Robotics4EU

Boosting Wider Adoption of Robotics in Europe

D1.3

Responsible robotics maturity assessment model (initial)

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Responsible robotics maturity assessment model (initial)

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The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf.

Table of Abbreviations and Acronyms

Abbreviation	Meaning
AI	Artificial Intelligence
MAM	Maturity Assessment Model
SME	Small or Medium Enterprise
TRL	Technology Readiness Level

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1 Executive Summary

The overall objective of the Maturity Assessment Model is to provide the producers, end-users, regulatory bodies and any other relevant stakeholders, with the capacity to assess the maturity of robots. We aim to develop a tool that can be used both as a self-assessment by robot manufacturers and by external auditors in the context of a potential future Responsible Robotics label. The topics covered in the Maturity Assessment Model can also serve as a best practice guide for robot manufacturers. In this context, *maturity* refers to the societal readiness of robotics solutions, and it highlights to what extent the robot meets society's ethical values and its economic, legal and social needs.

The Maturity Assessment Model will be designed throughout the Robotics4EU project, through desk research and consultation of the stakeholders. This deliverable presents the first draft of the Model, based on the desk research and consultations carried out during the previous activities of the project (Deliverable 1.2 "Needs Analysis of the Robotics Community") and on the public debate event organized to determine specifically the scope of the Model.

The event welcomed thirty participants originating mostly from Europe (one from the Middle East and one from South America), who raised many excellent points to help Robotics4EU partners lay the foundations of the Model.

The Model must include tools for reaching a high level of maturity (for the developer) and tools for verifying the level of maturity (for potential external inspection). The maturity score must be self-explanatory and relevant to the recipient.

The objective of the maturity score is to spot the robots that are not mature enough for society, even after they are on the market. However, the score and the scoring procedure must be wisely designed so as to limit negative impacts on companies: the maturity score must rather be a reward than a punishment. The scoring procedure must also be economically realistic so as to maximize its uptake by industry.

Several estimators may be designed to assess the socio-economic and ethical maturity of the robots. A definition of the perimeter of application of the robot may drive a risk analysis that includes the environment (operational and organizational environment) and the stakeholders (users, presence of people passing by, etc.). The maturity score is not intended to lead to an inspection of the compliance of the robot with law, since regulatory requirements are managed by other dedicated frameworks. However, the designer could show that they contribute to the development of an adapted regulatory framework. The maturity score could also reflect the involvement of the designer with public communication activities, and the efforts they put in knowledge transfer.

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2 Introduction

2.1 General principles

The overall objective of the Maturity Assessment Model (MaM) is to provide the producers, end-users, regulatory bodies and any other relevant stakeholders, with the capacity to assess the maturity of robots. In this context, *maturity* refers to the societal readiness of robotics solutions, and it highlights to what extent the robot meets society's ethical values and its economic, legal and social needs.

The MaM will thus provide a "tool" for the assessment. This tool will include requirements (i.e. checkpoints), with this logic: the more items are checked, the more "mature" the robot is. The checklist can be filled in through:

- Qualitative descriptions of the robot on specific topics. This can be statements, observations, explanations, listing, amounts, etc. These descriptions must be reasonably verifiable.
- Statistics about the robot on specific topics. This may include measurements or estimations, for example obtained through testing of the robot (check whether an important behaviour occurs, or to check the absence of an undesirable behaviour in specific situations).

2.2 Expected use and impact of the MaM

The MaM should provide a certain level of guarantee about the societal acceptability of a robot. To achieve that, the checklist should lead to the production of a score. The guarantee obtained through this score (i.e., is this robot really acceptable or not) depends on the way the assessment is performed. Traditionally, the designer of a verification methodology has to estimate an appropriate trade-off between feasibility of the verification (can the proof be easily obtained?), the effort of verification and/or the effort to achieve compliance, and the expected degree of guarantee (e.g. if the final validation should ensure the safety of a product, the expected guarantee is high).

In the duration of the project, we are both exploring the nature of the checkpoints and the way these checkpoints can be verified: this is the MaM itself as it is presented in this first version of the deliverable, including the requirements and proofs that can be observed for each requirement. We also elaborate throughout the project on the type of *in fine* validation one could obtain from the MaM.

Operating the MaM, i.e. checking the compliance of a given robot with the list of requirements, can be performed:

- Through self-assessment (first-party verification): the robotic manufacturer uses the checklist on their own, and estimates their own degree of compliance. With such an approach, there is no guarantee on the conformity of the robot. However, this approach is intented to be pedagogical, by providing the manufacturer with the list of the essential elements that needs to be fulfilled in order to commercialize a societally acceptable robot. The approach hence enhances the potential acceptability of the robot, and ideally the manufacturer should be provided with guidance to achieve conformity. In this regard, Deliverable 1.2 ("Needs Analysis of the Robotics Community") has outlined a list of good practices which can be linked to each requirement.

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- Through third-party verification: third-party verification is performed ideally by an independant entity, “independant” meaning that the third-party does not present any conflict of interest that may fragilize the validity of the assessment, such as competitive interests. The verification may lead to a sort of certification, a “stamp”, that recognizes that the robot is compliant with the list of requirements. Such a stamp can be called a certification or a label, and this requires an additional layer of verification. Indeed, the list of requirements for the MaM is established in a way that disregards the nature of the verification (first party or third party), since we need to explore first the nature and feasibility of the checkpoints. A certification or labelling protocol would require a specific strategy for third-party verification and validation, with checkpoints specifically designed for such a context.

The impact of the MaM would thus depend on the operation strategy decided in the project, which is going to be the output of the trade-off above mentioned. The activities performed in the project should allow gathering this information.

2.3 Design methodology

The Deliverable 1.2 “Needs Analysis of the Robotics Community” produced in May 2021 identified 5 categories of issues that may hinder the acceptance of robots in society (socio-economics, ethics, data related issues, legal, education & society engagement). For each of these categories, a number of issues were listed from desk research and consolidated through large-scale online polls and a small number of in-depth interviews with robotics community stakeholders. The table below presents an excerpt of these issues as an illustration.

Category of issue	Relative issues
Socio-Economic Analysis	• Rising skill gaps and skill depreciation • Insufficient protection of worker rights
Education and Engagement of society	• Education issues (lack of resources, knowledge availability • and informal science education) • Lack of trust in science • Insufficient empowerment of the general public

Table 1. Example of categories and the related issues (from Deliverable D1.2).

All points of verification in the Model must be as verifiable and accurate as possible. However, one can see from the list of issues provided as examples that they are not directly assessable if they are worded in this form; to perform a valid assessment, indicators must be designed. For example, the issue of “Rising skill gaps and skill depreciation” could be estimated by first defining how one can rate skill depreciation. An indicator could be in this context whether the individual working with the robot still performs tasks of an equal value as what is expected in his/her position.

The list of issues presents many other statements that cannot be assessed without defining first observable indicators: “transparent”, “not harmful for the environment”, “respects minorities”, “liable”, “controllable”, “data are protected”.

In addition to establishing the *content* of the Model (what will be assessed?), the research should also cover the ecosystem of the Model.

First, we must define **who is going to operationalize the "tool" so as to compute the score**. Two main options are explored: an external inspection (e.g. an auditor in a supervisory agency; the employer before deploying the robot in their factory) or a self-performed inspection (e.g. the manufacturer for CE marking; the integrator before selling a full machine). This choice will strongly impact the Model, since several aspects may not be observable by an external entity if the information is not provided by the designer. The choice may also depend on the regulatory framework (the legal requirements for a given robot) and the incentives to produce a maturity score (e.g. for marketing reasons).

We must also understand **who would need to know the maturity score** of the robot. In this regard, we have identified several different entities:

- Robot designers: manufacturers or integrators, who may want to guide their development or obtain a quality label or a certification.
- supervisory entities and regulatory bodies, who would be asked to certify the robot.
- end-users: the customers of robot designers, who will directly interact with the robots either professionally or as individueals. The maturity score should allow them to make a better-informed choice among the different technologies available on the market.
- The general population: any person who is impacted by the robot, either directly or indirectly, and that does not have a direct impact in the choice of technology. They would benefit from the maturity score to inform the trust they can put in the robots (when they are in the public space) and in companies using them (the end-users). This can also help involve the general public in public decisions such as consultations and referendums.

Finally, one should guarantee the **relevance and interpretability of the maturity score**. In other words, customers should be able to understand the meaning of the rating obtained by the robot, and the consequences linked to the rating. Additionally, not all categories of issues are relevant for all robots; for example, a robotic toy does not cause major concern in socio-economics. Therefore, we split the assessment into several scores, for example one for each category of issues, along with detailed assessment results. The score of maturity would then allow customers to make an informed choice, depending on the importance they attach to a particular issue in their own context of use.

The design of the Model will be carried out throughout the Robotics4EU project, by leveraging both research works and massive consultation of the community of stakeholders (end users, citizens, designers, regulatory bodies, etc.).

The previous works carried out in Robotics4EU have highlighted the issues on which to focus the definition of the Model. The selection of issues was based on desk research and consultation.

The Maturity Assessment Model must be straightforward and realistic enough to maximize its uptake by industry. This means that the work must be based on research results, but it must also be easily transferable to industry by providing concrete technical solutions and by being in line with the current economic and regulatory framework. To achieve this, its design is based on a very early confrontation with the stakeholders (end users, industry, policy makers, etc.).

The creation of the Model must first consist in defining the perimeter of the assessment:

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- Who would need the score, and what would the score mean to them
- Who could compute the score, and with what tools
- What form the score should take

Desk research and public debates were the first activities organized in the context of the task, so as to address these questions and obtain first lines of analysis of the topic. Additional consultation activities will be performed throughout the project to refine and validate the content of the model with the interested parties.

2.4 Structure of the document

The organization and results obtained from the debates are presented in section 3 "**Error! Reference source not found.**", along with a preliminary desktop research of assessment models.

Section 4 presents the Maturity Assessment Model in its draft version, along with the environed work activities to be carried out until the end of the project to finalize the Model.

The Section 5 summarizes the document.

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3 Initial analyses

3.1 Literature works on maturity assessment

3.1.1 Maturity assessment in robotics/new technologies

The assessment of the maturity of a robot requires defining the concepts of “maturity” and “assessment”. As stated by (Wendler, 2012)[1], “*the purpose of models dealing with maturity is to outline the conditions when certain examined objects reach the best (perfect) state for their intended purpose. For instance, these objects can be software development capabilities. In addition, there has to be a “final” state of maturity (fullness of growth) in which no further development is possible*.”

In the context of Robotics4EU, maturity has been defined as the degree of acceptance by society at large when AI-driven robots are concerned. As defined in Deliverable D1.2 “Needs Analysis of the Robotics Community”, the notion of maturity is thus linked to ensuring that all issues (socio-economics, ethics, data related issues, legal, education & society engagement) are reasonably addressed and solved before the robot is placed on the market.

In the context of Industry 4.0, many studies tackle the topic of the digitalization of companies. Although these works do not fall right into the scope of Robotics4EU project (societal acceptance of AI-driven robots), the notion of the maturity of technology and its impact on human being is strongly tackled, and relevant tracks can thus be leveraged. In the context of Industry 4.0, companies face the need of reaching higher levels of automation and connectivity. In a review of several existing assessment and maturity models for SMEs (Rauch, 2020)[2], the authors note that in Industry 4.0, most works relative to the development of assessment models for SMEs are tackled at the research/academia level, but there is still some area of improvement for validated models fully exploitable by industry. In all the examples presented below, the authors offer highly interesting reviews of models for the assessment of maturity; we are not going to cover them all, since they all focus on the evaluation of the maturity of companies in the very specific context of Industry 4.0, which appear a bit remote from Robotics4EU main objectives. However, all these studies provide a good representation of the methodology to apply in the design of maturity models.

The work presented in (Ganzarain, 2016)[3] highlights a process model in three stages for the general implementation of an Industry 4.0 strategy in SMEs. This model focuses on allowing companies to identify new opportunities for diversification, based on an analysis of the capacity and resources of the company (the first stage of the process), the identification of the requirements and technologies required (the second stage), and performing actions towards diversification that include training capacitation, launching Industry 4.0 projects and designing risk management procedures (the third stage). The

[1] Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and software technology*, *54*(12), 1317-1339.
[2] Rauch, E., Unterhofer, M., Rojas, R. A., Gualtieri, L., Woschank, M., & Matt, D. T. (2020). A maturity Level-Based assessment tool to enhance the implementation of industry 4.0 in small and Medium-Sized enterprises. *Sustainability*, *12*(9), 3559.

[3] Ganzarain, J.; Errasti, N. Three stage maturity model in SME’s toward industry 4.0. J. Ind. Eng. Manag. 2016, 9, 1119–1128. [http://dx.doi.org/10.3926/jiem.2073]

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model is scalable according to the maturity level of the SME in view of implementing Industry 4.0; the scale goes from 1 (no specific Industry 4.0 vision) to 5 (transformation of the business model).

In the same vein, (Mittal, 2018)[4] explore a maturity model that is dedicated to the economic sustainability of SMEs in the context of their digital transformation. In this work, the authors analyze the fact that most maturity models provide guidelines that are more adaptable to larger enterprises rather than to SMEs, which may imped the economic growth of the later by denying them access to adapted strategical and management tools towards Industry 4.0. The maturity model offered in this work is based on five dimensions relative to organizational dimensions: finance (e.g. cost-benefit analysis, investments risk and returns management), people (e.g. leadership, training and education), strategy (e.g. decision making, standards), process (e.g. quality control, machines operation) and product (e.g. logistics, time to market). Each dimension can be rated on five maturity levels (from Novice to Expert), and at each level the company can access a toolbox that allow the SME to reach a higher level of maturity. Seven types of toolboxes (Mittal 2018b) are offered in this model, that cover manufacturing and fabrication, design and simulation, robotics and automation, sensors and connectivity, cloud/storage, data analytics, and business management. Each toolbox offers several tools (software, strategy, etc.) that can be implemented.

Overall, we can understand from these works that the assessment model must include truly operationalizable estimation tools. By that, we mean that the model has to offer a defined list of dimensions, that cover specific checkpoints or topics of verification. In addition, the model should offer a scale, in which each step is presented as a clearly understandable description of the level of compliance with the checkpoint. As we can see in the examples listed here, the scale steps can be very specific to the dimension or checkpoint addressed, or they can be general to the entirety of the model.

Among the outputs of our desk research, outside of the specific field of Industry 4.0, the notion of “maturity” is more seldom addressed directly. The notion seems to be included in the field of “responsible robotics”, as highlighted by initiatives such as the FRR Quality Mark for (AI based) Robotics, designed by the Fundation for Responsible Robotics[5]. The label addresses seven principles:

- Security
- Safety
- Privacy
- Fairness
- Sustainability
- Accountability
- Transparency

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[4] (Mittal 2018a) Mittal, S.; Romero, D.; Wuest, T. Towards a Smart Manufacturing Maturity Model for SMEs. In Advances in Production Management Systems; Moon, I., Lee, G., Park, J., Kiritsis, D., von Cieminski, G., Eds.; Springer: Cham, Switzerland, 2018; Volume 536, pp. 155–163.
[5] https://responsiblerobotics.org/

Among the initiatives related to responsible robotics that we came across, this initiative seems to be the most advanced – the creation of the label has entered its piloting phase – and concertation will be required to ensure a correct alignment.

3.1.2 Maturity assessment in AI

In the field of AI, many initiatives tackle the notion of "AI trustworthiness", which relates to the ability of an AI system to be trusted by relevant interested parties. In some way, trustworthiness is linked to the notion of acceptance. In most cases, the models developed derive from the works performed by the High-Level Expert Group for Artificial Intelligence (HLEG-AI), commissioned by the European Commission in 2018 to deliver works, analyses and insight for the design of European strategies and policies on AI. Among the produced works, the Assessment List for Trustworthy Artificial Intelligence[6]. This list, intended for self-assessment by AI producers, is made of checkpoints on seven key concepts for AI trustworthiness. These concepts are presented in Figure 1, which highlights the thematical relationship between the concepts and the issues addressed in Robotics4EU.

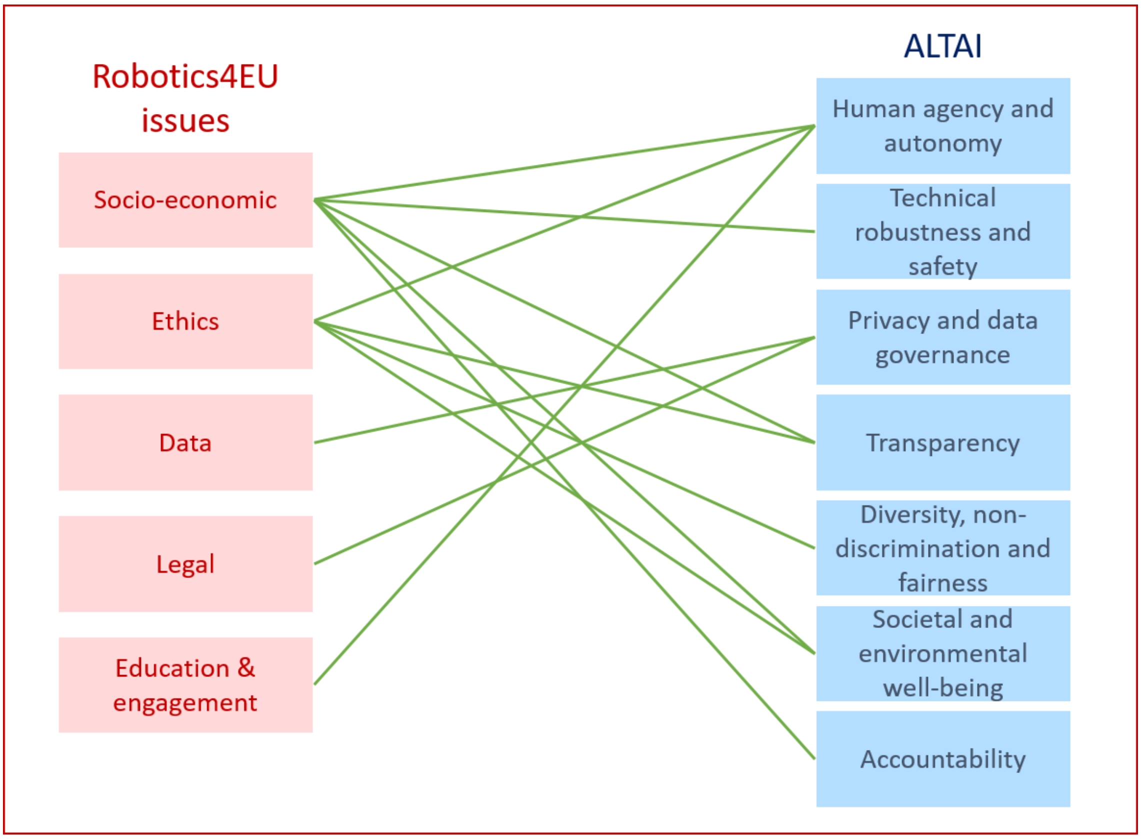

Figure 1. Mapping of Robotics4EU issues (for societal adoption of robotics) and ALTAI key concepts (for AI trustworthiness).

The questions presented in the ALTAI are meant to draw the attention of the AI producer to the most relevant and critical points of attention, and in this regard it does not provide any ranking or scoring methods. For example:

[6] https://digital-strategy.ec.europa.eu/en/library/assessment-list-trustworthy-artificial-intelligence-altai-self-assessment

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"**Avoidance of unfair bias** – *Did you establish a strategy or a set of procedures to avoid creating or reinforcing unfair bias in the AI system, both regarding the use of input data as well as for the algorithm design?*"

"**Stakeholder participation** – *Did you consider a mechanism to include the participation of the widest range of possible stakeholders in the AI system's design and development?*"

In this regard, the ALTAI can be considered as an accompanying tool in the design of an AI product, which would lead the producer to engage actions (by designing their own strategies) in response to each checkpoint. Since the robots considered in Robotics4EU are AI-driven robots, keeping these points of control in mind in the design of the Maturity Assessment Model seems essential, in addition to considerations that are specific to robotics (as highlighted by Robotics4EU project's activities).

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3.1.3 Maturity assessment model design process

The standard ISO/IEC 33004:2015[7] establishes requirements for the design of maturity models in the domain of new technologies, which constitute the rationales for the design of the Maturity Assessment Model. However, the standard is intended to provide specifications for the design of a model at a normative level, which should thus follow established standardization procedures. In the context of Robotics4EU, those rules are considered as the best practice from which we will borrow key elements for the design of the model, given our specific context.

The main elements of the standard are (with adaptation):

1. A maturity model shall document the community of interest of the maturity model and the actions taken to achieve consensus within that community of interest:
    a. the relevant community of interest shall be characterized or specified;
    b. the extent of achievement of consensus shall be documented;
    c. if no actions taken to achieve consensus, a statement to this effect shall be documented.
2. The maturity model shall define:
    a. a declaration of scope of application;
    b. its use with respect to a process quality characteristic associated with business success in the domain of application.
3. A maturity model shall be based upon one or more specified process assessment models that utilize a common process measurement framework for the specified process quality characteristic.

3.2 Robotics4EU debates

3.2.1 Introduction

A first activity was implemented by Robotics4EU in order to compare our preliminary desk analyses with the opinions of a range of interested parties. In this view, Robotics4EU organized and hosted a public debate.

3.2.2 Methodology

The debates were organized online by the Robotics4EU project partners.

The events went as follows:

- An opening speech with:
    - An **overall presentation** by the project leader.
    - A **presentation of the maturity assessment model** by the WP1 leader (Work Package "Needs analyses and responsible robotics maturity assessment model"). This presentation explained the overall objectives and themes of the future model.
- The **debates** with the participants, in breakout rooms.
- A closing speech summarizing **the project's following activities** towards the completion of the maturity assessment model (workshops, co-creation workshops, citizen consultation, high-level forum 2022) by WP1, WP3 and WP4 leaders.

[7] ISO/IEC 33004:2025 – Information technology — Process assessment — Requirements for process reference, process assessment and maturity models

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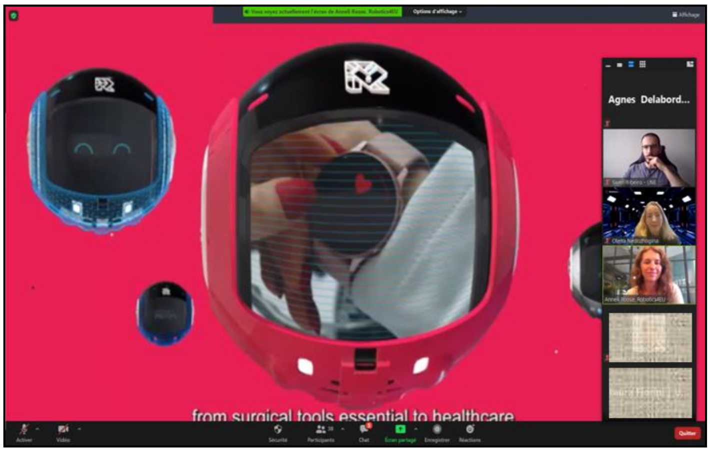

Figure 2. Opening speech - Robotics4EU presentation.

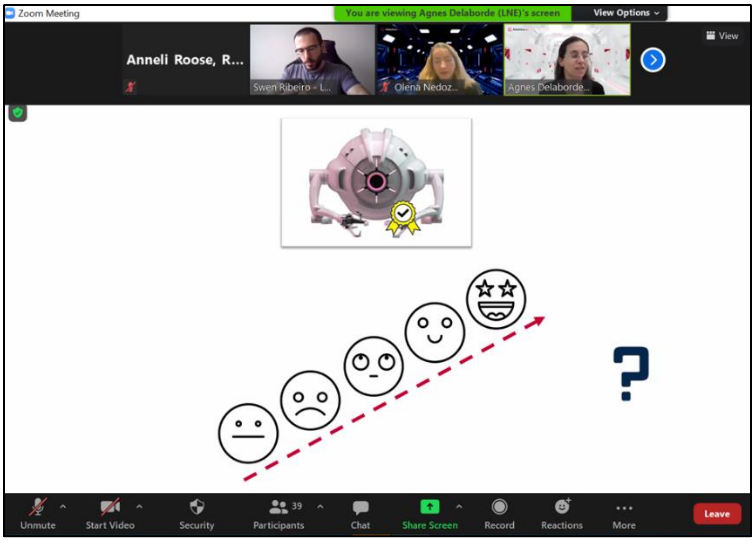

Figure 3. Opening speech - Maturity assessment model presentation.

Figure 4. Ending speech – Following activities in Robotics4EU.

In order to optimize the coverage of the topics broached during the debates and to facilitate moderation, the participants were split randomly into 6 groups:

- 2 groups worked on the topic "Stakeholders"

- 2 groups on the topic “Objectivation”
- 2 groups on the topic “Maturity score”

The debates had to focus on the assessment of the robot, rather than on finding ways to solve the issues. The purpose of these breakout rooms was to gather insights on the following topics:

- “Stakeholders” rooms:
  - The users of the score: who will have use of the maturity score?
  - The producers of the score: who is going to have to assess the maturity of the robot?
- “Objectivation” rooms:
  - To what extent can the issues be verified objectively?
  - Are there tools (guidelines, protocols, regulation, etc.) for that?
- “Maturity score” rooms:
  - The form that the maturity score should take.
  - The domain where the score should apply, and what it would mean.

Each breakout room was moderated by a Robotics4EU partner. To facilitate privacy management, debates were not recorded, so most facilitators were assisted by colleagues to take notes.

Each moderating partner had been provided with a handbook presenting the questions that had to be asked to the participants in order to guide the discussions, along with several examples of possible answers. Some questions are voluntarily overlapping, since different wordings may trigger different opinions. Optionally, the facilitators could also pick some ice-breaking questions in order to stimulate the exchanges.

“Stakeholders” topic

STAKEHOLDERS	
Questions	**Examples**
A. **What could be the different uses of the maturity score?**	- To make sure that the robot I want to buy is reliable/can be trusted. - To allow benchmarking several robots on the market that do the same task. - To ensure that the robot I sell is respectful of society.
B. **Who, in the community at large, would feel the need of knowing the level of maturity of a robot?**	- The individual who wants to buy a robot to use it at home - The employer who wants to deploy a robot in his/her manufactory - The insurance company, who needs to know to what extent this robot is adapted in your working place.
C. **Do you think that the producers of the score have enough tools to do that?**	- Enough knowledge to do that on their own - Reference methods, guidelines for estimating themselves if the robot is mature - Infrastructure at their disposal for testing

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D. **What types of robots really need to be tagged with a maturity score?**	Categories of robots presented by IEEE (https://robots.ieee.org/learn/types-of-robots/)

Table 2. Stakeholders topic - Questions and examples (moderator handbook).

"Objectivation" topic

For each category of issues (socio-economic, ethics, etc.), the participants discussed the 3 top issues obtained from the results of the survey (Deliverable 1.2 "Needs Analysis of the Robotics Community").

OBJECTIVATION	
Questions	**Examples**
A. **Socio-economics. What can we do to check if the robot won't cause these issues?** • Fear of technological unemployment • Rising skill gaps and skill depreciation • Loss of work autonomy	- What can be done to verify whether the robot is going to lead to loss of jobs? For example, check whether the robot performs all the tasks normally performed by the worker. - In your opinion, what may impact the autonomy of the individual who works with the robot? For example, the lack of collaborative features in the robot.
B. **Ethics. What can we do to check if the robot won't cause these issues?** • Issue of safety and security at workplace • Lack of responsibility and accountability • Lack of transparency	- Safety: the manufacturer must identify all the automatic processes, and estimate the associated risks. - Liability: the manufacturer should provide a user manual where all the good procedures for use are described, and the notion of "bad use" should be formalized for this robot, in the target operative domain.
C. **Data. What can we do to check if the robot won't cause these issues?** • Surveillance on the use of data • Vulnerability of cyber physical systems • Lack of contestability	- Make sure the user is aware of the data that is being collected (whatever the way). - Give proof that the robot is well protected against cyberattacks. - A thorough description of the data lifecycle has been performed.
D. **Legal. Among the issues identified in Robotics4EU, which ones are really adapted for the assessment?** • Unclear and unharmonized regulations • Lack and lag in regulatory development • Intellectual property infringement • GDPR seen as not sufficient • Lack of awareness of the rights related to data and technology • Lack of global governance • Lack of compliance to GDPR	It seems that several of these items are not linked to the robot itself but to the current state of the ecosystem.

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E. **Education and society engagement. What can we do to check if the robot won't cause these issues?** • Education issues (lack of education resources, etc.) • Inequality in development (education sector) • Lack of methods for engagement and empowerment	- Is there a way one can certify that the potential users are well trained? - Can the designer of the robot have an impact on the education sector (among the future engineers, the future operators of the robot, etc.)?
F. **Rank the categories of issues: which ones are the easiest to verify?**	If we need to assess the maturity of the robot, which issues are most suitable for inspection.

Table 3. Objectivation topic - Questions and examples (moderator handbook).

"Maturity score" topic

MATURITY SCORE	
Questions	**Examples**
A. **Should there be one single score of maturity or several scores for certain types of maturity?**	- Perhaps it is enough to have one overall score, so long as it is self-explanatory. How can we make the scores easy to understand by the community?
B. **What would be the impacts of a low score of maturity?**	- Impacts for the end users, for the manufacturer, for external observatories, etc. - Economic impact for the manufacturer: the robot cannot be sold. - No real impact so long as the robot complies with regulation.
C. **Are there domains where the maturity score is more relevant?**	- Is that linked to the proximity to a user? - Is it linked to the type of task performed by the robot, such as dangerous tasks or the use of dangerous tools?
D. **What granularity is required for the score?** • Pass/Fail • A/B/C • 0 (failure) to 10 (excellent) • Other	- If the objective is to help the final consumer, maybe we need a slightly finer score than "yes/no"? Or perhaps it is enough, so as to avoid drowning the consumer in information. - What would be the "pass" threshold if the score is ranked between 0 and 10? Does that mean that 5 is average?
E. **Is this acceptable to rate the robot according to its maturity score?**	- A displayed level of maturity may have an impact on the marketing of the robot. - If it is a legal requirement, yes, no problem. - No, it may damage the company's image.

Table 4. Maturity score topic - Questions and examples (moderator handbook).

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Aiming for maximal compatibility with all platforms and firewalls, we decided to use the **Zoom conference call** client. This client also allowed the creation of breakout rooms and automatic participant assignment for a uniform number of participants in each breakout room.

In addition to slides for presenting the questions during the debates, we created **Sli.do interactive polls** (https://www.sli.do/), which participants could join from their computer or smartphone without registration. Although these polls allowed some quantified answers, they were above all meant to stimulate the exchanges and provide a basis for discussion.

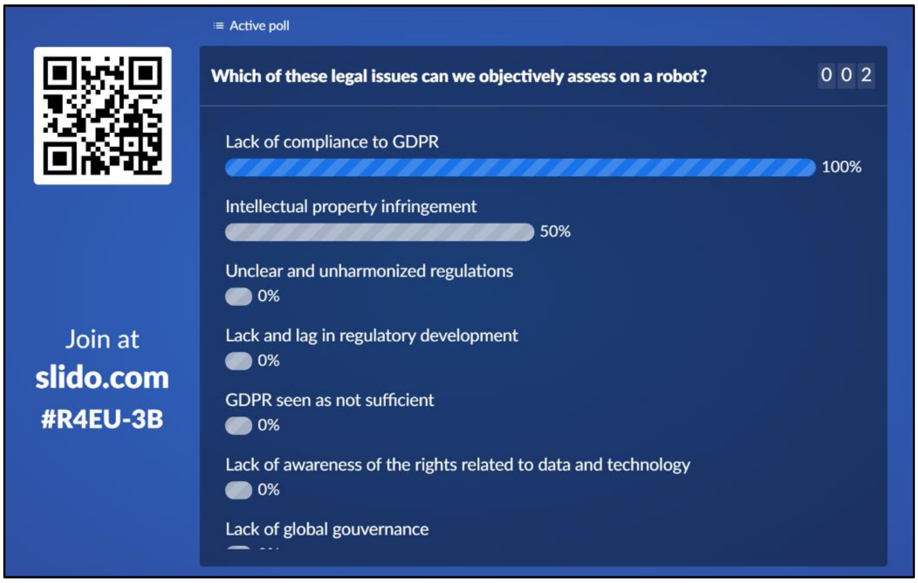

Figure 5. Sli.do poll (breakout room "Objectivation").

Through the consultations carried out so far in the project (surveys and interviews), we have been able to build up a base of contacts who accepted to be kept informed of Robotics4EU upcoming activities. All these contacts were personally invited to register to the debate, in addition to open online communication on the project social networks.

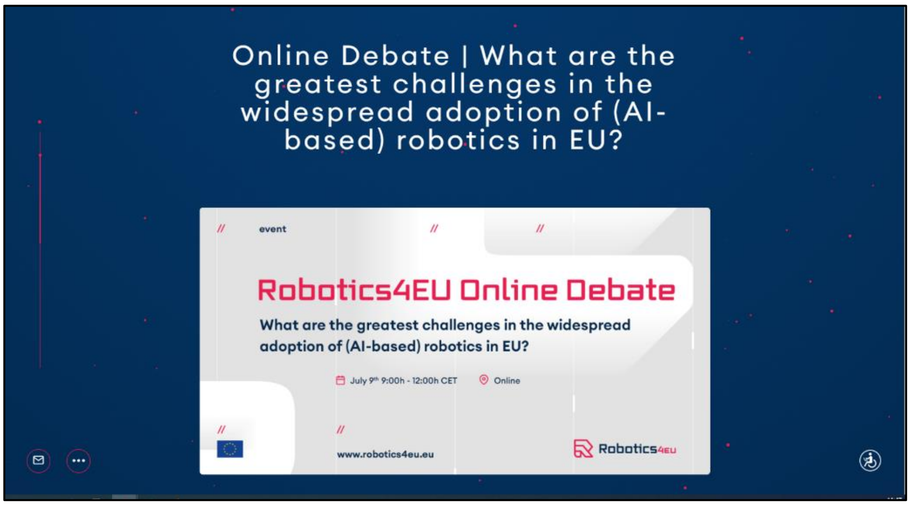

Figure 6. Announcement for the debates (Robotics4EU website).

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Figure 7. LinkedIn call for registration.[8]

The methodology used for the debates is the following: firstly, we carefully considered the results of the Slido polls to decide on the form the scoring should take.

Secondly, during discussion we took note of the topics that raised the most comments or the most heated discussions. We believe that these controversial topics should be the most important to adress in the Maturity Assessment Model, and we use them to inform the relative weight of different requirements in the final maturity score. In this way, the rich but informal discussions are taken into account.

3.2.3 Debates - results

The debates took place online on July, 9th 2021.

The event welcomed thirty participants originating mostly from Europe, for a duration of two hours and a half.

Upon registration, the participants were asked to fill in only two types of information: their country of origin and their profile (industry, academia/research, civil society, public authorities). The distribution is presented in Figure 8 and Figure 9 below.

[8] https://www.linkedin.com/posts/robotics4eu_when-it-comes-to-robotics-solutions-how-activity-6815292802113515520-bRKv

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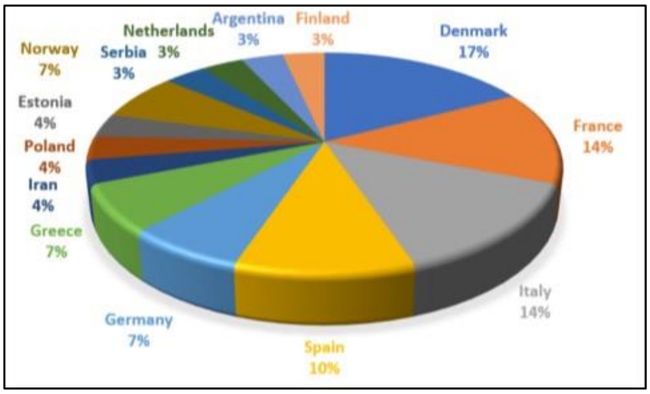

Figure 8. Regional distribution of the participants.

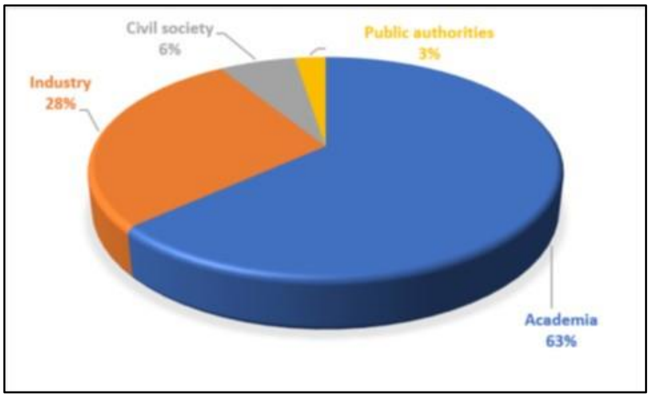

Figure 9. Profile distribution of the participants.

This section presents a synthesis of the answers provided by the participants during the debates.

Stakeholders

<u>What could be the different uses of the maturity score?</u>

Participants suggested that the maturity score could be used similarly to a TRL level (Technology Readiness Level).

The score would prove quite useful from innovation and commercial points of view, but it should not constitute a barrier that increases the time to market.

<u>Who, in the community at large, would feel the need of knowing the level of maturity of a robot?</u>

The main answers to this question were:

- The end-users, among which the workers who need to collaborate with robots.
  Participants noted however that they did not know what the workers could do with this kind of information, unless they can have a say on whether they agree to collaborate with a specific robot or not.
- Governing agencies, policy regulators and insurance companies.
  Participants noted that the health industry and the sectors related to it are paying great attention to non-technological aspects of robots, especially to ethics related issues.

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The participants raised the question whether the end-users, particularly, would care about a maturity assessment score on non-technological issues of a robot. The customers usually focus on the price and the performance level of a robot and not on whether it addresses ethical or socio-economic challenges. Therefore, the maturity score should be presented in a way that is relevant to end-users.

Who would be required to produce the score of maturity?

The robot developers would need to ensure that their robots meet the social and ethical requirements of the community. The maturity score could be a useful tool in this perspective, but it was unclear to the participants who should produce it.

From developers' point of view, it would be useful to provide robot developers with a standardized form where they could just tick boxes to verify their robot meets the required criteria.

Participants suggested that the maturity assessment could be provided by the academia (e.g. researchers) as a service to the robotics industry. The assessment should be a continuous process, depending on the specific use case each time. It should also be a two-way approach, meaning that the demands and requirements to the robotics industry must not only lead to punishment in case of non-compliance, but academia should also provide the necessary help so the industry can meet the expected criteria.

Some participants also suggested taking inspiration from Google's Advisory Council for the organization of maturity score evaluation, meaning that representatives from all stakeholders would need to take part in the evaluation.

Do you think that the producers of the score have enough tools to do that?

The participants noted that ethics constitute a major difficulty for assessment, since they are strongly based on subjective and cultural factors. Therefore, the developers should take into consideration cultural values and the societal acceptance level of the market in which they are trying to sell their product.

What types of robots really need to be tagged with a maturity score?

Participants agreed that medical robots urgently need to be tagged with a reliable maturity score, as their actions can have very heavy consequences. Overall, the participants found that all robots, except in the entertainment sector, need to be certified for reliability. An independent evaluation body could be necessary for the health sector.

Objectivation

Socio-economics. What can we do to check that the robot offers a positive contribution?

The participants debated around a statistic, mentioned orally by one participant, that 50% of jobs could be automated in the USA. This number can be interpreted in several ways: on one side, many dull, non-fulfilling jobs would get automated, and automation would alleviate the current "race to the bottom" of working conditions. In some cases, hard physical labour and low wages cause a workforce shortage (such as in agriculture), and automation could solve this crisis. On the other hand, some positions are occupied by humans, and replacing their tasks by a machine could cause skill depreciation. One should therefore proceed carefully to decide whether any given job should or should not be automated. In some cases, a human-robot interaction system could preserve human skills and sense of fulfilment while improving productivity.

Participants suggested that for any given automation opportunity, we need to ask the following questions:

- How many people are fired ?
- How many people are recruited ?
- What education do they have ?
- How many indirect, induced, secondary jobs does automation create?
- Is there a gain in terms of labour costs ?

Such questions may help quantify the socio-economic impact of a robot.

Ethics. What can we do to check that the robot offers a positive contribution?

The participants agreed on the importance of explainability: the robot or AI system must be able to justify its actions. It must not be a black box system. It is not necessary to provide transparency with access to code, but it is necessary to provide transparent explanations as to how the system works. The participants also pointed out that safety during operation cannot be measured prior to installation, as the environment has an effect on safety.

The question of defining the term “workspace” was raised, as some robots are designed to operate inside people’s homes. For agricultural robots, it is simple to impose a boundary around the field that the robot is not allowed to cross. However, in cases where robots interact with each other or with humans, sometimes it is necessary to turn off some safety features (such as collision avoidance). These cases need to be taken into account and regulated.

The cybersecurity concerns are very important in robotics, especially in start-ups where proper quality/security processes are not always implemented.

Data. What can we do to check that the robot offers a positive contribution?

Participants agreed that cybersecurity and privacy by design are extremely important. It is necessary to limit the vulnerability of the systems to attacks and changes in the environment.

Every piece of data that is collected must be justifiable: the robot should only collect the data that is necessary for its working. The data collection should be transparent to the end user. The robot should only collect the data that it declares collecting, and nothing more.

Several questions arose among the participants: how to organize the surveillance on the use of data, to make sure that the robot manages its data well? How can robots efficiently let you know what data will be processed?

Some participants suggested information that developers could provide for transparency over the use of data:

- How many times do we have to train the AI model?
- Do we have to tell people how we train our data?
- Do we have to tell people the origin of training data?

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Legal. Among the issues identified in Robotics4EU, which ones are really adapted for the assessment?

On the whole, participants noted that issues relative to compliance with regulation are the most adapted for assessment.

The participants suggested that assessments should be performed by multidisciplinary groups with experts from different fields, as all the issues are connected.

Regulatory entities cannot keep up with the pace of the technology industry. And indeed, sometimes, suppliers take advantage of the gap to make profit by developing technologies that are on the edge of what is legal, safe, ethical, etc. Participants wondered how to speed up the development of regulations. They noted for example that Denmark has developed early regulations for drones, which became harmonized in the EU. However, it can be dangerous to scale up regulations too rapidly from local governance to international organizations, as each country has different perspective, objectives, legal systems and context of use.

These aspects are not really within the power of robot designers, since they are more related to the state of the regulatory ecosystem. However, participants suggested that one can simply make sure that the robot providers have a regulatory referent in the company in charge of checking the compliance to regulation. It is not realistic to require that all companies take part in the development of regulations, but they may be required to prove that they do their best, to the extent of their capacities, to take part in the change of the industry and society toward a better use of robots. This may involve taking part in standardization, European regulatory consultations, etc.

Education and society engagement. What can we do to check that the robot offers a positive contribution?

Participants suggested the organization of public robot evaluations in situational settings, on topics that the general public is concerned about. Both experts and non-experts should participate in these evaluations. Robots would be rated by the subjects on the perceived safety, the trust they inspire in the subjects and their ergonomics.

Another suggestion was to include robot end-users in the design process, to ensure that robots will fulfil an existing need. Designing robots must be a co-creation process: technology should adapt to society, and society adapts to the technology. However, participants warned against the techno-push phenomenon, and the co-creation approach must carefully designed to ensure that the issues and expectations raised by the involved end users are correctly addressed.

Robot designers may be engaged in educational training activities, for example by teaching future users in how to use the robot. The teaching procedure must be adapted to the context of use of the robot (one cannot train customers when the robot is designed to welcome them in a mall), and the designer must show that they monitor the efficiency of this training with appropriate methods.

Rank the categories of issues: which ones are the easiest to verify?

Participants noted that the socio-economic and ethical issues may be the hardest to verify, due to their subjective nature, and the lack of standard assessment grids.

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Maturity score

Should there be one single score of maturity or several scores for certain types of maturity?

Participants pointed out the similarity of the maturity score with a TRL (Technology readiness level).

All participants agreed that it is necessary to have several different scores, since different parameters may be relevant according to the considered domain of application. Participants suggested areas in which these scores should differ:

- Transparency and acceptance should be validated by different scores.
- Individual score and community score, to reflect the “vertical” and “horizontal” aspects of maturity. There already exist many ways to evaluate individual interactions with robots, and we could use surveys to evaluate its impact on the community.
- Autonomy: there should be differences between the levels of autonomy of the robot (autonomous and semi-autonomous systems).
- Separate scores for cognitive and physical aspects (but it is unclear how they can be measured).
- Take into account the differences between domains and cultures: some risks can be acceptable in one context but not in another. For example, the criteria of acceptance are extremely different between entertainment and work robots.
- In the spirit of “ethics by design” trends, the participants noted that the design process should also be evaluated.

What would be the impacts of a low score of maturity?

The participants considered that, as in other industries, the maturity score may be issued by regulatory bodies and be mandatory: the system is allowed on the market only if the score reaches a sufficient threshold. A low maturity score could mean that the robot is unsafe to use, inefficient, not trustable or difficult to use.

Participants have suggested to take inspiration from the platform TrustPilot (https://www.trustpilot.com/) that offers ranking and user comments for companies in various sectors of industry. Crowdsourcing could then be used to rank the robots.

Are there domains where the maturity score is more relevant?

The participants noted that the presence of humans around the robot increases the need to compute a maturity score for the robot, since in such contexts the robot may be likely to cause physical or mental harm. This particularly stands true for the healthcare domain. In this context, the score should be very understandable and simple.

The score may also depend on additional background data. For example, in order to evaluate the quality of a performed task, analysing the technology itself might be more relevant than the analysis of the robot on the whole. In such contexts, the scores would be tied to the technology behind – the AI or the algorithm and not the robot.

The participants suggested that two separate scores be computed: a score for the hardware aspects of the robot and one for the software. Indeed, they considered that

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software can be easily updated, and the strategy for assessment would then need to be different that for the hardware.

<u>What granularity is required for the score?</u>

Participants were asked to choose between the following granularities:

- Pass/Fail
- A/B/C
- 0 (failure) to 10 (excellent)
- Other

In one breakout room, the 0-10 scale was most popular, followed by A/B/C and Pass/Fail. This preference was explained as follows: 0-10 is good because it is easy to interpret, naturally relatable to numbers, a threshold can be devised. It is more detailed and can be used for comparisons between systems. For safety critical applications, a pass/fail scoring can be used, as 0-10 scoring system could be arbitrary and depend on the evaluator. In conclusion, the scale should be changed depending upon the applications.

In the other breakout room, participants did not approve of any proposed score and chose “Other”. They estimated that a 0-10 scale is adapted for quantitative assessment, but it is important to have other perspectives, and take into account qualitative assessment (for example, to evaluate the quality of the interaction). The score needs to have more dimensions than just a number, and the form it takes should depend on the potential consequences of robots actions.

<u>Is this acceptable to rate the robot according to its maturity score?</u>

The participants opinion was divided between « Yes » and « Yes and no ».

Participants agreed that feedback is useful to improve the product, but a low maturity score could have a durable negative effect on the company. One proposition was to limit the access to the score to end-users only, for robots that are not public: for example, the company that acquires a robot may expect the supplier to provide them with the score. It would also be a good idea to provide a guideline to developers with advice on achieving a high maturity score.

Another concern was that mixing expert-provided maturity score with non-expert user evaluations could skew the trustworthiness of the maturity level. Participants agreed, however, that it is necessary to include end-users in the scoring process. That way, they can reflect a practical understanding of the robot capabilities. Participants noted that this may be more difficult when end-users are children (such as children patients in hospitals). In such cases, one should not directly ask the children “what do you think about the robot ?” but rather watch for their reactions to detect whether the children feel scared.

3.3 Robotics4EU workshops on knowledge transfer and capacity building

Robotics4EU project organizes knowledge transfer and capacity building workshops in all four domains (healthcare, agrifood, agile production and inspection & maintenance of infrastructures). These workshops follow a common methodology for engaging stakeholders of each domain in sharing good practice, and to advise and broaden the

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awareness about non-technological aspects of robotics. The detail and results of the workshops are presented in deliverables D3.2, D3.3, D3.4 and D3.5.

In each workshop, a short sequence was dedicated to presenting the early lines of the MaM (the objectives, the main themes and general approach). The three topics of the debate were addressed (stakeholders, objectivation, maturity score). The workshops favouring interaction and exchange time, the amount of information received and the animation of the exchange on the MaM differ from one workshop to another.

The overall idea was to gather potential additional reactions about the three topics of the debate, and potentially distinguish aspects that could be specific to a given domain. One should note that in this very context, comments relative to the type of issues that are more relevant in a domain or another were not the objective of the discussion – these elements have been recorded in the respective deliverables. The discussions were meant to highlight a domain in which the stakeholders, or the objectivation feasibility, or the nature of the score itself would be different. The discussions provided inputs that were not contradictory with the observations made during the debate, and no domain-specific aspects have emerged in the discussions. The additional inputs received during the workshops are merged into the following synthesis of observations.

3.4 Synthesis of the observations

3.4.1 The stakeholders around the maturity score

We note that the users of the score – meaning, the persons who may need to know the score – could be **the end users of the robot and the entities tasked with monitoring and supervision** (governing agencies, regulators, insurance companies, etc.).

If the recipient is the end user, the knowledge of the score must be accompanied with a capacity to react (choose another robot, reconfiguration, etc.). **The score must lead to better empowerment** in the user of the robot, which may require a revision of the organizational ecosystem.

The producer of the score – meaning, the persons who compute the score – may be **the designer of the robot**. However, they must have the right tools to do that, through checklists, guidelines, and optionally the help from experts (e.g. academic research). The procedure of evaluation would require, on the designer's side, that they have different skills to ensure the compliance of the robot (legal, technical, etc.).

3.4.2 How to perform the verification

The scoring may focus on the robot itself, the processes (design, development, operation, maintenance) and the company of the designer (management system, quality management).

The verification for socio-economic and ethical issues may be the hardest to tackle, due to the subjective and inter-individual nature of their components. However, the debates showed that **several estimators may be designed to assess the socio-economic and ethical maturity of the robots**. A definition of the perimeter of application of the robot would drive a risk analysis that includes the environment (operational and organizational environment) and the stakeholders (users, presence of people passing by, etc.).

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The maturity score is not intended to lead to an inspection of the compliance of the robot with law, since regulatory requirements are managed by other dedicated frameworks (certification, CE-marking, regulation, etc.). Since the issues for acceptability of robots in society rather lies in the gap between technology and regulation, the score could rather highlight to what extent **the designer contributes to the development of an adapted regulatory framework**. All requirements must naturally be adapted to the size and capacities of the company: a large group would be able to appoint full-time an individual for standardization, but it cannot reasonably be expected from all start-ups.

The compliance with education and society engagement requirements could be checked through the **involvement of the designer with public communication activities**, and the efforts they put in **knowledge transfer** (appropriate documentation, training courses, conferences, public demonstration, co-creation processes, etc.). The designer may need to prove the impact of this knowledge transfer (did people indeed learn about the robot, or how to use it?).

3.4.3 What type of scores

On the whole, **the score must be able to communicate about several properties of the robot**, such as its transparency, its respect of ethical values, etc. The score must be adapted to several factors, including the domain of application, cultural aspects, level of autonomy, etc. **The score must be understandable, self-explanatory and relevant** to the recipient.

The score can be based on the compliance with a checklist provided to the designer of the robot. The elements of the checklist can be filled in in a declarative manner, where the designer explains what actions were engaged to match the criterion. The scoring can also be based on evaluations, like public competitions or crowdsourcing assessment. However, non-expert evaluations must be appropriately carried out to ensure the validity of the results (absence of biases, management of human error, etc.). **Third party auditing may be engaged**, for example in a process of labelling: an independent organism would rate the robot and provide a quality label that may enhance marketing.

We noted previously in the project, through the Deliverable 1.2 “Needs Analysis of the Robotics Community”, that efficiency and safety of the robots are compelling issues for the public. Participants noted that robots in critical domains (for example healthcare) must be the first focus for the maturity score, since failures could lead to heavy consequences. Robots from the entertainment sector may be less concerned. However, **the production of a maturity score for critical systems must be handled with care**, due to the strict specific requirements in these areas and the existence of notified actors for their certification. Indeed, the certification result must always prevail, and we must not generate potential confusion with the attribution of a maturity score.

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4 First lines of the Model

4.1 Introduction and design strategy

As a reminder, the design of the Maturity Assessment Model is an ongoing work in Robotics4EU project (from Month 1 to Month 36), and the model may be complemented with knowledge emanating from other initiatives in the duration of the project.

This section provides a first draft of the Maturity Assessment Model, which draws its inspiration from the various sources indicated above, the expertise of the project partners, and the elements communicated by the consulted (in the debates, and in the surveys and interviews presented in deliverable D1.2).

The Maturity Assessment Model will be analyzed and submitted to validation in the context of the task T3.6 High-level stakeholder forum. A selection of items will be presented to the public for debate and discussion; these items will be mainly selected depending on the estimated difficulty for addressing the checkpoint in question, or in order to decide on the relevance of the checkpoint.

Subsequent work meetings will take place, between the partners of the project first, then with invited experts, in order to carefully analyse each checkpoint in terms of feasibility and relevance.

4.2 Maturity Assessment Model (v0)

4.2.1 Ethics

	General objective of the observation	Requirement	Examples of design choices that the robot designer can make to fulfill this requirement
1	The user can reasonably understand the functioning of the robot	The robot designer has implemented strategies to allow the robot to communicate with the user about the reason why it made its decisions.	- The AI software includes explainable modules (by design or post-hoc) and the result is accessible to the user. - The user can access a human-understandable log of all the actions performed by the robot, along with a description of the events that triggered the actions. - The robot explains his actions in any other user-friendly and ergonomic way.

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2	If the robot is expected to move (navigation or moving parts) in the vicinity of humans, safety risks are controlled.	A comprehensive risk analysis has been conducted taking into account the reasonably foreseeable habits of the individuals in the operating domain.	- The AI software includes explainable modules (by design or post-hoc) and the result is accessible to the user. - The user can access a human-understandable log of all the actions performed by the robot, along with a description of the events that triggered the actions. - The robot explains its actions in any other user-friendly and ergonomic way.
3	If the robot is expected to move (navigation or moving parts) in the vicinity of humans, it communicates its intentions to them.	The robot designer has implemented strategies to warn the user and the humans in the vicinity of the robot, about the proper attitude to adopt for a totally safe interaction with the robot. These strategies take into account possible limitations of the user and other humans (such as disabilities).	- Depending on the user and the context, it can be through user manual, audio and visual warnings when certain conditions happen, signage, etc.
4	All the stakeholders involved in the design are identified.	All the people who intervene in the design process are listed and their tasks are specified so that any part or software of the robot can be traced back to its developers.	- The design process is fully documented, indicating clearly the scope and responsibility of each member of the staff and the sub-contractors. - Changes made during the design of the robot are tracked (nature, person in charge), along with test results.
5	Gender and minority equality are maximized.	Attention is given to diversity of the persons involved in the design of the robot.	- The company has a Corporate Social Responsibility (CSR) plan - The company's social accounting report is publicly available.
6	Gender and minority equality are maximized.	The software has been controlled for age, gender and minority	Testing datasets using human subjects (face, voice, motion

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		bias using appropriate testing datasets.	recognition...) are representative of the diversity of the population.
7	The robot designer contributes to enhancing research integrity.	A declaration of interests has been published.	For example: the declaration of interests publicly states the sources of funding.

4.2.2 Socio-economics

	General objective of the observation	Requirement	Examples of design choices that the robot designer can make to fulfill this requirement
1	Technological unemployment fears addressed	During the development process, an assessment of the impact the robot will have on jobs has been performed. Jobs destroyed as well as created (construction, maintenance of the robot) are taken into account and the final report is public.	Robots designed to work alongside humans - not creating an exclusive automated workspace. The robots should be easy to use - re-training a manual worker should be financially viable (1 month training at most?). So workers will have the ability to stay instead of re-hiring.
2	Technological unemployment fears addressed	The robot producer should be exemplary in the automation of their development process.	If any part of the robot production is automated, the workers are offered internal training to work in collaboration with the robot or to find a more qualified job.
3	Skill gaps compensated	If the producer has identified a risk for job destruction, he/she has produced a report addressed to the client to warn and detail about the extent to which jobs may be impacted.	List the existing training programs to help restructure work around the automated solutions. -Our company provides training to employees to keep them working in collaboration with the robot
4	Worker autonomy	The designer has implemented a strategy that allows the final user to have control over the speed and frequency of the activities of the robot.	- Possibility to stop or slow the workflow in case of a need or a difficulty - Possibility to slow down the pace of the robot if anyone finds its speed disturbing

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5	Regional and geographic disparity	When designing the manufacturing process of the robot, regions with a large vacant workforce are privileged in order to provide employment opportunity to disadvantaged areas. Cost of transportation is taken into account.	Manufacturing is in the same country as design, integration and testing.
6	Ecological impact	The software is designed with economy of resources in mind.	Attempt to limit necessary hardware specifications and computation should be as energy-efficient as possible.
7	Ecological impact	Hardware design uses ecologically responsible materials and components whenever possible.	The sourcing of components is inspected and possible recycling options are laid out.
8	Ecological impact	Hardware is designed to be mantainable.	Use of standard parts whenever possible Modular conception System can be disassembled several times (use of screws instead of glue, parts designed to withstand disassembly)
9	Ecological impact	Maintenance and end-of-life of the robot is ensured by the manufacturer	Reparations are performed when possible, used robots are refurbished and sold as second-hand. Non-reusable waste and components are collected and valorized/recycled.

4.2.3 Data

	General objective of the observation	**Requirement**	**Examples of design choices that the robot designer can make to fulfill this requirement**
1	Transparent data collection and processing	The designer has implemented a strategy to let user know what type of data is collected about him/her and his/her environment, both online and offline.	- Existence of documentation stating the user data collected and accessible by the user (e.g. in the user manual) - Existence of a terminal allowing the display of such information on the robot

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2	Transparent data collection and processing	For the data mentioned in the previous requirement, the designer has implemented a strategy to let the user know how and why it is processed by the robot.	- Existence of documentation explaining the process of data and accessible by the user (e.g. in the user manual) - Existence of a terminal allowing the display of such information on the robot - How/Where data is stored and for how long is it stored?
3	Transparent design process	The design processes related to data collection and data processing are well-documented.	Existence of a documentation on the design processes for on data collection and data processing, detailing the activities, resources, roles and responsibilities among the team. This document does not need to be made public.
4	Cyber security	The designer has conducted a risk assessment for data leaks on personal data, and implemented adapted mitigation strategies.	This document does not need to be made public.
5	User empowerment	The designer has implemented a strategy to let the users have the continuous possibility to access, modify or delete the data collected from them.	- Existence of such a functionality on the robot
6	Surveillance issue	The data susceptible to be shared with third parties is specified.	- Existence of documentation explaining the third-parties involved or stating about the absence (e.g. in the user manual) - Existence of a terminal allowing the display of such information on the robot

4.2.4 Legal

	General objective of the observation	Requirement	Examples of design choices that the robot designer can make to fulfill this requirement

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1	Risk assessment	A comprehensive and formalized risk analysis has been conducted, both on the software and hardware parts of the project. This requirement applies whatever the stage of development of the robot.	The risk assessment includes identification of risks, analysis of their criticality, and explanation of mitigation strategies implemented
2	Comprehensive implementation of regulation requirements	The robot designer is aware of regulations that apply to his/her robot (robot specific and sector specific).	All applying regulations have been listed and the requirements were taken into account during the design process
3	(draft) AI Act	The (draft) AI act has been taken into consideration in the development of the robot.	The impact of the future AI Act is studied in the design process.
4	Intellectual property	During the development process, intellectual property respect is ensured at all times	The licence terms are respected for software, and every technology is tested against existing patents.
5	Intellectual property	A patenting process is in place, financed and applied when relevant.	Employees are aware of the existence and application process for patenting, and are encouraged to do so, for example monetarily.
6	Contribution to regulation	At his/her level, the robot designer is involved in actions dedicated to enhancing standards and regulation.	- Be a member of a standardization committee in the domain (AI, robotics, IoT, etc.) - Be an active member of a group or association that ensures linkage with public authorities (competitiveness cluster, DIH, etc.)

4.2.5 Education and engagement of society

	General objective of the observation	**Requirement**	**Examples of design choices that the robot designer can make to fulfill this requirement**
1	Contribution to education	The robot designer has engaged partnerships with local schools or universities.	The company participates in demonstrations or practical courses in robot use, programming or design.

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2	Contribution to education	The robot designer engages in open communication on the way the robot and the AI systems work.	Educational videos or contibution to general public-oriented events such as science faires
3	Accessibility	Open-source software is used extensively and if modifications are made, they are published as open-source as well.	The corresponding licence terms are strictly respected
4	Research-to-industry	Collaboration with a research laboratory in the early stages of development	The new technology implemented in the robot has been described in scientific publications or conferences
5	Empowerment of general public	The robot designer has engaged consultations on design choices with the general public.	A survey was organised among the general population concerning the interfaces or functionalities of the robot
6	Empowerment of general public	Public feedback is properly addressed.	Transparent design choices

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5 Conclusions

The initial work we have carried out in Robotics4EU has laid the foundations for the scope of the Model.

The objective of the maturity score is to **spot the robots that are not mature enough for society**, even if they are already on the market. In this regard, the Model would help increase the acceptability of the robots. However, **the score and the scoring procedure must be wisely designed so as to limit negative impacts on companies**.

The maturity score must **rather be a reward than a punishment**. It should not only be coercive, but a joint and adaptive approach to make sure that the robot meets the expected criteria. The score can come as a quality mark for robots or companies.

The Model must include **tools for reaching a high level of maturity (for the developer) and tools for verifying the level of maturity (for potential external inspection)**. These can be the same tools. For example, such a question may help the validation and implicitly tells the manufacturer what is relevant to consider in the design:

- *Is the company engaged in public dissemination about the robot skills?*
    - *For potential customers (e.g. advertisement)*
    - *For the general public (e.g. press communication)*
    - *Scientific conferences (e.g. talks, papers)*
    - *Other activities*

The work led to the design of an initial version of the Model, that is presented in this deliverable.The Model will be designed throughout the Robotics4EU project, with a final version delivered at the end of the project. In addition to research work, the Model will be refined through several consultations with the stakeholders (industry, citizens, research, policy makers, etc.).

The refinment and validation of the MaM will be performed with smaller groups or one-one-one interviews, in order to browse through all checkpoints and validate them with the interested parties. These activities are organised in the context of the task 3.6 of the project.

In the context of the co-creation workshops (WP4) to test robotics solutions in application areas, the MaM will be tested upon concrete industrial usecases. To this effect, a strategy will be designed in order to achieve an additional validation of the model.

In summary, the design of the MaM through the rest of the project will focus on:

- Validating the checkpoints, in terms of feasibility and relevance, internally (inside the consortium) and externally (with invited experts).
- Defining a procedure for verification (audit points, links to existing external technical material and procedures, entities in charge of the verification, etc.).

Verification of the economic realism of the method with respect to industry (incentives for scoring the robot, opportunities and limitations relative to the industrial domain and the company type, etc.).

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