# 205070 - High Performance Computing Projects for Aerospace Engineering

**Coordinating unit:** 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering  
**Teaching unit:** 758 - EPC - Department of Project and Construction Engineering  
**Academic year:** 2017  
**Degree:** MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)  
**ECTS credits:** 3  
**Teaching languages:** English

## Teaching staff

**Coordinator:** Manel Soria  
**Others:** Ivette Rodríguez  
Josep Maria Bergadà  
Daniel Garcia-Almiñana  
Silvia Rodríguez-Donaire

## Prior skills

The student must have a basic understanding of programming (in C or Fortran), fluid dynamics, Computational Fluid Dynamics (CFD), and project management.

## Teaching methodology

After a short theoretical introduction, almost all the lessons are developed in a workshop-like format, with students distributed in groups to work in a group project.

## Learning objectives of the subject

- Understand what is a high performance computing project for aerospace applications  
- Understand the basic aspects of high performance computing aerodynamics, such as turbulence models, mesh generation, post-processing  
- Be able to planify a high performance computing project, from its initial proposal to its conclusion, managing correctly the computer time available, as well as the project schedule

## Study load

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group: 27h</th>
<th>36.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td>Hours small group: 0h</td>
<td>0.00%</td>
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<tr>
<td>Guided activities: 0h</td>
<td>0.00%</td>
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<tr>
<td>Self study: 48h</td>
<td>64.00%</td>
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</table>
## Introduction to turbulence modelling for aerodynamic applications

**Description:**
The equations governing turbulent flows (the Navier-Stokes equations) are well known since 1820. However, the computational effort needed to solve them is huge and grows with $Re^3$ (Reynolds number to the power of three). Thus, to understand and predict turbulent flows typically found in aerospace applications, with very large $Re$ numbers, turbulence modelling is needed. In this part of the course, the basic turbulence concepts will be reviewed and the main ideas behind LES and RANS models will be outlined.

**Related activities:**
- Theory lessons

**Specific objectives:**
- Understand the main turbulence concepts and the main ideas behind LES and RANS turbulent models

## Fundamentals of Parallel Computing for CFD

**Description:**
The key concepts of parallel computing for CFD will be outlined.

**Related activities:**
- Theory lessons.
- Workshops.

**Specific objectives:**
- Understand the different types of parallel computers
- Understand the main parallel programming models
- Understand the distributed memory programming model
- Understand the standard MPI
- Be able to program, compile and debug a small MPI program (in C or Fortran)
Use of CFD software

**Description:**
Using an open-source CFD code, the fundamentals of CFD will be described. The topics to be covered are: mesh generation, selection of a turbulence model, selection of an algorithm, parallel running of the code, post-processing of the results, obtention of mesh-independent results.

**Related activities:**
- Workshops

**Specific objectives:**
- Understand how to generate a mesh
- Be able to select a turbulence model, understanding the implications of the decision in terms of simulation cost and accuracy
- Be able to select the main parameters for a CFD solver: accuracy, algorithm, number of iterations etc
- Understand the concept of mesh independency

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Supercomputing project management

**Description:**
The steps involved in the management of a supercomputing project will be outlined. The main aspects to be discussed will be: estimation of resources needed, proposal submission, project milestones, dealing with uncertainty in computing cost.

**Related activities:**
- Workshops

**Specific objectives:**
- Understand the main aspects associated with the management of a supercomputing project

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Qualification system

- Individual exercises: 30%
- Final group project: 70%

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Bibliography

**Basic:**