

## AREAS OF APPLICATION

In the first place, the developed solutions can be applied in similar metal making industries like steel and aluminium, but also copper and lead making. Furthermore, they can also be transferred to other process industries like glass or cement, and partly also to the manufacturing industry.



## CONTRIBUTING PARTNERS

VDEh-Betriebsforschungsinstitut GmbH, Jozef Stefan Institute, Fundacion Azterlan, K1-MET GmbH, University of Ljubljana, Kungliga Tekniska Hogskolan

## CONTACT

Bernd Kleimt,  
VDEh-Betriebsforschungsinstitut GmbH  
(bernd.kleimt@bfi.de)

H2020 Call: DT-SPIRE-06-2019  
Start date: 2019-01-10  
Duration: 42 Months  
Type: Innovative Action  
Budget: 6,1 M€  
Coordinator: Jožef Stefan Institute  
Contact: info@inevitable-project.eu  
[www.inevitable-project.eu](http://www.inevitable-project.eu)



INEVITABLE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869815.



**MONITORING AND CONTROL OF PROCESSES IN METAL PRODUCTION**

# APPROACH

The process chains for metal production (e.g. steel, aluminium) are complex and involve numerous metallurgical and physical sub-processes. The aim is to produce products fulfilling several quality targets in a reliable and reproducible manner under minimised energy and resource effort. To

achieve this target, a thorough knowledge of the process behaviour is required, which should be reflected within process and sensor data analysis tools and predictive process models, to be used within on-line monitoring, control and decision support systems.

# SOLUTION

Within the SPIRE project “Optimization and performance improving in metal industry by digital technologies” (INEVITABLE) such on-line monitoring, control and decision support systems have been developed and applied in various metal making processes, as primary and secondary steelmaking, cold rolling and aluminium investment casting. Models and solutions based on them were developed to provide several cognitive solutions for:

- **Process & Equipment monitoring**, where digital twins for parallel simulation and soft virtual sensors to estimate unmeasured process behaviour were developed.
- **Decision Support Systems** to support process operation optimization and enable better final product quality prediction.

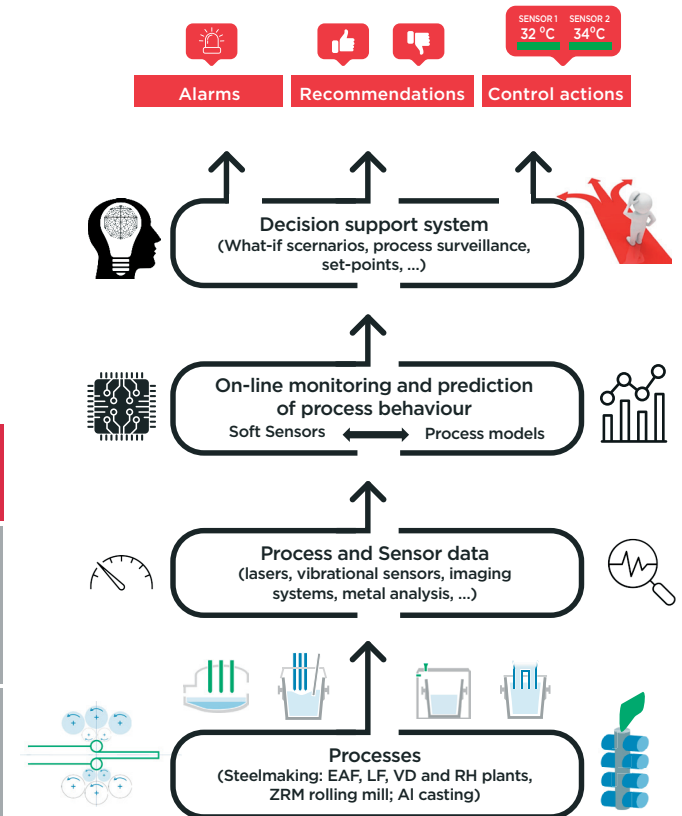
The solutions adopted different approaches to develop digital entities of specific segments of the metal production chain:

- First principle models of a process segments with well-known physics (use of algebraic and differential equations)
- Statistical & AI-based modelling (e.g. image and frequency analysis, feature extraction, cause-effect relationship analysis, data-based models like multi-variate regression models, ANN, Neuro-Fuzzy-based models, Gaussian processes, Bayesian networks) for modelling the process behaviour for known operating conditions and for improving the 1st principles models

**INEVITABLE project provides several best practices** of cognitive digital based solutions where modelling approaches were applied within the process chain of metal production.

# UNIQUE VALUE PROPOSITION/ADDED VALUE/NOVELTY:

The solutions for process & equipment monitoring developed in the INEVITABLE project provide a thorough and real-time insight into the process behaviour by means of innovative soft sensors and predictive process models. They serve as basis to build comprehensive Decision support and Optimization systems which guide the operators in achieving an efficient process performance and improved product quality.



Process	Electric Arc Furnace (EAF)	Sendzimir Mill (ZRM)	Ladle furnace (LF), Vacuum degassing (VD), RH plant		Alloy casting	
Company	ACRONI	ACRONI	SIDENOR	VOESTALPINE	EIPC	
<b>Process &amp; Equipment monitoring</b>	Digital twins	Process in EAF	Rolling of coils	Stirring process in Ladle	Stirring process in Ladle	X
	Soft sensors	Bath, Off-gas, Slag (temp, composition)	Bath, Off-gas, Slag (temp, composition)	Melt temperature, Slag composition	Melt temperature in tundish	Trends of critical parameters
<b>DSS &amp; Optimization</b>	Final product quality prediction	X	Thickness deviation	Castability & Cleanliness level	Castability & Cleanliness level	Final product
	Optimization of process operation	Process / Operator settings	Process / Operator settings	Advisory system	Surveillance tool for steel refining process	Scheduling in nonferrous casting process