

## Position Description

### Group of research topics: Additive manufacturing

|                                   |  |
|-----------------------------------|--|
| <b>Position is funded by</b>      | <ul style="list-style-type: none"> <li>- COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon 2020, European Union</li> <li>- Centre Internacional de Mètodes Numèrics a l'Enginyeria (CIMNE), Spain</li> <li>- RMIT University (RMIT), Australia</li> </ul> |
| <b>Research Host</b>              | CIMNE and UPC, Spain   |
| <b>PhD awarding institution/s</b> | Dual PhD awarded by the Polytechnic University of Catalonia (UPC) and RMIT University, Australia   |
| <b>Locations</b>                  | <ul style="list-style-type: none"> <li>- Primary: Barcelona, Spain</li> <li>- Secondary: Melbourne, Australia</li> <li>- Annual workshops in Barcelona, Spain</li> </ul>   |
| <b>Contract</b>                   | Full time, 36 months   |
| <b>Gross annual salary</b>        | 25.898 EUR (gross amount before employee's taxes and contributions)  |
| <b>Preferred start date</b>       | 01/09/2022 (tentative)   |
| <b>Deadline for applications</b>  | 15/07/2022 (Reference: CIMNE-DC1)  |

### Your choice of research topics (only one of these projects will be funded):

| Project 1: Thermo-metallurgical modelling for AM processes   | Project 2: Thermo-mechanical modelling of WAAM process   | Project 3: Modelling of multi-material L-PBF process   |
|--|--|--|
| <p>The project will focus on the thermo-metallurgical coupling for additive manufacturing (AM) process simulation at melt-pool and at component scale level. Direct-Energy-Deposition (DED) will be used as the main AM technology. The key objective is to develop a numerical model to predict the microstructure evolution including phases, grain size and mechanical properties induced by the thermal cycles due to the AM process. Moreover, its relationship with the material strength will be investigated. <i>Further information may be obtained from the Supervisors.</i></p> | <p>Wire arc additive manufacturing (WAAM) is a directed energy deposition (DED) AM process that uses an electric arc as a heat source to melt a wire feedstock. The WAAM process is capable of producing thin-walled components and is relevant for many industries, such as aerospace, automotive and marine. This PhD project will focus on the thermo-mechanical modelling linking the processing parameters and resultant mechanical properties and defect formation. <i>Further information may be obtained from the Supervisors.</i></p> | <p>Multi-material additive manufacturing using laser-based powder bed fusion (L-PBF) has the potential to disrupt the manufacturing of multi-material parts and enable local tailoring of mechanical and functional properties. In this PhD project, the candidate will develop thermomechanical models to investigate the formation of interfaces and study the complex melt flow in metal-metal composites. <i>Further information may be obtained from the Supervisors.</i></p> |

**Supervisors:**

Prof. **Michele Chiumenti** (CIMNE/UPC) **and** A/Prof. **Andrey Molotnikov** (RMIT), Prof **Raj Das** (RMIT)

**Research Fields:** Computational mechanics, Finite Element analysis, Additive Manufacturing, metallurgy modelling, microstructure evolution, HPC programming.

## REDI

The REDI (RMIT European Doctoral Innovators) program is a unique opportunity offering excellent PhD conditions including enviable international experience, top-class research discipline and transversal skills training as well as networking with academic and industry leaders across 60+ supporting partners and 12 countries.

As a REDI researcher you will be:

- enrolled by two entities, with the chance to be awarded dual doctorates and gain alumni status from multiple institutions, including the Marie Curie Alumni Association.
- seeing the world and spending a year at RMIT University in Melbourne, Australia (ranked in the top 20 of universities under 50 years old in the world).
- part of a rich multidisciplinary network of researchers and supervisors who come together in annual, week-long training events in Barcelona.
- working closely with industry and gaining experience with the 40+ leading companies supporting the program.
- earning a salary above national standards for doctoral positions with full social security benefits (with further support available for eligible researchers with additional needs).
- receiving support and guidance from two highest-calibre, experienced supervisors with high PhD completion rates.
- enhancing your career prospects through comprehensive technical and transversal skills training from leading institutions, intersectoral and international experience and mentoring.
- working on innovative and exciting projects of high commercial and societal value with up to four years to complete your research.

For more information visit: [rediprogram.eu](http://rediprogram.eu)

## Are you REDI? (Expected Profile)

**Your background and skills:** You should possess advanced knowledge of Continuum and Computational Mechanics (master level) and Material science (metallurgy). Likewise, programming skills, like Fortran 2008 Object-Oriented, are considered an asset. Lastly, high working knowledge of English (Minimum B2) is required.

**Your work experience:** Professional experience is not required.

**Your research experience:** Research experience in Computational Mechanics, FE method including writing of user subroutines, programming skills (object oriented) and metallurgy is required.

## Employment Benefits and Conditions

CIMNE offers a 36-months position based in Barcelona (Spain), extendable up to 48 months in duly justified cases. International travel is foreseen, including to Australia (up to 12 months). There is a probation period of three (3) months and there are 40 working hours per week.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of est. 25.898 EUR gross per year (gross amount before employee's taxes and contributions). Of this amount, the estimated net salary to be perceived by the Researcher is est. 1.704 EUR net per month\*. However, the definite amount to be received by the Researcher is subject to national tax legislation. For more information on the estimated net salary, please use the [net salary calculator](#).



*\*Net salaries can fluctuate in accordance with an individual's personal circumstances (marital status, age, disability, family and dependents, etc. The above indicative net salaries offer an approximation of what a single person in their early 20s could expect to receive in their bank account after taxes.*

**Benefits include:**

- 23 days paid holiday leave
- Sick leave
- Parental leave
- The candidate will have access to HPC CIMNE computational cluster (<https://hpc.cimne.upc.edu>) and also have access to the experimental facilities at RMIT Centre for Additive Manufacturing ([www.rmit.edu.au/research/cam](http://www.rmit.edu.au/research/cam))
- 1,000€ yearly travel allowance to cover flights and accommodation to participate in the annual workshop at RMIT Europe in Barcelona (Spain)
- 10,000€ allowance to cover flights and living expenses for up to 12 months in Australia

For more details, please see: [https://doctorat.upc.edu/en/programmes/structural-analysis?set\\_language=en](https://doctorat.upc.edu/en/programmes/structural-analysis?set_language=en)

**REDI to apply? First a little more about us...**

**CIMNE**

The International Centre for Numerical Methods in Engineering - CIMNE, ([www.cimne.com](http://www.cimne.com)) is a research centre, created in 1987 by consortium between the Catalan Government and the Technical University of Catalunya (UPC), devoted to the development and application of numerical methods to a wide range of areas in engineering. CIMNE has been selected as a Severo Ochoa Centre of Excellence for the period 2019-2023. This is the highest level of recognition of excellence and leadership awarded to a research centre in Spain.

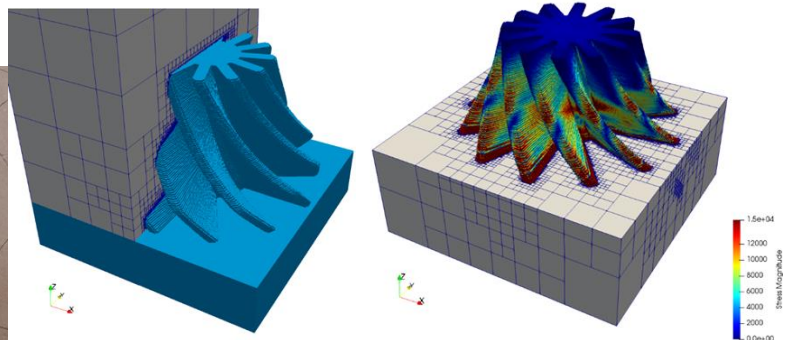
CIMNE is focused on the numerical simulation in both solid mechanics and fluid dynamic analysis related to a wide class of engineering problems and particularly metal forming processes including **Additive Manufacturing**.

The research activity carried out at CIMNE includes:

- Mathematical formulation and solution strategies;
- Numerical methods and **software implementation** issues;
- **Multi-physic** approaches and multi-scale techniques and including metallurgical models;
- Large scale simulation via **HPC** computing focused on industrial applications.



Hand-prosthesis made by Additive Manufacturing (FFF)



Turbine component made by Ti64 AM process (DED)

CIMNE is devoted to the development of ad-hoc specialized software platform for the numerical simulation of different industrial processes such as casting, welding, Additive Manufacturing processes as well as Heat Treatment analysis. The numerical simulation of the entire process manufacturing chain including standardization of the material database and I/O formats is also a leading R+D line at CIMNE. Developments of numerical simulation of Additive Manufacturing

(AM) processes by Metal Deposition (MD) by a fully coupled thermo-mechanical framework tailored to the analysis of both wire-feeding and blown-powder and powder bed technologies. Complex thermo-viscoelastic-viscoplastic material models are available to characterize different alloys for the fabrication of various components for the aeronautical and aerospace industry. An advanced high-performance and object-oriented software platform has been developed reaching highly scalable implementation based on Balancing Domain Decomposition by Constraints (BDDC). Great performance of this HPC framework is ensured for the solution of complex industrial application including AM simulations. The material models are calibrated and the numerical results are validated through the experimental campaign carried out at different laboratories.

CIMNE is actively working on the internationalization of the research, creating links and collaborations with research/industrial centers worldwide, e.g. in Australia (Monash University, **RMIT** university), China (Northwestern Polytechnical University of Xi'an, and the SKLSP Laboratory), Peru (Pontificia Universidad Católica del Perú - PUCP) and multiple centers in Europe (Hydro and SAPA in Sweden, Fraunhofer and ACCESS in Germany, CNR in Italy, SINTEF and NEST-AS in Norway, LTAS-MN2L in Belgium, IK4-LORTEK, Spain).

### Engineering Mechanics - Industrial Manufacturing Processes group

The PhD candidate will be integrated into the Industrial Manufacturing Processes group. The main activity of the group is:

- Manufacturing processes simulation including Additive Manufacturing and FSW processes
- Advanced mixed finite element technology
- Constitutive modeling including Failure Mechanics
- Multi-scale and multi-physics analysis

The research team is formed at present by:

**Prof. Michele Chiumenti:** <http://chiumenti.rmee.upc.edu/index.html>  
Prof. Miguel Cervera: <http://cervera.rmee.upc.edu/>  
Dr. Narges Dialami  
Dr. Manuel Caicedo  
As well as 7 PhD students.

The research team has published over 60 international journal contributions over past 5 years and participated in over 10 competitive projects (national, European and non-European international).

### RMIT

RMIT is a global university of technology, design and enterprise, ranked in the top 20 of universities under 50 years old in the world. World-class people, leading edge resources, collaboration with industry partners and multi-disciplinary approaches are just a few of the trademarks of research at RMIT, which boasts almost 90,000 students and campuses in Australia, Vietnam, a centre in Barcelona, Spain and research and industry partners on every continent.

The student will be integrated into RMIT Centre for Additive Manufacturing which is globally recognised Centre focusing on the industrial additive manufacturing. (<https://www.rmit.edu.au/research/centres-collaborations/centre-for-additive-manufacturing>). The Centre is located in the CBD of Melbourne and houses state-of the art facilities with a total investment of \$40 Million. The RMIT Centre for Additive Manufacturing has five research themes and about 60 staff including 20 academics, 17 PostDocs and nearly 30 PhD students.

A short video highlighting the facilities is available at [https://www.youtube.com/watch?v=hylMixMj\\_qw](https://www.youtube.com/watch?v=hylMixMj_qw)





## CAM Facilities

- [Advanced Manufacturing](#) ( \$40m research and teaching facility)
- [RMIT's Microscopy and Microanalysis Facility \(RMMF\)](#) and
- [Micro Nano Research Facility \(MNRF\)](#)



| Laser Powder Bed Fusion                                     | Directed Energy Deposition   | Industrial polymer printers   | Subtractive manufacturing                     |
|---|--|---|---|
| 4 SLM Solutions printers (2 single laser, 1 double, 1 quad) | TruLaser Cell 7020<br>3 kW laser ( powder and wire)<br>WAAM (arc plasma) | FDM, SLA, SLS<br>J750 Colour 3D Printer<br>Envisiontec 3D DLP Printer<br>Fortus 900mc | 5 and 6 axis CNC, wire cutting, welding, etc. |



Source: City Melbourne

The PhD student will be working closely with:

**A/Prof Andrey Molotnikov** <https://www.rmit.edu.au/contact/staff-contacts/academic-staff/m/molotnikov-dr-andrey>  
**Prof Raj Das** <https://www.rmit.edu.au/contact/staff-contacts/academic-staff/d/das-professor-raj>

The Centre has published over 180 papers in 2021 and actively participates in many national and international collaborations.

As Doctoral Student at RMIT you will be able to benefit from a wide range of training and mentoring opportunities including:

- **The PhD Up** program offering a huge range of workshops, seminars and short courses to build research knowledge and skills, including research writing, publishing, research methods, ethics, project management and careers (see more at: <https://www.rmit.edu.au/students/student-essentials/information-for/research-candidates/enriching-your-candidature/phd-up-program>)
- **RMIT PhD Online Modules**, designed specifically for PhD students, including *Researching your literature review*, *Writing a research proposal*, *Choosing where to publish*, *Writing for Publication*, *Research Integrity*, etc.
- **RMIT Creds**, RMIT's Digital Credentials Platform, which includes over 80 credentials covering a wide range of topics such as *Understanding Responsible Research and Innovation*, *Academic Integrity Awareness*, *Emotional Intelligence*, *Diversity Matters*, *Agile Ways of Working*, *Why Gender Matters*, *Cross Cultural Communications*, etc. (see more at: <https://www.rmit.edu.au/study-with-us/levels-of-study/short-courses>);
- **The e-Grad School**, the online learning modules of the Australian Technology Network (ATN) of Universities' covering a multitude of transferrable skills such as *Critical and Creative Thinking*, *Leadership and Communication*, *Entrepreneurship*, *Research Commercialisation*, *Public Policy*, etc.
- **The RMIT Mentoring platform** also gives you access to mentoring from trained professionals and experts, including:
  - o *Career Mentoring* - career guidance from industry professionals from all disciplines and global locations.
  - o *Women@RMIT Mentoring* - career guidance from industry professionals who are committed to gender diversity and equality in the workplace (especially for female students in male dominated industries)
  - o *Pride Mentoring* - a chance for students who identify as LGBTIQ+ to receive professional and social guidance from industry professionals who also identify as LGBTIQ+ or are familiar with the additional challenges these groups face in the workforce.

Find out more: [rmit.edu.au](https://www.rmit.edu.au)

## UPC



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101034328

The Universitat Politècnica de Catalunya · BarcelonaTech (UPC) is a public institution of research and higher education in the fields of engineering, architecture, sciences and technology, and one of the leading technical universities in Europe. Every year, more than 6,000 bachelor's and master's students, more than 500 doctoral students graduate and 3,067 graduates in lifelong learning. The UPC has a high graduate employment rate: 93% of its graduates are in work and 76% find a job in under three months. It is ranked in the main international rankings.

The UPC has a wide spread presence in Catalonia, with nine campuses located in Barcelona and nearby towns: Castelldefels, Manresa, Sant Adrià de Besòs, Sant Cugat del Vallès, Terrassa, and Vilanova i la Geltrú.

The UPC is an International Campus of Excellence with two projects: the Barcelona Knowledge Campus (BKC) and the Energy Campus. Through these projects, it promotes employability, social cohesion and regional economic development. It interacts with research centres, science and technology parks, businesses and other agents as a hub for attracting talent in emerging research areas. In addition, through its four UNESCO Chairs, the UPC contributes to the exchange of knowledge and fosters cooperation.

The campuses are accessible, well connected by public transport and equipped with the necessary facilities and services to contribute to learning, research and university life.

UPC offers a wide range of training and mentoring opportunities to Doctoral Students including:

- Hola! Cultural and Language Reception Programme and the UPC Language Programme such as basic Catalan and Spanish courses. Visit this website for more information: <https://www.upc.edu/sit/en/language-and-terminology-service/our-services#newtocatalonia>
- MOOC courses
- Summer courses

## A little more about you...

### Functions to be developed by the PhD candidate

PhD candidate to be asked for sharing his/her R+D activity between CIMNE focusing on the **numerical simulation of metal Additive Manufacturing processes** and RMIT for the corresponding **experimental calibration/validation** of the model as well as to develop suitable **metallurgical models** to be integrated into the software platform

## Requirements

- Excellent academic record.
- Advanced knowledge of **Continuum** and **Computational Mechanics** (master level).
- **Programming skills:** Fortran 2008 Object Oriented, Python, C.
- Windows and Linux OS
- Previous research or academic **experience in FE thermo-mechanical analysis**

It is also appreciated:

- Previous expertise in **microstructure** analysis and evolution, and **metallurgical modelling**.
- Previous experience in Parallel Computing (**HPC**)

## Eligibility

**You need to fulfil criteria of the REDI program and both universities to be recruited.**

To apply for REDI, you must comply with the MSCA-COFUND eligibility criteria by the application deadline:



- **Be in the first four years Full-Time Equivalent (FTE) research experience** of your research career and not yet have been awarded a doctoral degree. FTE Research Experience is measured from the date when a researcher obtained the degree entitling him/her to embark on a doctorate, **AND**
- **Not have resided or carried out your main activity (work, studies, etc.)** in the country of your research host for more than 12 months in the 3 years immediately before this call's deadline. Time spent as part of a procedure for obtaining refugee status under the Geneva Convention (1951 Refugee Convention and 1967 Protocol), compulsory national service and/or short stays such as holidays is not taken into account.

**AND** the following criteria:

- **Hold a bachelor's degree requiring at least 4 years of full-time study** in a relevant discipline awarded with honours and including a research component; **OR**
- **Hold a master's degree that includes a research component** or a master degree without a research component with at least a high distinction average; **OR**
- **Have evidence of appropriate academic qualifications and/or professional experience** demonstrating that the applicant has developed knowledge of the field of study or cognate field and the potential for research sufficient to undertake the chosen project.

**AND**

- Have **English level C1 language proficiency**.

In addition to the above, if your application is successful, you will be required to:

- Apply for a working visa in Spain (More information: <http://www.exteriores.gob.es/Portal/en/ServiciosAlCiudadano/InformacionParaExtranjeros/Paginas/RequisitosDeEntrada.aspx>)
- Apply for a student visa in Australia (More information: <https://www.rmit.edu.au/study-with-us/international-students/apply-to-rmit-international-students/student-visas/apply-for-a-visa>)

**In addition to meeting the eligibility criteria for the REDI Program, you will also need to meet the admission criteria of both institutions:**

## Admission at UPC

You will be enrolled as Doctoral Student at UPC for the entire duration of the assignment. At admission, you will need to supply:

- Degree certificate and the transcript of records of a Bachelor and Master (original and photocopy) in Engineering, Science or Technology and have completed a master's degree in a field related to the scientific area of the programme.
- Demonstrate basic knowledge in the field of Structural Analysis, particularly with regard to the mechanics of continuous media; solid and fluid mechanics; and linear, nonlinear, static and dynamic behaviour of materials and structures. It is recommended that candidates have some knowledge of programming (Computational Mechanics).

Homologation of a degree issued under a foreign education system is not required, but the UPC must verify that the degree certifies a level of training equivalent to an official Spanish master's degree and qualifies the applicant for

admission to doctoral studies in the country where it was issued. Admission on this basis does not imply homologation of the foreign degree or its recognition for any purpose other than admission to doctoral studies.

The academic committee will consider applications that do not meet these requirements on a case-by-case basis. In general, preference will be given to applicants who hold a master's degree in the sciences as defined in the Bologna Process guidelines.

For the recognition of degree equivalency, the academic committee for the programme will assess to what extent the qualification in question corresponds to one of the master's degrees listed above in terms of the number of credits and the subjects studied. The academic standing of the institution that awarded the degree will also be considered.

Students who have completed one of the following UPC master's degrees qualify for direct admission to the doctoral programme in Structural Analysis and will not be required to take any bridging courses:

- Master's degree in Civil Engineering
- Master's degree in Numerical Methods in Engineering
- Erasmus Mundus master's degree in Computational Mechanics

Students who hold a master's degree or have completed postgraduate studies recognised by the UPC as equivalent to one of the masters degree's specified above will be admitted to the doctoral programme automatically.

Candidates should demonstrate an interest in the research projects carried out within the framework of the programme; critical and analytical skills; initiative and perseverance in their academic work; the ability to work in a team; and the ability to communicate effectively, both orally and in writing.

More information: [https://doctorat.upc.edu/en/programmes/structural-analysis?set\\_language=en](https://doctorat.upc.edu/en/programmes/structural-analysis?set_language=en)

## Admission at RMIT

You will also be enrolled as Doctoral Student at RMIT for the entire duration of the assignment. At admission, you will need to supply:

- CV
- Complete transcripts for all academic qualifications
- Research proposal or statement of interest in an available research project
- Language certificates
- List of referees

More information: <https://www.rmit.edu.au/research/research-degrees/how-to-apply>

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