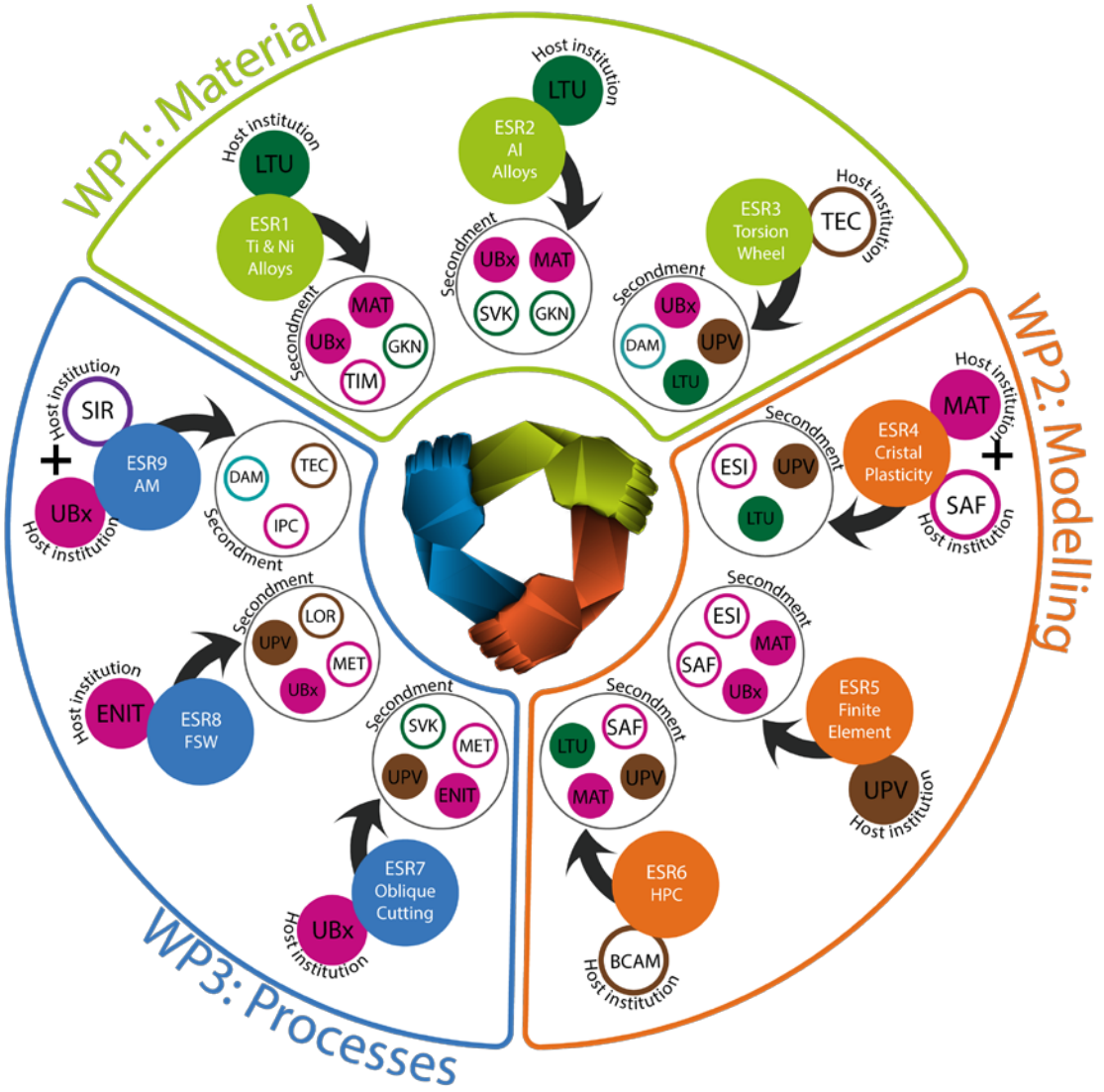
ESR 4

PHD setup and supervision

ESR4/Microscale-MAT

This project received funding from the European Union's Marie Skłodowska-Curie Actions (MSCA) Innovative Training Networks (ITN) H2020-MSCA-ITN-2017 under the grant agreement N°764979



France
Spain
Sweden
Belgium
Denmark
University
Company /research centre

SAF Safran Tech
ESI ESI Group
TIM Timet
MET Metallicadour
IPC Innovation Plasturgie Composites
DAM Danish Advanced Manufacturing Research Center

SIR SIRRIS
GKN GKN Aerospace Sweden AB
SVK Sandvik Coromant
TEC Tecnalia
LOR Lortek
BCAM Basque Center for Applied Mathematics

UPV University of Basque Country
ENIT Engineering School of Tarbes
MAT Superior National School of Mines of Paris
LTU Lulea University of Technology
UBx University of Bordeaux

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COMMON BASE PHD

PROJECT SUMMARY

ENABLE (European Network for Alloys Behaviour Laws Enhancement) aims to train early-stage researchers in what is referred to as an outstanding challenge for the future of manufacturing: developing novel solutions for forecasting and mastering processes relevant for all factories using metallic alloys. The project Enable is financed by the H2020 programme under the "Marie Skłodowska-Curie ITN action".

ENABLE proposes a complete rethink of the usual process simulation method by developing innovative multiscale, multiphysical and multi-level advanced (TRL 1 to 8) simulation. To extend the benefits to a wide range of industrial actors, the simulation will be carried out on several widely-used processes: Machining, Friction Stir Welding and Additive Manufacturing. The most popular metals in industry (Titanium, Nickel based and Aluminium alloys) will be chosen for the scientific investigation.

ENABLE will lead to the development of new tools that are better suited to production (reduced premature wear, increased service life, improved tools, etc.) and will reduce production time and thereby production costs.

A group of 9 ESR will be introduced to dynamic approaches to exploiting advances in fundamental research towards innovative applications. To "enable" this vision, each trainee will have access to closely integrated complementarities and world-class expertise in mechanical science, materials science, computer science/numerical methods, state-of-the-art scattering, advanced equipment and significant computational resources. Additional cross-disciplinary training and a strong involvement on the part of the 12 Industries and SMEs and research centres will provide the students with transferable skills

ELIGIBILITY CRITERIA

EARLY STAGE RESEARCHERS (ESRS)

- ESR shall, at the time of recruitment by the host organization, be in the first four years (full-time equivalent research experience) of their research careers
- Duration of recruitment: 36 months

ELIGIBILITY CRITERIA

- The ESR may be a national of a Member State, of an Associated Country or of any Third Country.
- The ESR must not have resided or carried out her/his main activity (work, studies, etc.) in the country of her/his host organization for more than 12 months in the 3 years immediately prior to her/his recruitment.
- Holds a Masters degree or equivalent, which formally entitles to embark on a Doctorate.
- Does not holds a PhD degree.

MOBILITY WITHIN THE CONSORTIUM

SECONDMENT

Visits to private sector partners and 10 months of secondment will be mandatory, to provide the ESRs with good exposure to the job market and private sector requirements. All ESRs will spend time working in a different European country and thereby enjoy significantly broader horizons than those of a typical single-country-based researcher.

ESR4
WP2 MODELLING

MICROSCALE

ESR4: *Multiscale computational approach for severe deformation processes in polycrystalline aggregates.*

MAT SAF ESI LTU UPV

The PhD student will work on a finite deformation crystal plasticity model implemented in the implicit finite element code Zset (common code for MAT-SAF). He will identify the material parameters for the titanium alloy for which experimental results are available within the project, using simulations of representative volume elements of polycrystals. The model will be also implemented in an explicit code for comparison. Finite element simulations will be performed at large strains in order to investigate the possibility of remeshing and field transfer in the context of crystal plasticity.

In a second step, the crystal plasticity framework will be extended to incorporate the effect of Geometrically Necessary Dislocations (GND) that arise in the presence of strong strain gradients. Two types of strain gradient crystal plasticity models will be considered. The first one is an available strain gradient crystal plasticity model incorporating the gradient of cumulative slip in the formulation. The corresponding implicit code is already available at finite strains. This first approach will be extended to incorporate the full dislocation density tensor (GND tensor) defined as the curl of the plastic deformation field. Again, implicit and explicit formulations will be proposed. Size effects associated with grain size and strong strain gradients induced by the loading will be investigated and compared to experimental results obtained within the project.

The last stage will be devoted to the identification of a homogenized polycrystal model at large strains from the simulations of the polycrystalline aggregates. This reduced model will be used to determine the effect of the crystallographic texture and its evolution during straining. A first version of the model is available and will be extended to incorporate suitable constitutive laws including dislocation densities and characteristic lengths deduced from

the full field simulations. The results of the homogenization model will serve for the calibration of more macroscopic models not based on crystal plasticity.

Available codes : Implicit finite deformation crystal plasticity, Implicit gradient of cumulative slip crystal plasticity model at finite deformation. Implicit homogenized polycrystal model at finite deformations. (Zset)

Codes to be produced : Explicit finite deformation crystal plasticity, Implicit and explicit Curl-based strain gradient crystal plasticity model. Explicit homogenized polycrystal model at finite deformations.

HOST INSTITUTION MAT+SAF

Doctoral School: Paris Sciences Lettres. Possibility of joined PSL and LTU doctoral degre.

AIMS

Develop and fine-tune the macroscopic strain gradient model via microstructural computations taking the polycrystalline nature of the material into account, based on computational homogenisation methods; in particular, determination of characteristic lengths of the gradient models.

COOPERATION WITH OTHER PARTNERS

ESR1, ESR2, ESR5, ESR6, UBx, LTU, ESI, BCAM

Cooperation with LTU: The experimental data made available at LTU by ESR1 and ESR2 (material characterization) require a cooperation between MAT-SAF-LTU for the identification of the material parameters of the dislocation based crystal plasticity model. The ESR4 will spend some months at LTU for that purpose.

Cooperation with ESI: The ESR will assist ESI adpating their model to their code.

Cooperation with UPV: Knowledge transfer with ESR5 and ESR6, calibration of the digital polycrystalline morphologies and finite-element meshes of the grains.

EXPECTED RESULTS

- State of the art on crystal plasticity.
- Simulation of polycrystalline aggregates within classic crystal plasticity for titanium alloys.
- Strain gradient crystal plasticity modelling of polycrystalline aggregates under severe loading conditions;
- Formulate physically-based and thermodynamically consistent crystal plasticity constitutive equations at the grain level from the literature and experiments performed within the project (ESR1 and ESR2).
- Provide digital polycrystalline morphologies, crystallographic textures and finite-element meshes of the grains (linked with ESR5 and ESR6).
- Implementation of constitutive models and homogenizations laws for polycrystals.

SUPERVISOR

PhD advisor 1 : Dr. Samuel Forest (Mines ParisTech)

PhD advisor 2 : Dr. Arjen Roos (SafranTech)

Co-advisors/Supervisors : Dr. Jonas Edberg (LTU), Dr. Didier Croizet (ESI), Dr. Dimitri Jacquin (Ubx)

DELIVERABLES

- D2.3: Crystal plasticity (05/2020)
- D2.4: Local behaviour law, scale change and homogenization (05/2020)

SECONDMENTS

	LOCATION	DATE
4 months	LTU	Month 16 (05/2019->07/2019)
2 months	ESI	Month 31 (08/2020->09/2020)
4 months	UPV	Month 33 (10/2020->01/2021)

PLANNING/TIME LINE

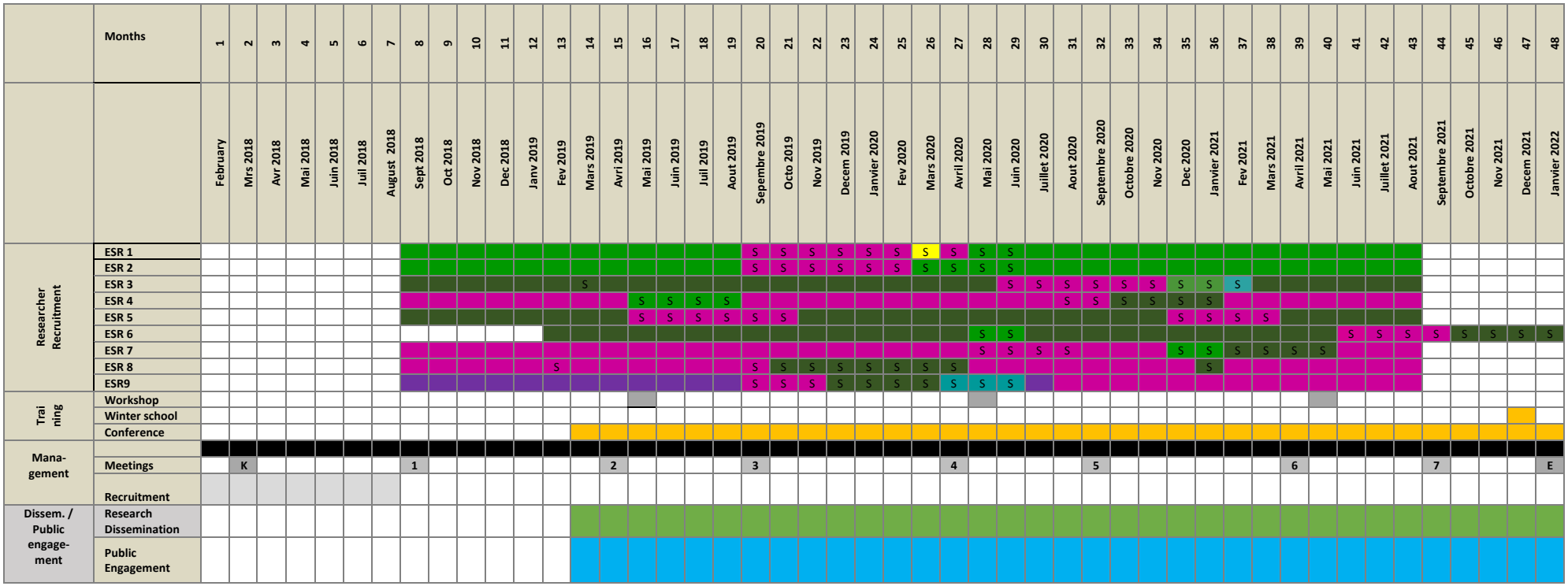
- Beginning of thesis : 10/2018
- D2.3: 05/2020
- D2.4: 05/2020
- Workshop in Bordeaux-France 05/2019
- Workshop in Lulea-Sweden 05/2020
- Workshop in Bilbao-Spain 05/2021
- Winter school in Tarbes-France 12/2021
- Midterm publication 07/2019
- Final publication 09/2021
- State of the art on crystal plasticity 01/2019
- Simulation of polycrystalline aggregates within classic crystal plasticity for titanium alloys 04/2019

- Strain gradient crystal plasticity modelling of polycrystalline aggregates under severe loading conditions 09/2019
- Formulate physically-based and thermodynamically consistent crystal plasticity constitutive equations at the grain level from the literature and experiments performed within the project (ESR1 and ESR2) 01/2020
- Provide digital polycrystalline morphologies, crystallographic textures and finite-element meshes of the grains (linked with ESR5 and ESR6) 09/2020
- Implementation of constitutive models and homogenization 02/2021
- the experimental design 06/2019
- Full strain gradient plasticity based on the dislocation density tensor (full Curl operator) 11/2020
- End of thesis 09/2021

QUALIFICATIONS
SKILLS

- Excellent Master degree in mechanical engineering, material science, computer science or related disciplines
- Strong interest in computational mechanics related to material science and working knowledge in the field of metallic alloys, fields measuring
- Significant laboratory experience in finite element computing and coding (C++)
- Strong background in plasticity theory and computation
- Familiarity with lab equipment, including chemical handling procedures and attention to detail as well as environmental, health and safety (EHS) requirements
- Excellent communication skills and willingness to work in collaborative projects with multiple partners
- Very good English language skills
- Self-motivation and the ability to achieve goals independently as well as to contribute effectively to the team

GANTT CHART



S = Secondment

K = Kick-off meeting

E = End of project

Sweden

Spain

France

Denmark

Belgium

UK