1st Annual event on

"Critical Raw Materials"

06 November 2017

Brussels, Belgium

EQUINOX

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A novel process for manufacturing complex shaped Fe-Al intermetallic parts resistant to extreme environments

The research leading to these results has received funding from European Community's HORIZON 2020 framework programme for research and innovation under GA N◦ 689510

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Outline

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- The consortium
- Objectives and impacts
- State of the Art
- Methodology
- Work Package structure
- Deliverables/Milestones timeline
- Current status

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Consortium - Responsibilities

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Prof. C.A. Charitidis (NTUA): Coordinator

Dr. W. Kochanek (KE): Technical coordinator

Participant No *	Participant organisation name	Country	Type	Responsibilities
1	National University of Athens (NTUA)	GR	RTO	Mechanical testing
2	TEKON	DE	SME	Demonstrators
3	Dr. Kochanek Entwicklungsgesellschaft (KE)	DE	SME	Preforms
4	IMDEA	ES	RTO	Infiltration
5	TU-Liberec (TUL)	CZ	RTO	Heat treatment, Microstructure
6	Access	DE	RTO	Modeling, Simulations
7	Open Source Management (OSM)	UK	SME	Dissemination
8	CES Operations (CES)	NO	SME	Demonstrators
9	Freni Brembo S.p.A (BREMBO)	IT	Industry	Demonstrators
10	Yuzhnoye (YUZ)	UKR	Industry	Demonstrators, Preforms
11	Innovation in Research and Engineering Solutions (IRES)	BE	SME	LCA, SbD principles

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Consortium

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Main objective

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The main objective of EQUINOX is :

to develop a novel process that allows to substitute Critical Raw Materials (CRMs) based stainless steel parts used in high volume end consumer products such as in the lock industry, electronics, process and automotive industry with **a new class of highly advanced ductile Fe-Al based intermetallics produced by a novel near net shape technology.**

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Specific objectives

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The main objective is supported by the following specific objectives :

1. Produce extremely fine grained FeAl-Material of high ductility via reactive infiltration of porous iron preforms with liquid Aluminum
2. Understand how ultrafine porous iron structures of complex 3D-shape can be tailored to be used as optimized preforms for reactive infiltration of liquid Al-alloys
3. Develop a reactive infiltration process by using two different techniques: suction and centrifugal casting
4. Simulate reactive infiltration process by physically based multi-scale models based on StarCast and MICRESS
5. Optimize mechanical properties of EQUINOX material with respect to microstructure based on process conditions and consecutive heat treatment

Laboratory scale . . .

6. Scale up the process from lab to small pilot plant with respect to the industrial needs
7. Transfer the concept to at least one real demonstrator which will be tested for high corrosion and wear resistance
8. **Evaluate the industrial impact** of EQUINOX-concept with respect to economic as well as technical aspects.

. . . and beyond

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Main impact

Flat products: attributing for 29.4 Mio t p.a. (82 % of the market)
Long products: attributing for 6.6 Mio t p.a. (18 % of the market)

First conclusion: Substitution potential of stainless steel may be found in the market sector of “long product” which represents a volume of 6.6 Mio t p.a.

Second conclusion: the economic impact of EQUINOX would be equivalent to a substitution of 290 Mio € p.a. of semi-finished stainless steel products.

MAIN IMPACT

EQUINOX would allow to save at least 18.000 Tons of CRM per year by substituting stainless steel through CRM free Fe-Al based intermetallics (even without considering stainless steel flat products)

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State of the Art (Steel Industry)

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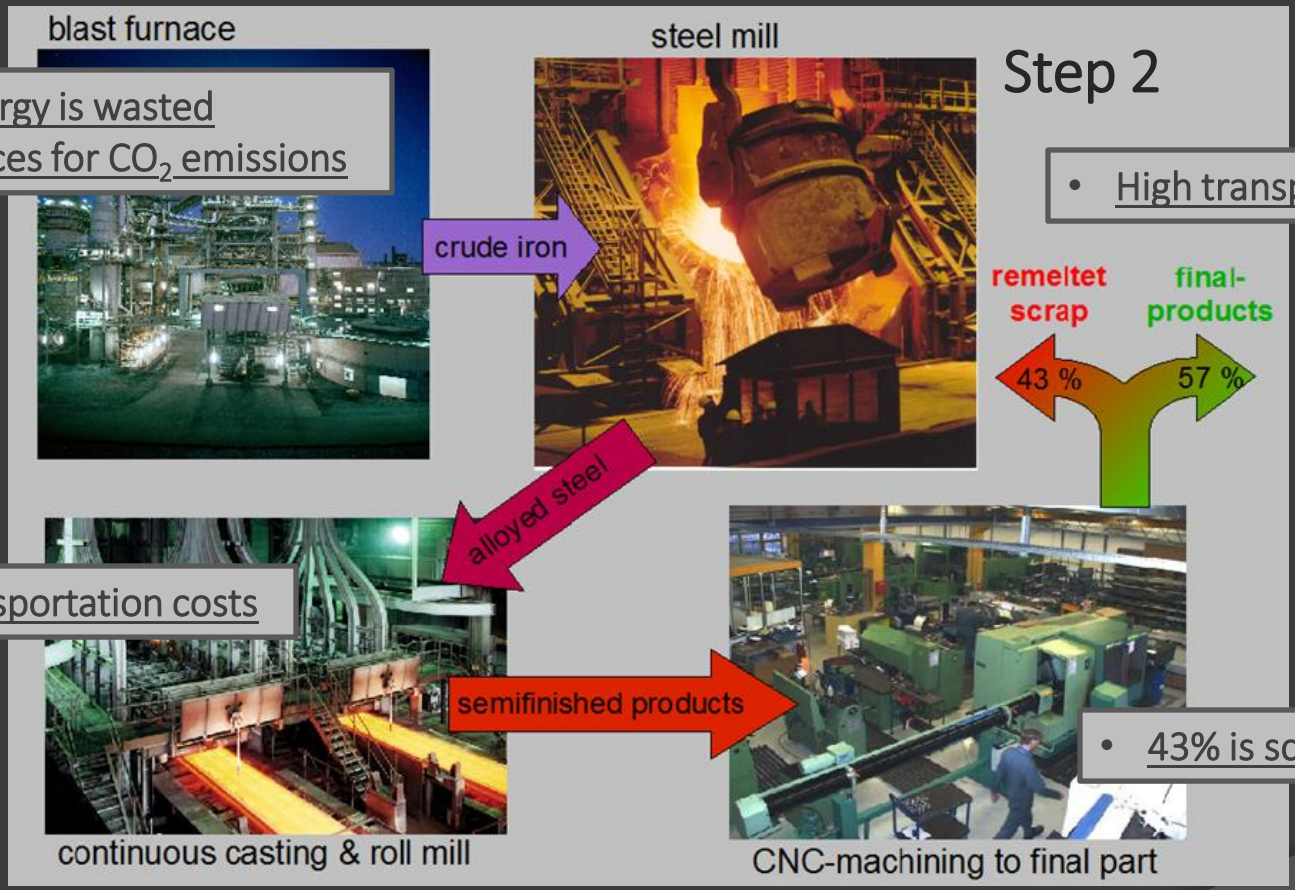
Step 1

- A lot of energy is wasted
- Major sources for CO_2 emissions



Step 2

- High transportation costs

Step 3

- High transportation costs

Step 4

- 43% is scrap material

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State of the Art (Intermetallics)

The major problem with many intermetallics is their **low ductility at ambient temperatures**.

Before intermetallics can substitute stainless steel as structural materials in high volume markets, they have to be modified to **improve their ductility**, without scarifying their strength and inherent **corrosion** and **wear resistance**.

Production technologies must be developed to translate these unique properties into technical products of complex 3D-geometry.

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The research strategy focuses on the structural factors at the submicron level

A new concept beyond sheer material composition

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Methodology

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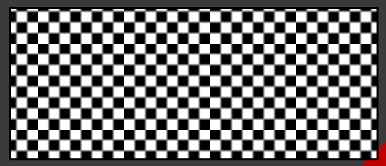
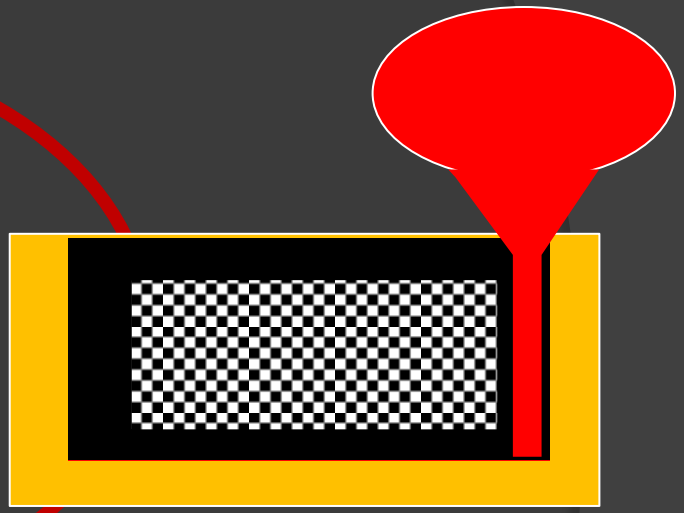
1. Fe porous preform
- ✓ MIM
- ✓ SLM
- ✓ KE

2. Al infiltration
- ✓ Pressureless
- ✓ Pressure assisted



Optimization loop



3. Simulation
- ✓ Microscopic
- ✓ Macroscopic

4. Subsequent heat treatment
- ✓ Phase tailoring
- ✓ Particle size tailoring

5. Corrosion and mechanical testing

6. Industrial demonstrator building

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Work Package structure

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WP1 Porous preforms → WP2 Infiltration by liquid Al → WP3 Modelling (Thermodynamics, kinetics) → WP4 Microstructure, Heat treatment → WP5 Corrosion, Mechanical testing → WP6 Demonstrator

WP7: Safe by Design - LCA

WP8: Dissemination

WP9: Management

Optimized Fe-Al-based part

Testing

Demonstrators

1. Modify particle surface to control wetting and kinetics ?

2. Modify Al-melt to control kinetics ?

WP1

WP2

WP3

WP4

WP5

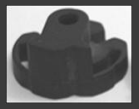
WP6

WP7

micress®

STAR-Cast

STAR-Cast



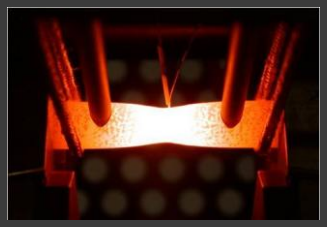
Complex 3D-shaped part, from iron oxide

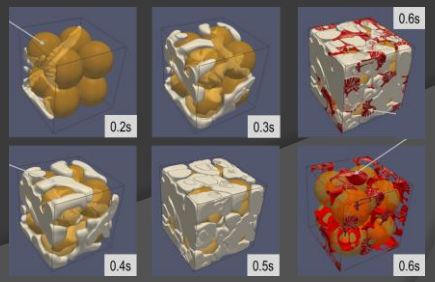
reduce

Porous preform based on ultrafine Fe particles

tailor

Porous preform, chemically tailored at the grain surface





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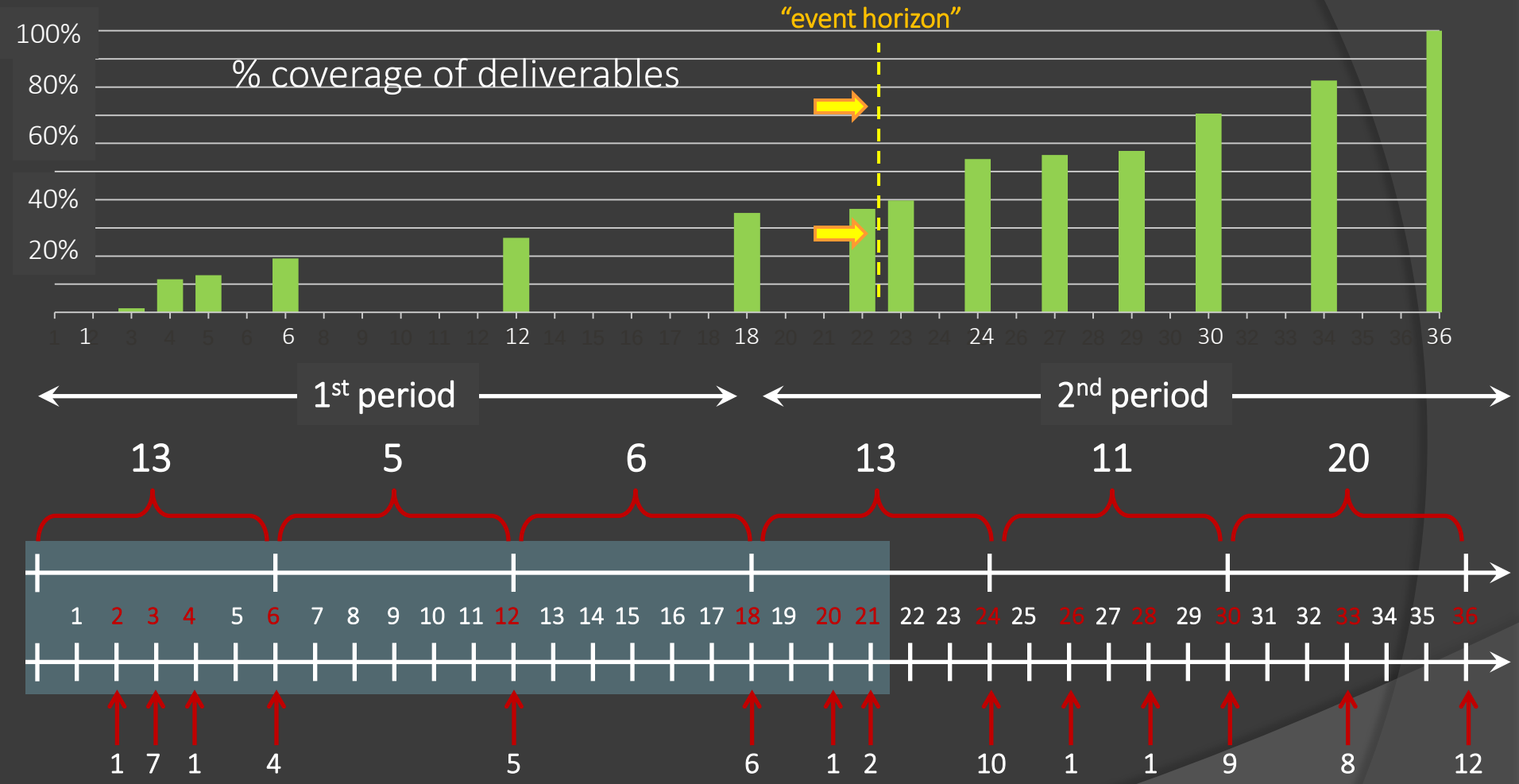
Current state snapshot



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Milestones timeline

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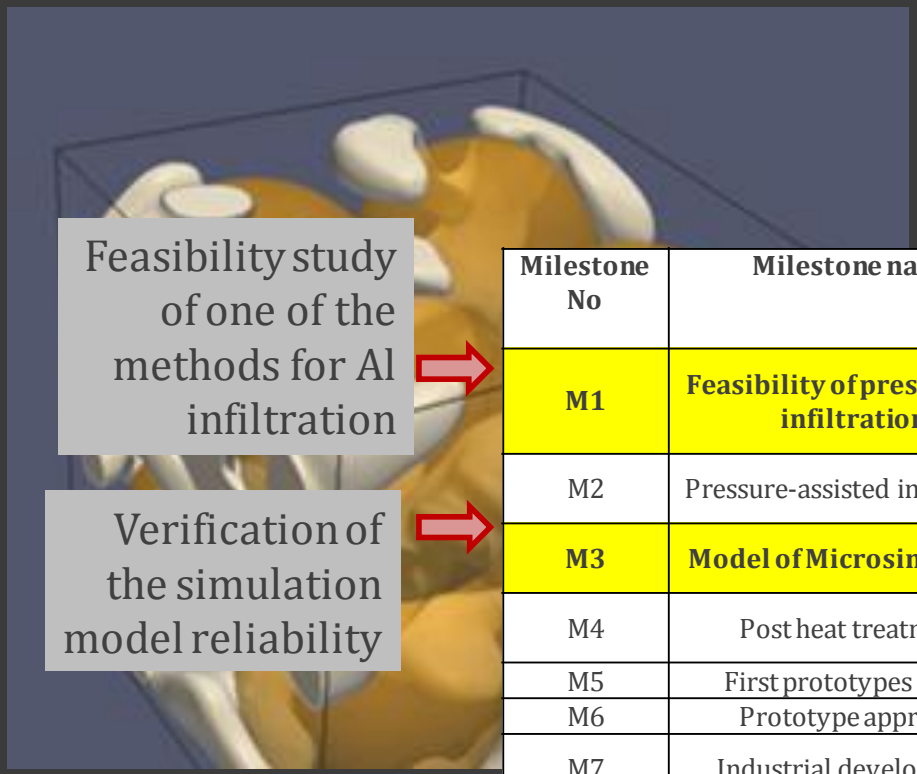
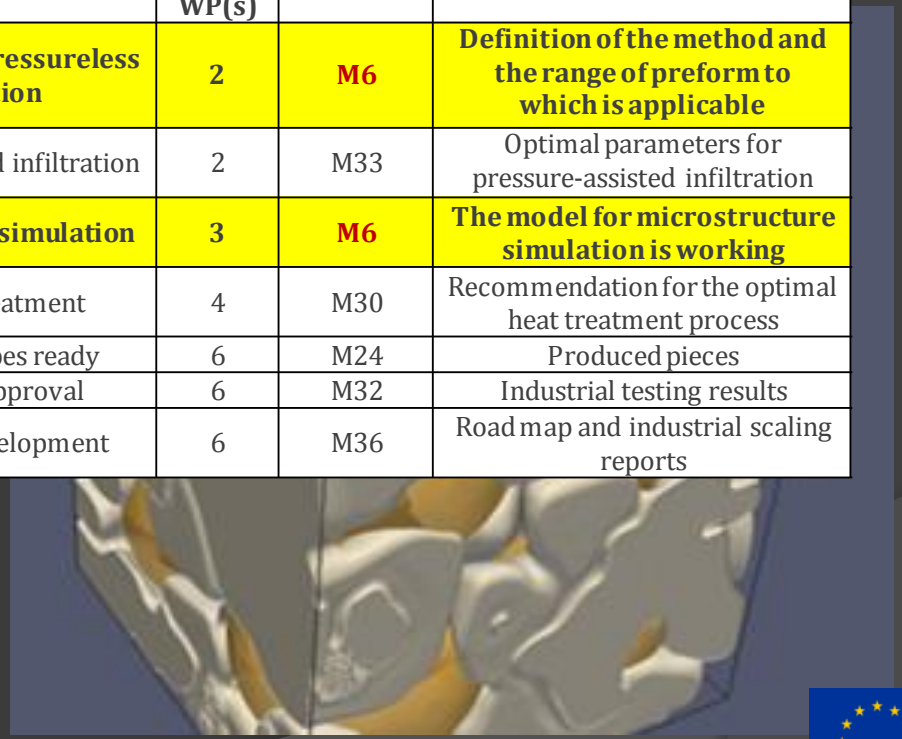


Feasibility study of one of the methods for Al infiltration

Verification of the simulation model reliability

Milestone No	Milestone name	Related WP(s)	Estimated date	Means of verification
M1	**Feasibility of pressureless infiltration**	**2**	**M6**	**Definition of the method and the range of preform to which is applicable**
M2	Pressure-assisted infiltration	2	M33	Optimal parameters for pressure-assisted infiltration
M3	**Model of Microsimulation**	**3**	**M6**	**The model for microstructure simulation is working**
M4	Post heat treatment	4	M30	Recommendation for the optimal heat treatment process
M5	First prototypes ready	6	M24	Produced pieces
M6	Prototype approval	6	M32	Industrial testing results
M7	Industrial development	6	M36	Road map and industrial scaling reports



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EQUINOX project portal

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Thank you for your attention

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