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Mapping, Educating, Training, Applying models in continuous CASTing

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1. INTRODUCTION

As mentioned in the Project Grant Agreement, METACAST, as a RFCS Accompanying Measure, intends to develop a comprehensive view of numerical modelling in continuous casting and to offer it to the European steel community, including all the stakeholders from the top managers of steelmaking companies to the researchers and students in universities.

Among the final outcomes of the project, indication on future trends and way to manage at best the 'modelling tools', also in view of the link with more structured architectures (process control, AI-ML methods relying on modelling), represents an important aspect worth to be considered to support at best the stakeholders in using all the resources available finalised to efficient and sustainable production.

In this report, focus on the guidelines for optimal use of modelling in steel industry is therefore given. The data were based on feedback had from stakeholders as outcome of discussions and questionnaire filling during the project duration. In particular, the last webinar (held on 5 March 2026) and a questionnaire launched in February 2026, were the main booster of the info collection leading to the formulation hereinafter presented.

2. ACTIVITY PERFORMED

As mentioned in the previous section, the info here presented is based on the hints and suggestions taken from the discussion had with stakeholders during the project activity, strengthened by answers to questionnaires distributed in correspondence with project event. In particular, the questionnaire launched on February 2026, and the subsequent Final webinar held on March 5th , where insights were shown and further discussion was held with the audience to 'validate' the first indication arisen, represented the basis the discussion elements here presented are based on.

- 28 questions
- Here general overview as the info should bring to the definition of trends; discussion on single issues (fundamentals, validation (application, management) are discussed and shown in sperate deliverables.

Pictures of the March 5th event are shown in **Figure 1**.

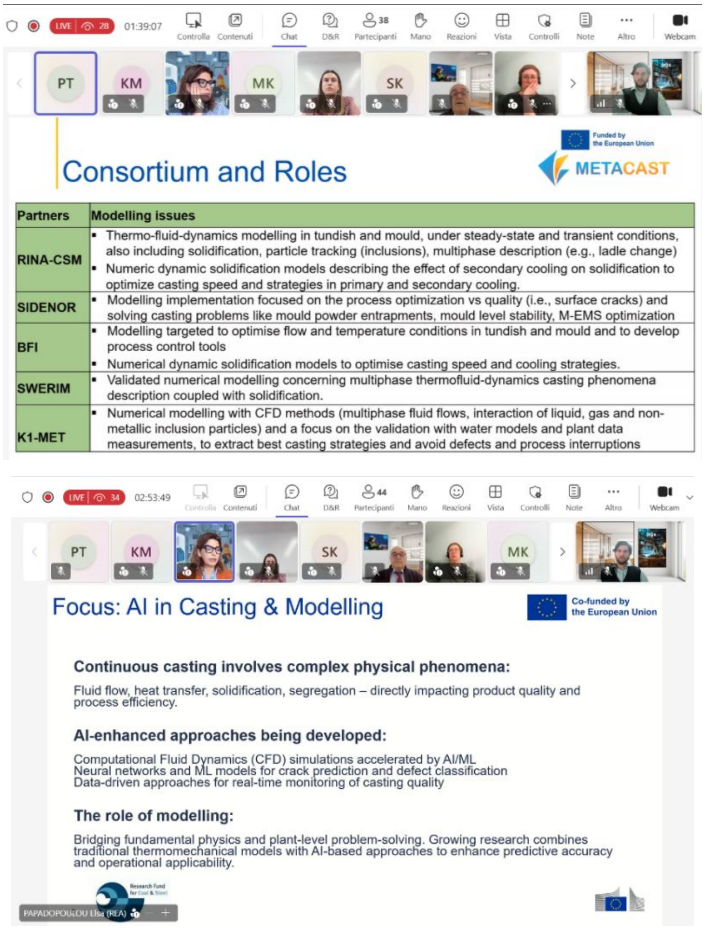


Figure 1 - Images from the March 5th event.

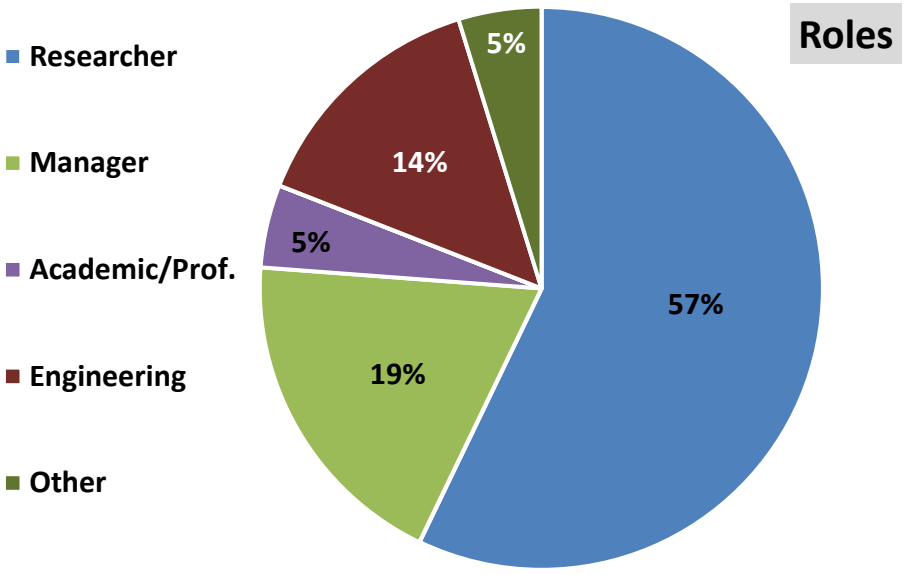


Figure 2 - Statistics from the questionnaire. Background and roles.

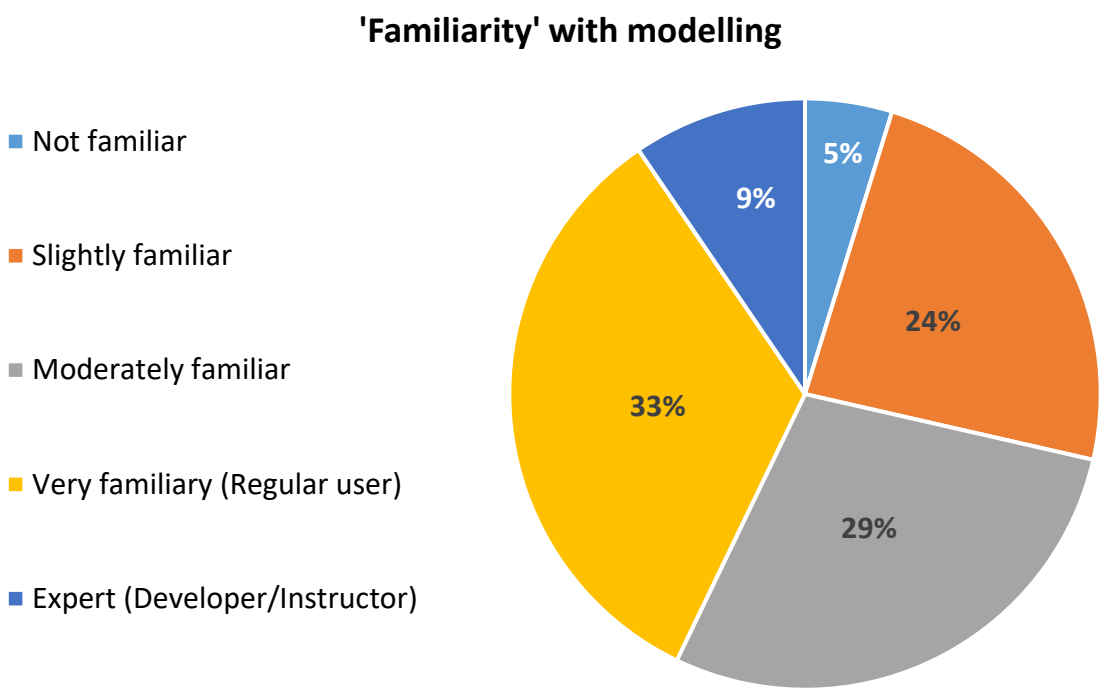


Figure 3 - 'Familiarity' with modelling of the respondents.

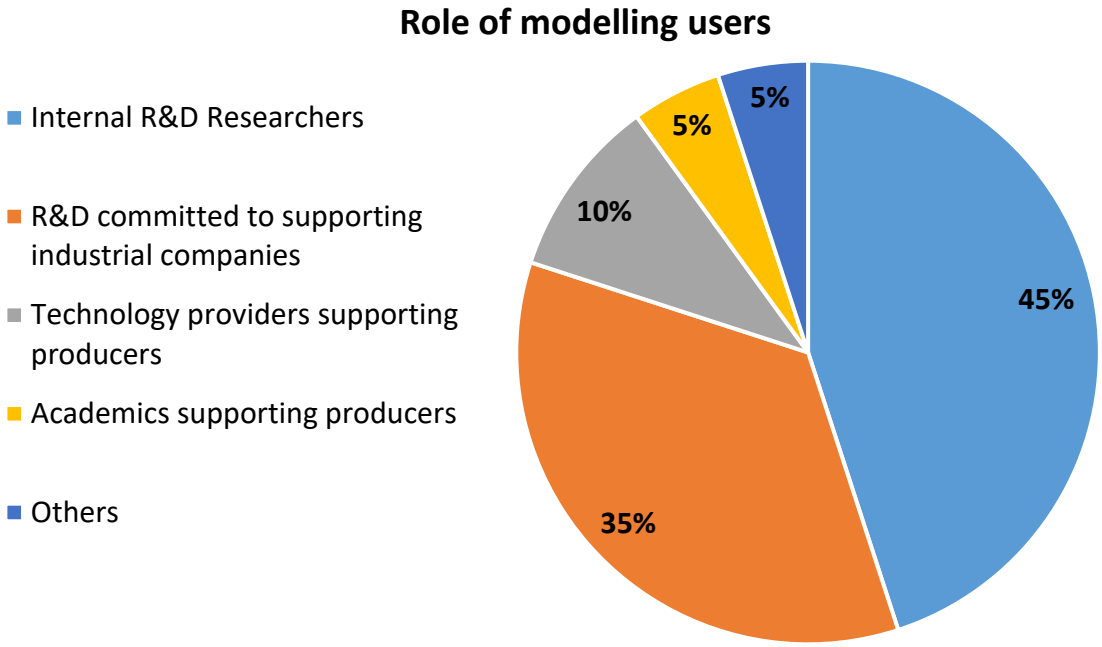


Figure 4 - From the questionnaire, role of the modelling users.

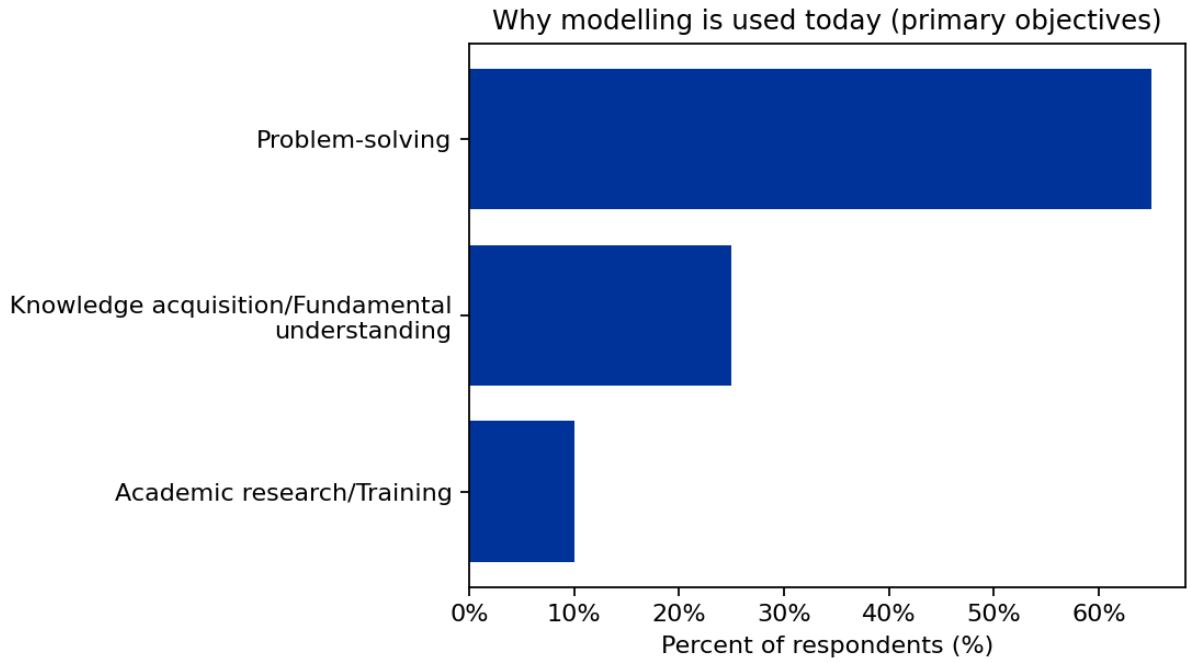


Figure 5 – 'Driving force' for the modelling users (% of respondents).

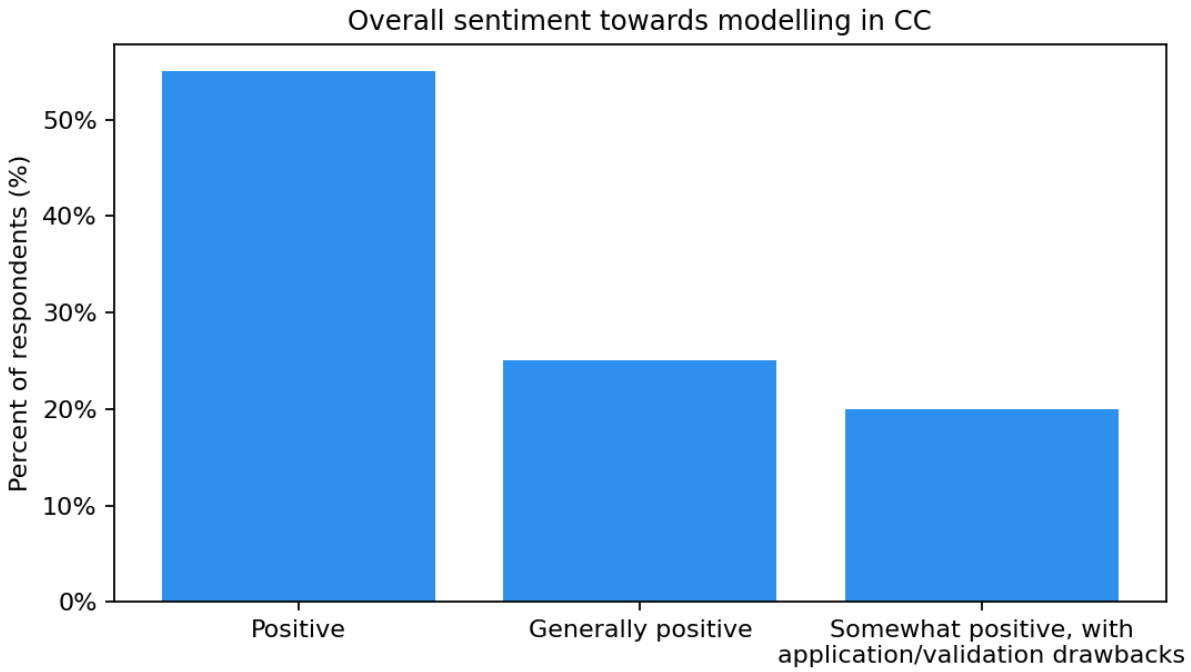


Figure 6 – Overall 'sentiment' towards casting modelling (% of respondents).

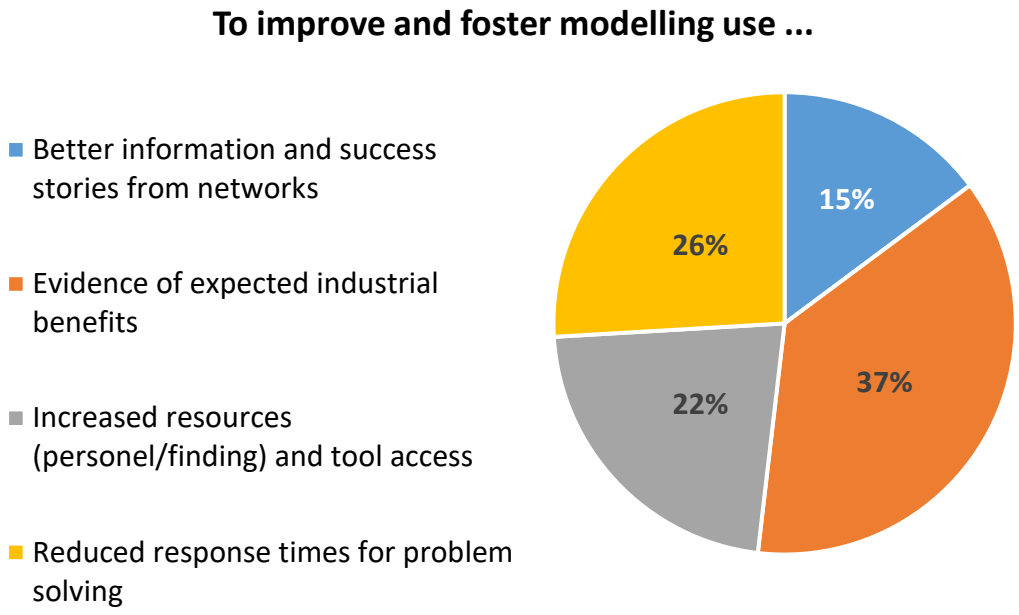


Figure 7 – Elements improving and fostering casting modelling use.

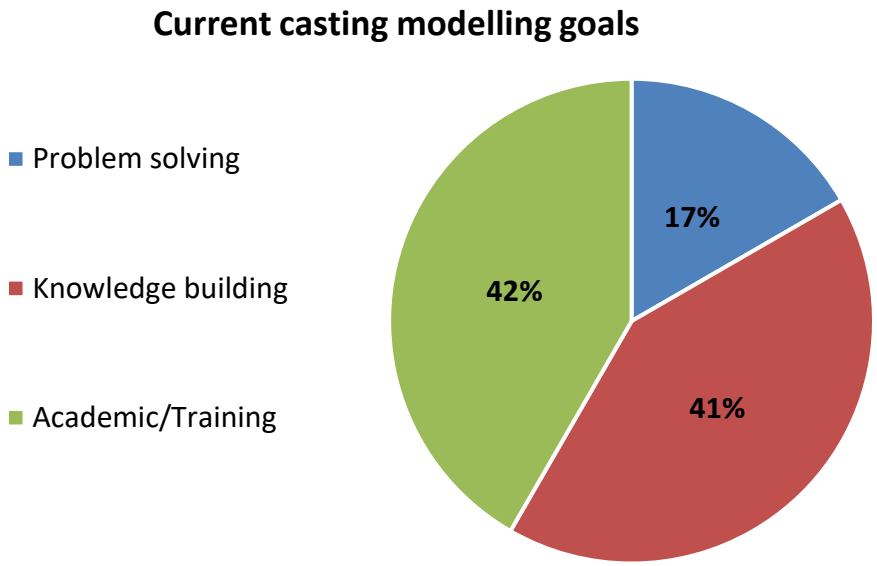


Figure 8 – Current casting modelling goals.

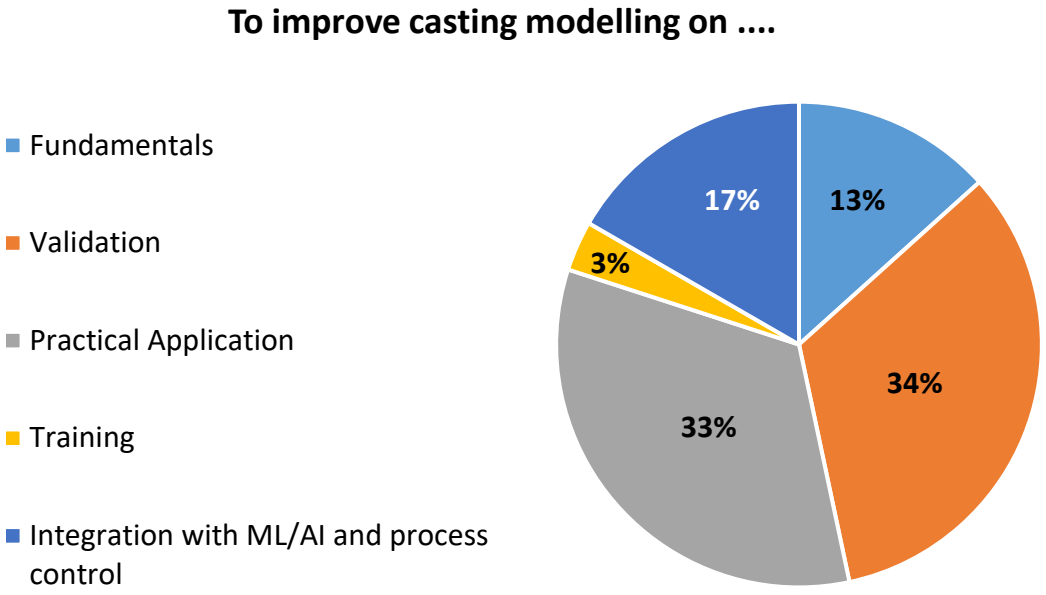


Figure 9 – Elements improving casting modelling.

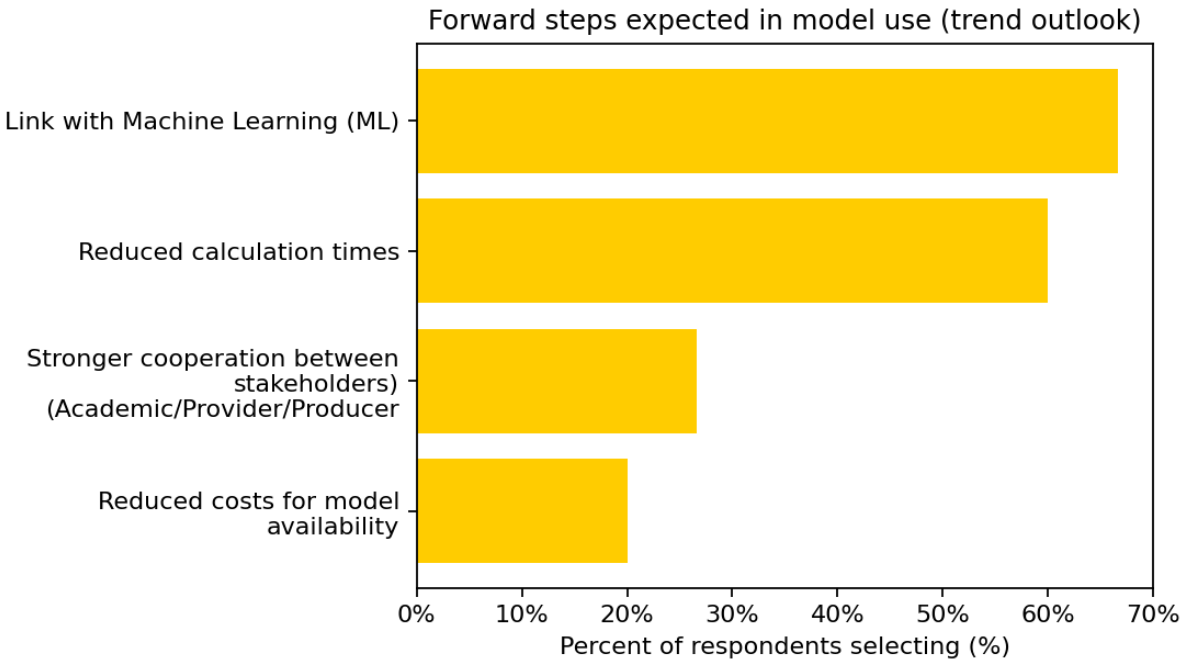


Figure 10 – Steps forward in casting models use.

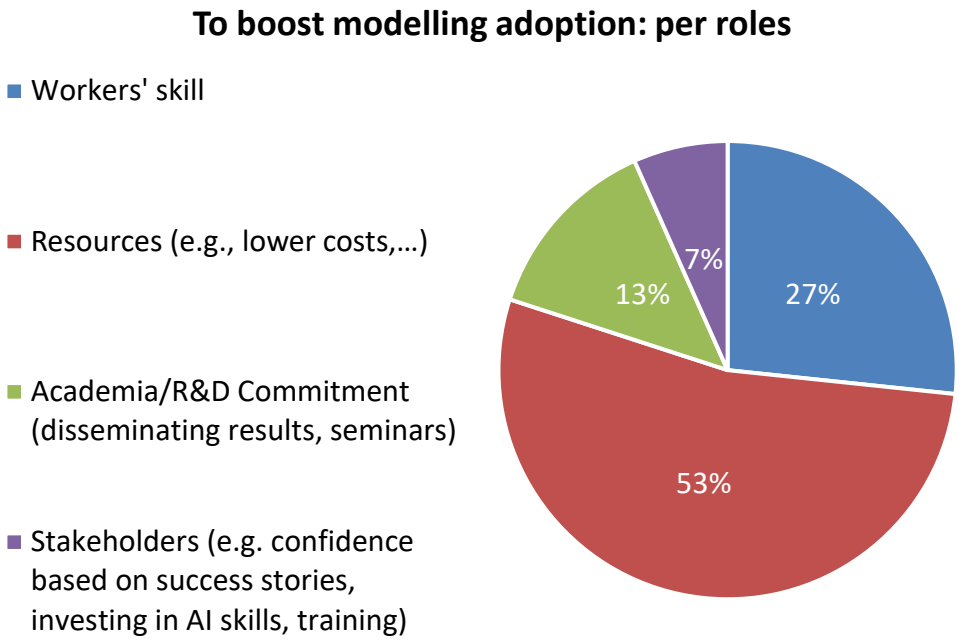


Figure 11 – Lines suggested to boost modelling use per stakeholder role.

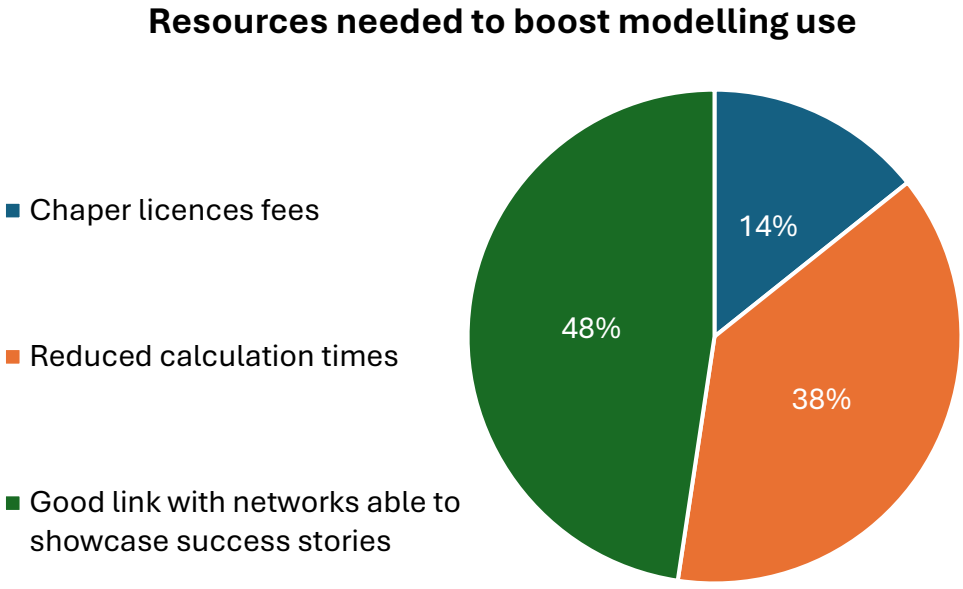


Figure 12 – Resources needed to boost modelling use.

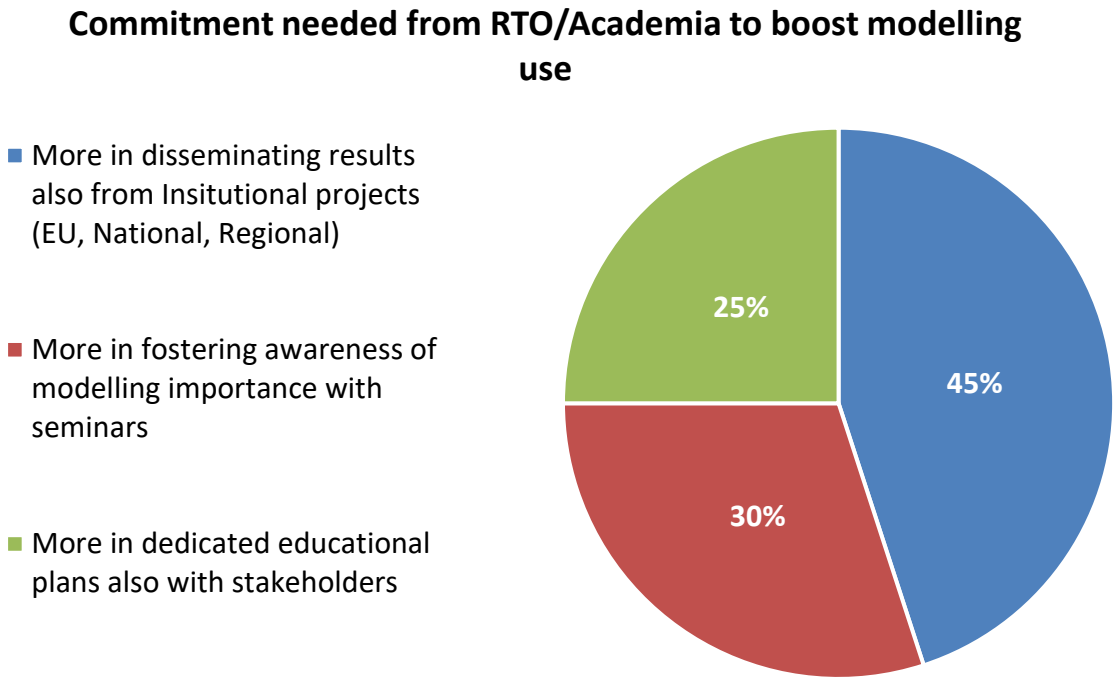


Figure 13 – Commitment needed from RTO/Academia to boost modelling use.

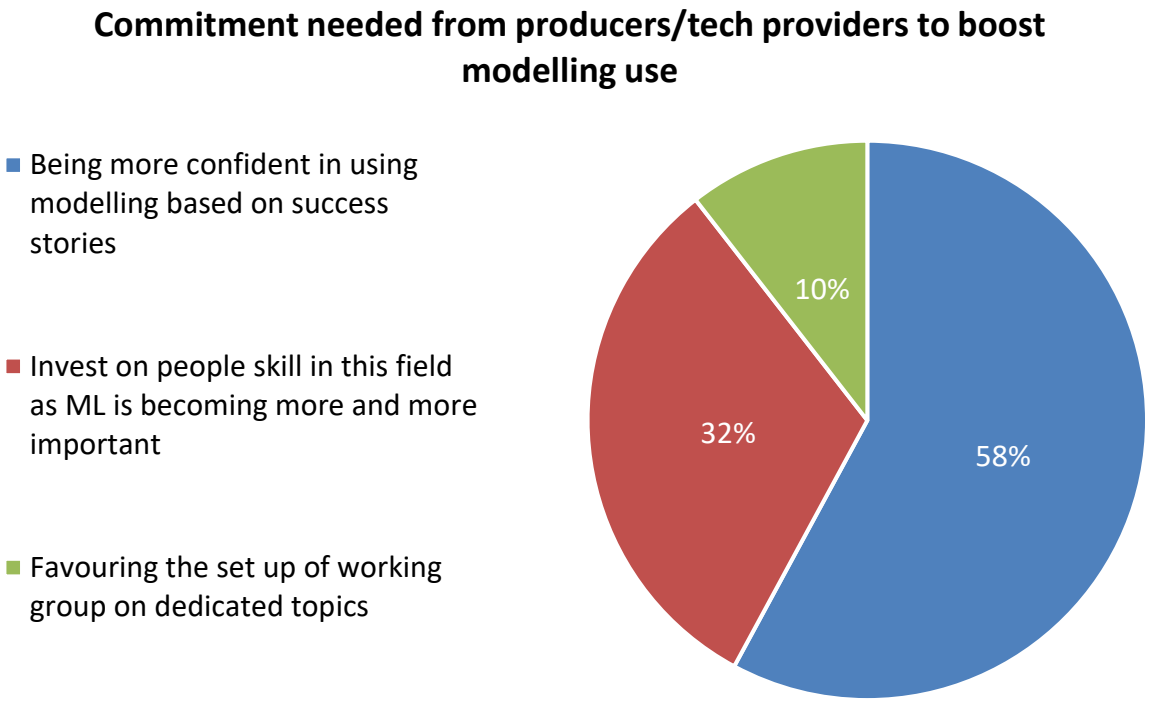


Figure 14 - Commitment needed from producers/tech providers to boost modelling use.

3. DISCUSSION

From previous consultations with stakeholders, the following points had emerged as relevant for future modelling trends.

- Increasing Awareness.
- Dependence on Strategic Contexts.
- Changing Drivers. (casting) modelling changed from 'Knowledge-Based' to 'Data-Driven Approaches'.
- Success Stories as Catalysts.
- Company structures devoted to modelling.
- Beyond Decarbonization: New Steels and Emerging Technologies.
- The feeding and booster role of Research Funding Programs.
- Training
- Gaps and Outsourcing.
- The AI/ML role.

Starting from these initial insights, the results of the final questionnaire were finally analysed. The findings are summarized below.

Overview of the stakeholder landscape. The survey encompasses 21 respondents, predominantly researchers (12) and engineers (3), with additional representation from industry managers (4) and academics. This mix reflects the broader modelling ecosystem in continuous casting, where R&D centers, engineering functions, and industrial process owners collaborate but often retain distinct priorities.

Modelling familiarity is generally high. 33% identify as *very familiar* and 29% as *experts or developers*. Only 1 respondent reports minimal exposure.

This confirms that the community surveyed is sufficiently knowledgeable to provide insight into both usage patterns and structural bottlenecks.

Current use of modelling in continuous casting.

Technical motivations for model use. The dominant motivation, selected by 65% of respondents, is problem-solving—indicating that modelling is viewed primarily as a tool for addressing industrial

issues rather than purely exploratory research. Secondary objectives include knowledge acquisition (25%) and training (10%).

When asked which modelling achievements are most successful today, a majority again highlight problem-solving (46%), followed by fundamental understanding (38%).This alignment confirms that practical application continues to be the primary driver for modelling adoption in the steel sector.

Concerning the Roles of model users, a significant portion of models is used by Internal R&D departments (47%), R&D groups collaborating with industry (37%) and Technology providers (11%). This indicates that modelling is still somewhat centralized in specialist roles, with limited penetration into plant level operational teams.

As reference to organisational perceptions and cultural trends, the sentiment and perceived value, the overall sentiment toward modelling is largely positive: 55% Positive, 20% Generally positive, 25% Cautiously positive with validation concerns.

Management views, however, are more conservative: 59% see models as *useful but secondary;* Only 29% consider them *essential;* 6% regard modelling as a non-essential "luxury" . This mismatch between technical enthusiasm and managerial prioritization is a recurrent barrier in industrial modelling deployment.

Again, regarding Management feedback, Management often expresses frustration with l**ong turnaround times (56%),** Limited applicability to urgent shopfloor issues (35%), insufficiently clear ROI (15%)

These points mirror typical resistance to advanced modelling tools in heavy industry processes where decision cycles are short and operational constraints rigid.

Referring to the trends, barriers to modelling adoption and effective use, the survey highlights three main classes of barriers:

a) Resource and cost constraints (High cost of licenses and skilled personnel (50%), Time required to perform modelling tasks (35%), Limited modelling staff and availability of experts (multiple questions converge on this)

b) Integration with industrial reality; here, Respondents frequently cite the difficulty of aligning models with real world plant issues:

- "Match with industrial issues" (30–35% across questions)
- Lack of fast, reliable results for urgent problems
- Validation gaps (10 respondents) marking it as the top area needing improvement

On Skills, training, and awareness. Training programs are present only in part of the community (Yes (internal + external= 60%): the remaining: No training program.

Reasons for lacking training include :“**Not necessary for company objectives**”, Cost concerns; Lack of available experts; Time constraints for learning

Awareness of the strategic importance of modelling remains limited: multiple responses point to the need for improved communication, success stories, and clearer expectations of industrial benefits.

Within this scenario, the emerging directions as trends in modelling use result as follows.

The survey reveals several converging trends that define the next decade of modelling in continuous casting. First of all, Acceleration toward hybrid and data driven approaches. As a matter of fact, The most expected forward step is integration with Machine Learning (ML), chosen by 10 respondents (highest share), with reduced computation times ranked second (9 respondents).This confirms a clear transition toward hybrid physicsML models, faster predictive tools, online or near real-time process-support models.

Then, demand is highlighted for faster turnaround and actionable output. Across multiple questions, respondents emphasize reduced response times (20–30%), need for “usable” results linked to operational constraints, expectations for simplified, accessible modelling interfaces

This suggests that future modelling must be streamlined, automated, and integrated into existing plant systems rather than standalone expert-driven activities.

In this view, Growing emphasis on evidence and success stories is expected. For improving modelling use, respondents prioritize Clearer evidence of benefits (55%), Success stories and networks (20–30%) aa well as Greater dissemination from academics/RTOs (up to 40%) The community identifies dissemination and demonstration, not technology gaps, as the key lever for adoption.

A further aspect evidenced is Skills evolution and digital culture. In this regard, Stakeholders request:

- Investment in ML-related skills (5 respondents)
- Creation of working groups on modelling topics
- Stronger academic industrial cooperation for training and awareness building

This aligns with the broader trend of metallurgical modelling transitioning towards AI-enhanced workflows where data-centric competence becomes essential.

As an overall outcome, the guidelines on optimal modelling use can be defined as follows:

- **Modelling must shift "from expert analysis to operational decision support":** This requires reduced computation times, more robust validation, and alignment with industrial time constraints.
- **Training and skills are a central bottleneck:** structured training pipelines, blended learning (R&D + plant teams), and internal champions are essential.
- **Demonstration and evidence must be priority actions:** case studies, validation benchmarks, and ROI-oriented dissemination are repeatedly requested by industry.
- ✓ **Hybrid physics-ML approaches are the strongest upcoming trend:** guidelines should explicitly cover when/how to adopt hybrid models, data requirements, and validation rules.
- **Industrial integration is more important than model complexity:** models that cannot integrate with existing Level 2/3 systems or provide rapid, interpretable results face low adoption.

4. CONCLUSIONS

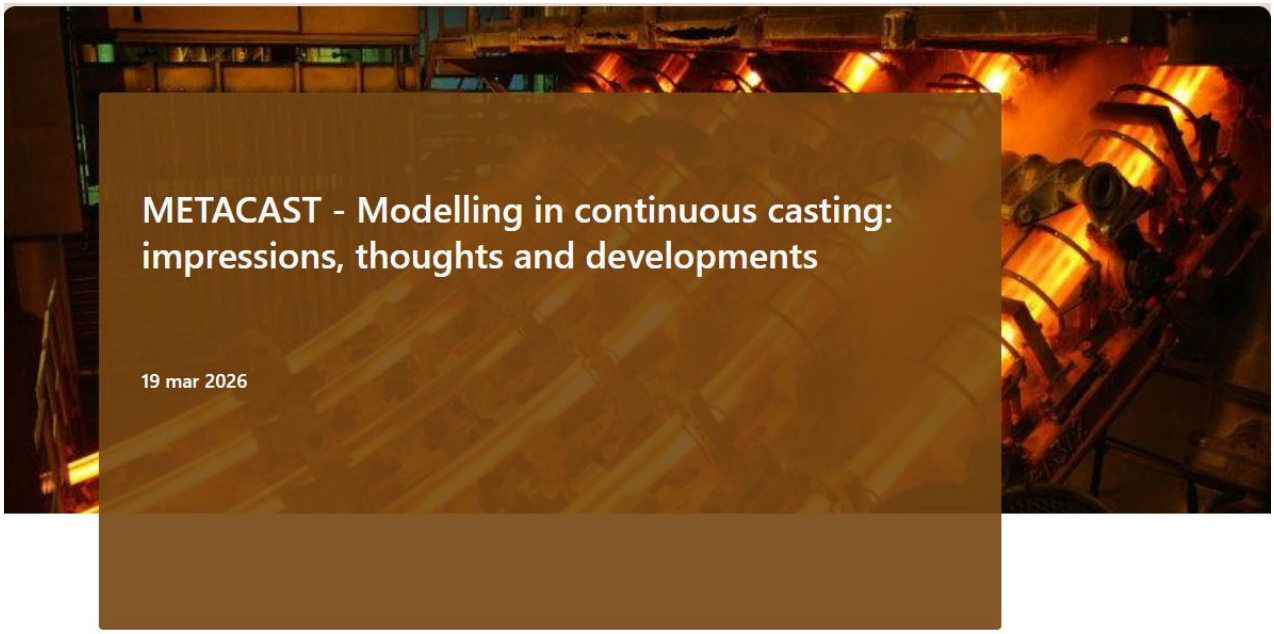
The METACAST consultations contributed to gain a consistent panorama across R&D, engineering, and managerial roles. The main outcomes are:

- modelling is widely appreciated, but under-adopted due to resource constraints and slow response times.
- The community strongly demands validation, faster tools, and linkage with machine learning.
- Awareness, skills, and training remain foundational issues.
- Dissemination and success stories are considered the most effective levers for change.

These insights form the basis for evidence-baced guidelines promoting more strategic, integrated, and future-oriented modelling practices in continuous casting.

Well-defined aspects concerning modelling use, training aspects and management view on modelling approaches and strategies are shown in separate documents (D2.3, D3.3 and D4.3) leaning on the overarching questionnaire form launched close to the project end and reported in Appendix.

5. APPENDIX – OVERALL QUESTIONNAIRE FORM



1. **What is your current professional role?** *

- ○ Researcher
- ○ Student
- ○ Manager
- ○ Academic/Professor
- ○ Legal
- ○ Marketing
- ○ HR
- ○ Engineering
- ○ Altro

2. **How familiar are you with modeling and simulation tools applied to continuous casting?** *

- ☐ Not familiar
- ☐ Slightly familiar
- ☐ Moderately familiar
- ☐ Very familiar (Regular user)
- ☐ Expert (Developer/Instructor)

Feedback from Model Users

This section is dedicated to those who work directly with modeling tools. It aims to identify the specific technical objectives, current skill levels, and perceived obstacles from a practitioner's perspective.

3. **What is the role of model users within your organization?**

- ◯ Internal R&D researchers
- ◯ R&D committed to supporting industrial companies
- ◯ Technology providers supporting producers
- ◯ Academics supporting producers
- ◯ Altro

4. **What is your primary technical objective when using models?**

- ◯ Problem-solving
- ◯ Knowledge acquisition/Fundamental understanding
- ◯ Academic research/Training
- ◯ Altro

5. **On a scale of 1 to 5, how would you rate your modeling expertise?** ***(1 = Interpreting results only; 5 = Full model development capability)***

☆ ☆ ☆ ☆ ☆

6. **What do you recommend to improve and foster the use of modeling within this context?**

- ☐ Better information and success stories from networks
- ☐ Clearer evidence of expected industrial benefits
- ☐ Increased resources (personnel/funding) and tool access
- ☐ Reduced response times for problem-solving
- ☐ Altro

7. **What is your general 'sentiment' regarding modeling in continuous casting?**

- ◯ Positive
- ◯ Generally positive
- ◯ Somewhat positive, with application/validation drawbacks
- ◯ Useful for understanding, but limited for problem-solving
- ◯ Not successful

Training Programme

This section targets the strategic view of modeling. It evaluates how management perceives the value of these tools and identifies the structure (or absence) of professional development programs.

8. **Does your company have a modeling training program?**

- ○ Yes, Internally
- ○ Yes, Externally
- ○ No

9. **What is the primary reason for the absence of a training program?**

- ○ Not necessary for company objectives
- ○ Prohibitively expensive
- ○ Lack of available experts
- ○ Altro

10. **What is the target audience for these training programs?**

- ○ R&D researchers
- ○ Researchers acting as interfaces for external consultants
- ○ Technology providers supporting producers

11. **What is the baseline skill level required for those entering model use?**

- ☐ Academic background
- ☐ Technical basics with on-the-job training
- ☐ Interpretation support only (work performed by externals)

12. **What are the main barriers/obstacles hindering a full and fruitful model training?**

- ☐ Model availability
- ☐ Models knowledge
- ☐ Time to deal with modelling
- ☐ Awareness of model importance
- ☐ Match with the industrial issues
- ☐ Altro

13. **What do you recommend to improve and foster training on modeling use?**

- ☐ Showcasing success stories and networks
- ☐ Evidence of industrial benefits
- ☐ Increased resources and tool availability
- ☐ Faster response times for reliable results

Stakeholders' management

This section explores the strategic view of modeling. We seek to understand if management perceives these tools as high-value investments or merely operational costs

14. **How does management generally perceive the value of modeling tools?**

- [ ] Essential for process control and plant solutions
- [ ] Useful for insights, but secondary to other methods
- [ ] A luxury or non-essential expense
- [ ] Altro

15. **What feedback does management typically provide regarding modeling results?**

- ◯ Positive: They value and act on the results
- ◯ Mixed: Results are useful but take too long to produce
- ◯ Negative: Results are rarely applicable to real-world issues

16. **What are the main strategic barriers preventing management from investing more in modeling?**

- [ ] High cost of resources (people and licenses)
- [ ] Urgency of industrial issues (models take too long)
- [ ] Lack of clear evidence regarding ROI/Benefits
- [ ] Altro

17. **Do the management currently arrange training plans for modelling use?**

- ◯ Yes, cared by internals/already skilled resources
- ◯ Yes, cared by model developers/code vendors
- ◯ Yes, cared by academics
- ◯ Not at all
- ◯ Yes
- ◯ Altro

18. **What do you need or should recommend to improve and foster the modelling use?**

- [ ] More information and showcasing success stories from networks (projects, academics,...)
- [ ] More evidence of the industrial benefits expected
- [ ] More availability of resources (people/money), easier availability of the model
- [ ] Reducing response times to have reliable results functional to problem solving
- [ ] Altro

19. **What are the main barriers/obstacles hindering a modelling formation strategy?**

- [ ] Resources (people, money for licences)
- [ ] Time to deal with modelling (need of quick answers to problem solving)
- [ ] Awareness of model importance
- [ ] Match with the industrial issues
- [ ] Altro

Optimal Use of Modeling in the Steel Industry

This final section focuses on the future outlook and the most significant steps required to bridge the gap between theoretical modeling and industrial reality

20. **What is currently the most successfully achieved goal of casting modeling?**

- [ ] Problem-solving
- [ ] Knowledge building
- [ ] Academic/Training
- [ ] Altro

21. **Which aspect of casting modeling requires the most improvement?**

- [ ] Fundamentals
- [ ] Validation
- [ ] Practical Application
- [ ] Training
- [ ] Integration with ML/AI and process control
- [ ] Altro

22. **What is the most important forward step expected in model use trends?**

- [ ] Link with Machine Learning (ML)
- [ ] Reduced calculation times
- [ ] Reduced costs for model availability
- [ ] Stronger cooperation between stakeholders) (Academic/Provider/Producer
- [ ] Altro

23. **What is required from the following perspectives to boost modeling adoption?**

- ○ Workers' Skills: (e.g., Internal education vs. external experts)
- ○ Resources: (e.g., Lower costs, less time-consuming results)
- ○ Academic/R&D Engagement: (e.g., Disseminating results, dedicated seminars)
- ○ Stakeholders: (e.g., Confidence based on success stories, investing in AI skills)
- ○ Altro

24. **What is needed for the point of view of the resources for boosting the modeling adoption?**

- ☐ Lower modelling costs
- ☐ Less time consuming model results
- ☐ A fruitful link with networks able to showcase modelling fruitful use and success stories
- ☐ Altro

25. **What is needed for the point of view of the academic/RTO engagement for boosting the modeling adoption?**

- ☐ More commitment in disseminating results also from Institutional projects (EU; National, regional)
- ☐ More commitment in foster awareness with dedicated actions/seminars
- ☐ More commitment in dedicated educational plans together with stakeholders
- ☐ Altro

26. **What is needed for the point of view of the stakeholders (producers, technology providers) for boosting the modeling adoption?**

- ☐ Being more confident to modelling use based on success stories
- ☐ Invest ton people skill in this field as ML is becoming more and more relevant
- ☐ Favoring the setup of working group on dedicated topics
- ☐ Altro

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Greetings

27. **Thanks for answering. If you would like to contribute further to the survey, please leave your email and we will contact you.**

Inserisci la risposta