TECHNICAL DESCRIPTION

AI for Manufacturing Challenge

"*Revisiting industrial design with AI*"

1) Organisation of the Challenge

As part of its AI2021 plan, the Paris Region is launching a Challenge to revisit industrial design with AI.

The Paris Region aims to contribute to the emergence of innovative solutions for factories, warehouses and the entire production ecosystem, and to support the development of international champions in the field of AI applied to Industry 4.0.

The Challenge is organised by the Paris Region, in partnership with EIT Manufacturing and the manufacturers Fives and Michelin.

2) Context of engineering activities for manufacturing

- *Sequencing of design activities in manufacturing:*

In the manufacturing industry, the design of products or industrial projects follows a structured sequence of phases: opportunity or preliminary design studies, functional and economic analyses, detailed design, prototyping, industrialisation and execution. At each stage, engineers must balance technical performance, cost and deadlines while complying with regulatory and contractual obligations.

This complexity is accentuated by the diversity of environments (V-cycle in heavy industry, agile methods in software), the need to manage configuration, "make or buy" decisions and the integration of field feedback.

In detail:

- Pre-project phases, in the case of projects:

- Calls for tenders, research and comparative analyses of preliminary technical and economic solutions (feasibility studies, preliminary designs, preliminary simulations, preliminary estimates, risk analyses, make-or-buy analyses, etc.), drafting of the contract offer

- Pre-project phases, in the case of products:

- Opportunity studies, market analyses of use cases with the aim of framing the project and its objectives (KPIs)
- Functional and value analysis, drafting of functional specifications.
- Research and comparative analysis of preliminary technical and economic solutions (feasibility studies, preliminary designs, preliminary simulations, preliminary estimates, risk analyses, make-or-buy analyses, etc.)

- Detailed design phase for a unique solution (mechanical, electrical, automation, software, etc.): complete definition file, parts lists, manufacturing plans, electrical diagrams, software code

- Execution phases, in the case of projects:

- Purchasing, pre-assembly then pre-validation in the factory, transport, on-site installation, commissioning, training and final validation.

- Execution phases, in the case of products:

- Prototyping and validation in order to test actual operation and validate the design; then industrialisation (methods, manufacturing means) and production startup with the aim of mass production.

- Closure and follow-up phases:

- In the most common scenario: after-sales service, maintenance, technical support, sometimes also: remote monitoring or even remote control, preventive maintenance
- In all cases, feedback, modification handling.

The whole is managed by a project or product management responding respectively either to a project owner and a contract, or to a steering committee (company management).

- In activities where modification costs are high (heavy industry, etc.): the V-model is preferred.
- Conversely, typically in software activities, agile methods (such as SCRUM) are preferred.
- Each stage is subject to a checkpoint deciding whether to move on to the next stage, iterate, return to the previous stage, or stop the activity completely.

- *Challenges and specific features of these design activities*

  - Complying with regulatory requirements (machine standards, European standards, etc.)
  - Controlling the contract, controlling the configuration
  - Meeting functional requirements (e.g., increasing the availability rate of the machine or process)
  - Mastering and respecting intellectual property
  - Reducing the cost price, often requiring a reduction in operating costs
  - Reducing the time required to make the product available to the customer, in particular on-site installation times
  - Standardising components and maintaining the standard
  - Choose “Make or Buy.”
  - Monitor the fleet sold and understand the actual operating conditions.

It should be noted that the context of the activity has a significant influence on the design activity itself:

- In the preliminary design phase, it is often decided to adapt existing designs in order to reduce design time (“copy and paste”).
- The larger the project, the more challenging it is to coordinate interfaces.
- For activities with high technological stakes: the presence of patents within the company or among competitors can be a determining factor.

- For activities with high regulatory stakes (nuclear, etc.): documentation becomes an even greater challenge (deliverables, design process, validation & verification activities).

In addition, design work is always carried out using both highly specialised tools (calculation, drawing, simulation and ERP software) and more basic files for handling specific and temporary needs (typically spreadsheets and presentations). Finally, it requires constant dialogue, which itself requires tools (meeting minutes, emails, multiple shared spaces, multiple discussion channels, etc.). Digital continuity, i.e., the uniqueness of data, its sharing and its control over time, is therefore a major challenge.

In this context, artificial intelligence opens up new possibilities for assisting or automating certain design decisions, improving the exploration of variants, making technical and economic estimates more reliable, anticipating risks and accelerating the generation and maintenance of consistent and up-to-date technical documentation. It is becoming a key lever for optimising design in an industrial context that is increasingly constrained in terms of deadlines, competitiveness and sustainability by reducing low value-added tasks or promoting their verification.

3) Objective and structure of the challenge

The objective is to improve engineering efficiency by automating recurring tasks, while keeping the designer involved in order to take his or her opinion on the proposed solutions into account, consider it in the future, and obtain his or her validation before implementation.

To guide the candidates, the manufacturers propose a list of use cases:

• UC1: Assistance to designers in the production of technical documents and manuals
• UC2: Assistance in the design of recurring elements
• UC3: Detection and assistance in the processing of non-conformities
• UC4: Translation of specifications into design constraints
• UC5: Design proposals based on historical designs

This list is provided as a guideline; any other solution relevant to manufacturing engineering may be considered.

The solutions proposed by the Candidates will have a TRL between 4 and 7, with the objective of reaching a TRL between 7 and 9 by the end of the project.

Unless otherwise specified in the use case sheet, the selection of candidates will take place in two phases:

- An initial phase in which candidates will not have specific data from manufacturers and will be able to present their solutions based on previous work carried out in fields and use cases of their choice.

- At the end of this phase, 10 candidates will be selected and will be able to compete under a confidentiality agreement for the second phase, in which manufacturers will provide data that candidates can use to demonstrate the relevance of their solution.

Candidates may express their needs for other data necessary to carry out the projects. It should be noted that artificial intelligence models cannot be trained on data from manufacturers due to the excessive amount of data that this would require. The transmitted data will only be provided at the inference stage.

The deliverables expected at each stage are as follows:

Stage 1 (pre-selection):

- Pre-selection form
- Pitch presentation of the current solution (maximum 10 pages, free format)

Stage 2 (selection):
- Selection form
- Deliverables generated by the solution based on the technical data provided
- Pitch presentation of the solution applied to the chosen use case (maximum 10 pages, free format)
- Description of the work and budget estimates to achieve the target TRL (project sheet)
- Hearing

4) Presentation of proposed use cases (use case sheets)

UC1: Assistance to the designer in the production of technical documents and user manuals

Expected functions of the solution

• Generate technical documents listed in input data from a machine technical file (3D/2D plans, Bill of Material (BOM), etc.)
• In the event of a modification to the technical file, provide the designer with a list of the documents affected and a list of modifications per document.
• The solution must provide the designer with the technical documents generated or the changes to be made
• The solution must take into account the designer's comments when preparing the final version

Data provided for step 2

• 1 technical file for a “MACHINE” subassembly including
  - 1 3D/2D assembly and the associated BOM
  - 1 electrical and/or pneumatic diagram and associated BOM(s)

• 1 template of each type of document to be generated:

  - Project Quality Plan (PQP)
  - Piping & Instrumentation Diagrams (P&IDs)
  - Functional verification sheets
  - User manual

Deliverables to be generated with the solution

• 1 document of each type:

  - Project Quality Plan (PQP)
  - Piping & Instrumentation Diagrams (P&IDs)
  - Functional verification sheets
  - User manual

UC2: Assisting the designer in the design of recurring elements

Expected functions of the solution

• Generate the design of certain recurring elements in accordance with business rules (e.g., piping, covers, bearing assembly, key assembly, etc.)

• Ask the designer for all the information needed to design the solution

• Propose different solutions to the designer, optimised according to different KPIs (cost, space requirements, quantity of material, etc.)

• Be able to answer the designer's questions about the characteristics and performance of the proposed solution

• Implement the solution chosen by the designer in the technical file.

Data provided for step 2

• 1 3D assembly including a shaft and a frame

• Technical and functional specifications for the assembly to be produced (forces, speeds, desired service life, environment, etc.)

• Company-specific business rules for bearing assembly

Deliverables to be generated with the solution

• 1 assembled 3D assembly including shaft + bearing + frame

• 1 calculation note justifying the design approach and specifying the characteristics and performance of the assembly produced (service life, safety coefficients, cost, etc.)

UC3: Automatic detection and assistance for designers in handling non-compliance

Expected functions of the solution

• During the design process, identify functional design non-compliance (dimension chains, drill hole locations, mountability, etc.) or regulatory non-compliance (dimensioning, standardization, etc.)

• Based on non-conformities detected by a verifier, manufacturer, or user and transmitted in the form of text, photos, diagrams, etc.

• Propose different solutions to the designer, optimised according to different KPIs (cost, accessibility, space requirements, etc.)

• Implement the solution chosen by the designer in the technical file.

Data provided for step 2

- 1 technical file for a “MACHINE” subassembly including 1 3D/2D assembly and containing design errors
- 1 non-compliance report (description, photo, etc.)
- Company-specific business rules

Deliverables to be generated with the solution

- 1 technical file for a “MACHINE” subassembly including 1 corrected 3D/2D assembly
- 1 non-compliance processing report

UC4: Translation of technical specifications into design constraints

Expected functions of the solution

• Upon receipt of the call for tenders, identify the structural elements, functionalities and parameters required by the customer

• Integrate customer requirements and specifications into internal models: review of requirements, technical documentation, summary documents of contractual clauses, etc.

Data provided for step 2

- 2 or 3 customer RFPs (customer specifications)
- Internal follow-up file:
  - Requirements review template (type of project sheet listing the main lots, delivery conditions, acceptance, payment, deadlines, etc.)
  - Classification and presentation template for internal technical specifications
  - Contract summary template

Deliverables to be generated with the solution

- 1 internal tracking file completed by RFP

UC5: Design proposals based on historical designs

Expected functions of the solution

• Identify customer specifications from a call for tenders

• Analyse existing assemblies or sub-assemblies (internal repositories of existing systems, external royalty-free repositories, supplier catalogs)

• Propose a preliminary design that meets the customer's specifications, including technical parameters (dimensions, standardisation, etc.)

• Propose variants of the solution to the designer, optimised according to different KPIs (cost, accessibility, space requirements, etc.)

• Implement the solution chosen by the designer in the technical file.

Data provided for step 2

- 1 technical file for a subassembly including several previous 3D/2D designs structured by metadata
- The applicable business rules (technical specifications)
- 1 customer RfP (customer specifications)

Deliverables to be generated with the solution

- 1 technical file for the subassembly including 1 3D/2D assembly meeting the customer's specifications