

# The Long and Winding Road:

## MBSE Adoption for Functional Avionics of Spacecraft<sup>1</sup>



Joe Gregory<sup>a\*</sup>, Lucy Berthoud<sup>a</sup>, Theo Tryfonas<sup>b</sup>, Alain Rossignol<sup>c</sup>, Ludovic Faure<sup>d</sup>

<sup>a</sup> Department of Aerospace Engineering, Queens Building, University Walk, University of Bristol, UK, BS81TR

<sup>b</sup> Department of Civil Engineering, Queens Building, University Walk, University of Bristol, UK, BS81TR

<sup>c</sup> Airbus Defence and Space, Rue des Cosmonautes, Toulouse, France, 31400

<sup>d</sup> Airbus Defence and Space, Gunnels Wood Road, Stevenage, UK, SG12AS

### Background

#### Model-Based Systems Engineering (MBSE):

“The formalised application of modelling to support systems engineering activities”

MBSE promotes: Consistency, Communication, Clarity, Maintainability, Re-use

**BUT:** large-scale MBSE adoption in an organisation is difficult.

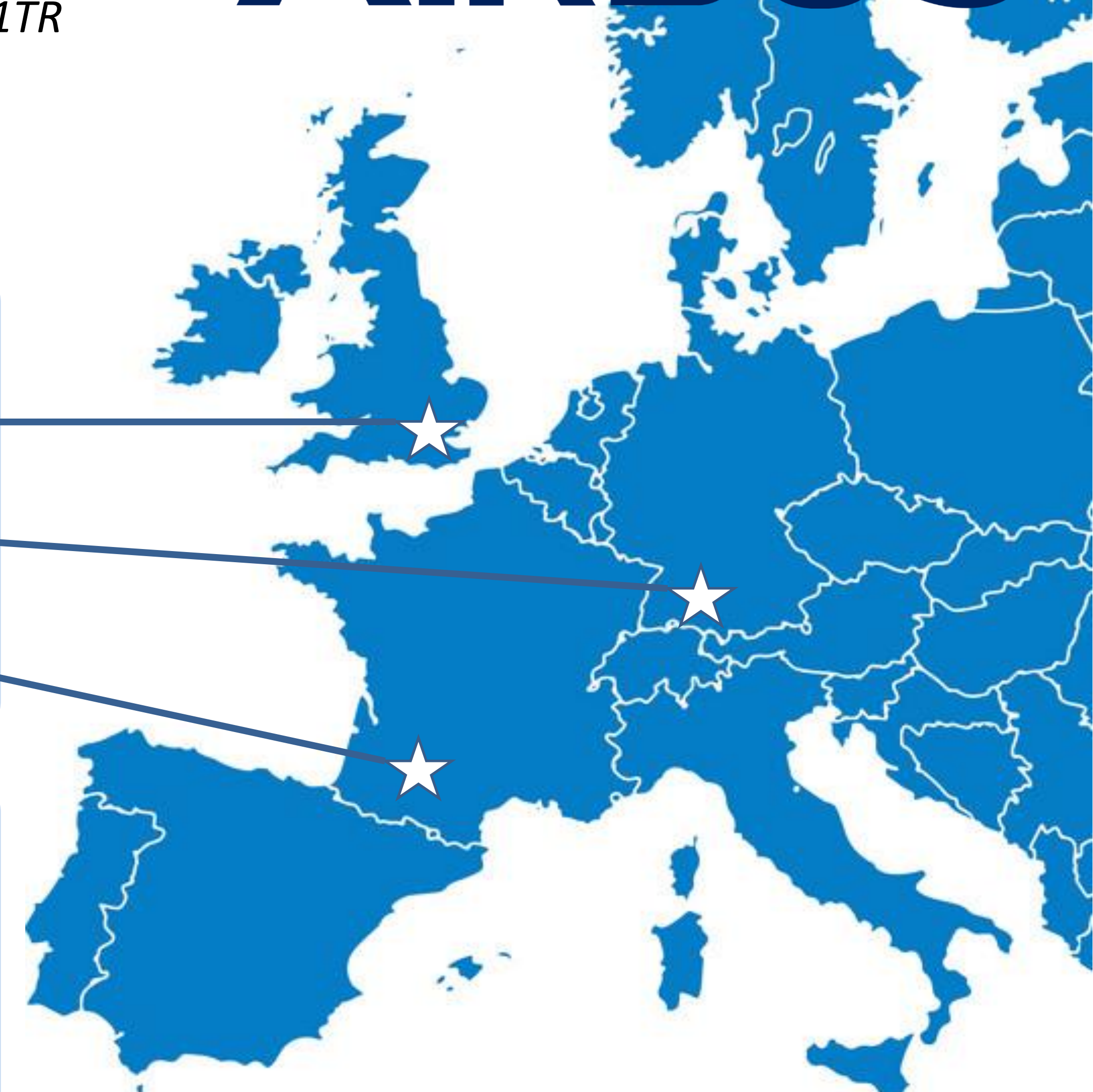
It can be a **long and winding road** to industrial implementation.

### Airbus Sites

Stevenage, UK

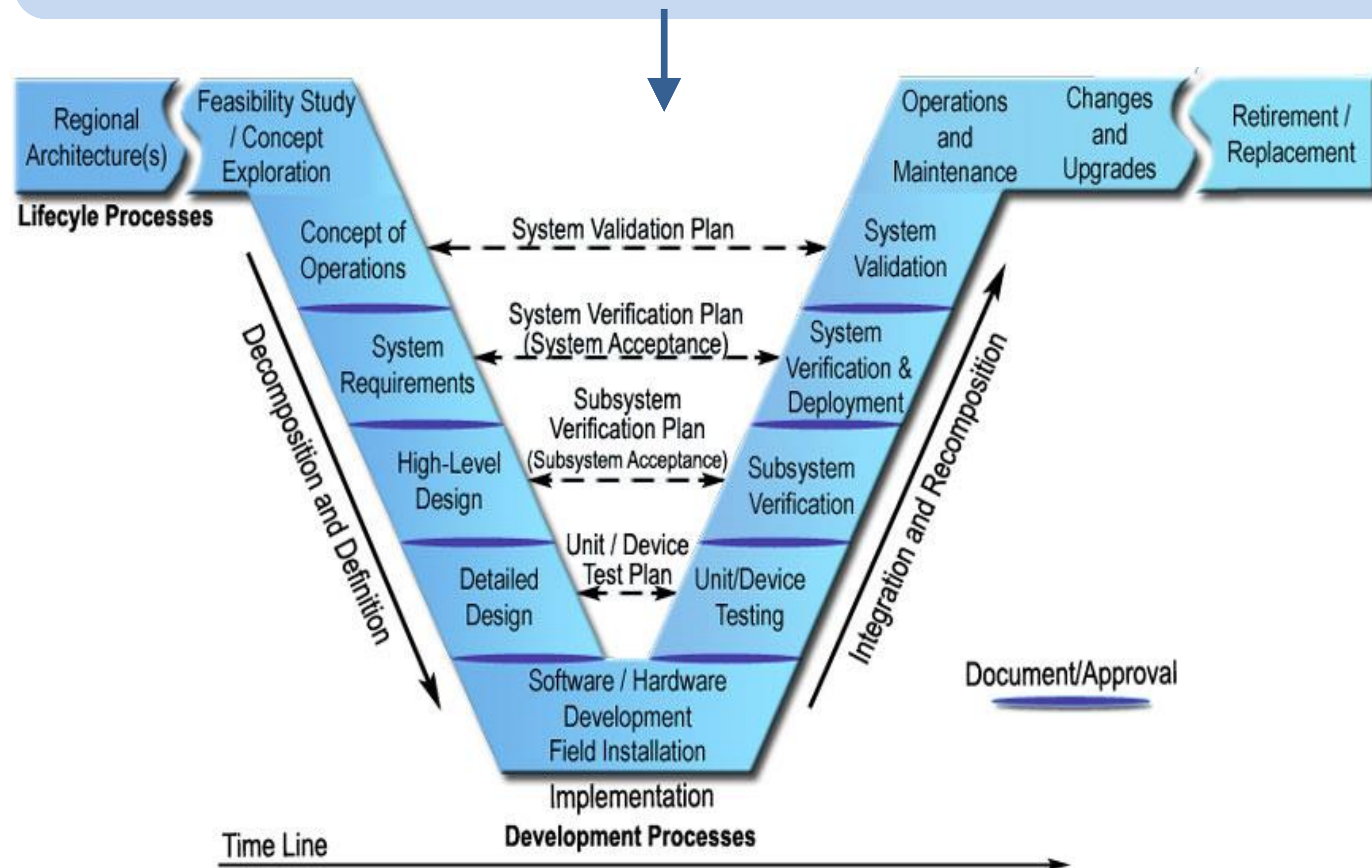
Friedrichshafen, Germany

Toulouse, France



### Research Objectives

1. Investigate the **status of current systems engineering** practices at Airbus Space by interviewing Airbus engineers:
  - a. “Where are the issues with your current systems engineering practices?”
  - b. “Could MBSE techniques help to resolve these?”
2. Analyse the responses to **determine potential areas of application** for MBSE techniques
3. Use this data to produce an MBSE approach that addresses **real systems engineering issues** – and win support



### Methodology

Organise multiple interviews at three European Airbus sites:

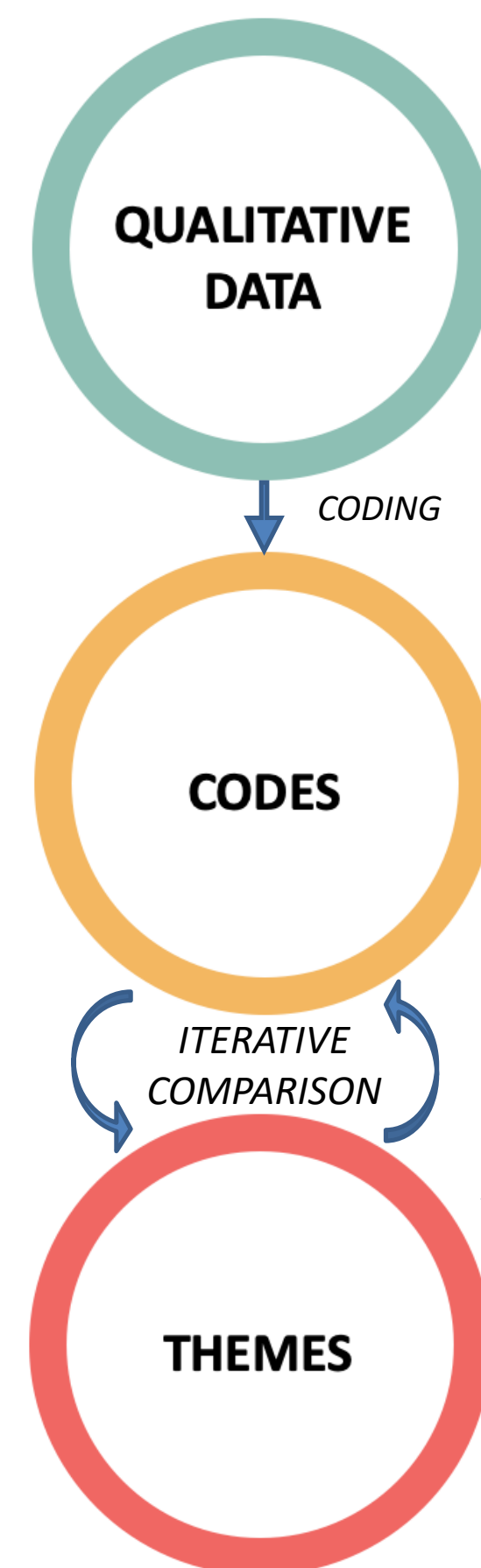
- **Nine** semi-structured interviews
- **Three** in Stevenage, **Three** in Friedrichshafen, **Three** in Toulouse
- **Two** key questions – defined in ‘Research Objectives’

Interview engineers from three domains:

- **13** ‘Operations’ engineers
- **8** ‘Failure Detection, Isolation and Recovery (FDIR)’ engineers
- **4** ‘Software’ engineers

Produce our own analysis approach, to use on qualitative responses:

- We begin with the psychology-based approach of **thematic analysis**
- It is **adapted** to our needs in this field of engineering
- It uses the concept of ‘coding’ to extract **key themes**



### Results

**205** responses were received from the nine interviews

- **48%** of the responses came from ‘Operations’ engineers
- **37%** of the responses came from ‘Software’ engineers
- **15%** of the responses came from ‘FDIR’ engineers

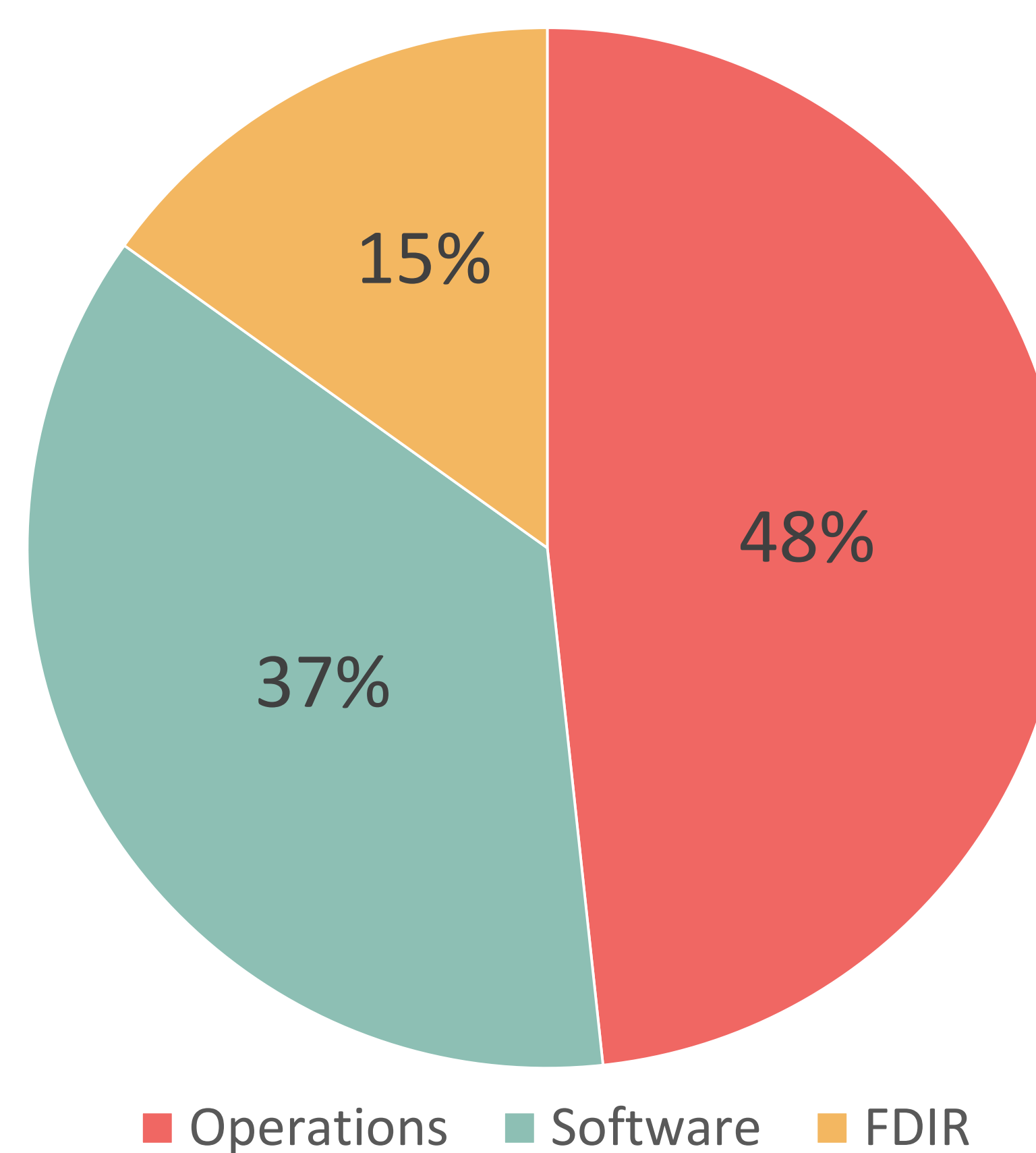
**Three** major themes were identified

- **49%** of the responses addressed Airbus’ systems engineering **process**
- **26%** of the responses addressed Airbus’ **organisation** structure
- **25%** of the responses addressed the availability of appropriate **tools**

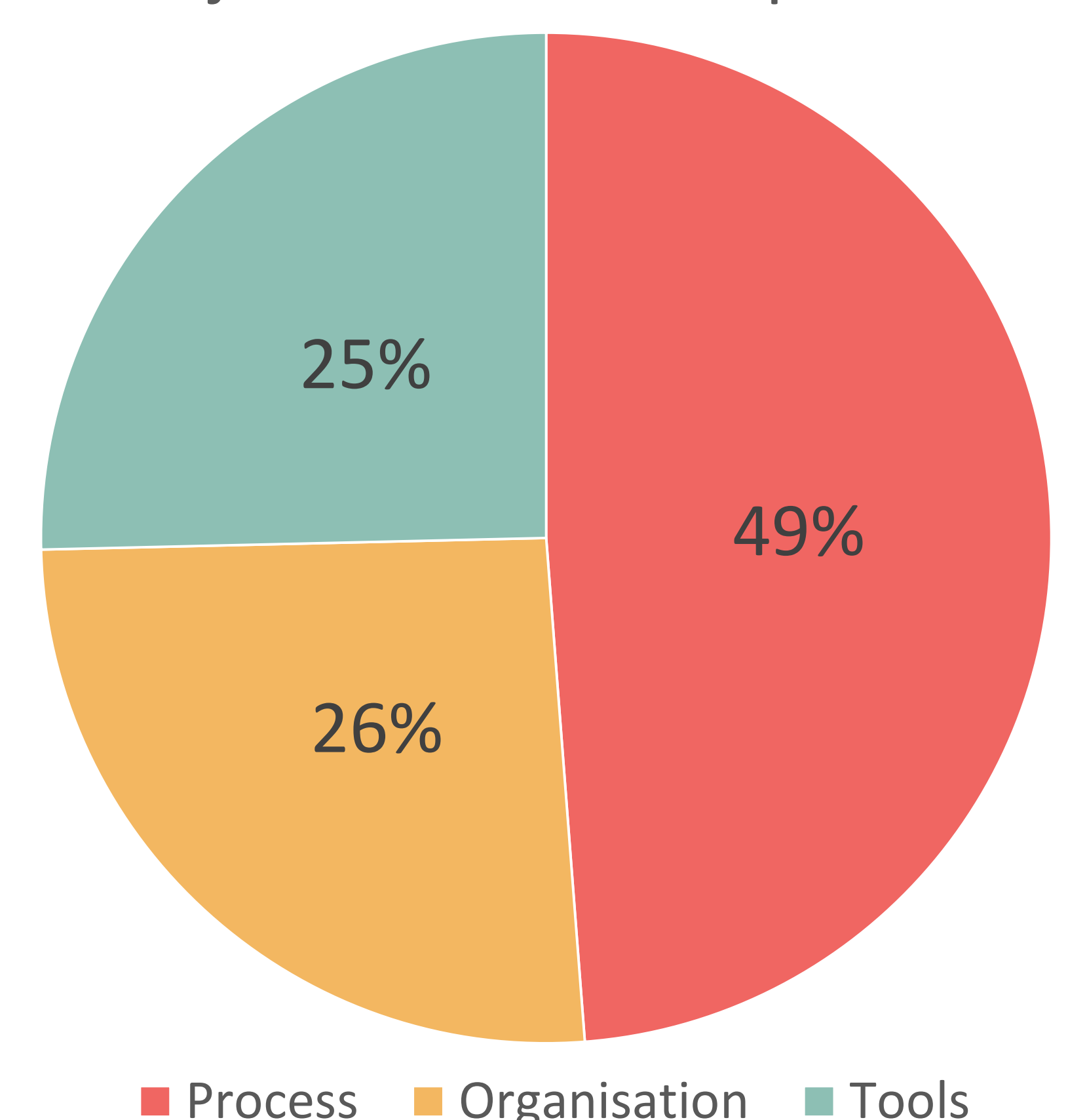
Within each of these three major themes, **six** subthemes were identified. These 18 subthemes were grouped into **four** areas that could benefit from the application of MBSE. From most to least popular, they are:

- **Organisation Modelling** (34%) i.e. team / project structure
- **Early functional validation** (27%) i.e. of the spacecraft system design
- **Communication & consistency** (24%) i.e. information transfer processes
- **Model Template Development** (15%) i.e. enable re-use across projects

### Responses from Domains



### Major Themes of Responses



### Conclusions

- MBSE can yield **numerous benefits** when implemented correctly.
- The road to institutional MBSE implementation, however, can be **long and winding**.
- One way to aid implementation is to identify **real issues** that MBSE could resolve.
- A method to identify these issues, based on **thematic analysis**, has been developed.
- This approach has highlighted **four potential application areas** for MBSE at Airbus: *Organisation Modelling, Early Functional Validation, Communication and Consistency, Model Template Development.*
- Pursuing the development of MBSE techniques in one of these areas increases our chance of **winning support** for MBSE implementation.
- This repeatable approach **can be adapted** and used in other organisations.

### Acknowledgements & Contact Details

This research was funded by the EPSRC and Airbus. The authors would like to acknowledge support from Alexandre Cortier, Stephane Estable, Thomas Fenal, Joanna O'Rourke, Antonio Prezzavento.

1. J. Gregory, L. Berthoud, T. Tryfonas, A. Rossignol, and L. Faure, “The long and winding road: MBSE adoption for functional avionics of spacecraft,” *Journal of Systems and Software*, vol. 160, p. 110453, 2019.

2. Caltrans and USDOT. 2005. Systems Engineering Guidebook for Intelligent Transportation Systems (ITS), version 1.1.1. Sacramento, CA, USA.

3. Nielsen Norman Group, 2020. “Thematic Analysis” [Online]:

<https://www.nngroup.com/articles/thematic-analysis/> Last accessed: 13/03/2020

\*Corresponding Author: Joe Gregory, Department of Aerospace Engineering, University of Bristol, BS81TR, [joe.gregory@bristol.ac.uk](mailto:joe.gregory@bristol.ac.uk)