WE CAN
DO SO
MUCH
TOGETHER

VIRTUAL UPSCALING

Annual meeting

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INTRODUCTION

Introduction

- Two case studies
  - planned within WP3
  - to extract requirements for the generic virtual upscaling tools developed in WP4
- Task 3.2
  - the second case study
  - related to Wire and Arc Additive Manufacturing (WAAM)
  - conducted by Tecnalia

Introduction

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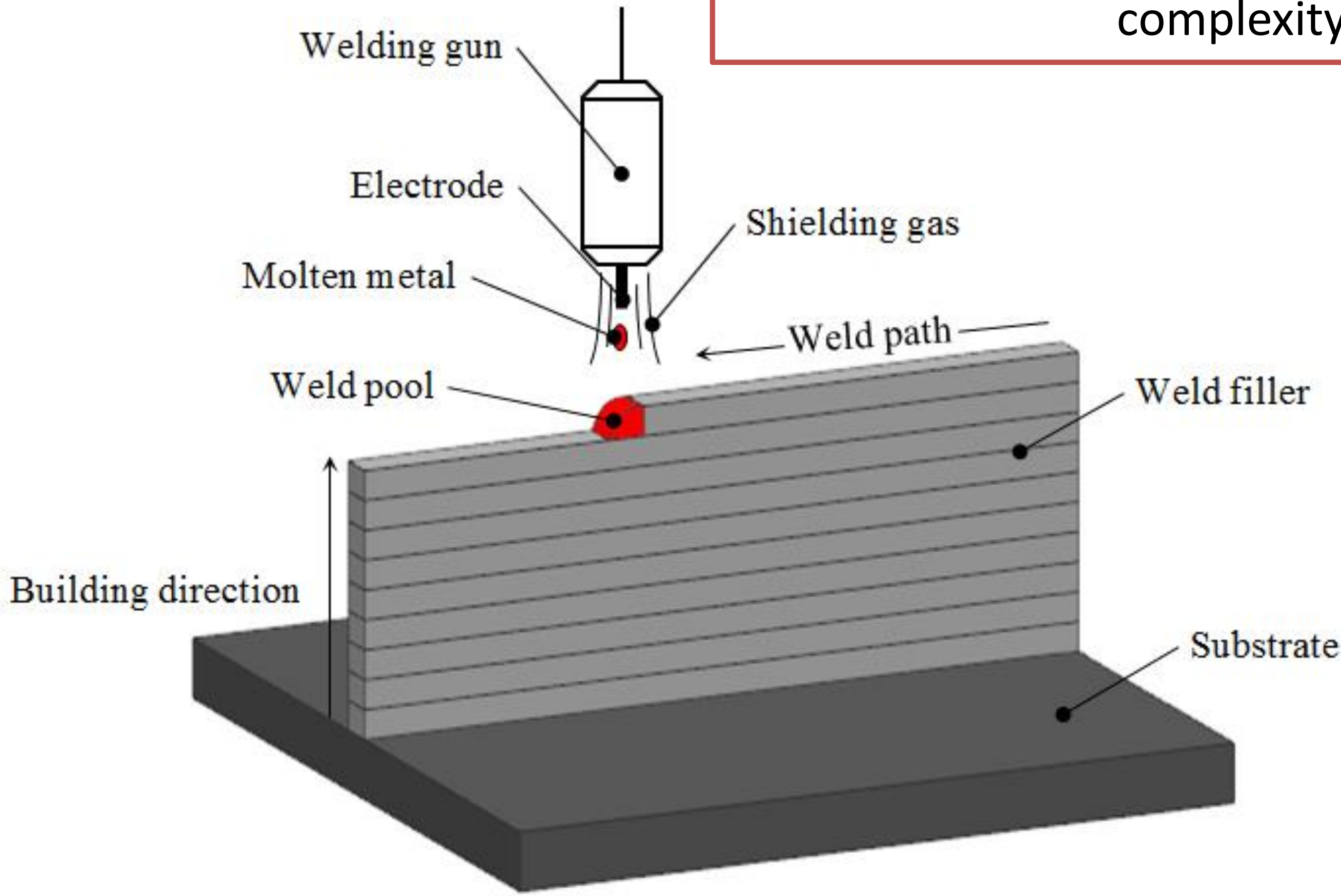
- What's a WAAM process?

Main advantage: high deposition rate
Main drawback: lower geometry complexity



Introduction

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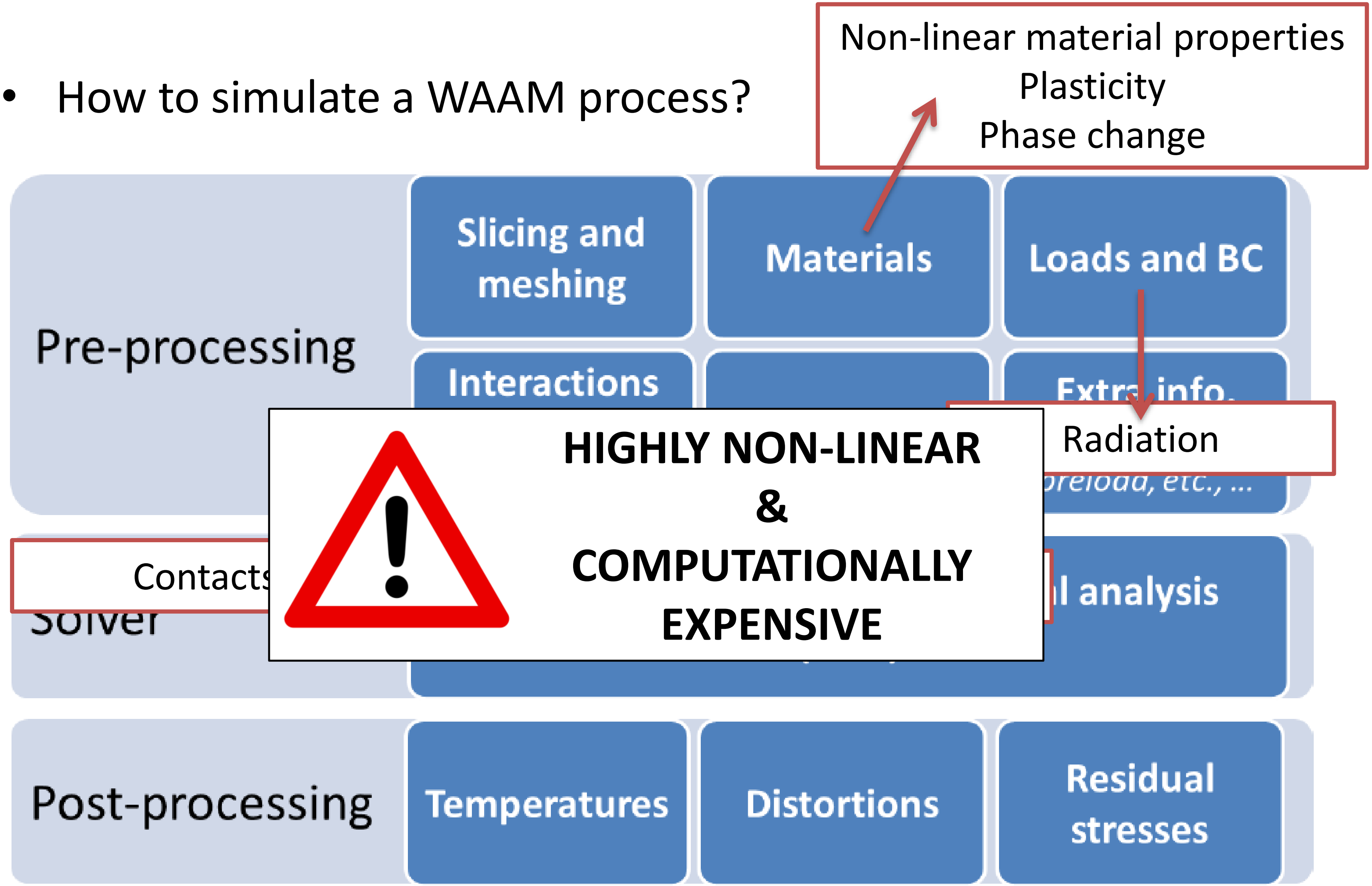
- WAAM relatively new fabrication technique
- Great potential due to benefits such as material efficiency, lead time, cost, etc.
- However, specific problems
  - distortions
  - residual stresses
  - pores
  - cracks
  - etc.

PROCESS SIMULATION BECOMES CRITICAL

Introduction

- How to simulate a WAAM process?

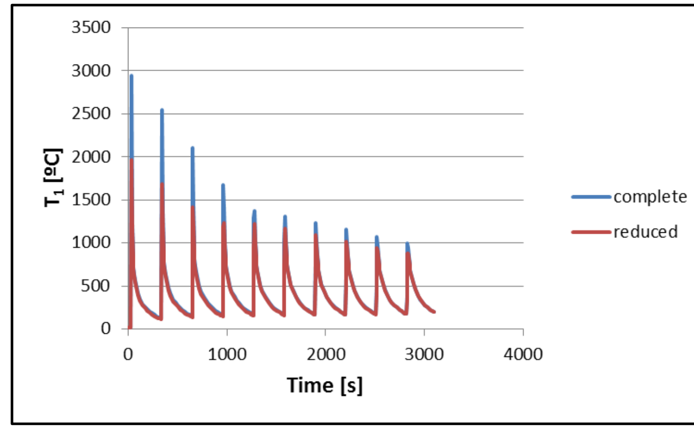


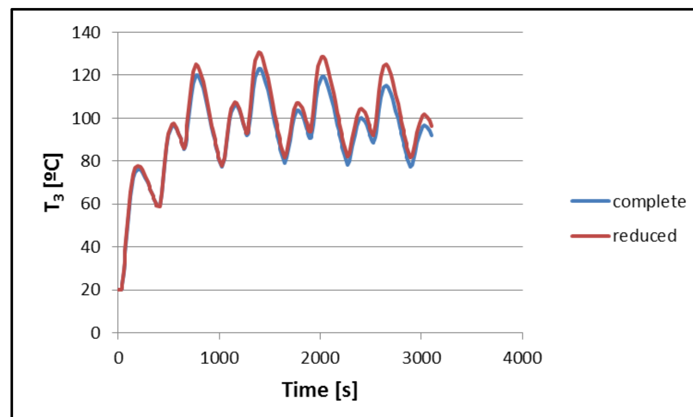
Introduction

- How to achieve a computationally efficient simulation?
  1. Reduced model complexity → Efficient 2D models
  2. Alternative approaches

Combination of the Finite Difference and the Finite Element methods

To be developed within the Virtual Upscaling project





OBJECTIVES

Objectives

- Development and validation of a simulation procedure able to efficiently simulate WAAM processes
- Implementation of a simulation procedure
- Assess the accuracy of the numerical results and the reduction of computational cost, compared with current FEA
- Extract requirements for the Modelling Factory with this development

SIMULATION PROCEDURE AND TOOL

Simulation procedure and tool

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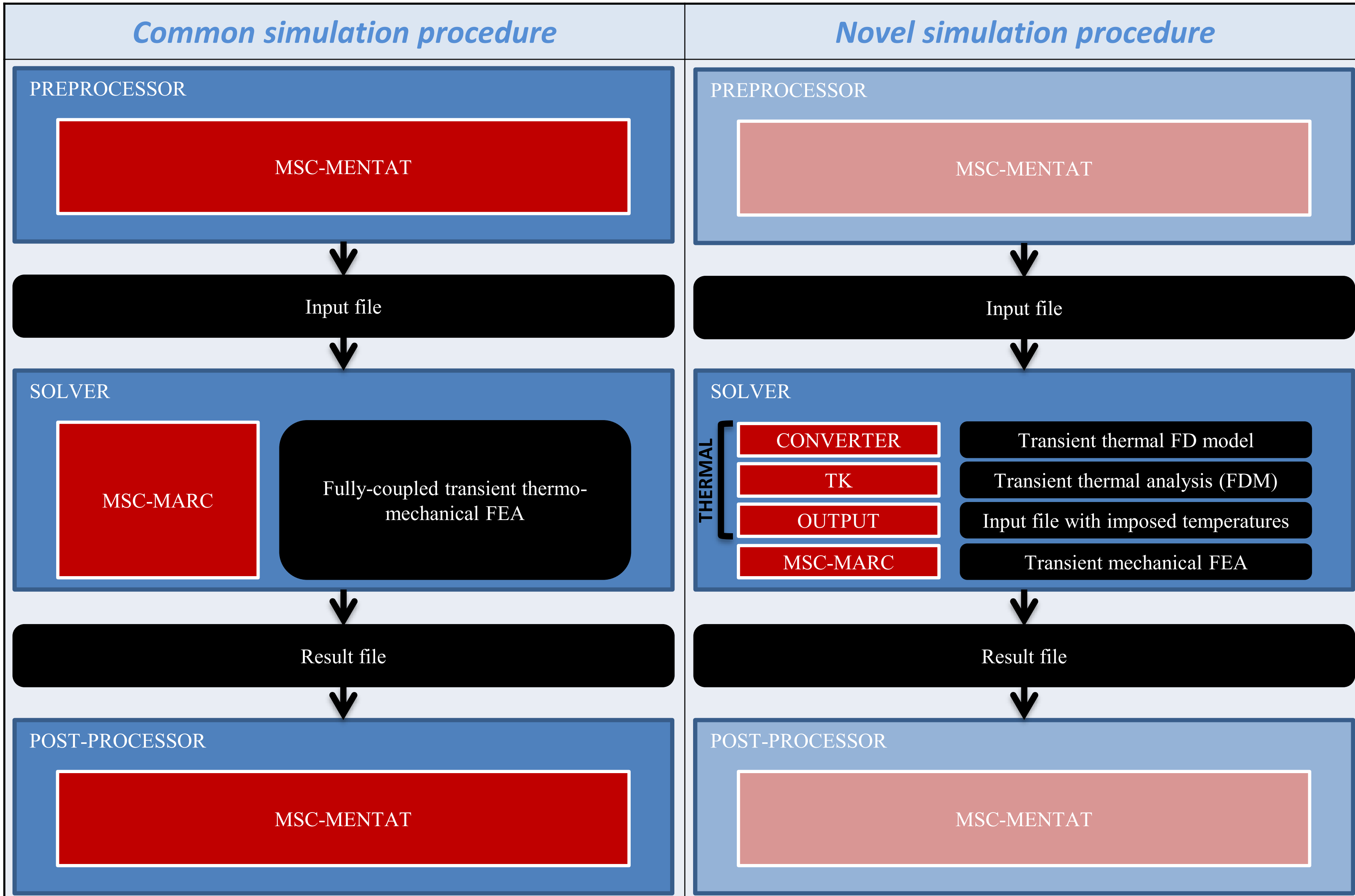
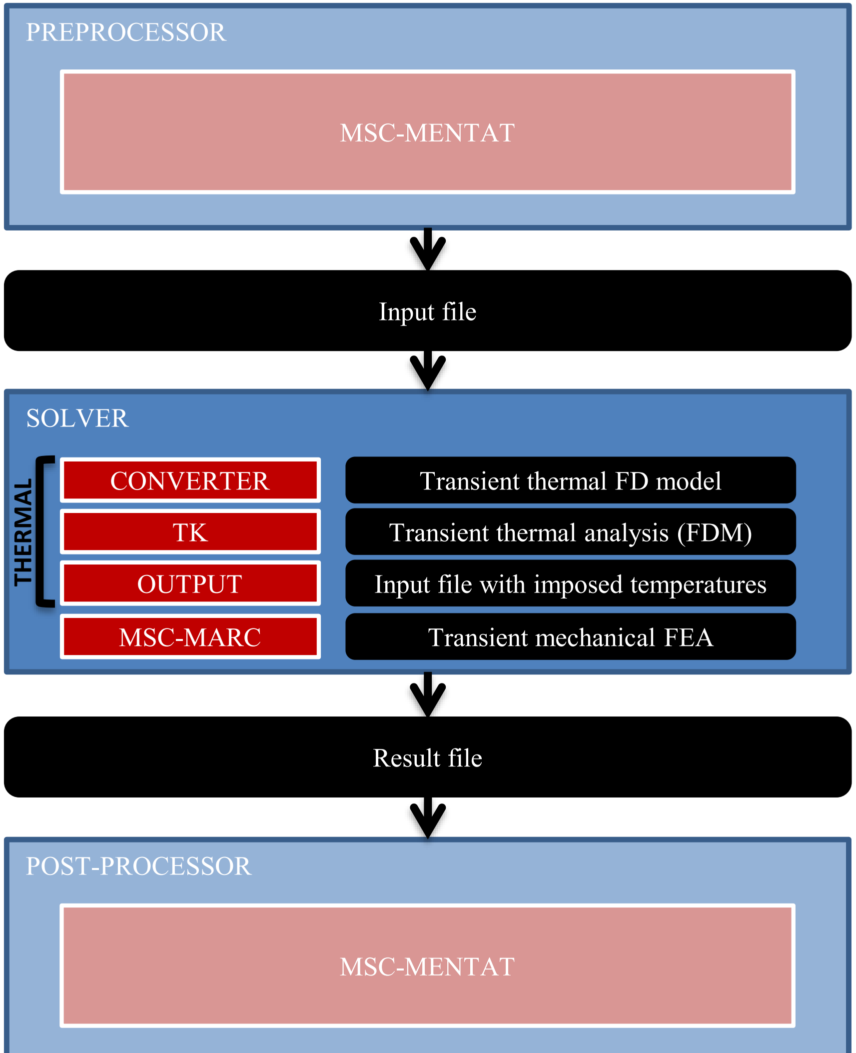
- Based on the combination of the Finite Difference and Finite Element methods
  - FDM is usually more efficient than FEM, as good thermal results can be quickly achieved with simpler mathematical models (less DOF)
  - but requires a deeper knowledge of the phenomenon to be modelled
- This procedure is considered to be more efficient than a common fully-coupled transient thermo-mechanical analysis because:
  - being a <u>weak coupled analysis</u>, the simulation cost will be considerably reduced without any significant loss in accuracy
  - a <u>coarser mathematical model</u> can be used thanks to the Finite Difference Method, while keeping results accuracy
  - a <u>greater time step</u> can be applied for the mechanical analysis

Simulation procedure and tool



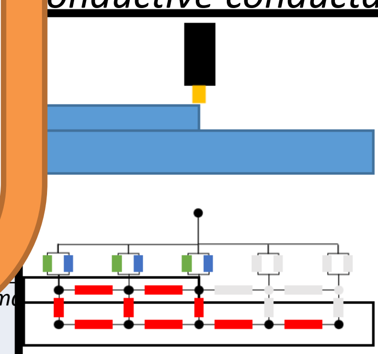
Simulation procedure and tool

Simulation steps



6. Mechanical analysis (FEM)

- *Acc ding to a discretization level and isot mal nodes ordering criteria*
- *Mo formed by:*
  - *oordinates of the isothermal odes*
  - *hermal capacitances of the othermal nodes*
  - *onductive conductances among*
  - *t each*
  - *nditions*



	ains inactive until the atime.
me ime)	ependent thermal iated to the material ntil the activation time atime.
TGL2(*i,j,atime*)	Transient convective conductance between the nodes *i* and *j*, that remains inactive until the activation time *atime*.
TTGR(*i,j,jdmat,atime*)	Transient temperature-dependent radiative conductance between the nodes *i* and *j*, associated to the material *jdmat*, that remains inactive until the activation time *atime*.
HEAT *i*	Transient power applied to the node *i*, defined as a time-dependent table
TSINK *i*	Imposed transient temperature of the node *i*, defined as a time-dependent table

Simulation procedure and tool

- Several codes used for the resolution of the problem, but the simulation tool operates as a unique piece of software
  - each software is sequentially executed through a batch file
  - the information is exchanged through the communication channels
- The user is able to complete the calculation by just executing this batch file

```
@echo off
:A
cls
start /wait %1convert.exe
start /wait %1solve.exe
start /wait %1output.exe
C:
cd "C:\USUARIOS_CALC\HARITZ\PROYECTOS\2017 VIRTUAL UPSCALING\03 programa\04 ejecutable programa"
C:\MSC.Software\Marc\2014.1.0\marc2014.1\tools\run_marc -jid NewInput|more
del centroids.dat
del newinput.dat
del nodal_temperatures.dat.dat
del output.dat
del output_memoria.dat
del temperatures.dat
del *.log
del *.sts
del *.out
del fort.*
del *.*.$$$
exit
```

CONCLUSIONS

Conclusions

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- Development of a novel simulation procedure to efficiently simulate WAAM processes
- A simulation tool, consisting of a pre-processor, a solver and a post-processor, that follows this simulation procedure is presented.
  - arrangement of a simulation tool package to subsequently solve the thermal and the mechanical analyses
  - such a solver operates as a unique piece of software
- The communication among the codes and modules is completed by means of input/output files, in which the data is organized through specific cards

ACTIVITIES FOR 2018

Task 3.2
Status

Objective	Progress	Corresponding deliverable	Date	Progress
Development of a simulation procedure able to efficiently simulate WAAM processes	100%	D3.2.1 Description of the thermo-mechanical model and consequent efficiency	M4, Dec. 2017	100%
Development of a simulation tool that follows this procedure	100%			
Assess the accuracy of the numerical results and the reduction of computational cost	50%	D3.2.2 Validation against current approaches	M5, June 2018	50%
Validation of the simulation procedure/tool	30%			
Extract requirements for the Modelling Factory with this development	0%	D3.2.3 Documentation of the procedure over the multi-scale modelling chain	M5, June 2018	0%

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