VALCRA -Technical work summary

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AIMs

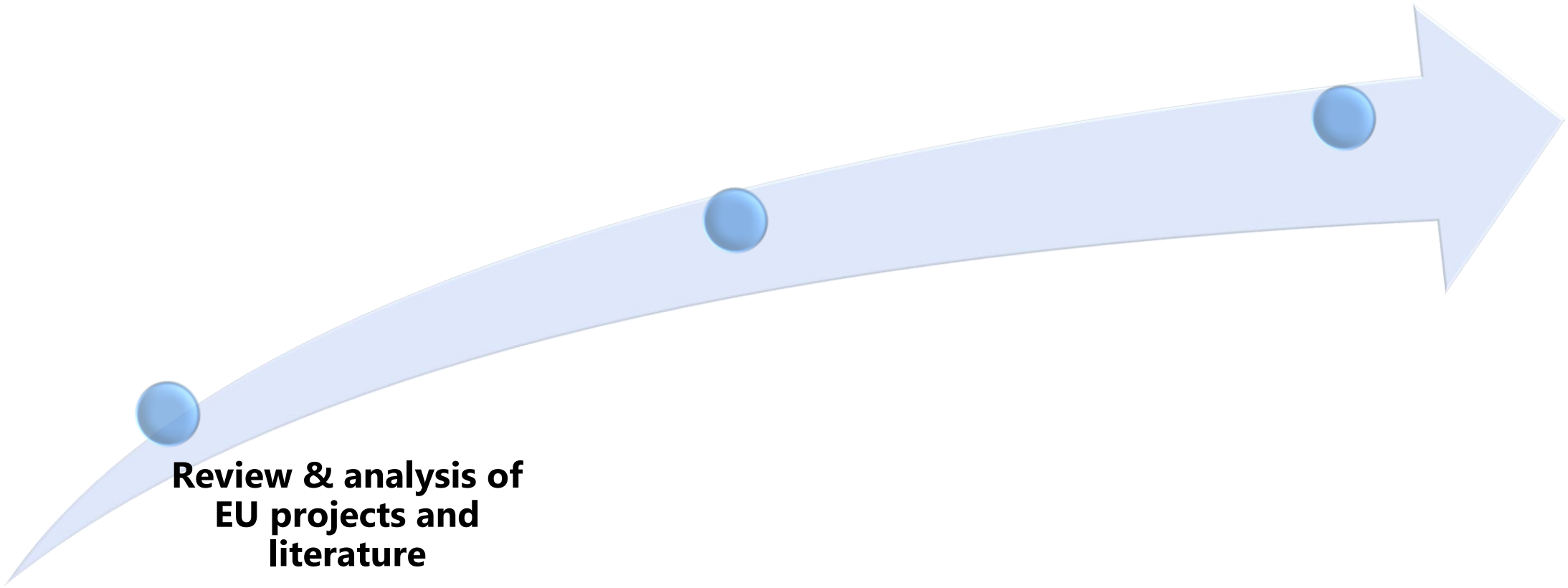
Overview of technical work and future needs

- Give an overview of technical outputs derived from RFCS projects
- Analysis of feedback from the audience, collected during VALCRA events, with focus to direct involvment of steel producers
- **Identification of common key-points, where future reasearch could be addressed**

VALCRA background

Milestones of technical work

VALorisation and dissemination of RFCS projects results and experience in steel surface quality issues: on as-cast **CRA**cks formation



Review of EU Funded Projects

Deliverables

Review & analysis of EU projects and literature

D2.1

- **Complete list of relevant reports and papers**
  - Classification of projects and literature to identify the main topics covered by EU funded research
  - Spreadsheet list of **32 projects**
  - Spreadsheet list of **60 papers**

D2.2

- **List of topics**

Analysis by argument of the collected reports

D2.3

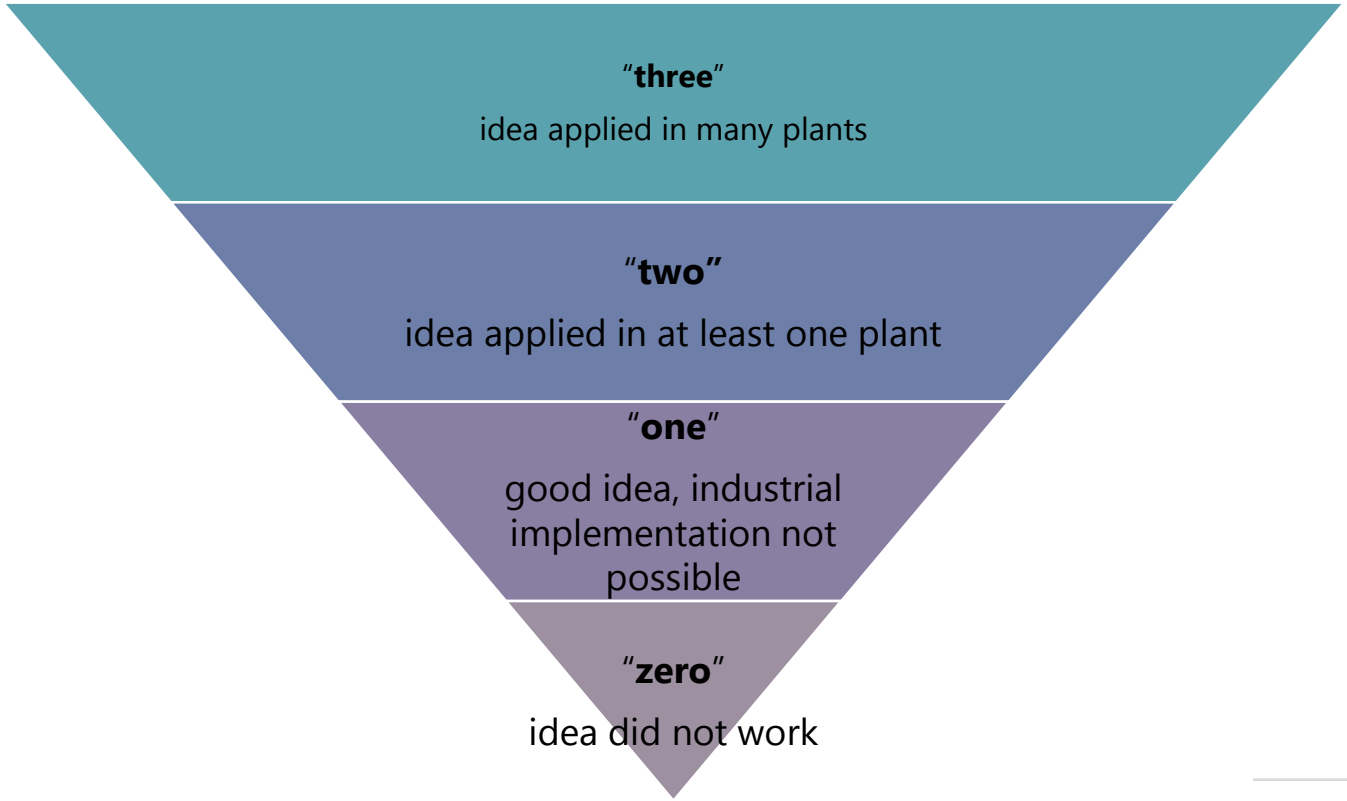
- **Classification and ranking of projects**
  - Assessment of the RFCS projects
    - Success of project
    - Industrial/economic impact
    - TRL evolution

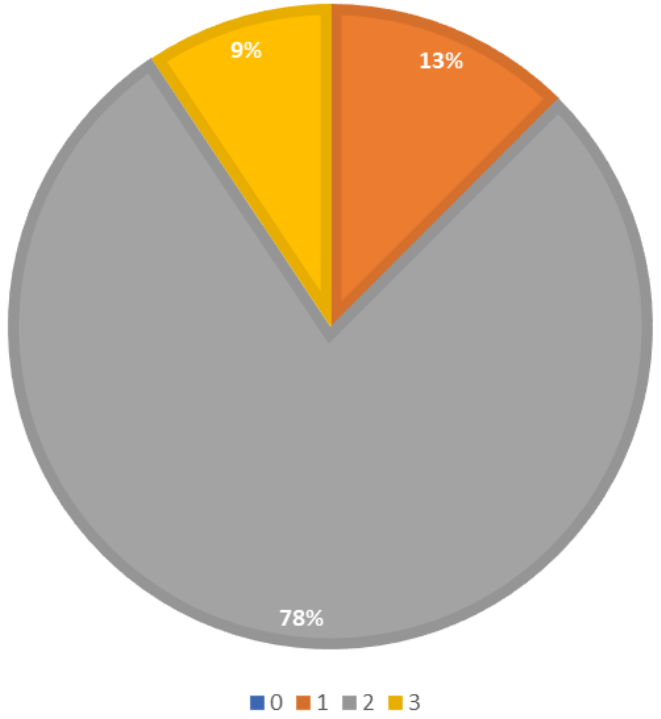
D3.1

- **State of the Art for each Research Topic**
  - Evolution of the state of the art in the last 25 years
  - Best practices or solutions
  - Future developments

Review of EU Funded Projects

Project Assessment – Industrial application of idea/results

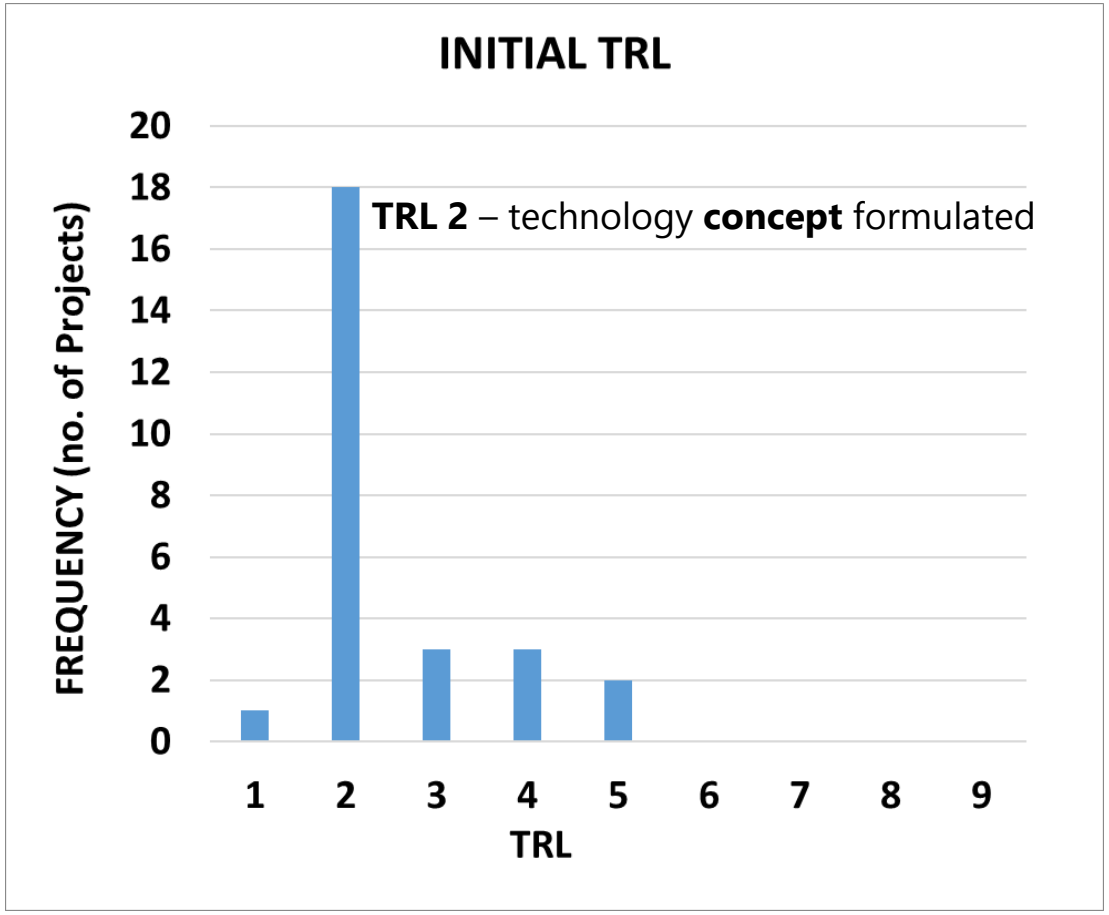


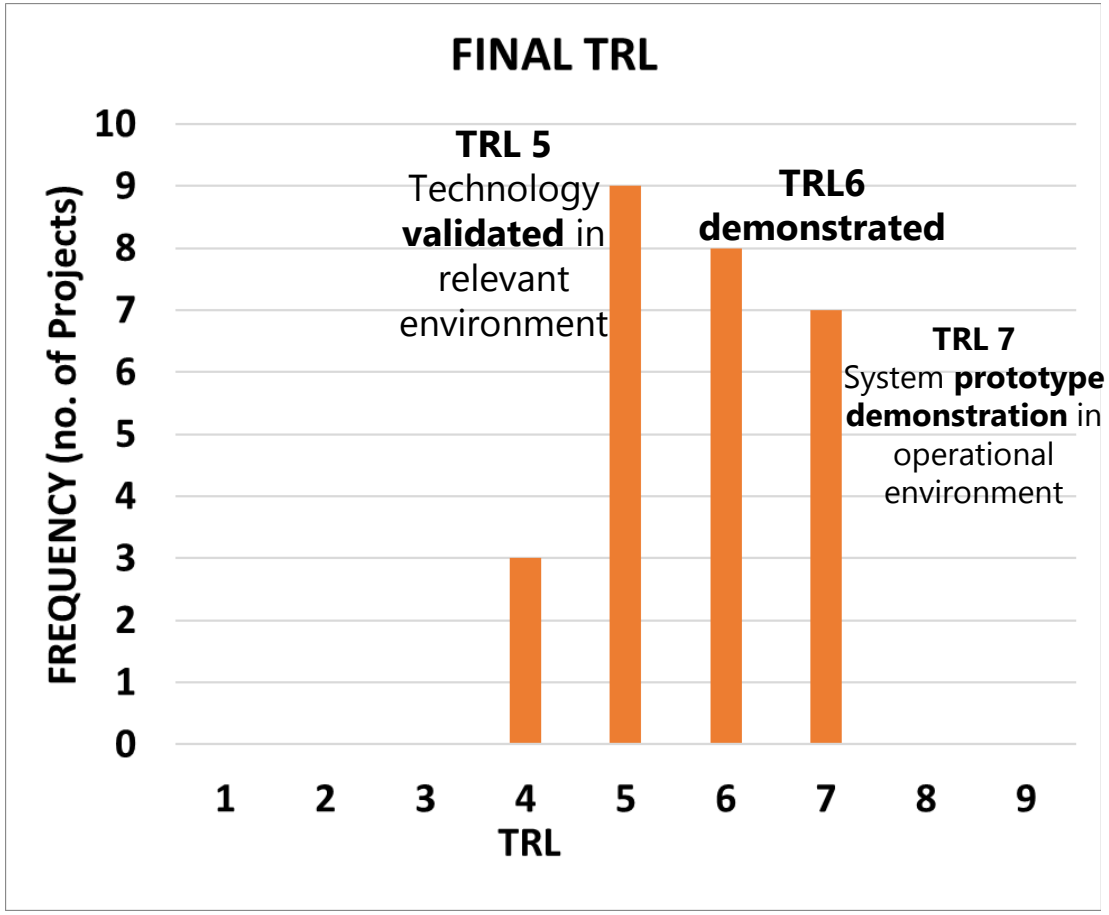


% of projects with score 1,2,3

Review of EU Funded Projects

TRL evolution during project

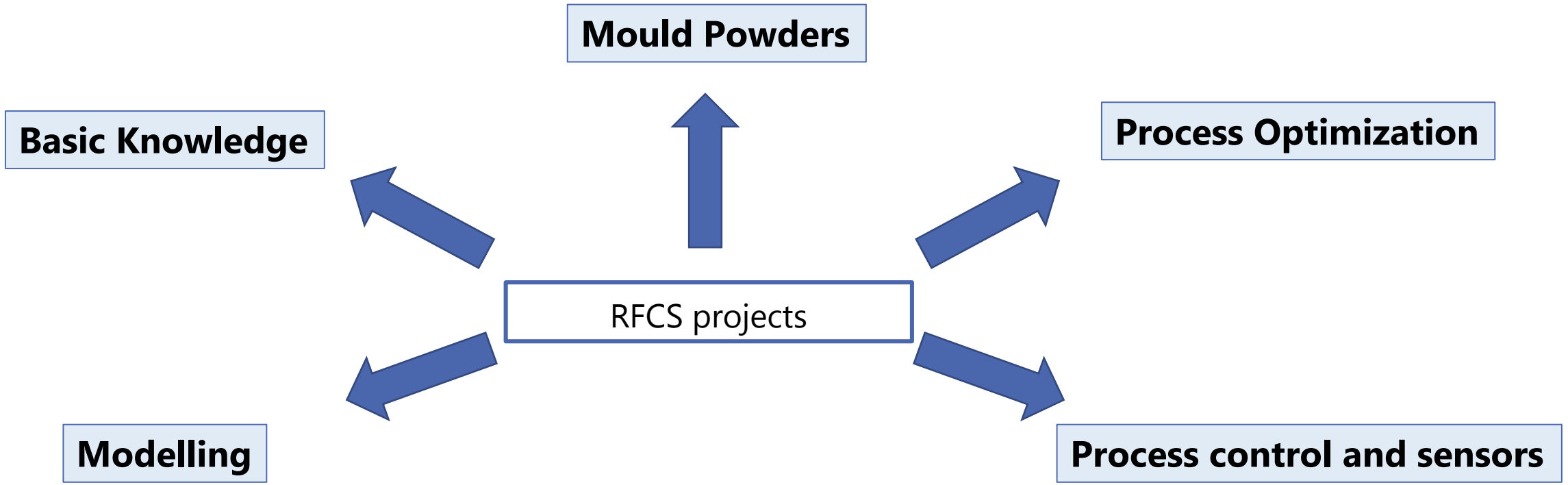




Analysis of RFCS projects

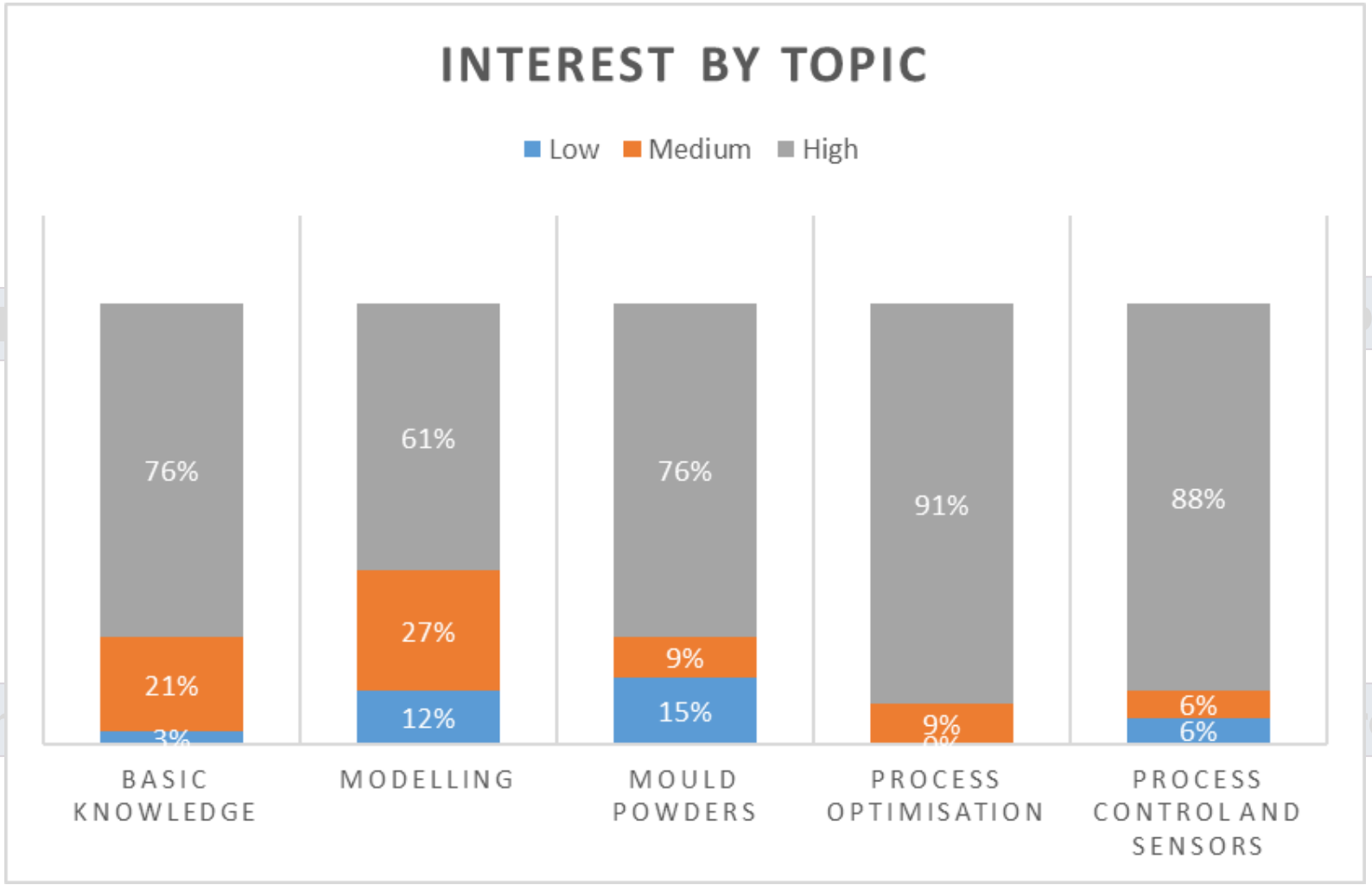
Definition of topics

RFCS projects have been divided, analyzed and ranked



Analysis of RFCS projects

Interest by topic



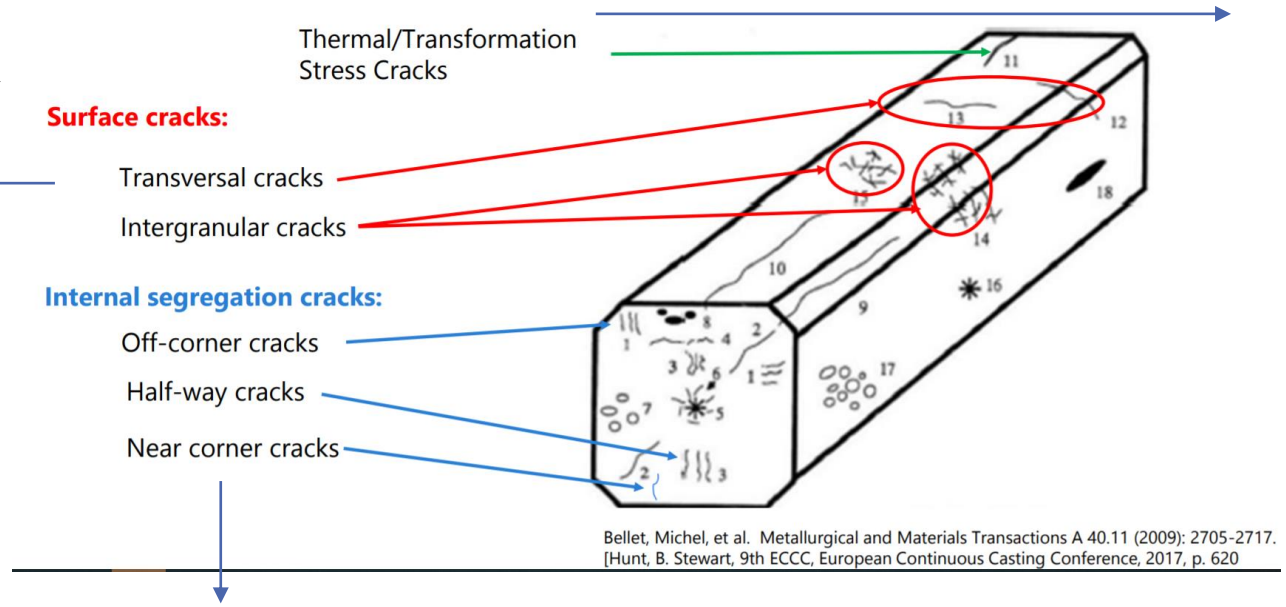
RFCS: where we are

Basic Knowledge

Fundamentals of the crack formation occurrence, involving all the chemistry and physics of the change of state also related to the cooling pattern imposed by the operating conditions and the steel grade features

- *Crack prevention in Continuous casting"*
- *NITRIDES*
- *PRECIPITATION*
- *PMAP*
- *KINPCC*

Microalloyed steel with Al, Ti, N, V, B, Nb



Bellet, Michel, et al. Metallurgical and Materials Transactions A 40.11 (2009): 2705-2717.
[Hunt, B. Stewart, 9th ECCC, European Continuous Casting Conference, 2017, p. 620

- *PMAP*

C, Cr and Mn, combined with microalloyed elements that precipitate during austenite transformation

- *Study on brittleness of carbon steels during solidification*
- *ICCRACK*
- *PMAP*

C, S [Mn/S], B, casting conditions

RFCS: where we are

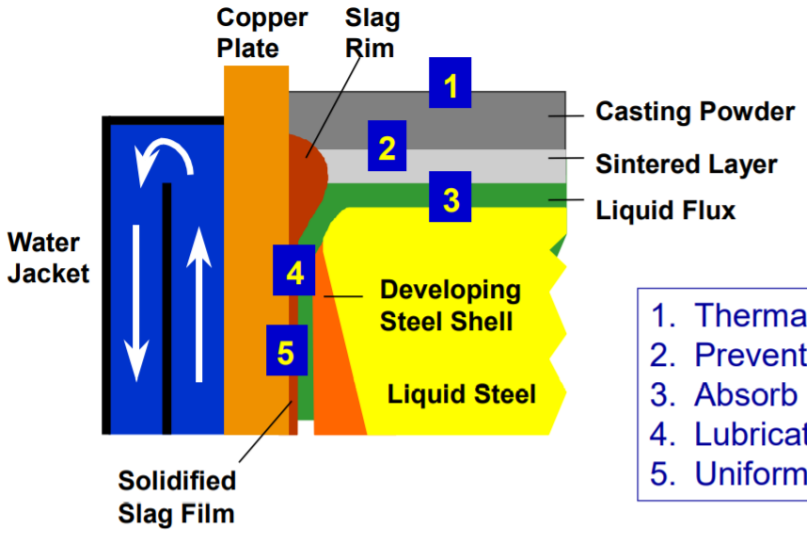
Mould Powders

- **Consumption Rate,**
closely linked with the lubrication properties

- **Composition of Mould Powders,**
and its modification with interaction with steel composition

- **Powder feeding,**
with the aim of consistent and reliable feed trhough closed loop control

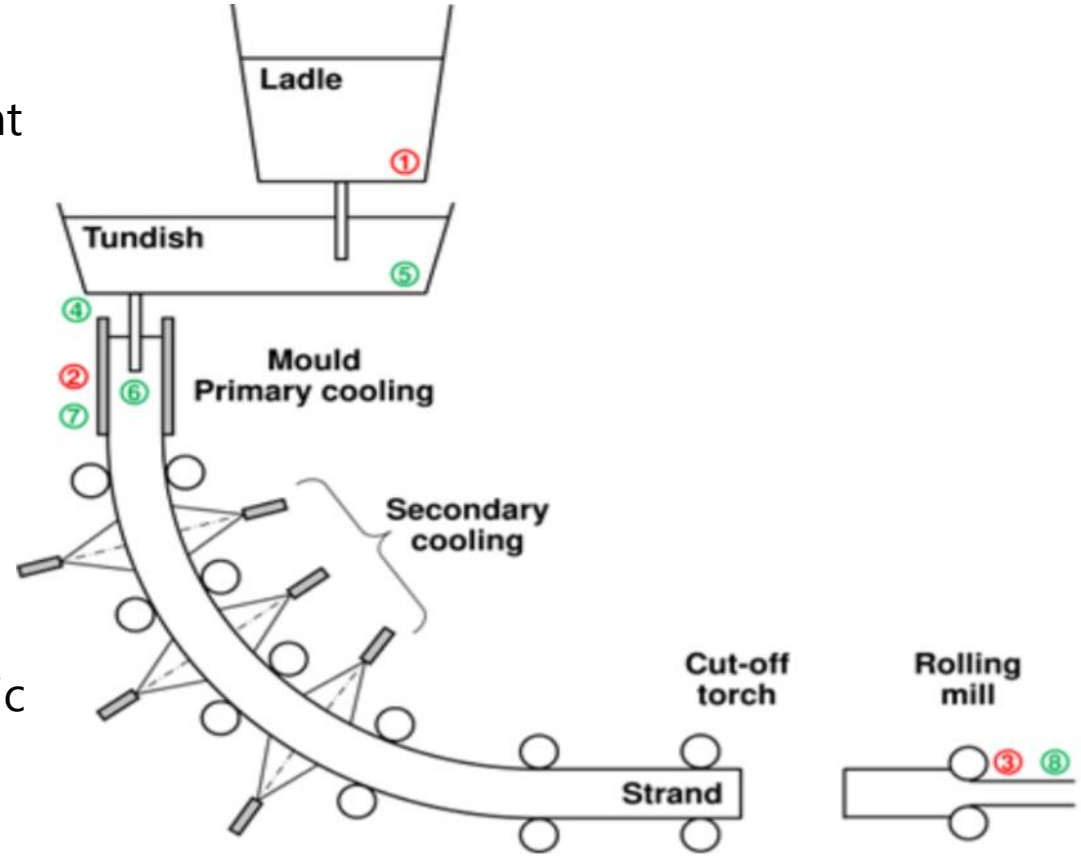
- **Modelling of mould powder,**
direclty integrated with general modelling topic



RFCS: where we are

Process control and sensors

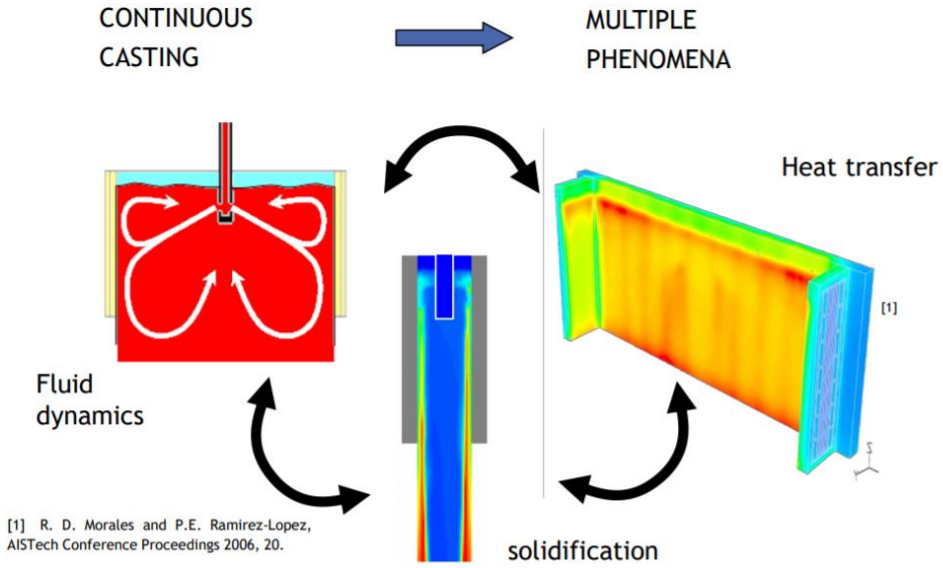
- **Sensoring**, for better process control
- **Mould powder monitoring**, IR Camera Measurement of mould powder cover
- **Fibre Optical Temperature Sensors**, for mould monitoring
- **Continuous Temperature Measurement in the Melt,** (DynTemp®)
- **Detection of surface defects**
  - development of the EMAT-EMAT[**E**lectromagnetic **A**coustic **T**ransducer] system
  - conoscopic holography



RFCS: where we are

Modelling

- Numerical model for new cooling strategies
- Evaluation of as–cast microstructure.
- 3D numerical models in FEM to simulate bending
- Modelling of new mould geometries
- model to describe solidification of the steel inside the mould.



- Multi-beam mode
- Roll forces, surface speeds and trapezium shape distortion were measured
- measurement of strand deflection during inter-roll bulging
- Numerical model for an adjusted design for the cooling circuit in the copper mould plates
- FEM model was utilised to compute the resulting heat flux in the copper plates
- Full strand inter-roll bulging model

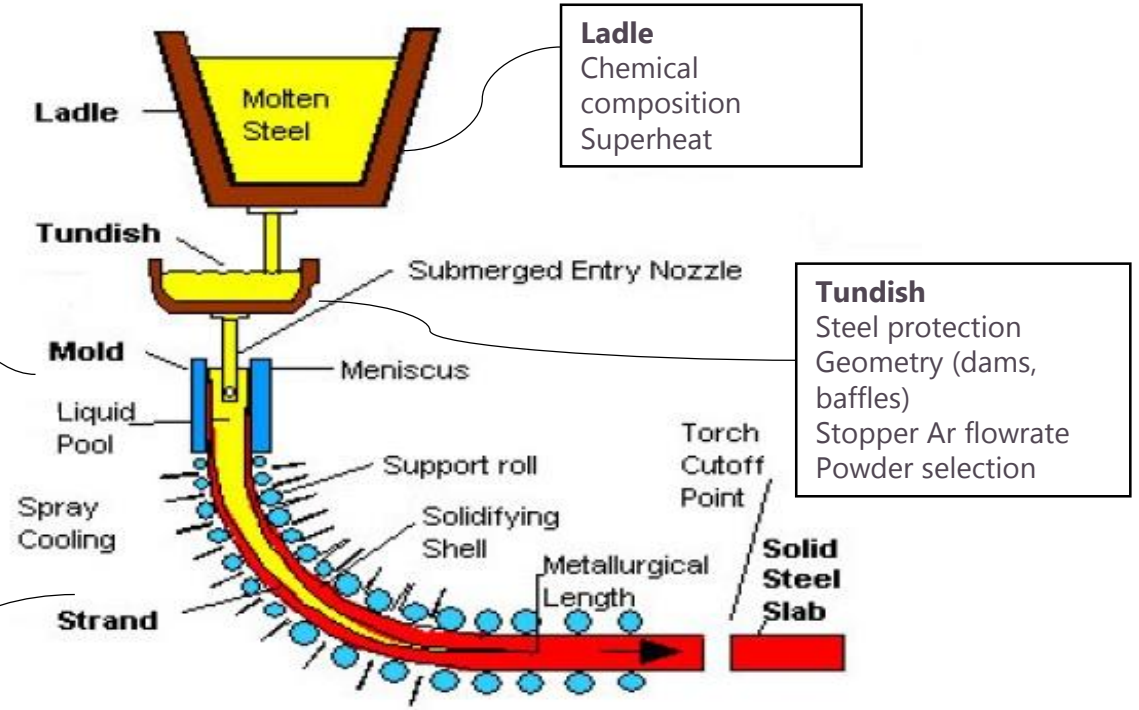
RFCS: where we are

Process Optimization

It is the sum of contributions of all the other outputs. Where solution is tailored on specific steelgrade.

- **There is no a general recipe to optimize the production process**
- **Many optimization strategies concern the microalloyed steels.**
- **Technical solutions, have achieved a TRL 6/7 starting from a TRL 2/3.**

Mould
Heat flux, water ΔT
Casting speed
Mould oscillation
Mould taper
Powder properties
SEN design
Level control
Electric Mould Stirring (EMS)



Ladle
Chemical composition
Superheat

Tundish
Steel protection
Geometry (dams, baffles)
Stopper Ar flowrate
Powder selection

Secondary cooling
Design (ex. nozzle position, distance, size, etc)
Water flowrate distribution
T trend along the strand

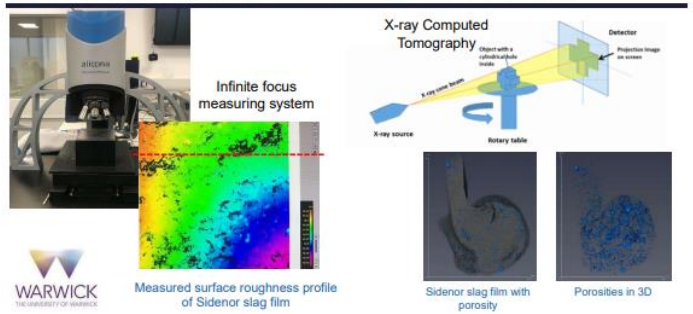
VALCRA dissemination activities

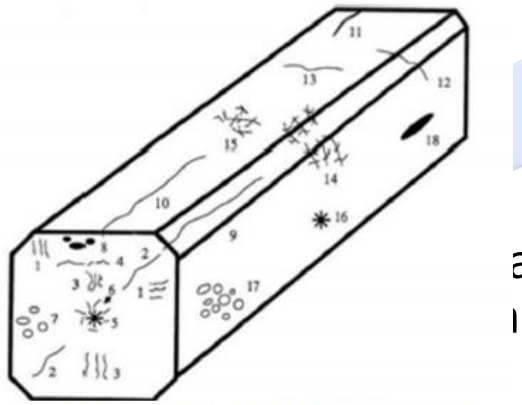
Organization of technical and interactive events

VALorisation and dissemination of RFCS projects results and experience in steel surface quality issues: on as-cast **CRA**cks formation

WP2 Slag film characterisation

Use of novel techniques e.g. for surface roughness and porosity





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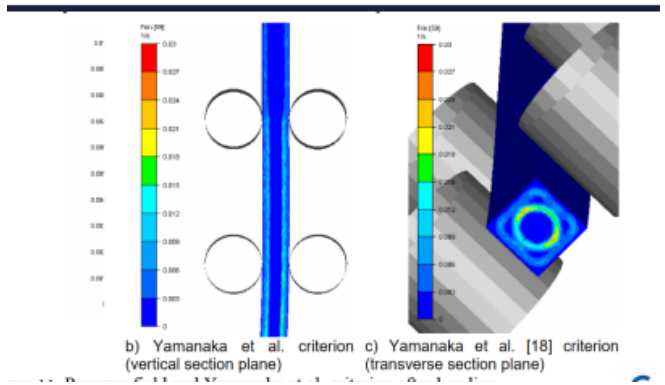
Dissemination events & interaction with participants

analysis of EU
nd literature

Thermo-mechanical simulation in 3D



VALCRA dissemination activities

Audience feedback for identification of future needs

VALorisation and dissemination of RFCS projects results and experience in steel surface quality issues: on as-cast **CRA**cks formation

Review & analysis of EU projects and literature

Dissemination events & interaction with participants

November 16th

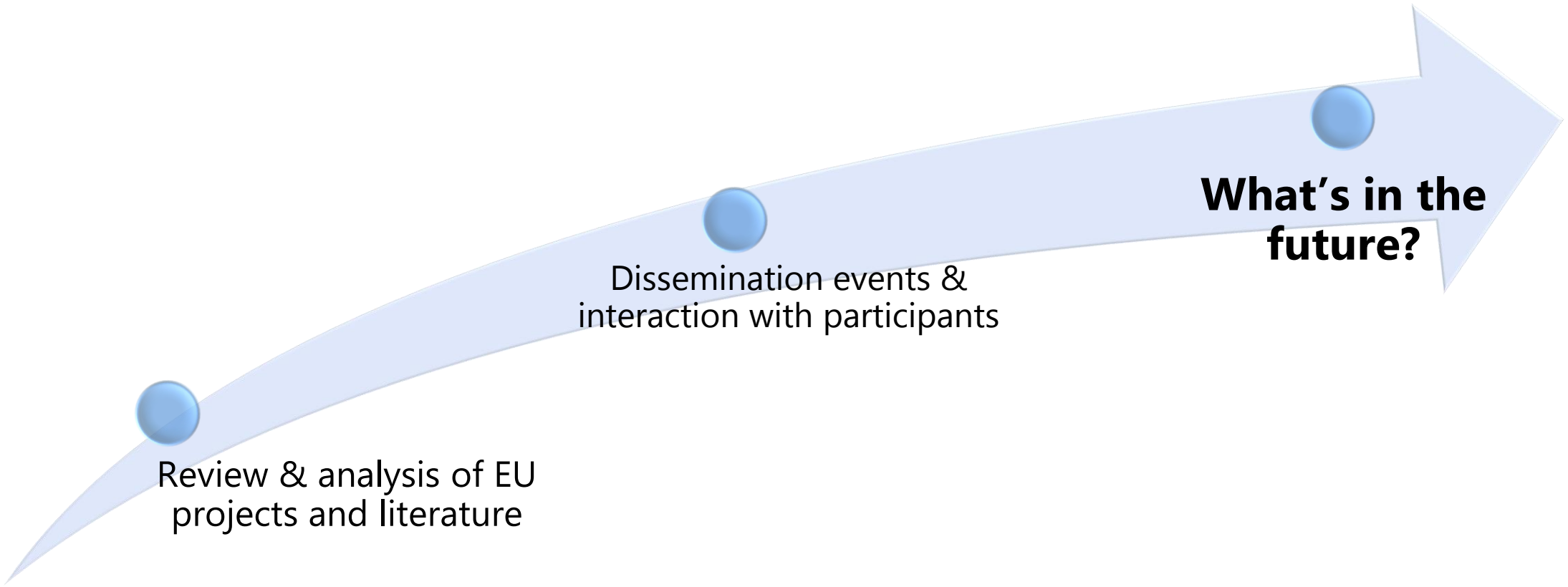
VALCRA: A roadmap for future research targets about cracks in continuous casting

- FERALPI GROUP — *Piero Frittella*
- sidenor — *Izaskun Alonso Ona*
- SSAB — *Anna Dahlstedt*
- ACCIAI SPECIALI TERNI — *Andrea Francesco Ciuffini*
- IMERYS TRANSFORM TO PERFORM — *Marc Walter*
- ArcelorMittal — *Jean Francois Domgin*
- TATA — *Begoña Santillana*
- voestalpine ONE STEP AHEAD. — *Sergiu Ilie*
- outokumpu — *David Brooks*

VALCRA – CC roadmap

Last milestone of the project

<u>Which is the strategy to reduce crack occurrence, to better manage the process, to increase process control?</u>



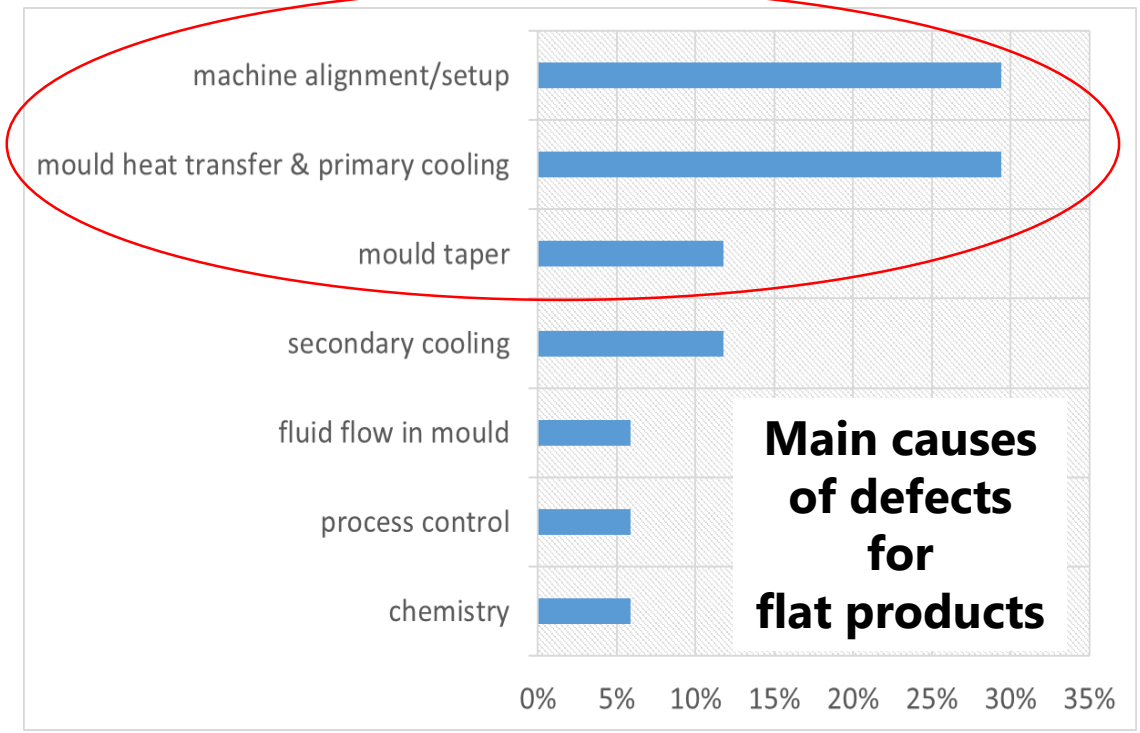
Steel continuous casting: where we go

Drivers

- Increasing complexity of steel grades
- High quality
- Cost reduction

Steel continuous casting: where we go

Solidification in the mould



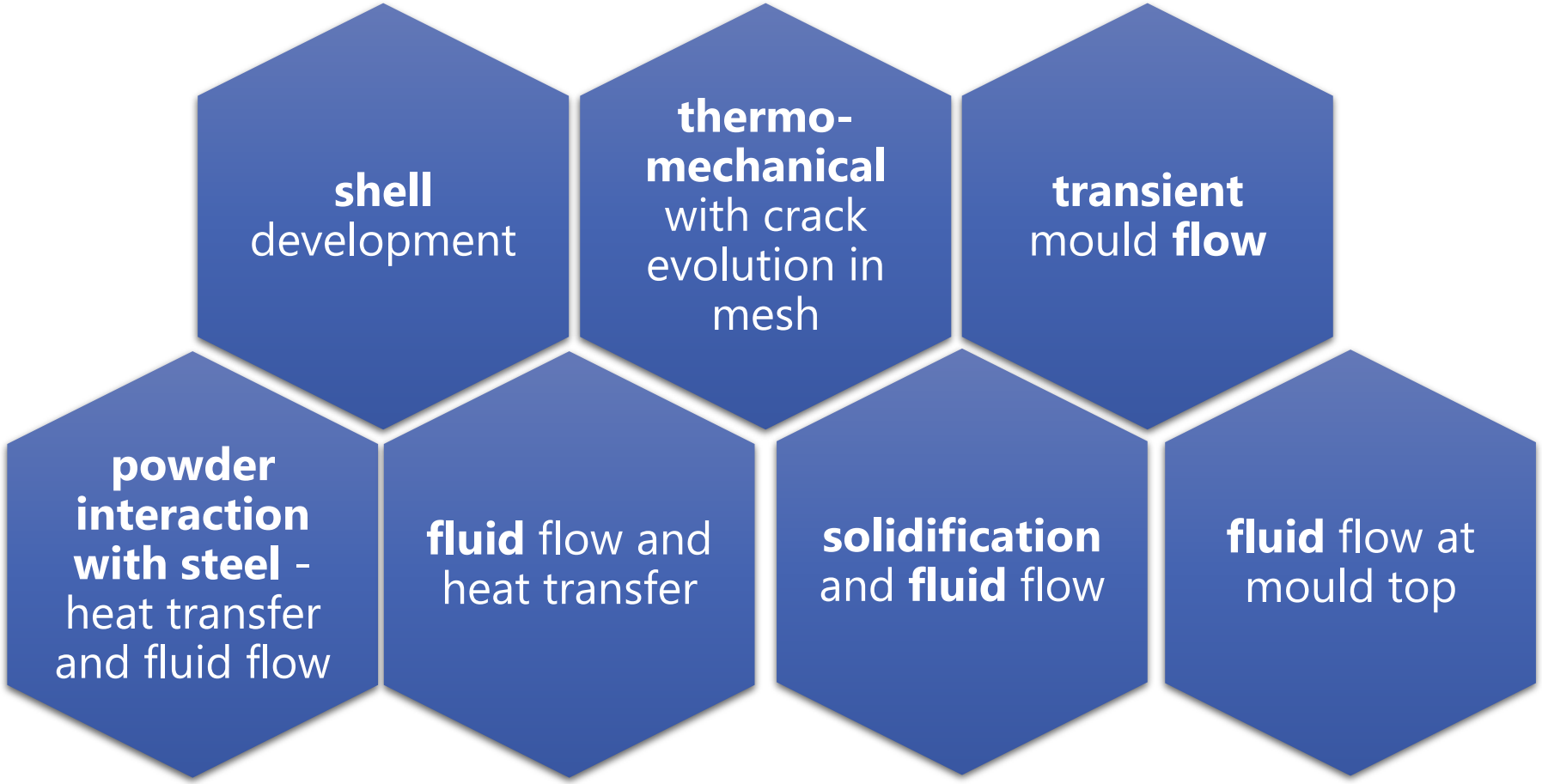
What we need:

- *Innovative sensors*
- *Geometry of mould*
- *Inclusion control & fluid-dynamics*
- *Mould coating/Mould design (channels, water flowrate)*
- *Mould thermal monitoring*
- *Automatically refining of oscillation settings*
- *Monitoring of mould powder layer*
- *Measuring of temperature in mould copper walls*

Steel continuous casting: where we go

Solidification in the mould - *Modelling has a primary importance*

Examples of models requested by industrial producers

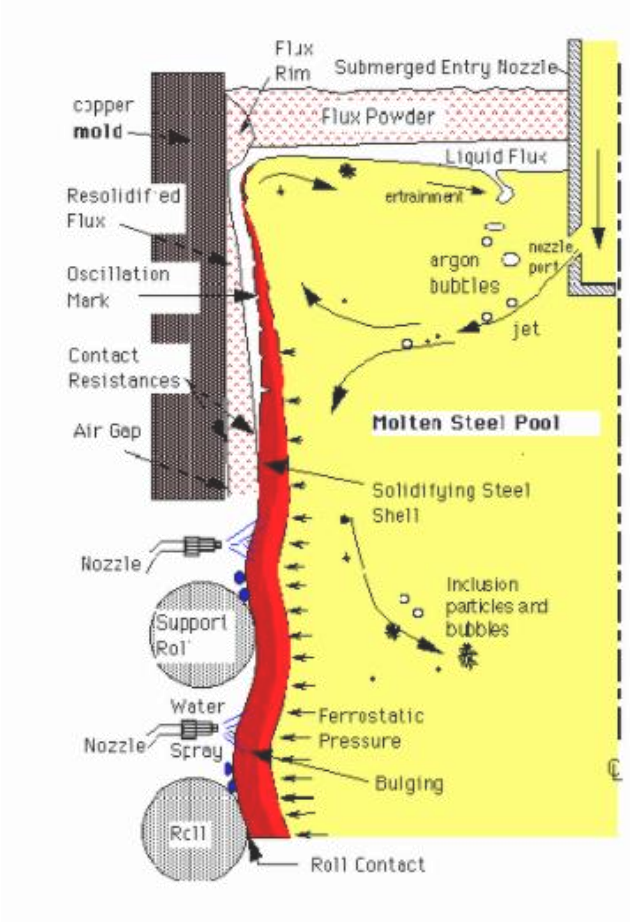


Steel continuous casting: where we go

Mould powders

What we need

- *Find new powders for new steel grades*
- *Benchmark in characterization and properties prediction by models*
- *Development of F and C free powders*
- *Modification of flux effect related to use new elements to reduce costs (ex Ce vs Ni)*



Steel continuous casting: where we go

Detection of defects

Requirements

- *Online*
- *Prediction quality deviation*
- *Enhancing reliability of current solutions*
- *Reduction of investment costs*
- *Direct connection of defects detected with surface inspection systems with specific parameters on continuous caster*
- *Big data applications*
- *Independent of specific application*

Positive effect on Near-Net-Shape Casting technology

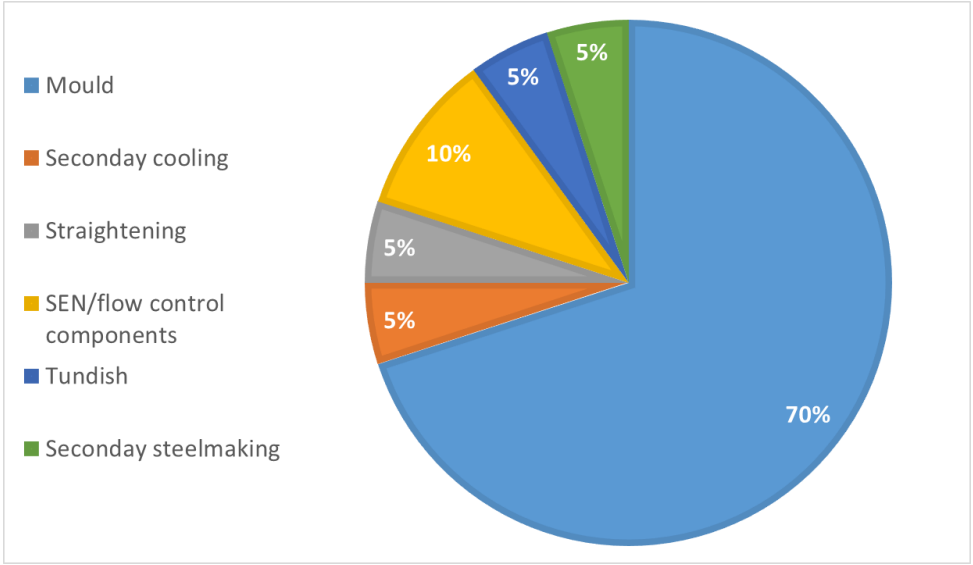
Steel continuous casting: where we go

Request of new and reliable models

What we need

- *Digital twins*
- *Characterization of material thermo-mechanical behavior as a function of process conditions*
- *Online metallurgical based models*
- *Strong connection with **material characterization***
- *Implementation of big data analysis*
- *Implementation of models to cast new steel grades*
- *Ease of use, fast response, **low CPU time***
- ***Virtual reality** for **training** and technical **decision making***

What part of process/caster should models focus on?



Steel continuous casting: where we go

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Keep in mind the current perception about modelling

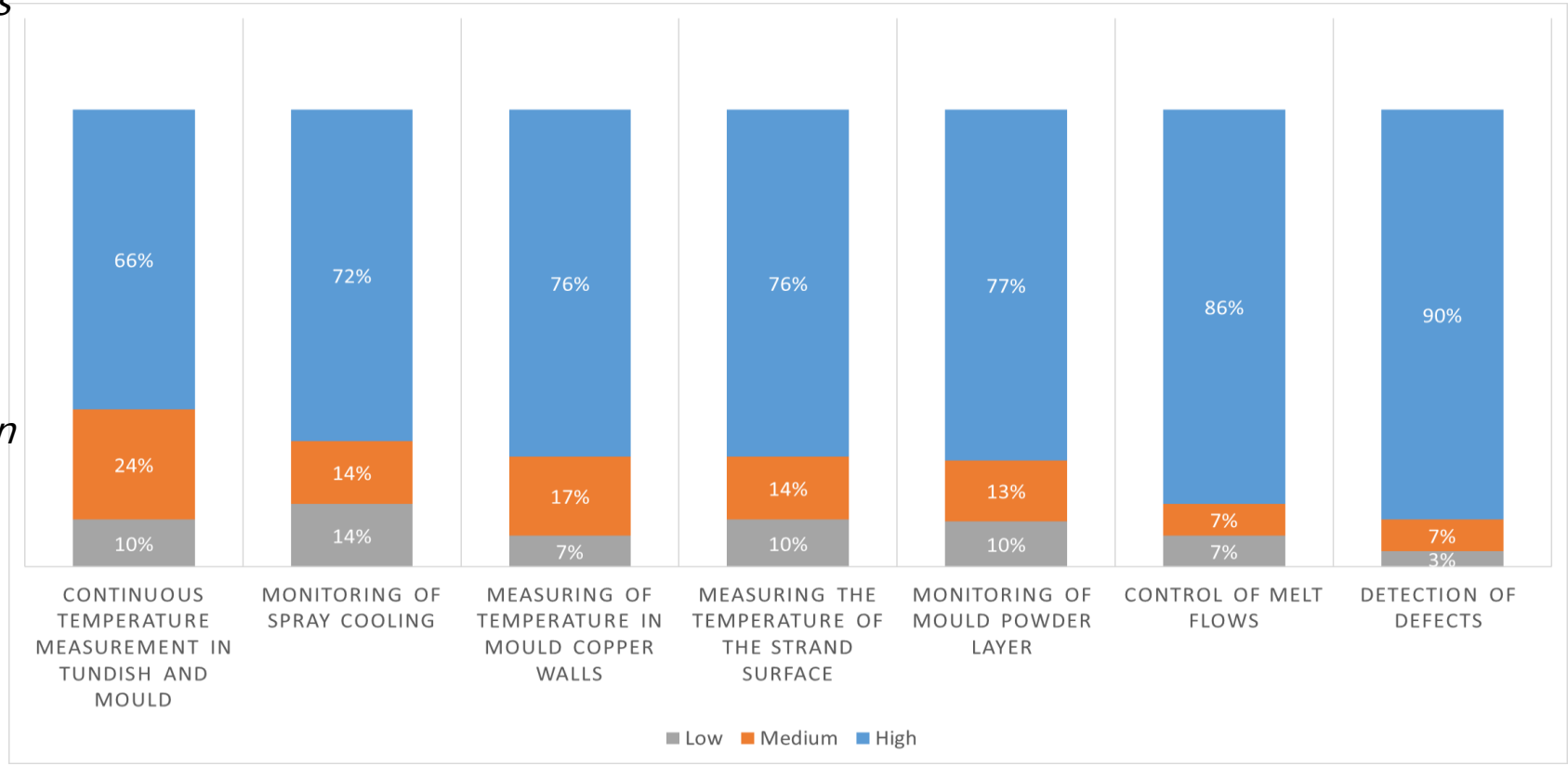
Barriers are related to "not only" technical issues

Steel continuous casting: where we go

Sensors and monitoring

- *Safety*
- *Energy and raw material savings*
- *Reduction of defect occurrence on the final product*
- *Cost effectiveness / level of investment*
- *Reliability and accuracy (e.g. reduce false-positive readings in defect detection)*
- *Independent of specific application*

Which monitoring technique capture attention?



Steel continuous casting: where we go

Further needs

- **Aging plants and equipment in EU**
  - ✓ *Extend the effective life*
  - ✓ *Adapt older casters to produce newer higher specification steel grades*

- **Integrated process control**
- **Increased staff skills and training and a relevant role of R&I**
- **Resources and energy saving**

  Also, with respect to the overall aim of 'carbon neutral' steel production → Green Deal

- **Other elements to be studied***: Cu, Sn, tramp elements in general*
- **Near-Net Shape Casting:** *do further improvements in sensor, modelling and early detection of defects allow the near net shape savings to be realised?*

Conclusion

Roadmap for the future

- Revamping Aging Plants
- Modelling and other Digital platforms / Modelling heat transfer
- Expand the knowledge to Alternative Elements (Ce, Cu etc)
- Sensors coupling to A.I. and other digital technologies to suggest corrective actions
- Performing and environmental- friendly mould powders, linked to a mould powder database
- Focus on spreading of research outputs in wide range of players
- Role of dissemination

Thanks for the attention!

Stay informed

http://valcra.eu/

https://www.linkedin.com/company/european-continuous-casting-network

VALCRA linkedin group (linkedin.com/groups/13794289/)