**

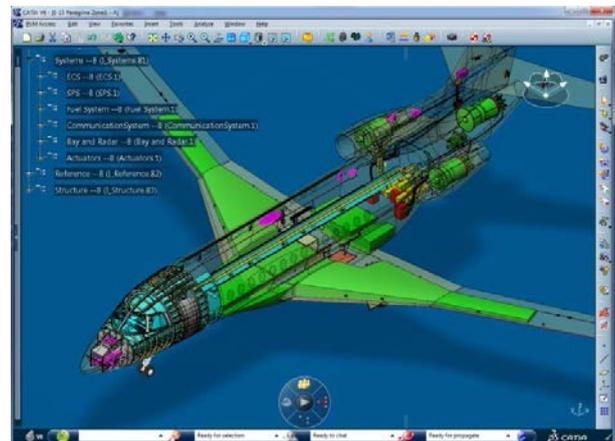
- Develop a Computer Aided Design (CAD) based software tool to allow visualisation and understanding of design margins on a product digital mock-up
- Develop mathematical methods to analyse design margins and identify critical design parameters in a product
- Investigate how and why design margins are applied in engineering design to compensate for design uncertainties and reduce risk during the development of precision engineered products

**Project Description:**

During the engineering design process, designers commonly add *design margins* or *factors of safety* to requirements to account for design uncertainties. These uncertainties may be associated with the loads that the product will experience during use, or variability in manufacturing processes or material properties. Design margins may also be applied to allow for potential growth of the product in future developments, or to protect against product degradation in use. Through the development process, requirements and loads on parameters may also change. The result is that many products are overdesigned, but due to a lack of understanding of design margins, the developers do not know by how much [1].

Margins arise from a design perspective to protect against the impact of engineering change, as well as from a safety perspective to protect against product failure. The safety community has developed multiple approaches to describe and optimise safety factors. For example probabilistic approaches are used to model the variability of design parameters using a statistical distribution, so that the failure probability can be assessed based on the interaction between distributions [2,3]. In manufacturing, geometric design and tolerancing (GD&T) is used to define the allowable variability in product geometry and model the stack up of tolerances in a product. The aim of this

project is to develop a methodology bridging the gap between design and manufacturing to help engineers to better understand the margins on their products, and the influence of design margins on the overall product design. The research will draw on insights from previous design margins research, as well as modelling methods from design for safety and GD&T. The first step will be to develop a classification scheme for different types of design margins. Mathematical models will then be developed that can be used to analyse the different types of design margins and their interactions. A software tool will be developed that will allow engineering designers to understand and visualise design margins and their interactions directly on a digital mock-up of the product (as shown in Figure 1). In this way, designers will be able to better understand the effect of design margins and the interactions between different types of design margins on a product.



**Figure 1: Example of aircraft digital mock-up**

**Research Methods:**

The main research methods that will be used in the project are summarised below:

- Perform a structured literature review to investigate the sources of design margins in engineered products, considering a wide range of sources including design, manufacturing, and safety margins.

- Classify design margins into different types and identify the key parameters for each class
  - Develop mathematical models for each class of design margin, and investigate the effect of combining multiple design margins on an engineered product, possibly building on existing methods in GD&T and/ or probabilistic design
  - Develop a Computer Aided Design (CAD) based software tool to allow visualisation and understanding of design margins on a digital mock-up of the product, and provide traceability links from the design margins on individual components to their source in the product requirements
  - Test the developed methods and software on case study products and assess the effectiveness of method
  - a CV including contact details of two academic references
  - An Open University application form, downloadable from: <http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process> (Note: This is an Advertised studentship and you do not need to submit a proposal).
  - IELTS English Language test scores on application. An average of 6.5 and no less than 6 in anyone of the four components. Applicant should have these results when applying.
- Applications should be sent to [STEM-EI-Research@open.ac.uk](mailto:STEM-EI-Research@open.ac.uk) by 28 February 2019

### Indication of project timeline:

**Year 1:** Structured literature review and classify design margins

**Year 2:** CAD based software tool to visualise and understand design margins, building on mathematical models of design margins

**Year 3:** Test the development method on case study products. Complete thesis write-up.

### References

- [1] Eckert, C and Isaksson, O (2017) Safety Margins and Design Margins: A Differentiation between Interconnected Concepts, In Procedia CIRP, Volume 60, 2017, Pages 267-272
- [2] Newcomer JT, Bierbaum RL (2017) A Framework and Taxonomy for the Design and Analysis of Margins. IEEE Annual Reliability and Maintainability Symposium (RAMS) 23-26 Jan. 2017
- [3] Booker, JD, Raines, M and Swift KG (2001) Designing Capable and Reliable Products. Butterworth-Heinmann.

### Further details:

Students should have a strong background in mechanical engineering and computer aided design and enthusiasm for engineering design or design for manufacture. Experience of mathematical modelling and/or geometric dimensioning and tolerancing is desirable. The student will join a well-established team researching engineering design at the Open University.

### Candidate Applications

- 1000 word cover letter outlining how they are equipped in their educational background and expertise to conduct the research project,