Faculty of Design

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System thinking & synthesis mapping to manage product material selection process

Papile, Flavia, Del Curto, Barbara and Coccia, Andrea

SYSTEM THINKING & SYNTHESIS MAPPING TO MANAGE PRODUCT MATERIAL SELECTION PROCESS

AN EXPERIMENTAL FRAMEWORK TO PROMOTE THE INTRODUCTION OF INNOVATIVE MATERIALS INTO INDUSTRIAL COMPANIES

F. PAPILE [1], B. DEL CURTO [2], A. COCCIA [3]

[1]Design Department of Politecnico di Milano (ITALY)
[2]Department of Chemistry, Materials and Chemical Engineering "Giulio Natta" of Politecnico di Milano (ITALY)
[3]Innovation Manager at Faber S.p.A.

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FABER AIR MATTERS

THINKING IN SYSTEMS

INTRODUCTION
CONTEXT: TOP-DOWN PERSPECTIVE

Drone over quarry in Barossa Valley, SA, Australia
Picture Retrieved from: https://unsplash.com/photos/oF7hh97lVqA

The **Anthropocene** is the new recognised **geological era** we are living in, profoundly characterised by **human activity consequences on ecosystems**.

Awareness is important, but projections preview an **increasing demand** for goods, energy and resources consumption and an increase of population.

Crutzen, P. J., & Stoermer, E. F. (2000). The International Geosphere–Biosphere Programme (IGBP): A Study of Global Change of the International Council for Science (ICSU). Global Change Newsletter, 41, 17–18.

OECD. (2018). Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences - Highlights.

OECD. (2019). Global Material Resources Outlook to 2060. In Global Material Resources Outlook to 2060.

INTRODUCTION
CONTEXT: TOP-DOWN PERSPECTIVE

Drone over quarry in Barossa Valley, SA, Australia
Picture Retrieved from: https://unsplash.com/photos/oF7hh97lVqA

*"The global growth markets, new technologies opportunities and emerging cultures are rewriting a system where the old paradigms seem didn't work anymore in the contemporary context.[...]**The result is a world where local's actions influence the global scale and vice versa.**"*

-Gaiardo & Tamborrini (2015)

Gaiardo & Tamborrini (2015). SYSTEMIC INNOVATION DESIGN METHODOLOGY: THE COMPARISON OF TWO CASES STUDIES.

INTRODUCTION

CONTEXT: TOP-DOWN PERSPECTIVE

Textures near Tianzifang, Shanghai.
Picture Retrieved from: https://unsplash.com/photos/SsV4Ck4GISU

Materials are at the basis of manufactured artefacts and **material selection** is one of the core tasks in industrial product design and development.

Over time, an increasing number of **characteristics and attributes** have been taken into consideration as influent elements on the product's material decision.

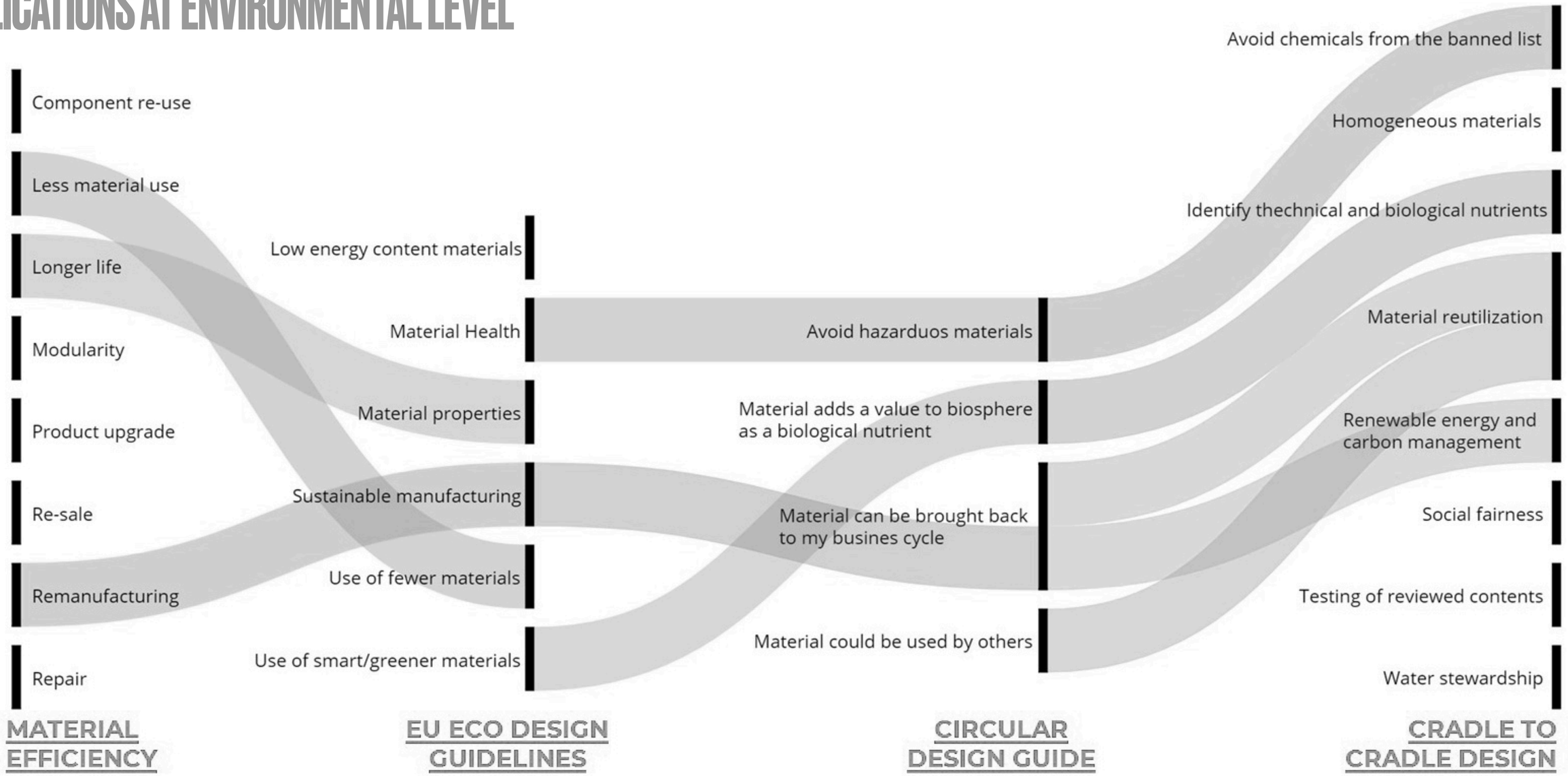
Materials became **expression of human socio-cultural and technical evolution** over time.

du Gay, P., Smart Martin, A., Miller, T., & Spyer, P. (1999). Beyond the Pale: Reviewing the Relationship between Material Culture and Design History. Journal of Design History, 12(4), 373–380.

Ashby, M. F. (2011). Materials selection in Mechanical Design. In Materials Selection in Mechanical Design (pp. 1–13).

MATERIAL SELECTION

IMPLICATIONS AT ENVIRONMENTAL LEVEL



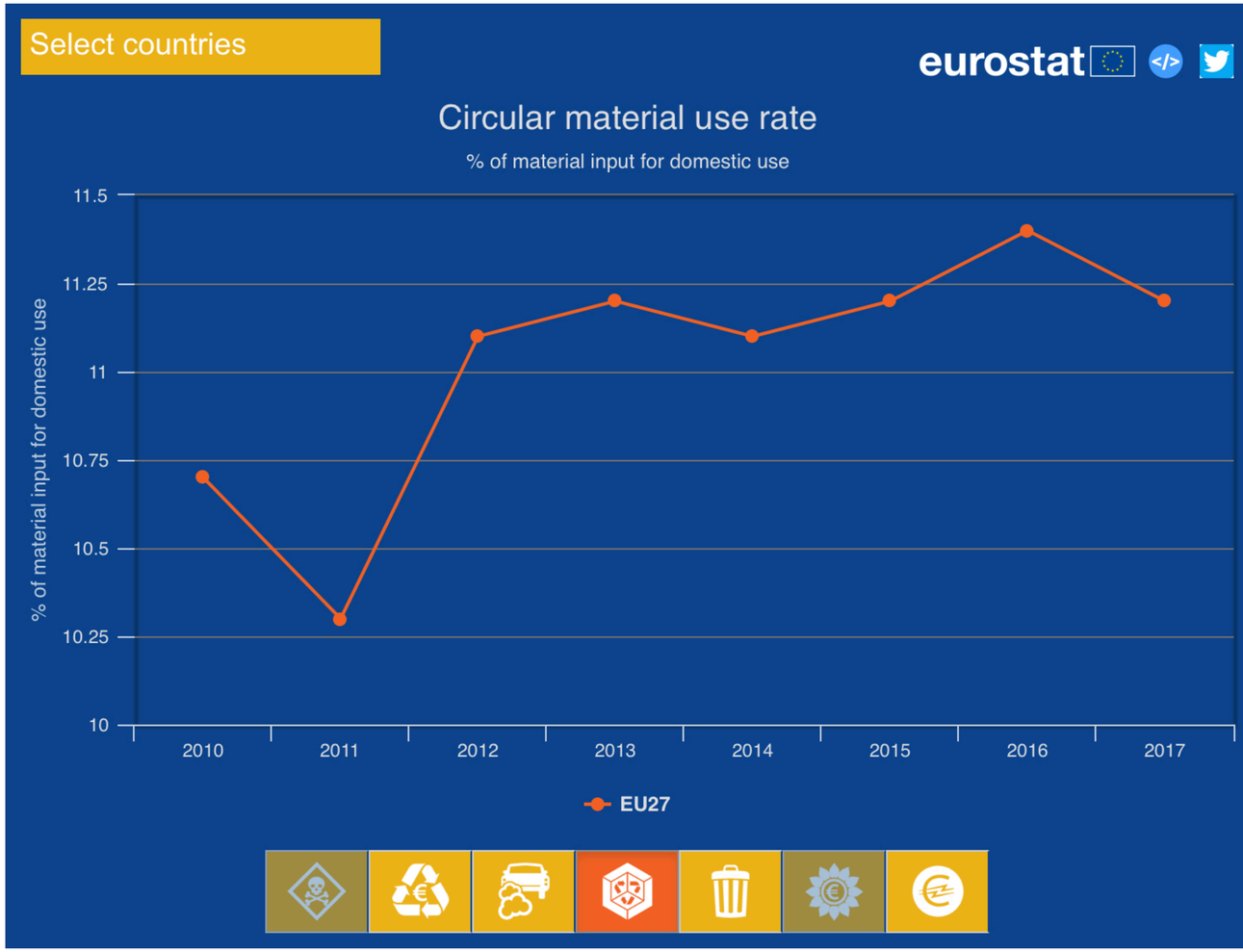
MATERIAL SELECTION
EUROPEAN SCENARIO

Observing European trends and coupling them through observations in industrial domain, material selection is an activity still perceived as central for improving products performance, sustainability and manufacturability. But the resistance in using innovative material is still high.

*average **gestation time** between the research, development and introduction of a **new material into the industrial flow***

=

*estimated to be at least **20 years.***



https://ec.europa.eu/eurostat/web/sdi/responsible-consumption-and-production

Karana, E., Barati, B., Rognoli, V., & Laan, A. Z. Van Der. (2015). Material Driven Design (MDD): A Method to Design for Material Experiences. International Journal of Design, (May).

Karana, E., Pedgley, O., Rognoli, V., & Korsunsky, A. (2016). Emerging material experiences. Materials & Design, 90, 1248–1250. https://doi.org/10.1016/j.matdes.2015.07.042

Markham, S. K. (2002). Moving from lab to market. Engineer, (JUNE), 12

MATERIAL SELECTION
INFORMATION MANAGEMENT

MATERIAL SELECTION

is an information management process composed by three main steps, with the aim to provide a narrow panorama of possible alternatives for a certain product.

Ashby, M. F., Bréchet, Y. J. M., Cebon, D., & Salvo, L. (2004).

decreasing number of alternatives

SCREENING METHODS
narrow down the choices to a manageable number for subsequent detailed evaluation

RANKING METHODS
Ranking methods can be used to further narrow the field to a few optimum candidates

CHOOSING METHODS

SCREENING TOOLS

RANKING TOOLS

CHOOSING TOOLS

INFORMATION NEEDED

QUALITATIVE INFORMATION ACONCERNING MATERIALS, GENERAL PRODUCT INFORMATION

QUANTITATIVE, NUMERICAL INFORMATION CONCERNING MATERIAL PROPERTIES

REGULATIONS AND NORMATIVES REQUIREMENTS

Ashby, M. F., Bréchet, Y. J. M., Cebon, D., & Salvo, L. (2004). Selection strategies for materials and processes. Materials and Design, 25(1), 51–67. https://doi.org/10.1016/S0261-3069(03)00159-6

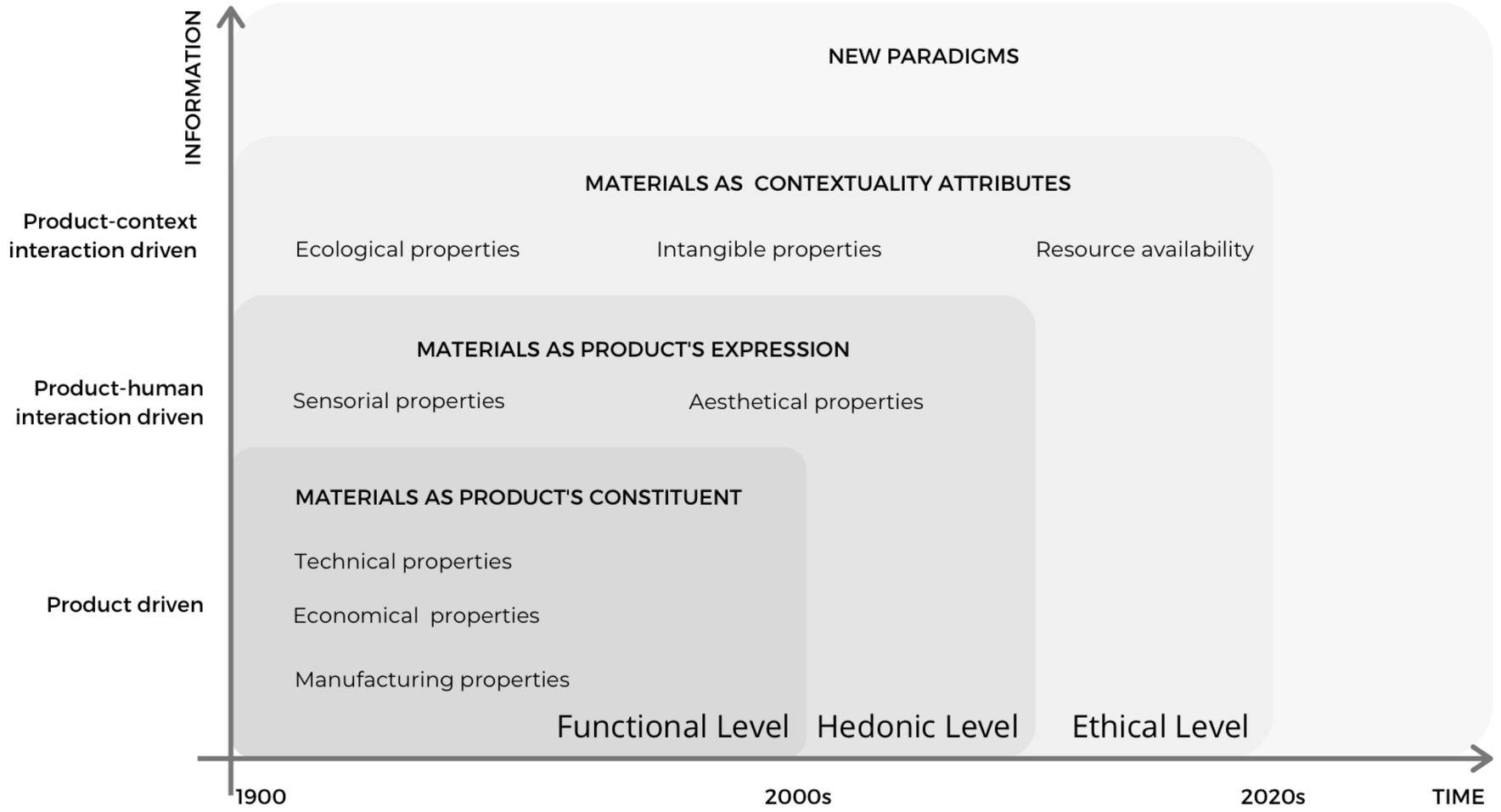
Jahan, A., Ismail, M. Y., Sapuan, S. M., & Mustapha, F. (2010). Material screening and choosing methods - A review. Materials and Design, 31(2), 696–705. https://doi.org/10.1016/j.matdes.2009.08.013

Ramalhete, P. S., Senos, A. M. R., & Aguiar, C. (2010). Digital tools for material selection in product design. Materials and Design, 31, 2275–2287. https://doi.org/10.1016/j.matdes.2009.12.013

MATERIAL SELECTION
INFORMATION MANAGEMENT

In the last 20 years, material science and chemistry advancements lead to the discovery and synthesis of almost **160,000 different materials** between which making a choice.

Information concurring in material selection process **evolved** over time, by including several levels in the choice.



Allione, C., De Giorgi, C., Lerma, B., & Petruccelli, L. (2012). From ecodesign products guidelines to materials guidelines for a sustainable product. Qualitative and quantitative multicriteria environmental profile of a material. Energy, 39(1), 90–99.

Ashby, M. F., & Johnson, K. (2014). Materials and design: the art and science of material selection in product design. ButterworthHeinemann.

Karana, E., Hekkert, P., & Kandachar, P. (2008). Material considerations in product design: A survey on crucial material aspects used by product designers. Materials and Design, 29(6), 1081–1089.

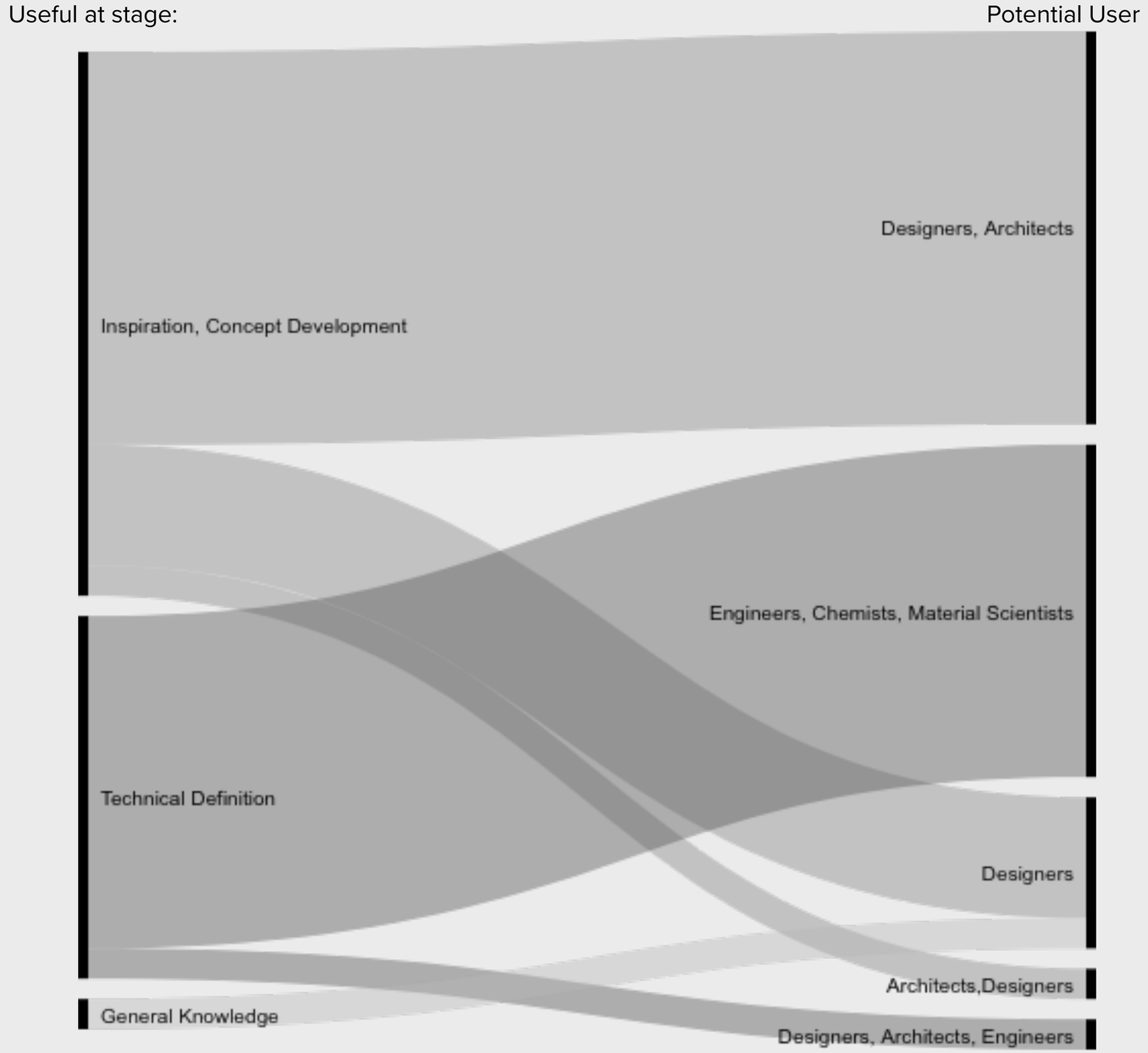
van Kesteren, I. E. H. (2008). Product designers' information needs in materials selection. Materials and Design, 29(1), 133–145.

Tian, H., Zhang, H., & Liu, T. (2019). Research on Material Selection of Product Design under Environmental Awareness.

MATERIAL SELECTION
INFORMATION MANAGEMENT

Almost **35 online sources analysed** between material repositories, softwares and libraries for material information management.

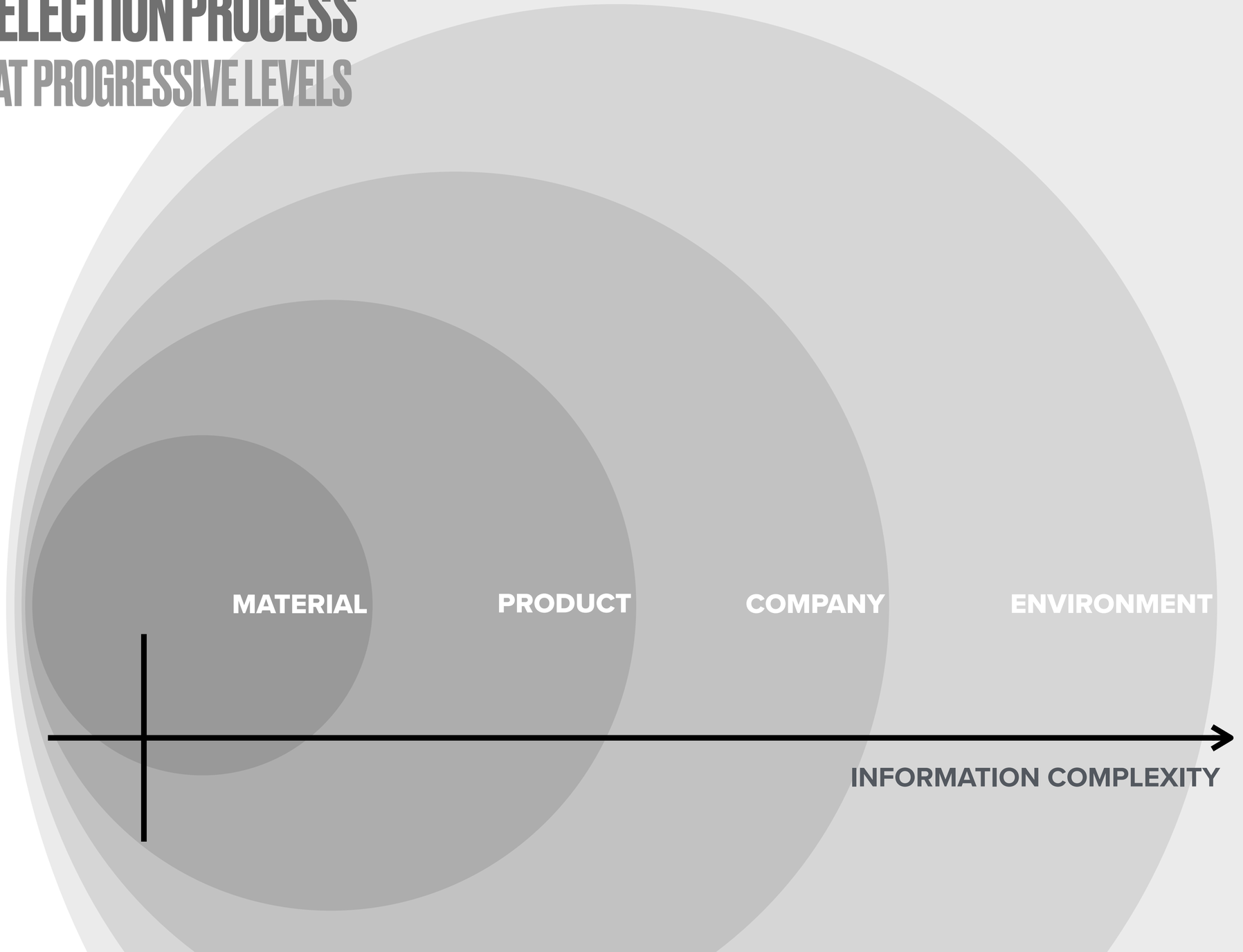
Mainly, the **repositories are made for designers or technicians.**



PROBLEM SETTING

MATERIAL SELECTION PROCESS

IMPLICATIONS AT PROGRESSIVE LEVELS



PROBLEM SETTING
MATERIAL SELECTION

- Current global context is demanding for **aware resources and material use**
- Due to its implication at several levels, **material selection** could be defined a **complex task**
- It is **plenty of tools made for supporting material selection** process, but them still refer only to designers or technical professionals
- This process needs to be reviewed **to promote a shift** towards innovative material use in industrial environment
- Material selection in industrial context should be managed as a **cooperative task** in order **to monitor** in a proper way all the material information to **promote an aware use of resources**

SYNTHESIS MAPPING

METHODOLOGICAL FRAMEWORK

FOR MATERIAL SELECTION PROCESS MAPPING IN INDUSTRIAL CONTEXT

Research activity	Methodology	Insights	Results	Needs
Desk Research	Litterature review	Existing material selection methodological pattern		Verify correspondance in Industrial context
	Analysis of material selection online tools		Existing methodologies refer to a precise material selection user	
Field Research	In site observations & interviews (qualitative analysis)	Innovation resistance level	Need for understanding material selection process workflow	Mapping information flow through internal workflow
	Questionnaires (quantitative analysis)	Material selection procedure evanescent	Need to transform material selection process into a coperative activity	Mapping relationships between different actors
	Workshop (Participatory action research)	Material selection perceived as a cooperative task		
Research Synthesis	Synthesis mapping of material selection process	Enlightening information management and relationships between actors	Procedural workflow promoting a flexible material selection process	**SYNTHESIS MAP**

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FOR MATERIAL SELECTION PROCESS MAPPING IN INDUSTRIAL CONTEXT

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METHODOLOGICAL FRAMEWORK

FOR MATERIAL SELECTION PROCESS MAPPING IN INDUSTRIAL CONTEXT

Field research was central for the work, in order to define the material selection process boundaries, **involving stakeholders** in the research in staged Workshops* .

Stakeholders were involved into:

- problem discovery
- problem definition
- possible new scenario design, concerning the material selection process into the company.

Jones, P. (2018). Contexts of Co-creation: Designing with System Stakeholders. https://doi.org/10.1007/978-4-431-55639-8_1

SYNTHESIS MAPPING
MATERIAL SELECTION

*"**Synthesis maps are a type of system map** that a team of designers and researchers team develops in a course studio or professional project.*

*Synthesis maps differ significantly in size, visual appearance, and application from the formal models used in systems engineering and analytical traditions. The purpose of a synthesis map is **to articulate the processes and relationships that are vital to stakeholders of the system**"*

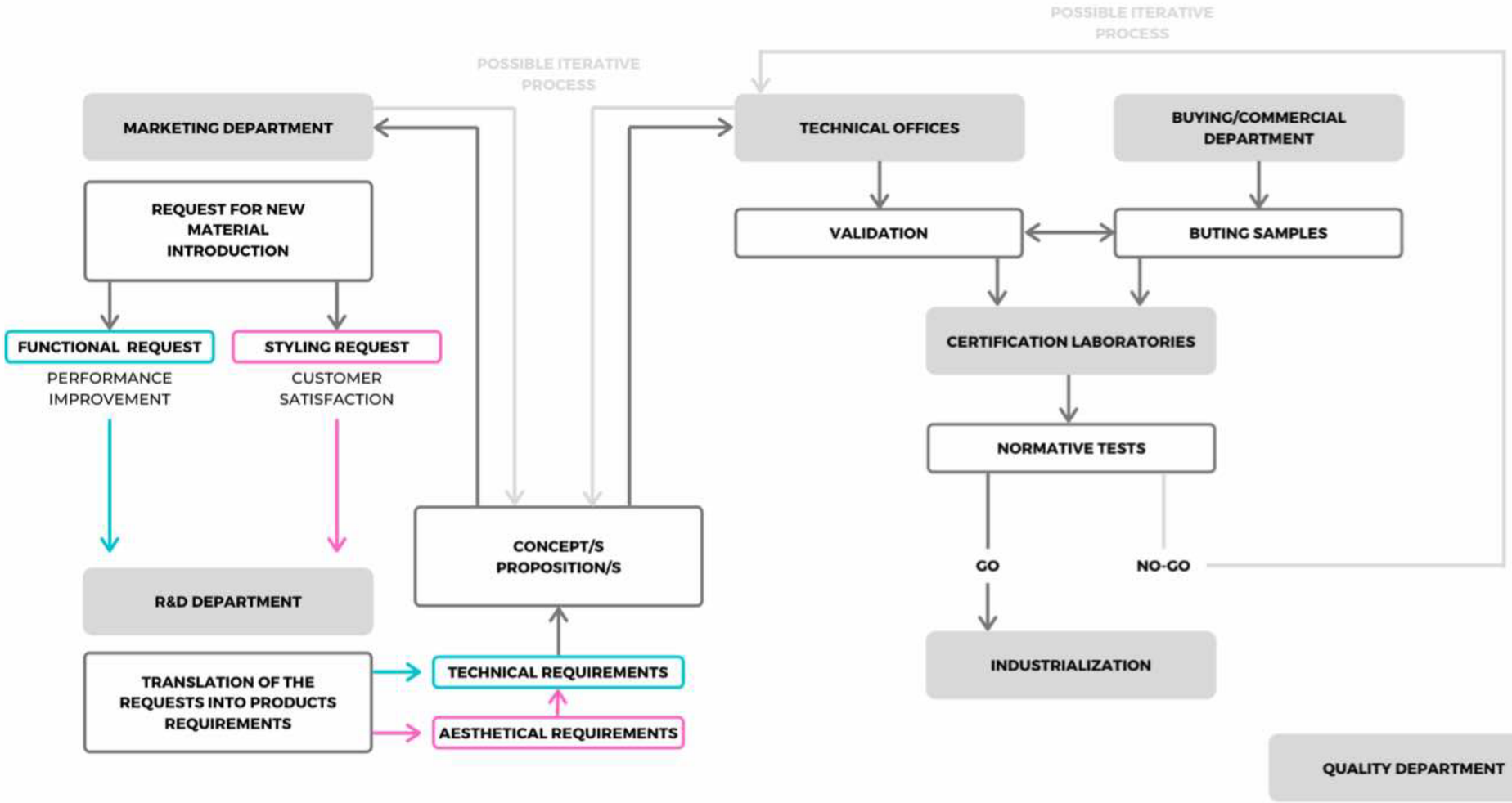
- Jones & Bowes (2017)

Jones & Bowes (2017). Rendering Systems Visible for Design: Synthesis Maps as Constructivist Design Narratives. She Ji Volume 3, Number 3, Autumn 2017 pp.229-248

SYNTHESIS MAPPING

MATERIAL SELECTION AS A COLLABORATIVE PROCESS

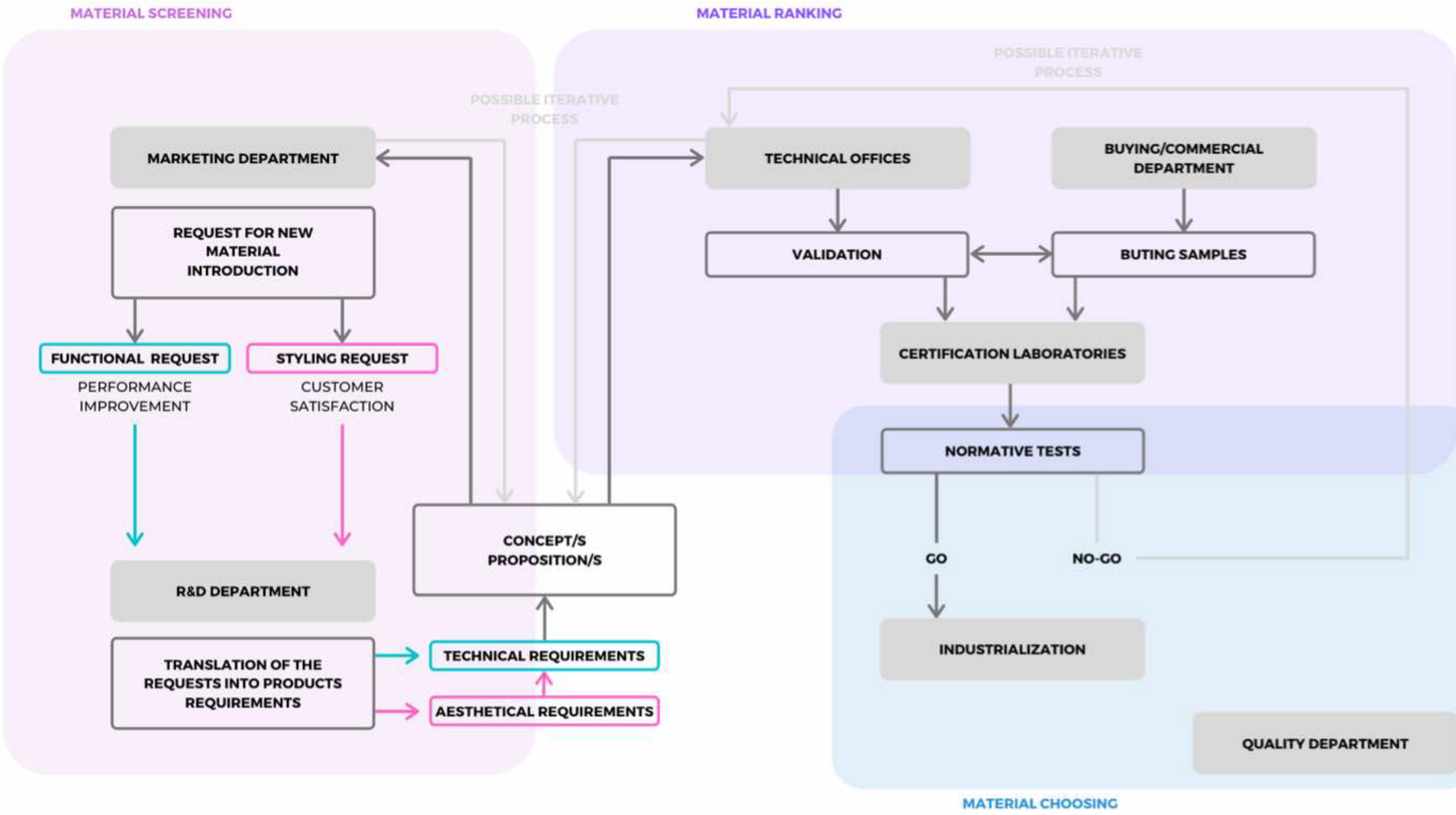
1. **WORKFLOW MAPPING**



SYNTHESIS MAPPING

MATERIAL SELECTION AS A COLLABORATIVE PROCESS

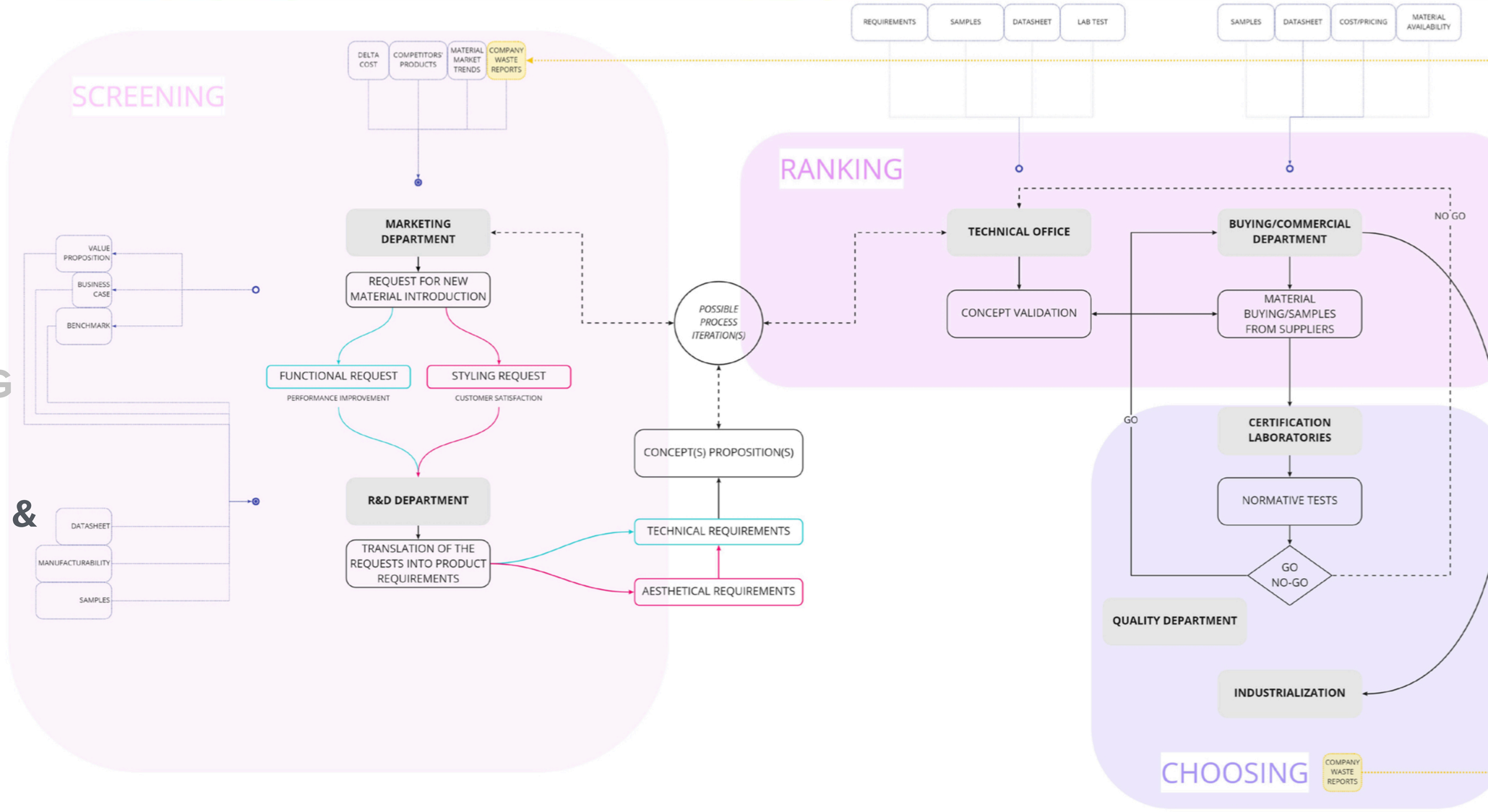
1. WORKFLOW MAPPING
2. MATERIAL SELECTION PROCESS OVERLAPPING



SYNTHESIS MAPPING

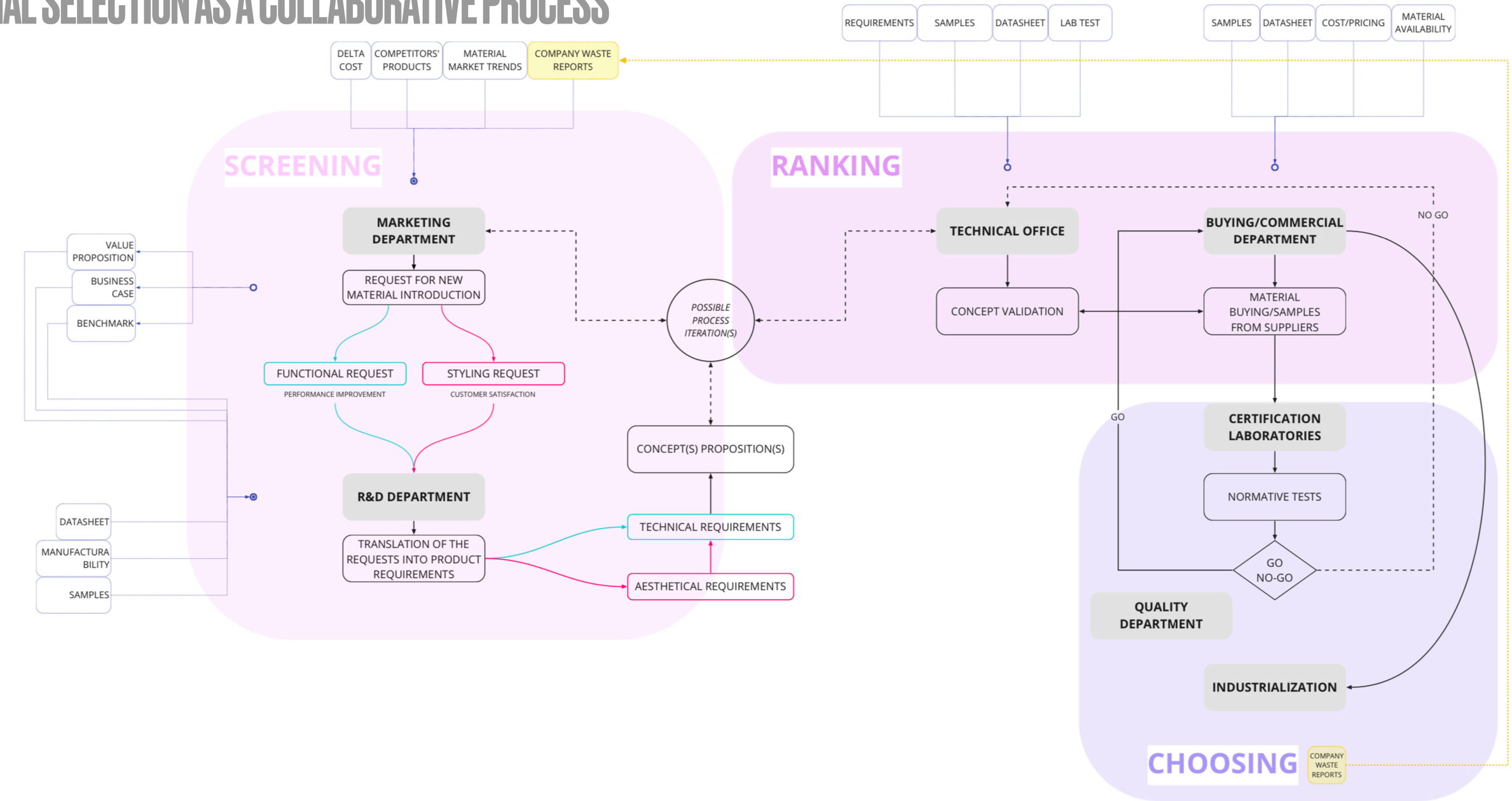
MATERIAL SELECTION AS A COLLABORATIVE PROCESS

1. WORKFLOW MAPPING
2. MATERIAL SELECTION PROCESS OVERLAPPING
3. **MATERIAL INFORMATION & DOCUMENTS**



SYNTHESIS MAPPING

MATERIAL SELECTION AS A COLLABORATIVE PROCESS



FURTHER DEVELOPMENTS

FUTURE USE OF THE SYNTHESIS MAP

- **Syntesis map** has been built in the industrial context **with employees**, trying to map material selection process in terms of **information flow,** product design process and **relationships between actors**
- The synthesis map will be tested as a **product design roadmap**
- A specific **focus** will be reserved to **material substitution** activity and its consequencies in terms of environmental efficiency.

FURTHER DEVELOPMENTS
CONCLUSION

- A systematic material selection activity could **fasten the introduction of new materials into the industrial environment**
- New materials introduction in the production systems could **facilitate the transition** towards new economic systems (e.g. Circular economy) without compromising the production efficiency
- Further enrichments of the synthesis map will provide an information flow even at an environmental level (evolving into GIGA.Maps)

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THANK YOU FOR YOUR ATTENTION.

E-MAIL: FLAVIA.PAPILE@POLIMI.IT

F. PAPILE [1], B. DEL CURTO [2], A. COCCIA [3]

[1]Design Department of Politecnico di Milano (ITALY)
[2]Department of Chemistry, Materials and Chemical Engineering "Giulio Natta" of Politecnico di Milano (ITALY)
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