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NEW DIGITAL INSTRUMENTS FOR THE COMMUNITY BUILDING IN HOUSING COOPERATIVES

Luciana Mastrolonardo [a], *Salvatore Di Dio* [b], *Giuseppe Spataro* [c], *Giulia Sala* [d], *Domenico Schillaci* [e]

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ABSTRACT
The research starts from a study carried out for Confcooperative Habitat, which focused on the systematic analysis of the materials produced for the launch of a new season of the cooperative movement. The goal is to improve the active action on communities for a tangible social impact able to propose a model that knows how to enhance the common urban spaces within the interventions. Finding the new needs and the new processes that characterize living, outlined also in their condominium and urban dimension of 'common good', therefore of 'common housing'. The procedural model proposed and modulated in an evolved platform, seeks to multiply the common practices of living in the city and live in harmony with the built environment, building networks of services with the community.

KEYWORDS
habitat, common housing, housing services, associative rating, community building

The study describes the research path for the definition of management with distributed leadership of the new communities of building cooperatives. The new cultural phase promoted by the National Federation foresees that interventions in the cooperative must be based on the principles of the Common Housing[1] (Maggioni, 2018) and of the Carta dell'Habitat[2] (Consonni, 2019). Therefore, the focus of the cooperative action moves from 'home' as a good, to 'habitat' as a set of services that define a better quality of life (evolution also recorded in the change of name, from Federabitazione to Confcooperative Habitat). The dwellings must have a series of qualitative flows in the product and in the space and elements that qualify the civil life and the existential dimension of those who live there, rediscovering a 'political function' (Olivetti, 1946). Cooperative developments provide habitat for their residents, become a catalyst for community building through their design and collaborative decision making structure, as well as lessen the impact on the environment through the sharing of resources and reducing the separation and sprawl of the developments overall configuration. Cooperative with affordable units can provide shelter for people with moderate incomes within these affluent communities and at the same time facilitate increased interaction among its residents for a better living quality. In this historical moment we are immersed in a process of change that, in nature and in time, is a revolution, an abrupt break with the past that led to a radical transformation of the system anything but linear: in the transition, we need to experiment with new solutions and then consolidate and replicate the best ones (Manzini, 2015). Starting point is the observation that the cooperative movement is at a crossroads: it must overcome the operating methods that have led it to lose sight of the mutual aim[3] at the base of the companies, but above all it must try to define new procedural modalities (Mastrolonardo, Radogna and Romano, 2018) for a social impact[4] capable of defining a real change, or an impact that has a transformative power on society and on the reference context (Zamagni, Venturi and Rago, 2015).

The context of the work is the national decreasing ones (metropolitan, provincial e regional): the strong urbanization of the population and the displacement in geographical areas of the north envisage scenarios in which, by 2036, only some cities in the north would result in a positive balance sheet of population, with a double-digit contraction in the rest of Italy, especially in the south (DemoSi Cresme, 2018). Added to this are new demands on housing dictated by a variety of changes in social composition that, combined with the growth of the condition of loneliness and malaise in the urban environment (Harvey, 2012), cannot be separated from a territorial assessment of the housing demand in degree to return a mosaic of variable intensity. They range from the gentrification risk of some historic cities, to the progressive contraction of internal areas, to the need for quality in the peripheral territories, which clash with an increasingly polarized market and with an increasingly evanescent public offer (Maak, 2015).

Despite the cultural difference that characterizes different realities, the study of good practices spread in other countries, for example, the Switzerland cooperatives (Jacomella, 2018), together with the definition of scenarios (possible or desirable) in the implementation of the theory of change (Keystone, 2009), can help define a framework of action for future interventions in a cooperative through: a) the identification of long-term objectives; b) the mapping of beneficiaries, stakeholders and relations in the production of value; c) the identification of the enabling conditions and the requirements necessary to reach the beneficiaries; d) the construction of indicators that measure impacts, to constantly evaluate the progress of the project; e) the construction of a narrative that tells the logical and value steps behind the process, to be defined in terms of mixed modes between virtual and real. The research works on social innovation and must therefore seek a clear vision in order to identify, among the many scenarios that can be verified with more or less probabilities in the future (Dunne and Raby, 2013), the desirable one for the impact to be generated, trying to choose an approach that manages to control, or at least monitor, the developments underway to guide a long-term process (Fig. 1).

Method, tools and articulation of the research – The idea of creating a working method, that can systematically guide the process (or processes) of building a cooperative of inhabitants through a common platform, emerged from the analysis of cultural revival of the cooperative system foundational documents (Fig. 2). To this end, a collaboration was initiated between Push, a design laboratory for urban and social innovation, and the Agenzia dell'Abitare, a consortium of cooperatives based in Abruzzo, to

incorporate the innovations that can generate into the digital platform new processes within the cooperatives. The work followed the study phases:
– Background analysis; the analysis carried out has gone through the scientific study of the state of the art, of the literature on similar themes, in particular on the international cooperative housing movement and on co-housing. In addition, the interviews of the Milan cooperatives, the monitoring of the work that it's being done in Abruzzo, and the study of online platforms that already follow complex processes related to living, to build a realistic background;
– Analysis of the Carta dell'Habitat, the mutual rating and the Common Housing; the study and definition of some specific objectives through the analysis of the text, which today represents the cultural base of Confcooperative Habitat, starts from the city as a polis and reaches the aesthetic of the city and the public space (Fig. 3);
– User Journey; the study uses the 'service design' tools, starting from the real path that the inhabitants make in the cooperative, from accession, to the delivery of the accommodation, in order to define the new process of service delivery in respect of values and through new tools (both digital and physical interaction);
– Preliminary study of the digital platform: the answer to the new needs emerged leads to the construction of a digital platform which identifies the contents and the objectives, which interact directly with the inhabitants in the construction of a network of spaces and services for living.

In the first phase, the research focused on the study of the habits, connections and needs of the inhabitants of some virtuous cooperatives in Milan and Modena, and on the identification of the design hypotheses that could facilitate the interaction between the inhabitants and the urban services in the future. The individual interviews, based on

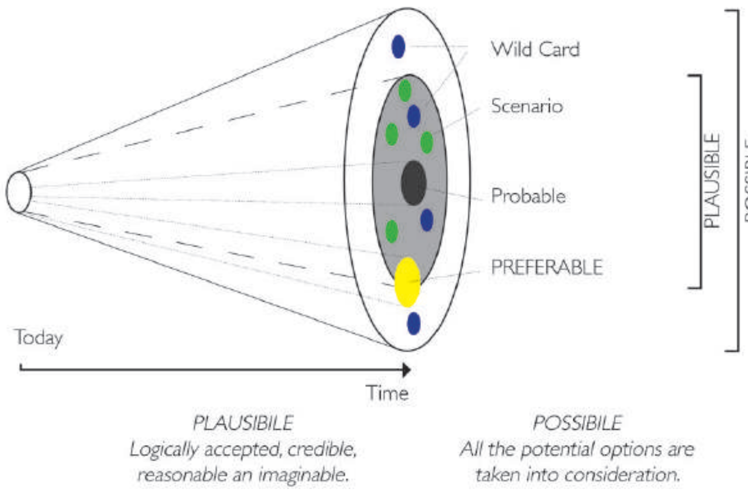
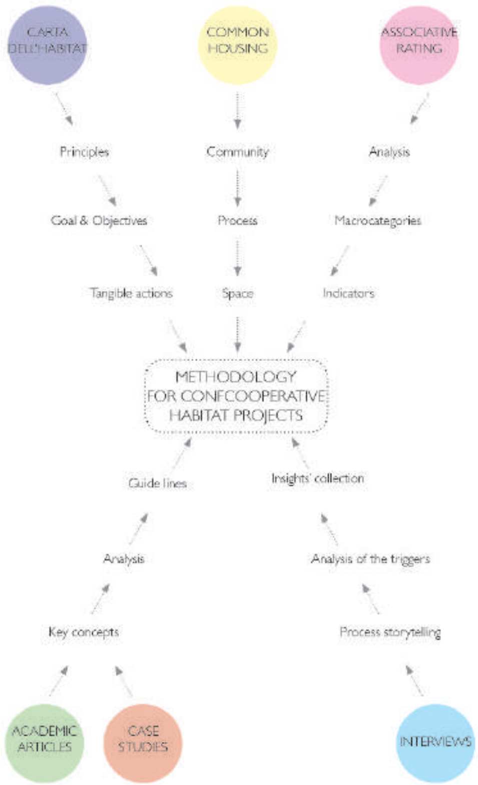
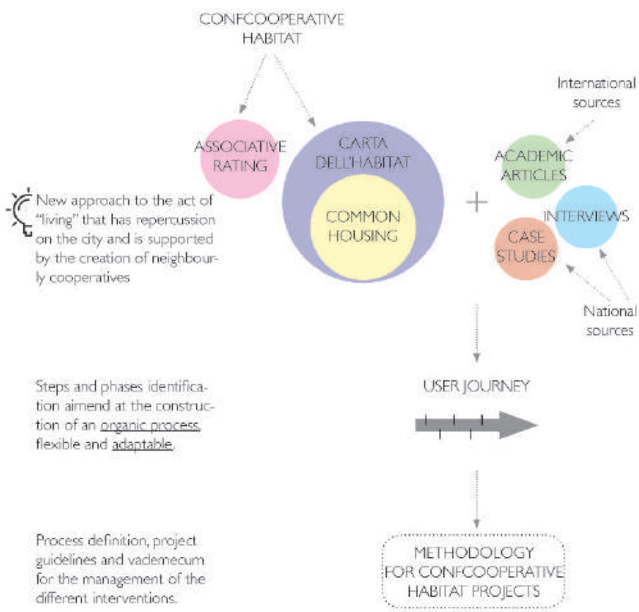


Fig. 1 - Speculative Everything: Design, Fiction, and Social Dreaming (credit: A Dunne and F. Raby, 2013).


CARTA DELL'HABITAT
COMMON HOUSING
ASSOCIATIVE RATING
Principles
Community
Analysis
Goal & Objectives
Process
Macrocategories
Tangible actions
Space
Indicators
METHODOLOGY FOR CONFCOOPERATIVE HABITAT PROJECTS
Guide lines
Insights' collection
Analysis
Analysis of the triggers
Key concepts
Process storytelling
ACADEMIC ARTICLES
CASE STUDIES
INTERVIEWS


CONFCOOPERATIVE HABITAT
International sources
ASSOCIATIVE RATING
CARTA DELL'HABITAT
COMMON HOUSING
ACADEMIC ARTICLES
INTERVIEWS
CASE STUDIES
National sources
New approach to the act of "living" that has repercussion on the city and is supported by the creation of neighbourly cooperatives
Steps and phases identification aimend at the construction of an organic process, flexible and adaptable.
USER JOURNEY
Process definition, project guidelines and vademecum for the management of the different interventions.
METHODOLOGY FOR CONFCOOPERATIVE HABITAT PROJECTS

a flexible scheme, focused on personal and family needs, community life, sharing, knowledge and interaction with the cooperative system. The needs expressed reflect a demographic complexity common in the cooperative, and a difficulty in defining shared needs, which are however divided into two categories: personal services and maintenance and care of the home. The multiple needs of the inhabitants – especially those linked to the different age groups and work commitments – make it difficult to reach a critical mass that can define services or assets of interest to all the condominiums. From the interviews a limited knowledge of the cooperative system emerges: most of the interviewees do not try to look for solutions for the purchase of goods or services in the cooperative world, because they consider their experience closed at the moment in which it comes into possession of the house, and refers to the building cooperative for bureaucratic or maintenance issues.

The state-of-the-art-study has reviewed the most interesting Italian cooperative interventions. Some operations reflect great foresight but results that are still far from the objectives, such as the cases of Via Cenni (Rossiprodi, 2016) and Quartiere Zoia in Milan (one of the subject of the interviews), both good practices and subject of competitions (the first open to designers and the second to cooperatives) by the municipal administration of Milan. These experiences have built the training/information/community building paths with the inhabitants, but, while making great strides forward and managing to better manage some collective decisions (relating to shared spaces, community gardens, bike workshop), they have not succeeded in creating communities that collaborate in the construction of the city. The study of some Swiss cooperatives (Jacomella, 2018), also visited by members of the National Council of Confcooperative Habitat, (documented on the association's web channels), is illuminating to better understand how to move in the new interventions envisaged, despite the basic cultural differences. Zurich is a pioneer city in Europe in the experimentation of new housing solutions (Boudet, 2017), and its cooperative system has historically distinguished itself among the main actors in the creation of the new urban fabric with around 30% of residential homes for rent of cooperative matrix.

In the Kalkbreite housing complex the compact architectural form that centrally collects the common spaces, defines the primary reason why the inhabitants, gathered in a cooperative, have been led to share practices, time and knowledge. The common identity has allowed us to experiment with some quality collective spaces such as a foyer, a canteen, a laundry, rentable offices, meeting rooms, a b&b, a nursery, a garden with games and a small conference centre. The popular district Kreis 4, was instead the protagonist of a process of urban regeneration, where some historic buildings were recently recovered by local cooperatives, defining common spaces and services. Other guided interventions can be considered Europaallee, which in its imposing size can define a wide

Figg. 2, 3 - Previous page. *Summary of the methodological process used; Document analysis method.*

range of shared spaces, and the former industrial site of Zwicky Süd, where the functional and high social mixité does not prevent the construction of shared objectives and spaces. These experiences have in common: the cooperation, the participation of all the tenants and the enhancement of the possible common interests, which enable spaces and collaborative services.

The numerous national and international experiences of free aggregation of citizens, aimed at reducing housing problems or simply to activate housing forms rich in useful activities for the community, are certainly an important source of analysis and reference to evaluate the different types of information and categories of activities and services presented. The Solidarity San Giorgio Co-housing in Ferrara and the Barona Village in Milan show experiences in progress from which to draw some noteworthy ideas, both positive and negative. The mistake could be overestimated social and environmental outcomes built around them storytelling.

Background and Innovation – Collected the information necessary to determine the functionalities that the web platform will have to provide to citizens and co-operators, the main platforms and organizations on the market have been analysed so as to be able to include in the design the elements deemed most effective and interesting. The web platform should accompany the inhabitants from the discovery phase of local initiatives to the subsequent phases of assignment and integration in the new internal and external community of the building. The digital tool should allow building cooperatives to advertise their local initiatives and gather the interest of future members by identifying the main needs and establishing a direct communication channel that is always updated on the evolution of the intervention, following the example of the Swiss cooperatives. In the phases following the assignment of the housing unit, the platform must make it possible to establish a communication channel between the resident members and the condominium administration to meet the need for transparency and return up-to-date information on economic and administrative issues with a friendly interface for internal communication with other tenants. Subsequent developments of the platform will allow the creation of a channel of direct promotions by the cooperatives of local goods and services as well as a tool to support the resident members for the creation of buying groups or the sharing of services, necessary to form a community and improve quality of life.

Numerous national and international realities have been analysed and some interesting ideas have also been collected by online services, not strictly related to the real estate theme, which have been characterized by their effectiveness in interacting with users and simplicity and clarity in the user experience (for example Ioabitosocial – platform for sharing and choosing interventions in social housing, Ioabitoincommunity – app to improve community life within the neighbourhoods, or planet app – app for residents to learn and participate in the events of the quarter). The most interesting example is the Habx platform that forms the group of future inhabitants even before starting the design and construction of housing, so as to obtain some important economies. These savings allow the companies participating in the platform to offer better quality homes, concentrating resources on what really matters to end users. The platform allows you to select a proposed project, from different companies and in the neighbourhood/city of interest, expressing your needs both in private spaces and in areas shared with the community, receive the project proposal and customize it with the help of the platform technicians, and finally to follow the construction process. Habx represents an interesting example of a platform for managing the co-design phase with users, above all for the experience of use, for the simplicity of presenting the different opportunities of choice and for the relationship of dialogue that is established with the user. The target audience is high economic level user, so it is very far from the cooperative model, but more oriented to the maximum personal performance of the individual intervention. Another example analysed which is a good reference, although referring to particular interventions, is Cohusing-Berlin, very community-oriented that starts research operations and cohousing in particular.

Another starting point of analysis is represented by the recent diffusion of web platforms for the promotion and management of crowdfunding initiatives, related to the real estate sector. There are mainly two different models of real estate crowdfunding based on the type of platform that places the instrument on the market: lending crowdfunding and equity crowdfunding. Some examples of operational realities in Italy are Walliance and Housers, through which it is possible to invest from home on a real estate project without having large amounts of capital. These platforms, despite being far from the objective of the new cooperatives, offer numerous points for reflection since in the selection and hierarchy of information to be exposed to users and in the management of the fundamental steps of the process (investment phase, planning, realisation, etc.) they have numerous points of contact with the needs identified for the Habitat platform.

As regards the research objectives, to the typical model of digital social platforms, it is necessary to combine more convivial tools, that is oriented to enable, support and facilitate the organization of activities to be carried out outside the virtual communication space, and therefore in the characterizing territory a community of place. This means designing systems with a particular attention to the collaborative and cooperative element that allow to support and assist the organization and management of practices that are aimed at achieving common objectives such as: improving the safety or decorum of common spaces, solving small conflicts between neighbours, lend objects or provide each other with assistance and help for daily activities, save money by doing group purchases or zero kilometres. The collaborative element has been identified as the main element that allows the people involved in a community of place to get to know each other and then understand how to complement each other's skills, abilities and interests, so as to improve common life and the place lived daily, without waiting for help from the authorities or social institutions.

The recurring themes and the way of presenting these realities have been identified from the single best practices, and also some of the main design errors that create problems in urban communities have been underline (Francis, 2002): 1) take for granted key issues and not to seek an overall alignment of users, through information/training; 2) to insert excessive barriers which, conceived and designed to protect the community within it and from episodes of crime and traffic, discourage the inhabitants from moving on foot and create less social control in the common areas; 3) not understanding what the residents really want, leaving key investment and innovation decisions without guidance and information; 4) forget about the extra services (car-sharing, parking for bicycles, concierge services, etc.) that can create more cohesive neighbourhood communities, if the conditions, terms and desire of these services are expressed by the community itself; 5) create unwanted green spaces in terms of position, size and quality, without considering that the inhabitants of the neighbourhood might not see its usefulness, or share its purpose; 6) not starting from community interactions, and not designing spaces that encourage proximity relationships (entrance door directly onto the street, balconies that are no more than 10 meters apart, porticos and other devices that make the relationships more frequent and solid: being visible to neighbours makes the community more inclined to socialization and safer).

User journey and community building – The data collection allowed to define some desirable solutions for the construction of new collaborative cooperatives. To this end, in the second phase of the project, the collaboration between Push and the Agenzia per l'Abitare played a fundamental role in the search for the main functions of the digital platform and in identifying the moments of interaction between the virtual platform and physical community building actions. In fact, to define a collaborative community, all the phases of the process must be managed and accompanied, in particular the initial and 'final', of handing over the keys, which must not be the end of the process but an intermediate moment.

The key objective is the community building among the inhabitants, which must be achieved through some successive steps and the definition of the process phases that the inhabitants and all those involved in the construction can use (Confcooperative Habitat, the territory Agencies, the cooperatives). To reconstruct this methodological path, the following were related: a) the principles promoted by the Carta dell'Habitat systematized and hierarchical; b) the study on Common Housing in depth in light of the principles of the Carta dell'Habitat; c) the procedures in the associative rating have been integrated into the definition of the objectives; d) some articles concerning co-housing processes that present some points of contact with the new investigated processes (Kraus, 2002; Wang and Hadjri, 2017).

Through the analysis of the documents and principles proposed by Confcooperative Habitat (Carta dell'Habitat, Common Housing and Associative Rating), a User Journey was defined on which the procedural steps will be built. The Carta dell'Habitat consists of ten principles that aspire to the creation of a new urbanity starting from the interventions promoted by Confcooperative Habitat. For each principle a goal has been identified (intended as the final goal, the result to be achieved at the end of the course), and one or more objectives (defined as a concrete and quantifiable result, functional to the achievement of the previously identified goal). For each objective the 'what', the 'how' and a set of concrete 'tools and activities' representing the tangible actions to be undertaken in the process were analysed (Fig. 4). After having analysed the 10 principles of the Carta dell'Habitat, having separated them into their logical components (what, how, actions), and having defined a system of consequentiality of the goals of each objective, it was analysed how they correlate with the identified steps in the User Journey.

The resulting hierarchy of the identified goals was linked to the steps defined in the User Journey (Fig. 5). From the analysis of the associative rating process connections emerged with the development of cooperative habitat projects which are not only formal, but also substantial, and which must be an integral part of the proposed methodology. The US context (Siciliano, 2009) was used as a basis for comparing the identified phases. Starting from the comparison of these phases, with what emerged from the first part of the study, all the phases were systematized and it was possible to outline the dif-

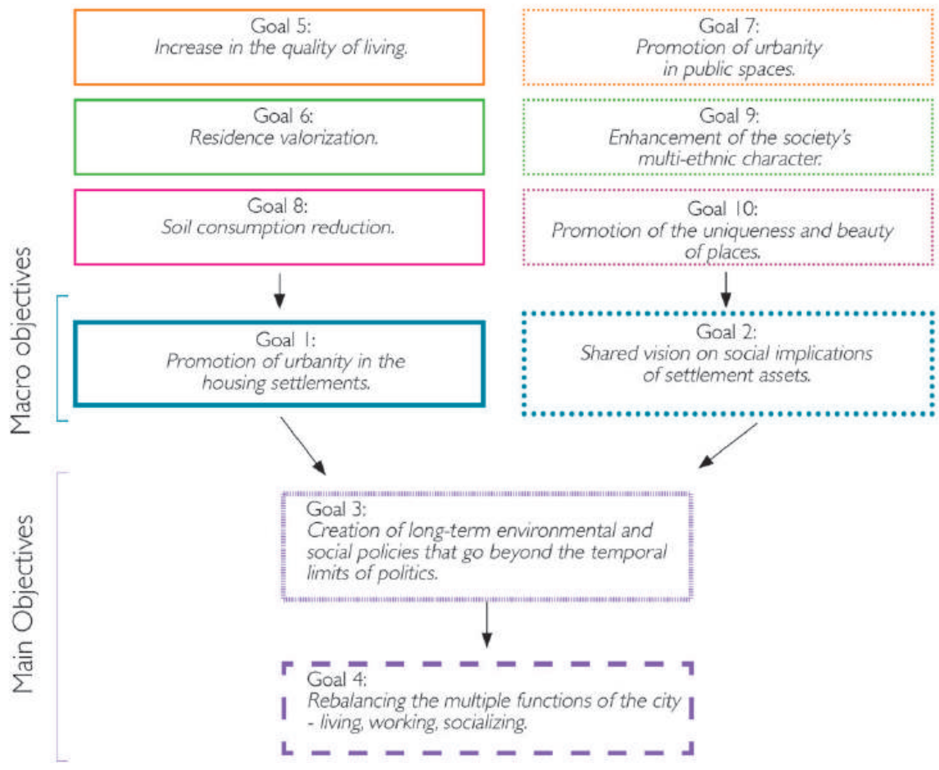


Fig. 4 - Analysis of the principles of the Carta dell'Habitat.

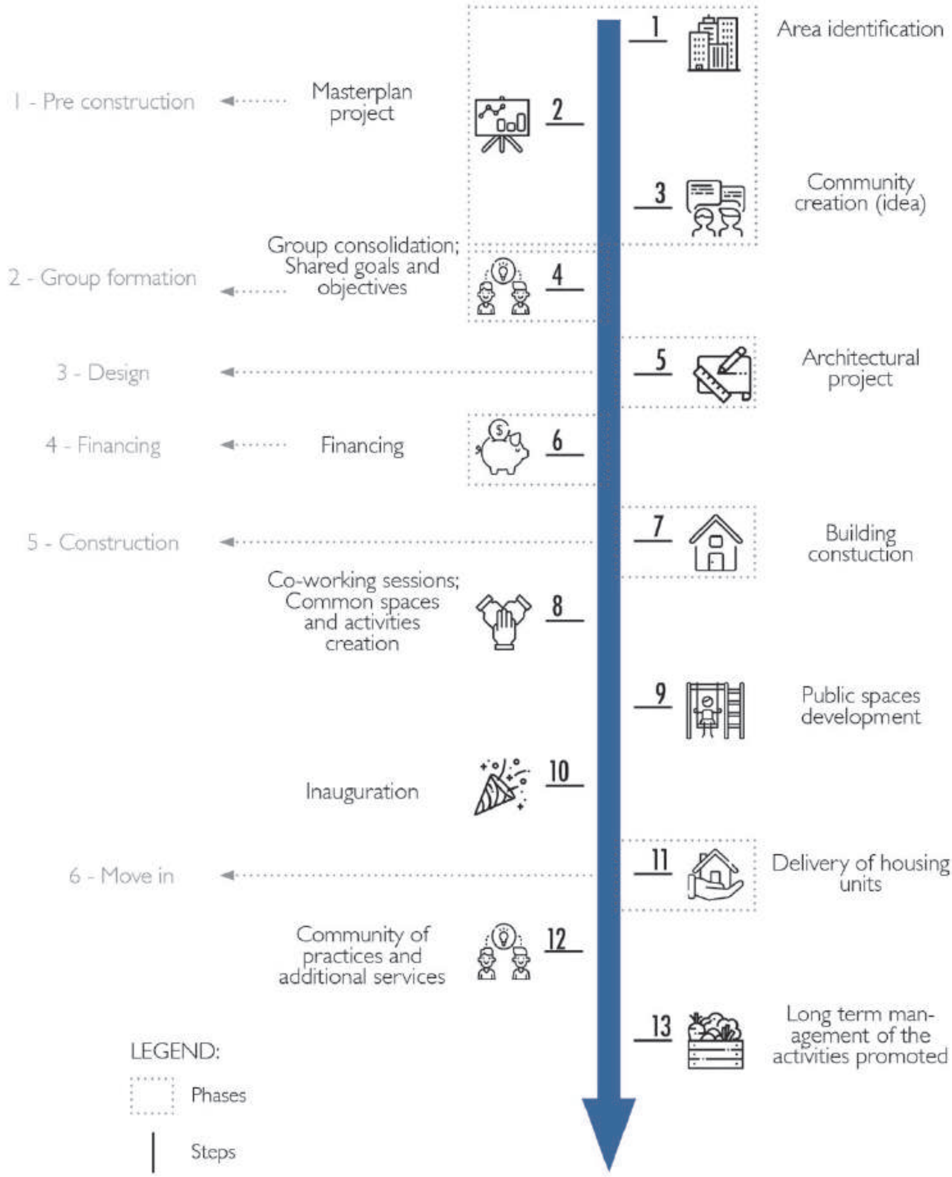


Fig. 5 - Definition of the User Journey.

ferent steps of the User Journey. The study of literature was then compared with the information obtained from the interviews and from the experience of the Agenzia per l'Abitare reversing the logical order to better adhere to the characteristics of the Italian cooperative context. The different goals are also characterized by a difference in terms of purpose, which can be linked to the creation of physical space or the social sphere. For each phase of the User Journey we tried to connect one or more goals derived from the Habitat Charter. When several goals are attributable to a single phase, the circle is divided into several segments. An exception is made for goals which, being considered 'main objectives' (pursuing a pact between the generations and making cities in the era of the metropolis) have a transversal dimension to the phases of the intervention.

The purpose of this study phase is to highlight the tangible actions to arrive at the concrete implementation of the principles promoted by Confcooperative Habitat. The guiding methodology for the process of constructing cooperative habitats in Italy focuses on the potentiality of the actions to be implemented so that the pre (and post) construction phases can effectively create the desired community cohesion. Through a simple and effective communication tool that can accompany the phases of the project, the operators of the sector will be able to guide the process more effectively and convey the most relevant messages related to their work. The inhabitants will be accompanied in the construction process and will be invited to continue defining new community initiatives. The methodology will focus on procedural aspects in order to be flexible and easy to apply even in very different contexts. The analysis, in the form of self-assessment, allows to define parameters and quality standards of the process, and at the same time to communicate the operations in progress with the users.

The described working method is declined in various tools that are made available to cooperatives: a Vademecum inspired by the principles of sustainable development and the new model of cooperative habitat desired, which concretizes the principles contained in the Habitat Charter, with instructions for create community cooperatives oriented to the principles of Common Housing; a Check List of things to do, steps to follow and key moments not to be underestimated, as a tool that simplifies a long and sometimes complex process at the base of the formation of the cooperative, which allows the actors to keep track of what it is done and what to do.

From the analyses previously conducted in the field, and from the study carried out during the last phase of work, it is clear that a digital platform represents the point of contact between Confcooperative Habitat, the resident members and the cooperative members to be able to transmit and implement the proposed innovations. The platform will have the role of highlighting the activities of cooperatives and members through a simple reading design. The showcase thus proposed can be used to clearly communicate the principles and actions promoted, and to interact with the cooperatives themselves. The platform will have the main purpose of telling and giving visibility to the initiatives promoted by Confcooperative Habitat. The strong point will be the proposed storytelling, focused on continuous communication of on-going activities and their progress over time. The methodology previously proposed, represents the backbone of the site contents; based on this, the highlights of the journey will be told. The study conducted highlighted the importance of keeping active members informed on what is going on around them to ensure that the cooperative is effectively active. The choice to create an online platform is dictated by various factors, including the immediacy of contact with users and the ease of information exchange. However, this is only the showcase of a work that will take place mainly behind the scenes through the work of Confcooperative Habitat, the cooperative and the resident members.

Conclusions – The research, through the systematic analysis of the principles of cultural renewal of Confcooperative Habitat, aims to define a set of processes for the creation of cordiality cooperatives for the sharing of spaces, using relational skills, service design and community organizing. We respond to a need that is to redefine the relational centrality, within the settlement model (habitat), which includes a direct public (partners) and indirect (neighbourhood and thematic communities). The social impact that we want to generate must be able to connect the widespread leadership to the theme of mutuality and governance, to choose which needs to focus the design efforts on for the reference (hybrid) communities. The Common Housing, which amplifies the space and defines the places and services to an urban dimension, calls to action the cooperatives, aware of the new socio-demographic trends and of the new housing needs within our society, to develop effective responses to the new needs. The starting points are the associative mutual rating, which defines the rules within which to move, and a new founding document, the Carta dell'Habitat, both necessary to regain again the radical and innovative role that the cooperatives played during the 20th century (Jacomella, 2018).

The result of the study is the construction of a map of interactions to be developed among the inhabitants, in which the platform becomes a tool for future cooperatives with a view to new interventions in Common Housing, through new procedural methods spot on the quality of urban space. In the study undertaken, the focus of the problem seems to be the management of the community and the most significant elements that have emerged concern: 1) the need to involve the inhabitants starting from the embryonic phases of the project, trying to make them active protagonists; 2) the co-planning of spaces (above all common ones) that must be shared in order to represent an added value for the community; 3) the creation of systems for monitoring, controlling and auditing the project phases that determine a system of trust towards the cooperative and its actions; 4) constant monitoring that can help the internal management phases of the intervention and the development of the community; 5) the role of external experts (facilitators, housing managers, etc.) who administer and guide the processes. The strength of the communities is based on the sharing of environmental and social values, but it must have a constant support to avoid problems linked to a participatory process that is too horizontal and to be able to face the promises made initially, sharing the responsibility of individuals towards common operations.

ACKNOWLEDGEMENTS

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NOTES

1) Common Housing is here understood as an evolution of cooperative living extended to the neighbourhood. The term evolves the abused concept of 'social housing', which in Italy has had a lot of literature and little practical follow-up, and is limited to a rental housing offer that meets the needs of the grey population bracket. Common housing also differs from the concept of a Co-housing niche, which can be implemented for minimum groups of people who find common utility in living together. The Common Housing brand has been registered (A. Maggioni, President of Confcooperative Habitat) and is used by the new inhabitants' cooperatives that manage to define a system of places for living.
2) The Carta dell'Habitat is the founding document of the cooperative principles of making cities, understood as the promotion of urbanity, civil coexistence, beauty and the art of living in the settlement aggregates.
3) The Associative Mutualistic Rating is a system of continuous evaluation of the associated cooperatives developed to ensure the mutualistic, entrepreneurial and social quality.
4) The impact is understood as «long-term sustainable change (positive or negative; primary or secondary) in the conditions of people or in the environment that the intervention has partially contributed to achieving, since it is also influenced by other exogenous variables (directly or indirectly; intentionally or unknowingly)» (Zamagni, Venturi and Rago, 2015, p. 1).

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[a] *Luciana Mastrolonardo, Architect and PhD in environmental design, she is contract professor at School of Architecture and Design of Ascoli (Italy). She is consultant of Agenzia per l'Abitare. Mob. +39 320/81.84.794. E-mail: luciana.mastrolonardo@unicam.it*

[b] *Salvatore Di Dio, engineer, Architect and PhD in Technical Physics at University of Palermo (Italy); he is Managing Director of PUSH, design laboratory of urban and social innovation. Mob. +39 347/13.73.406. E-mail: s.didio@wepush.org*

[c] *Giuseppe Spataro, Progect Manager of PUSH, design laboratory of urban and social innovation. E-mail: g.spataro@wepush.org*

[d] *Giulia Sala, Urban Planner of PUSH, design laboratory of urban and social innovation. E-mail: g.sala@wepush.org*

[e] *Domenico Schillaci, Urban Planner of PUSH, design laboratory of urban and social innovation. E-mail: d.schillaci@wepush.org*

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nZEBox
PRODUCT INNOVATION TO REDUCE CARBON FOOTPRINT OF THE CONSTRUCTION SITE

Monica Cannaviello [a]

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Abstract
The sustainability issue in construction must take into account all the transformation processes that led to the final product. Although the construction phase is negligible in relation to the overall life cycle, it is responsible for large amounts of CO_2 emissions and has a negative impact on the carbon footprint of the construction industry. The paper illustrates the results of a funded research that has addressed the issue of energy retrofit of logistics services (site cabins), since from studies conducted in the United Kingdom, this appears to be the most relevant measure that can reduce the construction site's CO_2 emissions. The nZEBox system satisfies the need to optimise not only the energy-environmental quality but also the aesthetic and communicative quality of the traditional construction site cabin.

Keywords
construction site, constraction site cabin, energy efficiency, carbon footprint, technological innovation

The nZEBox (nearly Zero Energy Box) system was developed to meet the market's need to improve the energy and environmental performance of logistics, in order to reduce carbon footprint of the construction site. The concept on which this system is based is to transform the traditional site accommodations into 'micro-architectures' (Perriccioli, 2016) which, even if temporary, are able to guarantee maximum comfort with minimum consumption of non-renewable sources and CO_2 emissions, at the same time satisfying all regulatory, design and architectural integration requirements. With the Clean Energy Package, the European Union sets new targets to reduce CO_2 emissions by at least 40% by 2030 relative to 1990. At the global level, strong action by governments, cities and businesses is needed to reduce the carbon footprint: a 'zero emission, efficient and resilient buildings and construction sector' (Global Status Report, 2018). This is a complex challenge, which to be met should involve all actors in the construction chain with a Life Cycle Thinking approach that takes into account all the life phases of the building organism, from cradle to grave.

To really reduce the carbon footprint of the construction industry, it is no longer sufficient to control energy and environmental impacts during the operational phase, but it is also necessary to reduce the embodied energy and carbon (Cannaviello, 2017). Building generates, in fact, impacts on the enviroment during the whole process, related both to the phases of raw material supply, production and transport (Hong et alii, 2014) and to the phases of demolition, decommissioning and final disposal. Some studies has shown, through a building LCA assessment, that the construction phase represents 3 to 9% of the total impacts (Delem et alii, 2013). According to the estimates of the UK Green Building Council, the CO_2 emissions generated during the construction phase can reach up to 10% of those generated during the entire life cycle. Carbon Action 2050 White Paper, Building in construction (Chartered Institute of Building, 2011) highlights the need for radical measures to reduce the large amounts of carbon emissions associated with construction processes.

Within the building process, the new challenge becomes to reduce the site's carbon footprint. This is also because the construction site has remained largely on the margins of innovation processes, perhaps because it is considered temporary and therefore negligible, while it plays a crucial role within the overall process and should be based on the same sustainability targets. The need to reduce CO_2 emissions on the construction site should be widened to all actors and processes involved (Fass and Elfsberg, 2017). In the United Kingdom, the Action Plan Carbon Reducing the Footprint of the Construction Industry (Carbon Trust & Strategic Forum for Construction, 2010) identified the energy efficiency of temporary prefabricated structures for the construction site (logistics) as the strategy that can have the strongest impact on CO_2 emissions due to the construction phase, as it has the greatest potential for reduction, precisely because of the very poor quality of these structures. «Referring to the idea of 'impermanence' in architecture has always meant to comply with a perspective that directly connects temporary constructions with housing emergency and provisional usage. The common perception of such buildings has always been associated with transitory, low-cost/low-building quality features and, often, with a sense of generality and unsuitability, both for the purpose they are realized for and for the environmental context they are put in» (Perriccioli, 2018, p. 5). This concept of temporary structures can also be extended to those for the construction site.

In this scenario, the paper illustrates the results of a research[1] that has focused on the issue of energy requalification of existing construction site cabins, which is an interesting niche market, in the global process of decarbonisation of the construction sector. The initial energy audit has shown that the cabins traditionally used on construction sites are not energy efficient, especially when compared with current legislative standards, and are, for most of the year and especially in summer, unable to ensure adequate conditions of thermohygrometric comfort for workers. The use of a high-performance portable cabins can lead to a reduction in CO_2 emissions of at least 50% compared to the entire construction process (Chartered Institute of Building, 2011) and in this direction the nZEBox system, consists of a set of components, to be applied to the traditional basic structure of the cabin, which are interchangeable according to specific needs (climatic conditions, surrounding context, type of building site) to optimize the performance of new or existing cabins. The research proposes a product innovation, relating both to the nZEBox system as a whole, and to the specific technological components, but also proposes a process innovation, relating to the control and optimization of the construction phase of the work.

Research methodology – In the more general context of sustainability of the construction site, the specific theme of the requalification of logistics services was examined, in order to identify technological design strategies capable of optimising not only the energetic-environmental quality but also the aesthetic and communicative quality of the traditional construction site cabin. The methodology sequence on which the research is based is as follows: Phase 1) Technological and energy analysis of the traditional cabin and identification of critical points; Phase 2) New concept for a high energy efficient construction site cabin: the nZEBox system; Phase 3) Setting objectives: requirements and performance to be achieved by the nZEBox system; Phase 4) Component stratigraphy design and energy performance assessment.

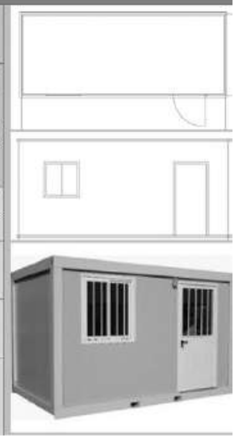
Technological and energy analysis of the traditional cabin and identification of critical points – Portable cabins have been widely used on the international market since many years, mainly in constrction industry as on site offices, with technical characteristics that have been nearly unchanged over time. Table 1 analyses the technical elements of the construction site portable cabin, which has variable dimensions[2] (especially in terms of length). To verify the energy quality of the traditional portable cabin, used as a construction site office, an assessment was made of the performance of the individual components, calculated with the software PAN 7.0, and a comparison with the reference values set by the Ministerial Decree 26/06/2015 (Tab. 2).

The most evident critical point is that portable cabins are generally the same in any context, with component characteristics that do not take into account the different climatic conditions, in contrast not only with the current legislative framework (which provides for different minimum requirements in relation to different climate zones), but also with the most basic principles of bioclimatic architecture. The comparison results between the performance of the cabin and the reference values set by the Ministerial Decree of 26/06/2015 show that the thermal insulation is inadequate, both for opaque and transparent components. The limit set for thermal transmittance is widely exceeded in any climatic zone where the cabin is located (in zone F the actual value is 250% higher than the reference value); the thermal inertia of the opaque components is very low and represents the most critical aspect in the summer season, both in terms of energy consumption and, above all, in terms of thermal comfort. As these are lightweight components, the requirement for surface mass cannot be met. However, the requirements regarding Periodic Thermal Transmittance, Decrement Factor and Time Lag are also not met; as regards the solar gain control in the summer season the critical issues concern above all the transparent components due to the absence of external shielding systems, but also the opaque components.

In order to verify the temperature trend (outside air temperature, external surface temperature and attenuated temperature), it has been assumed to place the cabin in a specific location (Naples, climatic zone C), using the climate data[3] of the place itself for the calculation (in particular the hourly values of temperature and irradiance). As shown in Table 3, the most critical aspect of the vertical wall and also of the roof is the low thermal inertia. The curve of the external surface temperature and that of the attenuated temperature practically overlap (as the time lag of the thermal wave is less than 1 hour), this means that the heat flow is immediately transmitted to the inside surface without any attenuation. As a result, the maximum summer indoor surface temperature is very high (see Tab. 3), with negative impacts on energy consumptions. The control of indoor thermal comfort conditions is almost entirely ensured by air conditioning systems, with high consumption of non-renewable primary energy throughout the year and production of large quantities of CO_2 emissions. Therefore, the influence of logistics services on the carbon footprint of the construction phase can no longer be overlooked, especially in the case of large and long-lasting construction sites.

New concept for a high energy efficient construction site cabin: the nZEBox system – The market for portable cabins for the construction site involves numerous companies at national and international level, which belong to different segments, from the production, assembly, marketing and rental. Few large companies can cover all market segments, but most only assemble the components. In recent years,

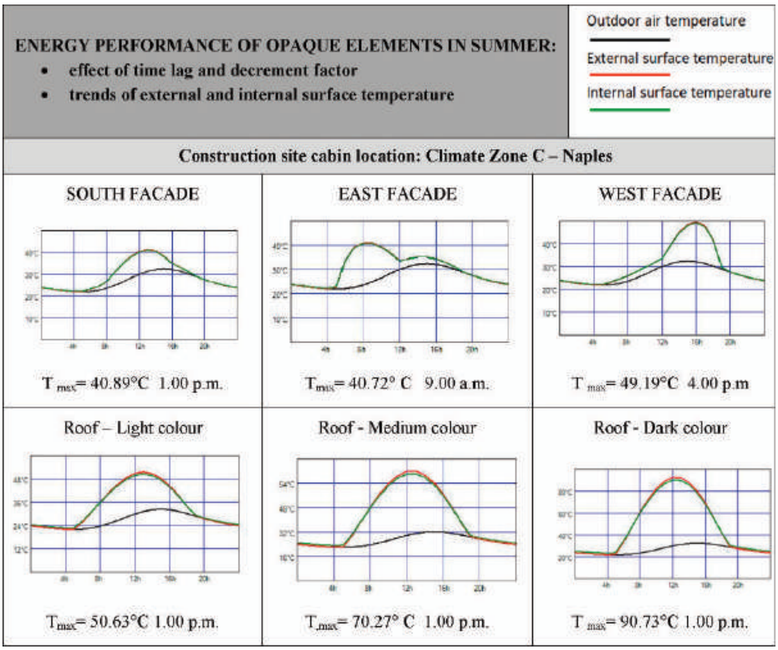
Classes of Technological Units	Technological Units	Classes of Technical Elements	Construction site cabin
Load bearing structure	Elevation structure	Vertical elevation structures	Uprights, consisting of welded and cold pressurized steel profiles, screwed to the roof and floor frame.
		Horizzontal elevation structures	Floor frame, consisting of welded and cold pressurized steel profiles and 4 welded corners. Floor cross members on the long side, floor cross members on the short side, load-bearing floor cross members (Ω profiles). Roof frame, consisting of welded and cold pressurized steel profiles and 4 welded corners. Roof cross members on the long side. Roof cross members on the short side. Folded galvanised sheet metal cover.
Envelope	Vertical Envelope	Vertical exterior walls	Constituted from panels with expanded polyurethane (density D=38-40 Kg/mc) between two galvanized and prepainted flat sheets. Thickness 40mm.
		Vertical exterior Windows	Double leaf window, extruded aluminium profiles complete with single glass (4 mm).
	Lower horizontal envelope	Ground floor	Steel profile frame, suitable for wall and floor support. Water-repellent chipboard panels with a thickness of approx. 19-20 mm are fixed to the frame, above which a vinyl sheet is glued.
	Overhead envelope	Roof	Constituted from panels with expanded polyurethane (density D=38-40 Kg/mc) between two galvanized and prepainted flat sheets, thickness 40 - 50 mm. The shaped perimeter profile is made of 1.5 mm thick galvanized steel, which also acts as an eaves channel.



Tab. 1 - Technological analysis of traditional site cabin components according to uni 8290.

Tabb. 2, 3 - Next page. *Energy analysis of traditional site cabin components and comparison with legislative reference values; Summer checks on the traditional site cabin.*

ENERGY PERFORMANCE ASSESSMENT OF CONSTRUCTION SITE CABINS				
Components	**Performance indicator**	**Unit of measure**	**Performance of site cabins**	**Reference limit D.M. 26/06/15**
Roof	Thermal transmittance (U)	W/m²K	0,7	0,35 (Climate zone A–B)
				0,33 (Climate zone C)
				0,26 (Climate zone D)
				0,22 (Climate zone E)
				0,20 (Climate zone F)
	Periodic thermal transmittance (Y_{ie})	W/m²K	0,56	0,18
	Decrement factor (f_a)	-	0,95	-
	Time lag (φ)	h	0h, 19m	-
External wall	Thermal transmittance (U)	W/m²K	0,7	0,40 (Climate zone A–B)
				0,36 (Climate zone C)
				0,32 (Climate zone D)
				0,28 (Climate zone E)
				0,26 (Climate zone F)
	Periodic thermal transmittance (Y_{ie})	W/m²K	0,69	0,10
	Decrement factor (f_a)	-	0,979	-
	Time lag (φ)	h	0h, 40m	-
Floor	Thermal transmittance (U)	W/m²K	0,42	0,42 (Climate zone A–B)
				0,38 (Climate zone C)
				0,32 (Climate zone D)
				0,28 (Climate zone E)
				0,26 (Climate zone F)
	Periodic thermal transmittance (Y_{ie})	W/m²K	0,18	-
Windows	Thermal transmittance (U)	W/m²K	5,71	3 (Climate zone A–B)
				2 (Climate zone C)
				1,8 (Climate zone D)
				1,4 (Climate zone E)
				1 (Climate zone F)
	Solar Heat Gain Coefficient (with shading) g_{gl+sh}	%	0,8	0,35



some producers, more responsive to energy and environmental aspects, have introduced production lines with more insulated components. However, no measures have been introduced to improve thermal inertia and solar control, or to provide for integration of renewable sources.

The concept behind the nZEBox system completely transforms the essence and image of a construction site cabin: from the traditional concept of the container, unchangeable over time, and always the same under any circumstances and anywhere in the world, to a new model of 'layered container', with the possibility to change the layout, case by case, in order to optimize performances and achieve the goal of nearly zero energy site accommodation (Cannaviello, 2017). The system provides for a load-bearing structure in metal carpentry, a sort of exoskeleton, to be adapted to the existing monoblock, with a series of prefabricated and modular components for the vertical perimeter walls and for the roof, adaptable to the needs (microclimatic context, site characteristics, etc.). The overall stratigraphy will thus be constituted by a support layer, consisting of the pre-existing cabin; by a thermal control layer (which represents the basic component), and by an exterior cladding layer. The components' aggregation logic is the same for both vertical walls and roofing.

The requirements for the thermal control layer, i.e. insulation and thermal inertia, must be guaranteed at all times, regardless of the others. For this reason, the 'basic component' foresees a stratigraphy capable of guaranteeing the expected performance (in terms of thermal transmittance, periodic thermal transmittance, decrement factor, time lag), which must be verified in relation to the specific climatic zone, without taking into account the finishing layer, which can therefore also improve overall performance. The external surface cladding is particularly significant, both in terms of comfort performance requirements and energy performance requirements, and in terms appearance requirements. It is believed, in fact, that the external surface of the monoblock, assumes a strategic role, not only from the energy point of view, meaning in terms of solar control and renewable energy production, but also in relation to the 'communicative' function that the cabin can assume with respect to the context, so as to become the distinctive element to highlight the commitment to sustainability of the company. The integration of renewable sources is a very important aspect, since both the external vertical wall and the roof of the cabin, as well as helping to reduce energy losses, can become energy producers, to meet the energy needs of the site cabins.

The external cladding layer can perform different functions depending on the specific requirements: solar control; energy production (integration of renewable sources); communicative function (advertising image for the company, visual integration with the context). The wall of the construction site cabin is therefore transformed from a 'simple wall', in which the technical element consists of a main layer that performs almost all functions, to a 'complex wall', that is, formed by the union of several technical elements that are assembled to perform multiple functions. The same can be said for the roof. For the external cladding, different solutions can be envisaged, applicable to one or more

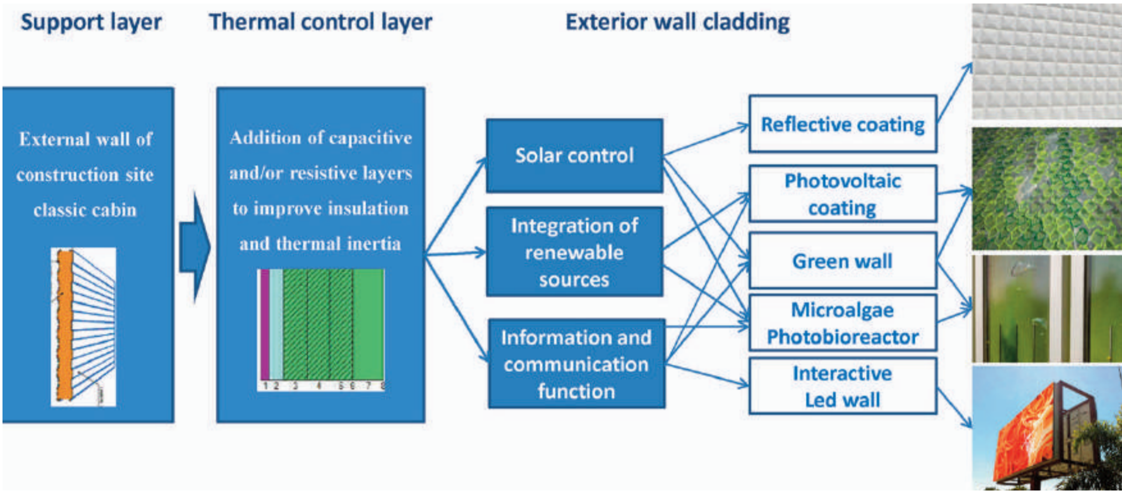


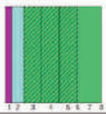
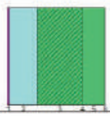
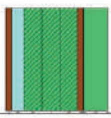
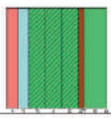
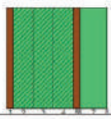
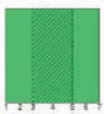
Fig. 1 - Diagram of the functioning of the external vertical wall of the construction site cabin.

ENERGY PERFORMANCE EXPECTED FROM nZEBox SYSTEM COMPONENTS				
Components	**Requirements**	**Energy Performance Indicators**	**Unit of measure**	**Expected performance**
Roof	Thermal insulation	Thermal transmittance (U)	W/m²K	< 0,32 (Climate zone A - B -C < 0,26 (Climate zone D) < 0,2 (Climate zone E – F)
	Thermal inertia	Periodic thermal transmittance	W/m²K	< 0,18 (*) < 0,3 (**)
		Decrement factor (f_a)	-	< 0,4 (*) < 0,6 (**)
		Time lag (φ)	h	> 8 (*) > 6 (**)
	Solar control	Reflectance	-	> 0.65 (Flat roof) > 0.3 (Sloping roofs)
External wall	Thermal insulation	Thermal transmittance (U)	W/m²K	< 0,4 (Climate zone A-B) < 0,3 (Climate zone C – D) < 0,24 (Climate zone E – F)
	Thermal inertia	Periodic thermal transmittance (Y_{ie})	W/m²K	< 0,1 (*) < 0,2 (**)
		Decrement factor (f_a)	-	<0,4 (*) <0,6 (**)
		Time lag (φ)	h	> 8 (*) > 6 (**)
Floor	Thermal insulation	Thermal transmittance (U)	W/m²K	< 0,42 (Climate zone A-B) < 0,26 (Climate zone C – D) < 0,24 (Climate zone E – F)
Windows	Thermal insulation	Thermal transmittance (U)	W/m²K	< 3 (Climate zone A-B-C) < 1,4 (Climate zone D-E) < 1,1 (Climate zone F)
	Solar control	Solar Heat Gain Coefficient (with shading) g_{gl+sh}	%	< 0,35

*Tab. 4 - Energy performance expected from the opaque and transparent components of the nZEBox system. * Where the average monthly value of horizontal irradiance in the month of maximum insolation is ≥ 290 W/m². ** Where the average monthly value of horizontal irradiance in the month of maximum insolation is < 290 W/m².*

fronts of the cabin: reflective wall (reflective ceramic materials); photovoltaic wall (integrated photovoltaic, Solar Ivy[4] type); green wall (with microalgae photobioreactors); Dynamic screen wall (videowall or Led screen type).

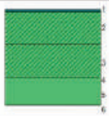
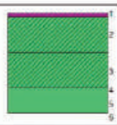
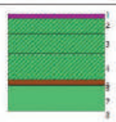
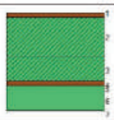
Figure 1 shows the block diagram with the layers of the vertical external wall of the site cabin and the functions and requirements for each layer. For transparent components, in addition to meeting the requirement for thermal insulation, it is necessary to ensure solar control, through the use of shielding systems or selective glass. The components of the Nzebox system are designed to be recovered for future and different reuse, with the aim of minimizing both assembly and disassembly times.

ENERGY PERFORMANCE OF EXTERNAL VERTICAL WALLS FOR DIFFERENT TECHNOLOGICAL SOLUTIONS							
Type of wall	Wall stratigraphy	Overall thickness	Superficial mass	Thermal transmittance	Periodic thermal transmittance	Time lag	Decremen factor
		cm	Kg/m²	W/m²K	W/m²K	h	-
Classic construction site cabin		4	7.84	0.70	0.69	0h, 14m	0.979
Type 1		16,1	57.80	0.30	0.13	7h, 20m	0.42
Type 2		17,4	12.30	0.23	0.23	1h, 16m	0.99
Type 3		17,1	49,3	0.29	0.09	8h, 26m	0.31
Type 4		18,1	82.80	0.30	0.08	9h, 43 m	0.26
Type 5		15,1	53.3	0.30	0.09	8h, 8m	0.30
Type 6		14,2	42,1	0.29	0.08	7h, 4m	0.29

Tab. 5 - Energy performance of external vertical walls of the different proposed solutions.

Setting objectives: requirements and performance to be achieved by the nZEBox system – The nZEBox system's goal is to conform the site cabin to the law requirements (Ministerial Decree 26/06/2015), in relation to the specific climatic zone, so as to ensure suitable conditions of comfort throughout the year, with minimum consumption of non-renewable resources. Since the logic on which nZEBox system is based is to make the various technological elements of the system interchangeable, through the creation of countless configurations, the performance check must start from the assessment of the individual components. Each of them must meet the minimum requirements set out in Table 4. Three different levels of thermal insulation have been designed in relation to the climatic zone in which the construction site will be located (climatic zone A, B and C, climatic zone D, climatic zone E and F).

As for Periodic Thermal Transmittance, different limits have been set depending on the average monthly value of the horizontal irradiance in the month of maximum insolation of the location where the construction site will be located. Minimum values have also been set for the decrement factor and time lag of the thermal wave of walls and roof. These values, which do not currently represent a mandatory legislative require-

ENERGY PERFORMANCE OF ROOFS FOR DIFFERENT TECHNOLOGICAL SOLUTIONS							
Type of roof	Roof stratigraphy	Overall thickness	Superficial mass	Thermal transmittance	Periodic thermal transmittance	Time lag	Decrement factor
		cm	Kg/m^2	W/m^{2}K	W/m^{2}K	h	-
Classic construction site cabin		4	7.84	0.70	0.69	0h, 14m	0.979
Type 1		17,5	57.80	0.23	0.05	7h, 40m	0.22
Type 2		19,9	45.9	0.20	0.04	8h, 5m	0.21
Type 3		17,1	49,3	0.29	0.09	8h, 26m	0.31
Type 4		18,1	82.80	0.30	0.08	9h, 43 m	0.26

Tab. 6 - Energy performance of the roof for the different proposed solutions.

ment, derive from the 'Qualitative assessment of the characteristics of the building envelope designed to limit the need for summer air conditioning'[5], and are differentiated according to the average monthly value of irradiance.

Component stratigraphy design and energy performance assessment – Six different types of stratigraphies of the basic component have been studied to be added to the vertical wall (Tab. 5) of the traditional cabin and four for the roof (Tab. 6), to improve its energy performance, not only in terms of insulation, but especially in dynamic summer conditions. It is believed, in fact, that in Mediterranean countries the control of thermal and solar inputs in the summer season is the most important aspect to consider (Cannaviello, 2010). «The external wall will ensure a higher dynamic thermal insulation, i.e. the internal conditions of the room will be less bound to the external ones, as smaller is the dynamic thermal transmittance Y_{ie} (i.e. the decrement factor does) and as greater is the time lag f [1-2,3]. It is therefore very interesting to find, for a given wall, the optimal stratigraphy that minimizes Y_{ie} and maximizes f» (Galbusera et alii, 2010, p. 89).

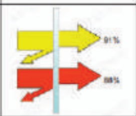
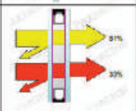
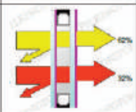
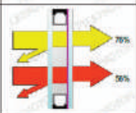
In order for the thermal control layer to guarantee the energy performance set out in the table in terms of thermal insulation and thermal inertia, the basic component must alternate resistance layers and capacitance layers[6]. The simulations carried out showed that the exclusive addition of resistance layers (8 cm of EPS with graphite), even if combined with a weakly ventilated air chamber of 5 cm (Type 2 solution), only meets the requirement for thermal transmittance in all climatic zone, but is not sufficient to improve the inertial behavior of the cabin (time lag 1h and 16m). For the layer with high thermal capacity, the use of wood wool panels mineralized with graphite has been tested. It is a natural mineral insulation characterized by very low thermal diffusivity (having a specific heat of 2090 J/kgK). These panels, in addition to ensuring excellent performance in the summer dynamic regime, are an environmentally friendly product as they are made with completely natural raw materials. They are also interesting in relation to the embodied carbon, as they derive from the use of only three materials, water, wood and magnesite, without chemical components, therefore they do not release any type of gas or harmful substance, and also the residues of production are biodegradable. For the resistive layer, the use of expanded polystyrene panels with graphite additive was investigated[7]. Inside these panels the EPS (Sintered Expanded Polystyrene) polymer is combined with a natural resource: graphite. This solution guarantees high thermal performance, even at low thicknesses, thanks to the graphite particles contained inside the insulating sheet. It guarantees dimensional stability, perfect flatness and safe gluing, even during maximum solar radiation.

In some of the proposed solutions additional layers have been included to improve dynamic performance and component stability. The different solutions have been designed to meet the requirements set out in Table 4, both in terms of thermal transmittance and thermal inertia, in relation to the specific location (climate zone and irradiance). They are therefore not always applicable, but depend on the location of the construction site.

For each technological solution, summer checks were also carried out to evaluate the inertial behaviour and the internal surface temperature. It is precisely in summer, in fact, that the cabin shows the greatest criticality, especially in the mediterranean countries.

In terms of energy, the window of the traditional cabin is one of the most critical elements of the envelope. It is inadequate both in terms of thermal insulation (Uw = 5.71 W/m^{2}K) and in terms of solar control (g_{gl+sh} = 0.8). The choice of technological solutions (Tab. 7) has been aimed at improving the energy performance of the windows in both aspects. For the glass, the calculation was carried out using the Pilkington Spectrum software, which verified the solutions proposed with respect to to solar control and light transmission. The energy performance of the window (glass + frame) was verified using the Termus software for calculating global thermal transmittance (U_{f+gl}). First two solutions aim to ensure solar control even without the shielding system, meeting the regulatory requirement only through the glass characteristics (g < 0.35). The Type 3 solution, on the other hand, has been designed for cases where solar control is not required for the glass, or because of the presence of shielding systems, or in the presence of shadows, or where the openings are located on the north front.

Conclusions – The technological and energy analysis of the traditional cabin has allowed to highlight the main criticalities and to develop specific strategies aimed at optimizing the energy performanceThe specific choices, however, must come from a careful

ENERGY PERFORMANCE OF WINDOW SYSTEM					
Window type		Thermal transmittance of glass	Total thermal transmittance (g+f)	Solar Heat Gain Coefficient	Light Trasmission
		W/m^{2}K	W/m^{2}K	%	%
Classic construction site cabin		5.8	5.71	88	91
Type 1		1.2	1.7	33	61
Type 2		0.9	1,2	32	62
Type 3		1.2	0.09	76	56

Tab. 7 - Energy performance of the window system for the different proposed solutions.

analysis of the climatic and microclimatic conditions and of the context: the construction site cabin must be transformed into micro-architecture contextualized and eco-efficient. Technological solutions therefore need to be assessed, in the context of the specific objectives, on a case-by-case basis. The site cabin, which over the years has remained one of the most obsolete elements of the construction process, can instead become chameleonic, transforming itself into a space for technical and formal experimentation to develop sustainable, resilient and high-tech solutions, also applicable in different contexts.

Placing such a product on the market can generate benefits for the company that uses it, not only in terms of reducing the consumption of non-renewable primary energy, but also in terms of image and greater comfort for workers. And, more generally, the benefits can concern the entire community, thanks to the reduction of the costruction site carbon footprint. The main limits are unfortunately related to the additional costs compared to the traditional site cabin. Only by understanding the added value of such a system could construction companies be prepared to invest in technological innovation and the environmental sustainability of the construction site. The concept behind the nZEBox system, designed to meet the construction site's sustainability requirements, could involve a wider market relating to all activities requiring temporary prefabricated structures for office use, emergency structures, refugee camps and event structures.

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NOTES

1) Research scholarship for Open Innovation processes within the priority technological ambits of RIS 3, financed by the Region of Campania for the period 2017-2018.
2) The module most commonly used as a temporary office on construction sites has external dimensions, length of 6 m ± 2 cm and width of 2.40 m x ± 2 cm. The minimum internal height is 2.30 m, but versions with an internal height of 2.40 m and 2.70 m are available. The monoblocks can be combined in different configurations, even on several levels.
3) UNI 10349-1:2016 – Heating and cooling of buildings – Climate data – Part 1: Monthly averages for the assessment of the thermal energy performance of buildings and methods for allocating solar irradiance to the direct and diffuse fraction and for calculating solar irradiance on an inclined surface.
4) Solar Ivy is a prototype of a photovoltaic panel, created by SMIT (Sustainably Minded Interactive Technology) and inspired by the climbing plant. It is, in fact, a series of photovoltaic cells printed with conductive ink to resemble leaves, which are anchored on a steel mesh.

5) Contained in point 6 of the Italian National Guidelines for Energy Certification (Ministerial Decree 26/06/2009).
6) i.e. layers with a low thermal diffusivity (m2/Ms).
7) The technical characteristics of the material are related to a product of the company Isolkappa Srl, partner of the research project.

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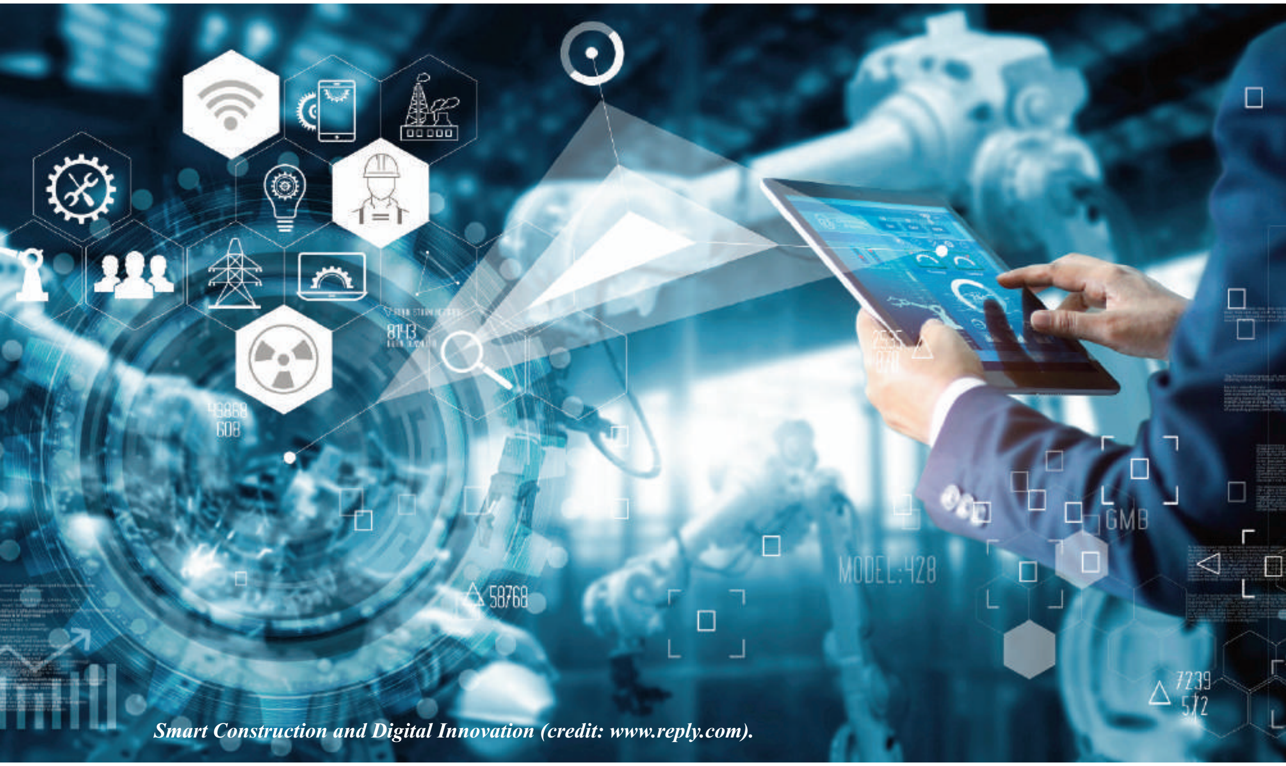
[a] *Monica Cannaviello, Architect and PhD in Technology of Architecture and Environment, she is Adjunct Professor at the Department of Architecture and Industrial Design (DADI) of the University of Campania 'Luigi Vanvitelli' (Italy). She has participated in several research projects, about energy efficiency of buildings, technological innovation and sustainable construction. Mob. +39 335/81. 57.889. E-mail: monica.cannaviello@unicampania.it*



Smart Construction and Digital Innovation (credit: www.reply.com).

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HYPER-DESIGNER
DESIGNER FIGURE AND PRACTICE IN ADVANCED BUSINESS CONTEXTS

Mario Bisson [a], Luca Pizzolato [b], Stefania Palmieri [c]

section
DESIGN

typology
ESSAYS & VIEWPOINT

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ABSTRACT
This report claims to analyse and describe the way a professional designer's work is evolving, focusing on the liaison with industry. What company role do designers play and what skills do they master? What aims do they have? Modern technologies and a change in the socio-economical background have revolutionised enterprises. Design must now breach new and unexplored boundaries concerning both engineering and innovation. The rising professional figure, capable of dealing with these complexities, expert designer, skilled manager, coordinator of distinct aspects of knowledge, will fulfil the definition of Hyper-designer.

KEYWORDS
working process innovation, operating methodology, industry 4.0, network, design thinking

Industry must now face new and ever more complex challenges, based upon the competitiveness of global markets. What are the major challenges nowadays? Which tools and skills do companies need to stay competitive? Who do they address in order to innovate? Founding a company now means facing global competitors that aim to satisfy emerging needs tailoring their solutions, rather than providing more affordable alternatives to existing goods (Shani and Divyapriva, 2011). Seeking innovation then would appear to be the only and obvious way to generate value and manage to stay effectively competitive. The required skills, knowledge, and expertise change and, consequently, professionals and stakeholders must change as well. Everything is subject to revision and change of strategy, a strategy which needs, now more than ever, to evolve and update within a limited time-frame inconceivable up until a few years ago. Among all the others, a designer's work is called for an advancement in its interdisciplinary nature and its relation with costumers: supporting industry does not only mean designing an item and its functionality but its role must affect all operational levels (new materials, new markets, new purchase proceedings, new retail channels) which combined make the item attractive to the market. This report aims to prove how a modern designer's modus operandi is leading the innovation and development process working on several levels of the current socio-economic framework.

Evolving companies – Let us try to identify the company development within the complex frame of the so-called Industrial Revolution 4.0. Within new social and technological backgrounds and due to several economical and financial crises, a new professional praxis, more capable to face needs and unknown financial factors, has come to life. Industry 4.0 does not simply mean using robots or softwares in order to boost production, but it also means combining the technological advancements with which science gifts us. A revolution based not on a single technology but on a set of converging ones. Every single company must realise how to best combine them, based on their unique features. In short, this is the goal of the so-called Digital Mass Production (Bianchi, 2017). However, this should not be the only distinctive feature of this new Industrial revolution. Technology remains a tool to manage the complex relation effectively and punctually between the rising demand and our responsiveness in terms of production. Several difficulties, which need to be tackled, originate from the very meaning of globalisation: the production of goods and services on a global scale is related to producers and consumers coming from vastly different social, economic, and cultural backgrounds.

The new production-management, based on interconnecting people and machines (Internet of Things[1]), and digitalised production, make high value transformations possible. For instance, limited series manufactured in a site responsible for both design and production. Implementing these technologies would consequently make moving production to cheaper countries where quality and flexibility are not guaranteed unnecessary. Basing design and production in the same place has proved to be instrumental to reach innovation. Company relocations, that took place within the last few decades, have caused European companies to undergo a process of professional impoverishment. Sometimes these companies are not capable of developing renovation projects, due to a lack of skills and resources, leading them to lose competitiveness and jeopardising their international role.

German designer Stephen Diez (2019), argues that companies are ever more incapable of developing internal innovation projects dealing with goods and goods production. A Design-Driven project (Verganti, 2009) must entail important innovation contents, he argues, and when the company cannot conceive them, a designer must take charge, for a designer's goal is that of providing smart and pragmatic solutions. An iconic example of how recent technologies have shaped design and entrepreneurship is rapid prototyping, a medium, now available to all sort of companies, which has revolutionised both design and production. A wise use of the afore mentioned medium can boost innovation: prototyping is useful to evaluate quickly and with relative low expenses new and perhaps extreme solutions. Fear to walk down unexplored paths in fact often leads to conservative choices, free from new costs and risks linked to the adoption of new machines and suppliers. Hence the importance of prototyping, an insurance to 'fail' quickly, if necessary, and evolve just as quickly, as theorised by Brown and Wyatt (2010). Innovation implies risk, foreseeing and minimising it allows for better developing innovation projects with less concern.

Digital transformation is pervasive and development processes, just as organizational structures must not lag. Production rate is nowadays essential to competitiveness, production must be organised in order to undergo continuous changes and the creation of close-knit teams is also key to not slow it down. It is therefore necessary to rely on figures of reference who are able to convey innovation also through the sharing of information and trigger an approach to participatory design[2] on all levels favorably oriented towards change and evolution. Another instrumental aspect is that of management's decision making. Managers are supported by several technological aids, a company needs however to be in the lead of by well-structured mindsets, proficient in providing 360° investment and partnership scenarios. The fact that technology itself is not enough to take successful choices proves once more the importance of methods such as Design Thinking[3]. Design plays a fundamental role in building efficient innovation strategies and designers are necessary to the evolution of Industry 4.0 which strongly demands specialised skills, tools and technology suited new and complex industrial circumstances.

Design and Industry – These two spheres are strictly and historically linked to each other by an evolving and dynamic relation. Design and industry are symbiotically bound, one's evolution causes the other to evolve as well. Thomas John Watson Jr[4] marked history when, giving a lecture at the University of Pennsylvania, he declared: «Good design is good business». Watson was an admirer of Olivetti's work, and tried to replicate the way the Italian conceived, developed and presented his products.

In Italy, the debate over the link between companies and design was born in the 1950's when, after the war, Italian industries became concerned with improving the quality of serially produced goods. According to Vittorio Gregotti[5] (1986), Italian design became crucial to conceal the structural and technological deficiencies companies were suffering. This debate was vital to the establishment of the award 'Compasso d'oro'. The idea was to reward the production of culturally significant goods and stimulate the growth of companies keen to develop quality production, thus making this award the first of its kind. Augusto Morello[6] (2009), one of the founding members of this award, argued that the relation between industry and design should be based on mutual curiosity, in other words, a productive encounter between the two can only take place when they are both able to understand the each other. In Italy, this relation has especially grown within the small framework of family-owned small and medium-sized enterprises (SMEs), which prompted the creation of a new, unique, and worldwide known profession, the designer. We live in a socio-economical context which does acknowledge the relevance of designers and requires them to develop higher quality design solutions.

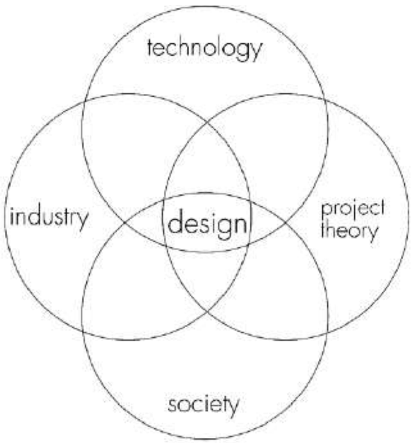
Design Thinking methods are becoming, on various levels, increasingly common among company managers. This happens because design offers a way to combine analytical skills, often supported by quantitative methods, with problem solving strategies, which are more critical, creative and understanding towards human and social factors (Hollanders and Cruysen, 2009). Design is key to providing solutions to inhomogeneous and complex circumstances. It would perhaps be interesting to point out that within the last ten years companies and enterprises like: Lunar Design and Veryday of McKinsey, Doblin and Flow Interactive of Deloitte, Intuity and Optimal Experience of PwC, Fjord e Reactive of Accenture have been hiring designers in order to change their production strategies.

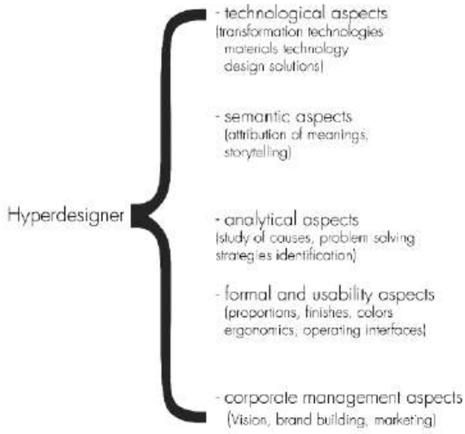
In the modern day, society gives most credit to enterprises that no longer make any material items. Consistency, reliability, experience, and the ability to build an image of themselves are now more relevant features than quality. Several high-tech companies, in the last five years, have remarkably invested in redesigning their work praxis: IBM have changed the designer-developer ratio from 1-72 to 1-8, Dropbox from 1-10 to 1-6 (dell'Era, 2018). The Design-Driven method is also based on studying people's functional needs as well as their emotional and social ones. This attitude acquires even more relevance within heavily digitalised contexts, usually only meant to provide technical performances. Digital technologies have not only accelerated business proceedings, but also triggered and spread creativity. This implies, that widespread digitalization process of society and products, stimulated by IoT and other channels, encourages design-oriented strategies. Designers consequently must channel, organise, and foresee all the possible business scenarios that technology is likely to bring into the world.

New context design – As we have previously discussed, design must explore new and unexplored contexts, hence its need to keep evolving and seeking more suitable tools. Due to its changing nature and its deep relation with the monetary and social circumstances, we are not able to let design fall under a static theoretical definition. We shall then refer to the definition given by the World Design Organization (2015), and updated during the 29th general gathering in 2015: «Industrial Design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative products, systems, services, and experiences. Industrial Design bridges the gap between what is and what's possible. It is a trans-disciplinary profession that harnesses creativity to resolve problems and co-create solutions with the intent of making a product, system, service, experience, or a business, better. At its heart, Industrial Design provides a more optimistic way of looking at the future by re-framing problems as opportunities. It links innovation, technology, research, business, and customers to provide new value and competitive advantage across economic, social, and environmental spheres. Industrial Designers place the human in the centre of the process. They acquire a deep understanding of user needs through empathy and apply a pragmatic, user-centric problem-solving process to design products, systems, services, and experiences. They are strategic stakeholders in the innovation process and are uniquely positioned to bridge varied professional disciplines and business interests. They value the economic, social, and environmental impact of their work and their contribution towards co-creating a better quality of life».

This declaration clearly states that design's ambition is to play the main character on the stage of innovation, managing and coordinating different sorts of knowledge, aiming not only towards financial success but also to social and environmental development (Fig. 1). Ezio Manzini's opinion summarises this thought very well. According to him society is made of people who need to design, individually and collectively in order to achieve their short and long-term life projects. This social stage is fertile for the growth of designers who function as social players capable of driving innovation on different scales (Manzini, 2015). The fact that all individuals have projects means all individuals need someone to help develop them, an expert who can master the cultural and practical tools which are in the hands of us all. Manzini also argues that what used to be called design has evolved, perhaps more quickly than the cultural context in which it was born. Design, on a professional and disciplinary level came to existence at the beginning of the last century, in connection to the changes lead by industrial development, resulting in a link between its original definition and the needs of the industry. The consequence was design being associated to industrial serial production. However, the recent social and industrial changes have linked design not only to goods production but also to services, organisations, and a growing number of everyday-life activities. Especially the latter are no longer conventionally performed (through the adaptation of 'the way it was always done' method) and need to be constantly re-designed. Therefore, evolved design must resemble an amalgamation of skills, accurate cultural tools that can solve all kinds of issues ranging from conceiving an item to co-creating social services and shaping new forms of democratic representation. A designer must be prepared to work under any sort of circumstances.

Hyper-designer: who is and what is his praxis – What has been discussed so far entails a reconsideration about the professional role of designers, their specialised skills, and peculiarities. A designer's contribution must be more advisory, strategic and leader of methodological and manufacturing innovation. All these aspects combined bring to life a real paradigmatic alteration which revolutionises a designer's work. Previously, a designer's profession was conducted vertically, now a Hyper-designer operates on multiple horizontal levels. The scientific and technological progress constantly fathers new specialised expertise. A designer, however, seeks a managerial role, which would not alter the integrity of existing projects and be instrumental in organising different opportunities, according to a company's limits and desires. A designer's vocational training is naturally multidisciplinary, and interdisciplinary by inclination, in other words a designer must aim to create cohesion between otherwise independent disciplines, for instance the technical and humanist spheres. Design contributes to providing strategies to analytical issues (cause analysis and problem-solving), semantic aspects (meaning allocation and storytelling), technicalities (choice of materials and specific project solutions), formal aspects (ratios, proportions, and operating interface) and finally company management, such as brand building and marketing (Fig. 2). Due to the





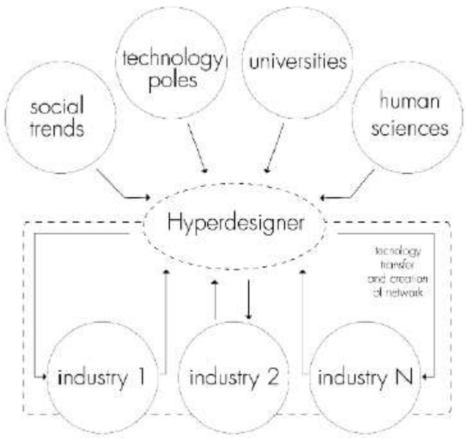


Fig. 1 - Design as a union and intersection of independent realities.

Fig. 2 - Hyperdesigner's contribution on different operational levels.

Fig. 3 - The central role of the designer for business innovation.

number of disciplines and skills designers needs to master, their work is often hard to define without ambiguities and can only be limited to the wider operating range of project making.

The collaborative paradigm – Just as in the previously mentioned case of the fertile partnership with Italian SMEs, the optimal operational paradigm for the Hyper-designer is to support companies through professional collaborations from outside the organization chart. The successfulness of this relation derives, on the one hand, from the independence accorded to designers which is key to gaining new skills and experiences and provides technological knowledge sharing. On the other, not belonging to the company's hierarchy allows the designer to operate within the company's network and decide if, where and how to take action and effectively establish links between company members and outsiders more freely. A hyper-designer is moreover capable of 'revising' a company's innovation process. Nowadays, managers hire designers bearing in mind the innovative contribution they can bring, rather than simply having them 'sign' a product to gain visibility. This is further proven by the furnishing industry, naturally keen on style, whose managers are not hiring popular designers but are drawing long-term contracts with the goal of obtaining more accurate and effective results.

Hyper-designers then play a medium to long-term role and specifically meant for the one company that hired them. They establish connections between parties, open cooperation opportunities with new stakeholders, bring to companies well-structured and functioning business strategies, which are fundamental to gain a competitive edge. A hyper-designer is called to face evermore complex and unknown scenarios. From a professional point of view this implies constantly challenging and testing one's own expertise. Only a deep and continuous social and technical analysis can be sure to obtain and maintain successfulness.

Conclusion – It would be hard to summarise every one of the far too many shifts and transitions that are taking place within the boundaries of global industry, design, and society. We have managed, however, to prove the necessity of having professionals who are capable of conceiving, coordinating, and developing strategic innovation processes. In light of the concepts expressed above, it is possible to identify a new virtuous and paradigmatic pattern which can trigger innovation and growth and is pragmatically and strategically embodied by Hyper-designers. (Fig. 3). Promoting and facilitating this dynamic pattern based on company networks, research and professional project making becomes more than ever crucial to spark cooperation and skill transfer. Companies that wish to address the innovation challenge must be open to technological development and support wide nets of strategies aimed to social, economic, and environmental evolution. Likewise, an evolved designer must seek to become increasingly Hyper if they strive to play the leading role on the stage of design, industry, and society.

NOTES

1) Term coined by Kevin Ashton, of Procter & Gamble, later MIT's Auto-ID Center, in 1999. Internet of Things (IoT) is the extension of Internet connectivity into physical devices and everyday objects.
2) Approach to design attempting to actively involve all stakeholders, originally born in 1970s in Scandinavia as co-operative design, and later evolved.
3) Managerial methodology developed and taught at Stanford University starting from 2005, oriented to the problem solving of complex problems through the integration of analytical and creative activities.
4) Thomas John Watson jr, historic CEO of IBM from 1952 to 1971.
5) Vittorio Gregotti, Italian architect, essayist and designer awarded the 2012 Milan Gold Medal for his career. For further details see: Gregotti, 1986.
6) Augusto Morello, design theorist trained in the field of industrial chemistry, business manager with Olivetti and La Rinascente, a lively promoter of Italian design, directed the magazine Stileindustria and held various institutional roles including that of President of the Milan Triennale and

ADI (Association for Industrial Design). For further details see: Morello, 2009.

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[a] *Mario Bisson, Architect, Associate Professor at the Design Department of Politecnico di Milano (Italy), Scientific Director of the EDME interdepartmental laboratory of Politecnico di Milano, Scientific Director of Color laboratory Politecnico di Milano, founder and scientific director of MDA, member of the Polidesign board of directors scrl. Mob. +39 331/72.65.620. E-mail: mario.bisson@polimi.it*

[b] *Luca Pizzolato, product designer for innovation, carries out professional research in the field of product and service design. He is teaching assistant at the Politecnico di Milano (Italy). Mob. +39 347/63.05.903. E-mail: luca.pizzolato@mail.polimi.it*

[c] *Stefania Palmieri, Architect, PhD in Industrial Design at the Design Department of the Politecnico di Milano (Italy), where she is a permanent researcher. She is responsible for relations with companies and professions for the School of Design. Its teaching, research and management activity aims to create a network of collaboration with the world of production at 360°, aimed at strengthening and stabilizing synergies between University and Enterprise for the creation of cultural and interchange networks. Mob. +39 335/67.59.314. E-mail: stefania.palmieri@polimi.it*

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ADDITIVE MANUFACTURING
DESIGN OF FUTURISTIC ARTIFACTS

Benedetto Inzerillo [a]

section
Design

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Essays & Viewpoint

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Abstract
Industry 4.0 is making its contribution to changes in the structure of the world economy to such a considerable extent that there is talk of a new industrial revolution. For some years now all the great business enterprises have possessed costly 3D printers that can create any artefact or component with little effort. This paper deals with the applications of additive manufacturing as part of the transversal processes in the field of design in research and concrete actions by design-oriented firms intending to invest locally. Among the projects developed in Palermo mention should be made of two interesting cases, where the innovation is geared towards the market of carbon-reinforced plastic and the integration of digital production processes.

Keywords
flexibility, personalization, technological, digital and robotic innovation, additive manufacturing

Ever since the crisis at the beginning of the 21st century a new industry called Industry 4.0 has gradually emerged. The process of transformation that has shaped it boasts a technological set-up, with an ever more significant impact, not only on the manufacturing sector but also on services, ranging from business to personal welfare and to services devoted to the community. Industry 4.0 is making its contribution to the changes in the structure of the world economy in such a decisive manner as to provoke talk of a new industrial revolution (Anderson, 2010). The inter-connection of technology in terms of the internet of things, artificial intelligence, robotics, additive manufacturing, virtual reality, digital traceability, self-propelled vehicles and drones, is now altering our lives (Schwab, 2016). For some years now, all the great firms have possessed large and costly 3D printers, which, by means of CAD programmes, and with little effort, can manufacture any object or component (Anderson, 2013; Sposito and Scalisi, 2017). Applications of additive manufacturing represent a principal goal, as part of the transversal nature of the field of design, from research to the tangible actions of design-oriented firms intending to invest locally. These artefacts are not the simple product of a practical function, but incorporate an infinite number of ‘ways of being’, giving rise to feelings, relationships and explanations of our world.

In the words of Maurizio Vitta, things have a voice and portray a world of meaning to those who have ears. «Whatever, at first sight, looked like an inert ‘thing’, a fragment organized from material which embodied a precisely defined and infinitely repeated function (something static, therefore, fixed once and for all on the stage of motionless daily life), reveals itself to become […], all of a sudden, a shape-shifting body, which then finds its place in time no less than in space, which takes on various features and physiognomies in accordance with the situations in which it is to act, and which is a generator of energies of disparate kind: semantic, symbolic, aesthetic, technical, ergonomic, cultural and so on. Whatever presents itself in this perspective is no 'object'; it is an event that comes alive through its process, which unravels itself before our eyes in continuous transformations, and which still remains inflexibly identical to itself and faithful to the task assigned to it from the very first moment» (Vitta, 2016, p. 6).

New Industry 4.0 – In this new open and competitive, global context, as intimated by Patrizio Bianchi, «an ever greater authorising element in the new industry is represented by the continuous inter-connection of every single individual, of every single business enterprise, every research structure in relational planetary networks. The real value added is identified more and more often in research products, which themselves become proto-types for industrial development, the cost of production of which proves to be much lower than the cost borne in achieving its initial formulation» (Bianchi, 2018, p. 66). An obvious example might be that of software, the duplication of which sustains marginal costs compared to those required to achieve its initial definitive form. With these prerequisites, the difficulties in entering the market for new competitors are subject to significant changes, moving from the dimension of production plants of large factories to the organization of laboratories in which prototypes are created, within the actual firm itself, or in research structures that are part of, or linked to, the University. The development of digitalization consents the continuous inter-connection between productive systems and, above all, between individuals belonging to populations a long way from each other, in terms of history and tradition; therefore, it is no longer only the development of telecommunications and informatics that are at the basis of the new industrial revolution, these having characterized the phase of the third industrial revolution (following the long Fordist period).

Patrizio Bianchi continues: «This hyper-connection, with the relative exponential data production, not only generates the possibility of responding to demand deriving from individual needs, but must also become a tool for tackling the large global challenges, such as water shortages, sustainability of life in large cities, famine and social inequality, which today represent new public assets at the global level» (Bianchi, 2018, p. 66). The social changes that have taken place over these years of global interconnection are consenting the development of abilities and skills essential for applying all the available technology, which over the next few years, will play a part in responding to the demands that characterize this historical period. The integration of different productive and scientific systems represents the new approach that enables us to tackle and handle the issues and the complexity of the contemporary world, but is also decisive in the organization of cyclical global production chains. Many firms have relocated the various phases of production to more competitive contexts, whilst maintaining the research, planning and control structures of the productive cycle in those countries in which science and technology are on a more solid footing o the systems of production.

Industry 4.0 is not only a moment of considerable technological advance, but also represents the capacity to put together science, technology, skills and social contexts, so as to respond to both general global issues and the demands of the individual (Lombardi and Rossi, 2017). It is worth making a few considerations: Industry 4.0 production has the aim and the capacity to introduce differentiation without interruption, in an industrial productive cycle, ending with personalization of the final product (generated, however, in series). As claimed by Adam Smith (1973)[1], there arises a problem of coherence between organization of production and the size of the market. The possibility of producing enormous volumes of personalized goods is today linked to the possibility of selling these very goods on the world market. Artisan production is an example of the advantages deriving from the utilization of the same skills and the same machinery for the production of various goods; the tailor can create both ceremonial and sports clothing, incorporating all the work-phases, because he has the skills and equipment that enable him to move from one product to another uninterruptedly.

On the other hand, Fordist production is an example of efficiency based on specialization on a single product, which is built by dividing up the production cycle into successive phases so as to optimize the skills and equipment regarding a single productive activity. In the first case, if one wishes to increase production, one has to arrange the workers in parallel formation. In the second case, however, the workers are arranged in line and are specialized in one single operation; in this way they increase the speed of execution, but inevitably miss out on other skills required to construct the final product. In the first case we might have personalized products for an individual, but at high cost; in the second case, the price will be lower for a standardized product.

In conclusion, Industry 4.0 is endeavouring to overturn the order of things, by changing the way of working and the nature of the organizations by means of a process of digitalization of the manufacturing sector and the refurbishment of the chain of values (Cipriani, Gramolati and Mari, 2018).

Generative Design – Among the most exciting issues linked to the manufacturing industry of Industry 4.0, we certainly find Generative Design, which can be described as a method of planning in which the output (be it an image, a sound, an architectural model, an animated object) is generated by a set of rules or an algorithm, thanks to the utilization of software (Wikipedia, 2019). In brief, the designer, thanks to this software, by inserting the structural limits of a project, is able to try out thousands of different solutions simply by pressing a key, and thanks to the results of these simulations, he can choose the best configuration possible for the desired artefact, with less wastage of time, material and money. This revolution is today already providing considerable feedback

(Bohnacker, Gross and Laub, 2012). Apart from being used on a daily basis in the design of industrial constructions of every kind, it is also utilized in futuristic projects, as in the construction of the first stainless steel bridge in the world, created entirely in 3D by the robotics company MX3D, or, the design on the part of Autodesk for Nasa of a lander, in the shape of an ultra-light spider, for the landings of space-vehicles.

As Beth Comstock (2018), author of the book Imagine It Forward, explains, generative design can be applied everywhere: from the design of houses and hospitals to the design of cars and motorcycles and, why not, for space travel. Let us imagine we need a chair and so establish certain parameters: it has to bear a determined weight, it has to be made of plastic and metal, its cost must not exceed a certain figure. So, we try to imagine applying these parameters and pressing a key; in a few minutes we shall see on the screen thousands of possible variations of the chair, each of which responds to the parameters demanded. Generative design is a sort of invisible revolution, difficult to understand for those not working in the field, but crucial for companies in reducing costs, the choice of materials and production techniques, and for improving the quality of the project, its efficiency and performance at all levels. The process is complex, almost handcrafted; there are thousands of algorithms that are continually being mixed around. These are hybrid technologies and methods, with nobody using algorithms in exactly the same way. Recently, at General Electric, an aeroplane engine was designed using generative design. Its predecessor was made up of nineteen pieces whereas this one, designed by applying generative design and additive manufacturing, was a single item weighing about a third. In the same way, Airbus designed a panel separating the part of the cabin where the cabin crew operate from the part where the passengers are seated; thanks to the algorithms this panel weighs 55% less than its predecessor. It was designed commencing from the growth-structure of mammal-bones and manufactured additively, because the forms created by generative design cannot easily be produced using traditional methods.

In all probability, with several constraints, this represents the future. Generative design will shatter all paradigms and consent the completion of designs outside the traditional framework. At present it is easier to design than to produce, because, given the parameters, the algorithm aims to construct an infinite number of versions of a product that complies with these paradigms. The problem, if any, is placing new forms on the market; it is easier to build more efficient and cheaper variations with the technology we already possess. A few examples: the insides of aeroplane wings are completely different from how they were ten years ago and, in many cases, have already been designed using and applying the thousand variations that generative design consents, but looking at them they seem the same. If they had a completely different form it is probable that nobody would trust them. Innovation is often disguised, since the general public is not always ready to understand it. Therefore, we must not imagine bold new forms; the aeroplane of tomorrow will be very similar to the one of today, but it will be lighter and might also fly a little more slowly. Reducing cruising speed is the best way to permit passengers to pay less and reduce costs with regard to weight and structure. The passenger might not like spending a longer time on his/her flight, but will appreciate the cheaper ticket. In other cases, it will be different; the key issue for generative design will be to remove material from a product to make it more efficient, lighter and less costly. This is actually already happening in the field of product design. An example for all is the new Illy moka pot, where the internal pressure and other parameters have been established and software has generated an infinity of variations. On the inside it is the computer that produces the moka, on the outside it is Alessi.

Additive Manufacturing and Generative Design – It is in this field that particularly significant projects are emerging. Among others, it is worth mentioning the experiences in the field of Generative Design of Francis Bitonti, who, in 2014, in collaboration with Michael Schmidt Studios and Shapeways, created the first Unibody parametric item of clothing, produced with additive manufacturing (Fig. 1), and in 2015, Molecule Shoe, a model of shoe created with Game of Life, an algorithm conceived in 1970 by the English mathematician John Conway, which generates clusters of three-dimensional pixels (Fig. 2). In 2016, the American studio Nervous System created a new type of sole for personalized running shoes, for the footwear company New Balance, with a foam structure constructed on the basis of the client's physical characteristics (Fig. 3). One of the main advantages of parametric additive manufacturing processes is being able, layer by layer, to add forms continuously characterized by extremely complex geometrics.

In the words of Dario Scodeller and Emilio Antinori (2017, pp. 34, 35), «much of the technology applied at the end of the 1970s in the field of rapid prototyping, has today become an actual production process for finished products. In this design process, via so-called slicing software, the virtual model generated in nurbs or mesh and then codified in a binary file, is subdivided into horizontal planes connoted by specific characters, such as density and filling form, thickness of leather, intensity of layers of horizontal subdivision, speed of growth, variation and positioning of diverse materials in the same component. In contrast to other traditional processes that subtract or conserve mass, this method of construction through aggregation of materials leads to a better management of the geometric complexity and, consequently, the possibility of combining functions and components».

In the field of additive manufacturing a new development in innovative processes is emerging, with the combining of robotics and materials (as in the case of the Sicilian start-up Ocore, which we shall be looking at later). One of the first to use an anthropomorphic arm for the extrusion pf thermoplastic polymers, was the Dutchman Dirk Vander Kooij, who, in the last few years, has created a great number of self-produced objects (Fig. 4). Fashion designers such as Iris Van Harpen and Anouk Wipprecht, creator of the spider-dress (Fig. 5), have collaborated in the production of artefacts created in 3D printing and electronically controlled kinematic motion. The artefacts designed by Joris Laarman, on the other hand, are the result of research combining generative modelling

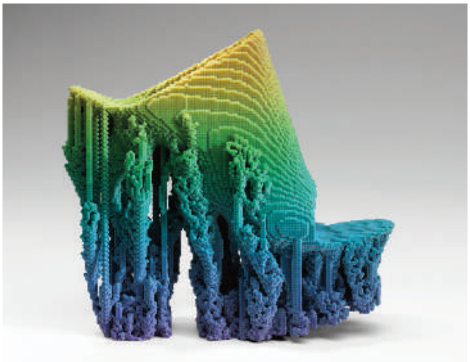


Fig. 1 - F. Bitonti and Micheal Schmidt Studios, Parametric Unibody dress, *New York 2014.*

Fig. 2 - F. Bitonti, Molecule shoe, *New York 2015.*

Fig. 3 - New Balance, Soles for personalized tennis-shoes, *Boston 2016.*

Fig. 4 - D. Vander Kooij, Endless Chair, *Zaandam 2010.*

Fig. 5 - A. Wipprecht, Spider dress, *Amsterdam 2015.*

and additive construction of Unibody products; one example is the Starlings Table, created using a 3D flight simulation programme, based on Craig Reynolds's boids algorithm, with which Joris Laarman simulated a flock of birds frozen in a given moment of generation and converted into a self-supporting, three-dimensional structure (Fig. 6).

Additive technological processes have made it possible to broaden the project's horizons, especially in the 'vision' of the near future (Autodesk, 2017). The first generative design products were developed in the bio-medical sector, and the aeronautical and aerospace industries, which demand important technological performance; studies have recently been added in disciplinary areas such as architecture, lighting design, product design, fashion design and all those sectors in which the potential to create forms via these new instruments, appear compatible with their main lines of aesthetic research. In this new design context there are basically two types of approach: either the creation of a totally new algorithm geared towards a final product, or, alternately, the utilization of an existing algorithm, modified and adapted in function of the artefact to be produced. The relationship between formal research and structural research in this field does not have a clear boundary and the established computational design strategies, which are aimed at improving structural performance, are supplemented by form-finding strategies that have been developed through intuitive processes (Figliola and Battisti, 2017). The innovative aspect of this new area of design consists in the absence of a predefined goal as regards the formal result; to this end, the statement by the computational designer Alessandro Zomparelli is interesting; he considers generative products as 'fossilizations of the digital world', and, therefore, signs of an algorithmic process that produces a flux of forms that are nothing but a progressive stratification of solutions.

Fig. 6 - J. Laarman, Starlings table, *New York 2010.*

The Generative Design of Philippe Starck – In the world of design, Stark is one of the creative spirits with the most success and the greatest impact. The long list of his iconic creations seems to have no end, but in his long career there is still something he has not achieved: to work alongside an intelligent machine in a process of co-creation. At the Salone del Mobile, Starck and Kartell presented A.I., a chair produced with an algorithm that emerges from simple inputs (Fig. 7): it has to be comfortable, to have the structural requisites of resistance and solidity necessary in order to obtain certification, and to comply with certain aesthetic canons of simplicity and clean lines.

Philippe Starck, Kartell and Autodesk asked A.I. to study how to help the body relax using the least quantity of material; A.I., with no culture, no memory, no influences, responded using only its intelligence. A.I. is the first chair designed outside our actual brain, a long way away from our habits and our way of thinking. A.I. is different from any other previous project by Starck; in fact, it has been conceived by a human being but was co-designed with a computer using generative software. In order to carry this out, Autodesk provided Starck with access to a research prototype of his generative design software. The software proto-type used by Starck includes functionality that is still in the process of being developed by the Autodesk Research team. Furthermore, this was the first project in which injection-moulding had been defined as a production stricture in Autodesk generative design technology. The project lasted two years, and at the beginning of the collaboration there was an evident gap between the designer’s expectations and the level of creativity exhibited by the software and what the software was capable of producing on its own.

Fig. 7 - P. Starck, A.I. seat Kartell, *Noviglio 2019.*

Starck expected the system to follow his initial directions and then to generate a chair that resembled, as far as possible, what he had imagined. However, the A.I. assisted system behaved in a way very similar to that of a child in his early learning phase. In the course of time, Starck became more attentive to his ways of describing what he wanted; the perfecting of the requisites allowed the software to better understand his design intentions and, in the end, to become more efficient. The process evolved into creative conversation very similar to what might happen between two human beings; Starck conveyed to the system his design intentions, whilst the A.I. tried to learn as much as possible, in order to be as useful as possible. As the relationship between the two matured, the system became a much stronger collaborative partner and started to anticipate Starck's preferences and understand the way he preferred to work.

Ergonomic and made-to-measure seats – Among the projects carried out in Palermo by design-oriented firms over the last two years, two of the most interesting cases are, without doubt, those of the chairs created in additive manufacturing. The chair can be personalized on the basis of postural requirements with a precise medical approach. In direct contrast to the words of Le Corbusier, we humans are different from each other, not only spiritually but also physically or, at least, dimensionally. Contrary to the object-type strategy, conceived precisely for a need-type, which does not really exist, design research here focuses on the configuration of a chair based on the person and on correct posture, with primary regard for health rather than ergonomics, using additive manufacturing techniques as leverage, characterized by building piece by piece, and bringing into play skills of a medical basis (orthopaedics, physiotherapy, motor science etc.).

The ergonomic and made-to-measure chair project originated in Palermo from research work and experimentation carried out over the years by the group Associazione IDEA (Innovazione e Diffusione per lo sviluppo Economico e Ambientale; lit. innovation and diffusion for the economy and environment), set up in 2003 by the architects Fausto Giambra and Fabrizio Fiscelli in collaboration with the Laboratorio di Disegno Industriale, run by Prof. Dario Russo (2016), as part of the degree course in Industrial Design at the Department of Architecture. The work is based on previous experiences in the same field emerging over the years, which provided useful input from projects that had been carried out and completed. There have been many projects emerging from this significant collaboration over the last few years: additive manufactured chairs, personalized and corrected ergonomically in order to prevent postural problems, orthopaedic shoes constructed with a foot-scansion to endure the correct posture, lamps and furniture of various kinds.

As a result of the experience obtained in the sector, IDEA is today one of the few in Sicily capable of organizing courses for designers and technicians operating with additive manufacturing, leading to highly-specialised qualifications that provide young people with new employment openings; from digital craftsmanship to restoration of cultural assets, from design to the orthopaedic sector. From these considerations and links with the University, IDEA set up a Maker Agency, becoming a place where firms can develop their innovative projects through collaboration with talented young people, qualified in the utilization of new technology (Magone and Mazali, 2016). IDEA has thus become a network geared towards innovation through the abilities and creativity of its young people, which bring them into contact with the world of work. Collaboration with the association IDEA has led to the creation of a web-site that connects on-line makers, users and additive manufacturing. Through this on-line portal it will be possible to select the chair-model from those in the catalogue and personalize it in accordance with specific ergonomic parameters (Lupacchini, 2008) and preferred colours.

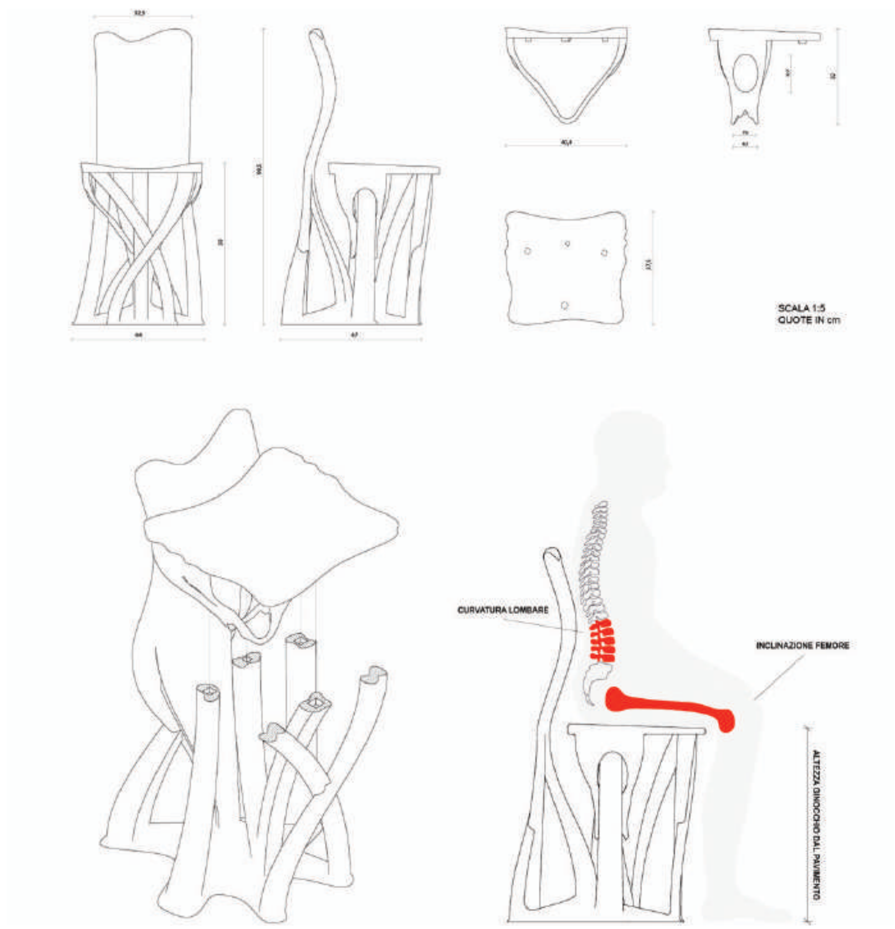
Flux: project for an ergonomic additive manufacturing chair – «The design method is simply a series of required operations, set out in a logical sequence dictated by experience. Its aim is to achieve the maximum result with the minimum effort». These were the words of Bruno Munari (1981, p. 16), who revealed himself to be a problem-solver many years ago and ahead of his time. Human Centered Design methodology, indicated as Design Thinking, was applied in the project, drawing inspiration from the Munari method, and simplified in certain phases. The process proceeds from the requisites of the people to whom the project is addressed; the project's key-points are defined and then one proceeds to the conception and, finally, the creation of the proto-type and the tests. In approaching the theme the designer Daniele Ficarrasi wondered, first of all, to what extent additive manufacturing technology had actually been exploited up to that point; this technology consents the construction of extremely complex forms with relatively swift modalities, costs and times and with solutions that cannot be accomplished with traditional techniques. Moreover, analysis was carried out on all the dynamics of parametric modelling that come into play when artefacts for FDM (Fused Deposition Modeling) additive manufacturing are designed.

The first models were produced by tracking sections perpendicular to the floor, which did not distance themselves from what already existed, appearing over-conditioned by the technological component; in fact, applying additive manufacturing in accordance with sections orthogonal to the buttressing surface, the supports are eliminated and production is facilitated. Furthermore, this modelling technique, to a certain extent restricts the possible results that can be obtained with additive manufacturing; as with all relatively new technology, additive manufacturing needs more research and closer examination in order to show off its real potential. Furthermore it was not easy to parameterize the model, the structure of which had to be redesigned entirely whenever the initial design was modified. The work of refinement on the completed project commenced, working continually on the section, with the aim of streamlining and lightening the load of the chair. The first checks were carried out using Grasshopper, Rhinoceros plug-in, gen-

Fig. 8 - Next page. *D. Ficarra,* Flux seat*, Palermo 2018*

erative design software and continued using Fusion 360 and Print Studio additive manufacturing software, with which the feasibility (of that which was being modelled) was verified step by step. The first forms, inspired by the branch-work in Mother nature, emerged, as often happens, almost by chance; through a system of optimizing forms (present in the modelling software), commencing from full profiles, applying their loads and utilization strictures, a model was generated that took into account the material and the maximum values of the activity. In this way forms began to appear that were more streamlined than those originally conceived, the development of which adhered to a logic of branch-work that put together and, at the same time, stressed the structural and aesthetic functions that the designer had been seeking.

After this initial phase the work proceeded with a further modification, which proved to be fundamental for the definitive project (Fig. 8); the model was conceived starting from its base and then following the line of planes parallel to the horizontal plane. This



meant being able to take a risk with even more sinuous forms, also satisfying the demands of the clients, who, with great enthusiasm, received the idea of producing an ergonomic chair that was totally different, in terms of form and function, to anything produced hitherto. The result obtained by tracking parallel sections proved to be the right choice, even though new problems arose with regard to that part of the seat, since this system generates a number of supports that are wasteful in terms of time and material costs (Fig. 9). Finally, from these considerations, the idea emerged of a structure that could be assembled in post-production, rather than produced as a single item, and this allowed us to resolve the previously-mentioned problems, by manufacturing separately the complete seatback support and the actual seat. Thus, several more models were produced, some of which were discarded due to purely stylistic imperfections and others that did not adequately pass the test of stability. The final configuration was obtained after further modifications that were not substantial but regarded small details (Fig. 10). The dimensions of the chair varied in accordance with the posture requirements of the ultimate user. Comparisons with experts in the sector enabled us to optimize the configuration of the chair by working on crucial points, such as the lower lumbar area and the incline of the seatback.

Figg. 9, 10 - D. Ficarra, Flux seat*, Palermo 2018: phase of production and final product.*

Sedia Reale (lit. Royal seat), made-to-measure, postural, on demand – After checking out developments, limitations and potential offered by this new technology and, after analysing many existing chairs, the designer Antonino S. Riolo chose four as reference-points for the project. He examined various aspects, including: ease of production using additive manufacturing technology, constructional stability, efficiency from the economic point of view, postural potential and, above all, ease of parameterization in adapting to the body of every user smoothly. The four project reference-points chosen were: the Endless Chair, that was built using additive technology, and thanks to the recovery of a re-adapted, old industrial robotic arm, took its shape from a continuous extrusion of recycled plastic; the Panton Chair was the first chair to be injection-moulded in a single block, with a profile that lent itself to swift additive manufacturing, since it consisted of a single continuous line; the Makerchair Puzzle was generated from a single form divided into 202 jigsaw puzzle pieces, enhancing the possibilities for small-time additive manufacturers in the construction of small or large furniture at accessible prices; lastly, the chair manufactured additively and designed by Zaha Hadid, was conceived as something lightweight but resistant, the design of which demonstrates the intelligent use of different densities of material in function of structural requirements.

The idea behind the design of the Sedia Ideale (lit. Ideal chair) was to produce a chair that can be configured by the user thanks to the utilization of a web-based configurator and can then be produced using FDM additive manufacturing technology, with the aid of PETG as a base material. The form is defined by two different profile curves, one for the external profile of the chair and the other for the central profile - three curves, in all, that generate a surface linking all three. This configuration is very efficient; one needs merely to move the two external profile curves apart or bring them closer together to modify the width of the chair. These curves are drawn with dots that, if positioned strategically, are joined together to form lines; laid out in continuous sequence, these lines form an entire profile curve. This enables us to choose the dots that, thanks to a simple translation, modify the height and depth of the seat. A lumbar cushion in TPU (a semi-ellipse, the minor axis of which measures 6 cm) is added to the configuration, which is positioned on the seatback by means of magnets sunk during the manufacturing phase, both in the seatback and the cushion. Finally, several furniture feet in TPU are fixed into the base of the chair.

The CAD project was conceived to be interpreted by a product configurator, which, by means of simple inputs, enables one to modify the height, width, depth of the seat and other personalized factors of an aesthetic order (Fig. 11). The Sedia Ideale is basically composed of two materials: PETG and TPU, to which one other element is added, in the form of neodymium magnets, which allow the cushion to be fixed to the seatback. PETG is a thermoplastic resin; it is a material resistant to bumps and chemical agents, is easy to mould and has a low withdrawal coefficient, which makes it ideal for large-size additive manufacturing, and suitable for moulding this chair. On the other hand, the lumbar cushion and furniture feet are made with a pre-formed elastomer

Fig. 11 - A. S. Riolo, Ideal seat*, Palermo 2019.*

Fig. 12 - Next page. *F. Belvisi and D. Cevola,* Mini 6.50*, Palermo 2018.*

called TPU, which is highly resistant to abrasions or ripping. The process of production begins with the slicing phase; the model is placed on its side on the additive manufacturing plane; in this way supports are not needed and the layers are oriented in the direction of maximum pressure. Once the production has begun, thanks to the interaction between additive manufacturing and robot, the process is interrupted automatically for magnets to be inserted, and subsequently starts up again and continues until the completion of the process. The same operation is repeated for the cushion and furniture feet. Being a parametric object, the measurements are not static, but vary within precise parameters defined by the designer; it will be the end-user who will bring his/her own chair to completion.

Ocore: the additive manufactured mini 6.50 – The ambitious project by two Sicilian designers, Francesco Belvisi and Daniele Cevola, was to build the first racing sailing-boat in the world, made almost entirely using additive manufacturing technology. The boat was a Mini 6.50 and was designed to participate in the Mini-Transat, a trans-Atlantic regatta (Fig. 12). The project was begun in 2014 originating in research into numerical modelling; in fact, certain civil engineering studies into the fractal behaviour of soil could be applied to large-scale additive manufacturing structures. Fractal structures are hierarchical and are commonly found in nature; the mathematics that defines them is usually a simple algorithm of easy computation, which can be used to generate complex and efficient structures. The intrinsic simplicity of fractal structures offers great advantages, both in generating additive manufacturing files and in simplifying models with regard to the structural and thermic properties of the object. A study was carried out together with Autodesk regarding the creation of structural elements based on fractals for boats; although many of the limitations imposed by conventional production techniques could be overcome, it was immediately evident that, in any case, the project would require the development of new tools, materials and design techniques.

One of the team's first tasks was to develop a range of thermoplastic materials for additive manufacturing, which would enable one to produce advanced structural components capable of resisting enormous stress. The materials for additive manufacturing were provided by the LEHVOSS Group and were based on high-performance thermoplastic polymers reinforced with carbon fibre, which means the artefacts are more resistant, more rigid and lighter. The additive manufacturer is fed with material in granule form, instead of the filament used for most FDM machines, since the pellets maintain good performance characteristics with a higher level of carbon fibre when compared to filaments. The first step was to create Ocore (www.ocore.it), a start-up with the task of developing additive manufacturing technology geared towards direct extrusion and to creating the design tools to support it. Instead of using the modality on which most additive manufacturing operates, Ocore positioned the head of the extruder at one end of the arm of an industrial robot (of 6 axes), produced by KUKA (Fig. 13). This provided

the additive manufacturer with a large volume of work. The robot's agility also gave the extruder greater liberty to manufacture than other conventional machines that can only deposit material along the vertical axis. Moreover, Ocore developed a new strategy for depositing material using an algorithm inspired by the fractals, with the aim of manufacturing the hull, deck and structure in a single piece (Fig. 14).

Almost all FDM additive manufacturers built today are run on software that generates instructions for manufacturing by slicing a mesh that defines the outline of the object in question resulting in a polygonal geometric shape. On the other hand, Ocore perfected a programme that translates the surfaces of Bezier, which outline the hull directly in the robot KUKA's native programmed language. This approach allows the arm to move very smoothly at a greater speed and precision when compared to the conventional control algorithms. The utilization of additive manufacturing enables one to create a structure that integrates films and reinforcement oriented perfectly with regard to the stress; then they are covered by a layer of carbon films that supports most of the boat's torsional and shear stress load. This approach enables us to achieve an excellent relationship between performance and weight and reduces the wastage of material to a minimum (Goldberg, 2018). The boat is designed to be constructed in transversal sections without solutions of continuity and then assembled longitudinally. In conventional sailing boats the hull and deck are usually built separately and then assembled subsequently (Larsson and Eliasson, 2014). On the other hand, in additive manufacturing construction it is more practical to manufacture the boat in transversal sections so that the hull and deck are manufactured as a single piece (Fig. 15).

The Mini 6.50 hull is manufactured in four segments, joined together with structural

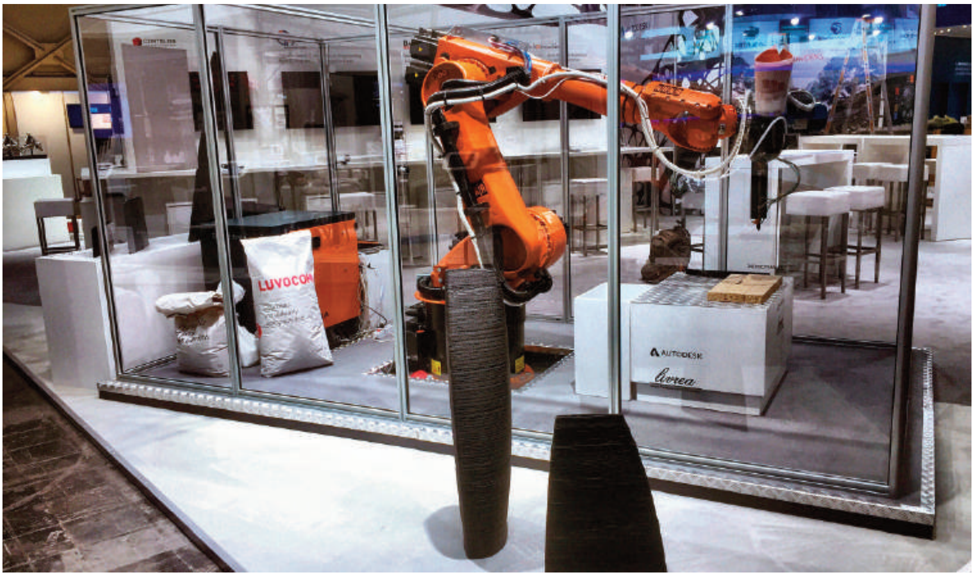


Fig. 13 - Previouse page. *The industrial robot Kuka, used in additive manufacturing.*

Fig. 14 - Construction in a single unit of hull, deck and structure of the Mini 6.50.

Fig. 15 - The working plane of Kuka.

Fig. 16 - Mini 6.50 *made entirely with additive manufacturing, Palermo 2018.*

adhesive and covered with a skin of epoxy and carbon resin (Fig. 16). A considerable advantage of this method is that it enables one to initiate production simply with a CAD file, without the need to build the required moulds in the traditional production processes of a boat, and with much shorter construction times. The other components of the boat built applying conventional methods also derive benefits from additive manufacturing technology. For example, the keel, which needs to be particularly sturdy, is made from carbon fibre and epoxy resin on an additive manufactured spindle. The rudders were also built using additive manufacturing, with a material base of polyamide loaded with 25% of carbon fibre, and with a notable reduction in production time (as much as 70%), whilst respecting weights and characteristics of equivalent rudders in composite material and with the possibility of trying out various configurations in order to speed up the process of refining the details of the boat; the costs are much lower than those for traditional systems (Luzzatto, 2018). Thanks to automation the production process is reduced to a few days.

Conclusions – The three experiments described above are, of course, not without limitations and critical points. In particular, in-series production of a project such as the one for the two chairs will require further trials, time and investment before it can be launched; production systems for complex objects utilizing additive manufacturing are still slow and clumsy, and do not result in large-scale production at accessible prices. On the other hand, it has proven to be a very effective solution for the experimentation of products of a high technological content. The case of Ocore does however open up new scenarios in the production of proto-types and components in the sector of racing boats and custom-built boats, but not without difficulties due to the structure verification complexity of a boat made from totally new materials and constructional techniques. Nonetheless, in both cases the utilization of additive manufacturing seems particularly effective, resulting in a significant reduction of costs and production time when compared to the technology applied hitherto (models, dummies, moulds).

The chair designed by Starck, in the same way as the projects presented above, provides food for thought regarding automatic learning and technology. Although creativity will probably never find its niche with robots, a programmed machine today can actually work out a project; the present level of quality of the above-mentioned experiments is in certain ways still rather unpolished, but from these examples it may be hypothesized that Man-driven machines will become ever more effective in creating products emerging from the human genius. At this point one might wonder what the role of the designer will be; in fact, his/her role in this phase is actually decisive for defining and applying the correct use of new technology, as well as protecting and maintaining his/her own position. One possible scenario sees all of us one day as designers. This process has been initiated over the last few years, also thanks to the accessibility of additive manufacturing, which potentially permits almost anybody to model and give shape to ideas, to create a proto-type and sell it on one of the numerous on-line market-places. Creativity is inborn in Man and in a scenario in which artificial intelligence is destined to replace certain skills, anybody will be able to start grappling with software and additive manufacturing. It is also true that, in the face of technology, in the last few years, we have not all suddenly become designers, and only those who have the right qualifications for creating and developing products can assume the role of designer. The designer's mission, therefore, will be to emerge from this new generation of makers and creators and become a mentor of machines (Gatti, 2018).

From the romantic point of view, one might consider transforming the relationship between designer and robot into one of craftsman and apprentice. By managing to educate and guide artificial intelligence in accordance with our skills, processes and creativity, the machine will be able to process an enormous quantity of data and tests that will provide feedback, subsequently recommending improvements and modifications for the success of a project. Collaboration between designer and machine might give rise to what Margaret Andersen, in an interview with the designer Anastasia Raina, defines as 'post-human design'. A design produced from a purely human perspective can be distinguished from an impersonal one produced via collaboration with a machine, by an element of unpredictability and controlled error. This element will be the strongpoint for post-human aesthetics and will result in emotional production, with Man still at the centre, even with the possible ingress of a new designer, who might analyse a number of possible solutions in a short time. We must, therefore, start to take into serious consideration the integration between Man and machine in such a way as to be able to develop and manage a new aesthetic understanding, which will be the result of combining thousands of possible options with choices still dictated by our purely human and emotional side.

NOTES

1) In his work (1973) Adam Smith claims the existence of two types of opposing and fundamentally successive economic organizations: one based on production for direct consumption in which each one produces for consumption whatever he has produced, and the other based on specialization o work, and as a logical consequence, on sale or trade via a product market of specialized work.
2) Bruno Munari, in his book *Da cosa nasce cosa* (1981), with a light-hearted approach renders the complex activity of the designer as something simple, trying to understand which are the most effective approaches for tackling a product design-project «Designing is easy when you know how to do it. Everything becomes easy when you know how to proceed in order to reach a solution to the problem [...]. The design approach does not change much; the skills change. Instead of solving the problem on one's own, in the case of a large-scale project, it will be necessary to increase the number of competent persons and collaborators and adapt the method to the new situation» (Munari, 1981, p. 8).

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[a] *Benedetto Inzerillo, Architect and PhD in Industrial Design. He has been teaching since 1998. He has taught Methods and Systems of Production in Sicily, Nautical design and Laboratory of industrial design. He has been a lecturer in Laboratory of industrial design II, in the degree course in Industrial Design at the Department of Architecture, University of Palermo (Italy). Mob. +39 340/19. 76.188. E-mail: benedetto.inzerillo@unipa.it*

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DESIGN 4.0

Elisabetta Cianfanelli [a], Lorenzo Pelosini [b], Margherita Tufarelli [c], Maria Luisa Malpelo [d]

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Abstract
The phenomenology of 4.0 is investing all fields in design sector, it is indeed crept into the design, production, sale and consumption, making them, in the context of product-system, actually areas to be designed. We are witnessing the rise of design processes managed by algorithms that provide solutions and improvements in terms of efficiency, performance, choice of materials and cost optimization. This contribution illustrates an experimentation of these apparatuses by applying generative design to evergreen products of Made in Italy, with the aim of understanding how these new procedures can be used to provide valid solutions and whether they are destined to supplant the role of the designer.

Keywords
design innovation, generative design, industry 4.0, made in Italy

In the era of 4.0 society, economy and products undergo profound transformations: their life cycle is reduced and their functionality fades, overwhelmed by the speed characterizing the Technological Revolution in progress, which requires the continuous advancement of new products and services. Society is thus forced to adapt to change and to seek new balances. In such a perspective, the Designer 4.0 operates in a system in which innovation and design culture take on new meanings, and research in the design field requires to be ‘quick & deep’ (Morace, 2018) in an era in which timeliness and connection with the territory must be supported respectively by technological evolution and culture. The phenomenology of 4.0 invests all fields in the design sector, it enters the design, production, sales and consumption making them, in the context of the product system, effectively areas to be designed. This paper describes a generative design experimentation applied to evergreen Made in Italy products, with the aim of understanding how these new procedures can be used to provide valid formal and functional solutions, and whether they are destined to supplant the role of the designer.

The design processes managed by algorithms provide solutions that offer improvements in terms of efficiency, performance, choice of materials and cost optimization. These are design processes in which real-time solutions are shared and all the phases are accelerated, delegating some optimization operations to the algorithms. In this context, the design process takes new paths: the solutions that the algorithms formulate depend on the inputs entered; designers must therefore identify the best solution to the problem based on various parameters, in a path of choice that must be governed. The most complex choices will concern the qualitative aspects, with a distinction between morphological aspects and the study of the shape of the product. While the algorithms are able to elaborate morphological solutions, the study of form is given by intangible components such as emotional values and culture of places, for which only the design culture proper to man can formulate a solution.

One of the central aspects for this research path is the relationship that the digital transformation has with the Italian productive system, therefore the need to understand which 4.0 channels we will have to activate in our manufacturing system and, consequently, which human resources are needed to be trained. Another aspect is the definition of the product and the emerging need to provide designers with some indications for the development of design 4.0. Moreover, Italian manufacturing as a connoting element of our economy, which only in some cases has found a development path 4.0 coherent with a system certainly far from heavy industry, how can it respond to this revolution through the culture of the project? In particular, we are wondering how these transformations will enter into relation with the Italian design culture and with the national manufacturing system condensed in the expression Made in Italy that in the collective imagination represents products of excellence and quality of life.

We can observe how even the role of the designer has transformed from a curator of the formal and functional aspects of the product into a designer capable of orienting company decisions, of interpreting transformations and designing new market scenarios. Italian design was also involved in developing an Italian user experience in product and service design. In particular, the design was able to make the experience of the Italian Life Style tangible, which is mainly composed of intangible values, as a qualitative experience linked to the emotional aspects of the product/service, as in the case of the fashion sector, of the gastronomy, furniture and automotive. In many of these product systems, values such as 'quality of use' or 'usability' lose their significance as they are dominated by the intangible values linked to the pleasure of owning an Italian product/service and with it experiencing an Italian emotion. Knowing how to design the Italian User Experience, has allowed many Italian companies to impose their products in specific market niches and fuel the success of the Made in Italy brand.

In this context the generative algorithm elaborates morphologies of components and products in relation to the three fundamental parameters that are the same parameters with which bionics studies its own models, i.e. the relationship between form, function and material. The observed digital scenario is destined to invest all production systems, regardless of their size, which therefore need adequate strategies to represent an added value that intensely changes the processes of production, management and organization of knowledge, but does not lose specificity. In this information age we are therefore faced with the need to optimally manage the balance between means and message, in order to safeguard the process of generating knowledge in which the aspect, perhaps primary, of generating value resides in a world 4.0.

The generative process of the project – Generative Design can be defined as a multivariable problem-solving system that uses Machine Learning algorithms to recognize images, texts and formulate innovative morphological solutions. It is an apparatus able to extrapolate three-dimensional models from two-dimensional images in an autonomous way. The generative process refers to the ways in which nature generates form in relation to growth; moreover, as in nature, the relationship between form, function and material is closely connected, in fact the algorithm generates a relationship between these three factors in order to achieve a perfect balance. The software platform dedicated to generative design development is conceived as a design assistant that, thanks to the range of solutions it offers, allows a broad overview of the complexity of the project. Each proposal is generated taking into account both the requirements previously set by the designer and all the variables linked to the material's feasibility of the object. Generative Design is therefore a design process in which the final product is the result generated by an algorithm capable of optimizing the relationship between form, function and matter. The concept underlying Generative Design could be identified with that of DNA sequence: this code, just like the genetic one, makes it possible to obtain a range of different design proposals that all belong to the same family (Soddu, 1998).

In such a computational framework it could be argued that it is no longer the creative that designs, but the computer. However, the designer still plays an important role as he elaborates and provides instructions to the computer by intervening on the algorithm, making the selection process of fundamental importance for the final result. The generative algorithms therefore allow, unlike the classic three-dimensional modeling methods linked to solid primitive operations such as boleans and intersections, to change the shape of the artifact at any time. Furthermore, Generative Design is a useful tool in the control and manufacture of unique artefacts. The current three-dimensional modeling techniques have given rise to a series of generative processes such as the Wall Grammar, which automatically generates the exterior of the buildings designed starting from the plan and the height of the roof (Larive and Gaildrat, 2006), or the CGA Shape Grammar (Watson et alii, 2008). In the Italian scenario, the most active researchers in the field of Generative Design are in the Co-de-iT network (Computational design Italy), while significant examples of Generative Product Design can be traced to the grater (for Sisma), the fashion accessories Carapace Project and the Feral lamp, born from smoke modeling and made by sintering polyamides (for Idea Factory), all products by Alessandro Zomparelli. Among the pioneers is Neri Oxman, professor of Media Arts and Science at the MIT Media Lab, where he deals with research, digital fabrication, computational design and synthetic biology applied to the project with the aim of reproducing nature's growth processes and applying the sequences used by our genome to create new perspectives in design and architecture (Oxman, 2011).

In summary, therefore, the traditional design compared with Generative Design, presents limits that derive from: 1) Ideation times greater than computerized ones and lower quantity of proposals; 2) Ideas initially rejected that could be re-evaluated; 3) technological and practical constraints; 4) Difficulties in making design changes at an advanced stage. Furthermore, the combination of Artificial Intelligence with the Generative Design capabilities gives rise to a series of competitive advantages in the ideational process thus configured: a) the designer establishes essential parameters such as weight, material, shape and production costs; b) the software uses its own algorithms to calculate a large number of feasible solutions capable of responding to user requests; c) the designer evaluates the best solution with the help of those generated and suggested by the system; d) the behaviour of the building with the simulation is checked; e) the product development phase and the engineering and optimization aspects are checked simultaneously in the design phase; f) we go directly to 3D printing, creating our own model in rapid prototyping. The advantages brought by the Generative Design can therefore be expressed in terms of: i) savings on the timing of the design and industrial processes; ii) analysis of the innumerable solutions among which the designer defines the product; iii) performance improvement and control; iv) saving time (and money) on: tests, simulations, checks, materials, processes, supply chain; v) calculation of production costs.

The experiment – The experimentation carried out investigates the new operating systems for generative design, distinguishing between functional and formal qualities. A first approach examined two iconic products of Italian design: the Superleggera chair by Giò Ponti from 1957 and the Invisible Sandal by Salvatore Ferragamo from 1947. In light of the results obtained, the research team reflected on the new possibilities offered to the development of a new design culture. The generative design process is distinguished by five main phases: Phase 1) Creation of the model; Step 2) Importing the geometry; Phase 3) Attribution of geometries, forces and pre-check; Step 4) Exploration of the outcomes; Step 5) Export.

Phase 1) Creation of the model. The elaboration of the model concerns the optimization of the overall geometry: in particular, attention has been paid to the extrapolation of the simplest and most essential geometries possible, in order to circumscribe the passages. The study models required the reduction of polygon meshes, in specific points of the geometry. These types of tools have made it possible to obtain a more streamlined result in the desired areas, allowing the definition of the remaining parts to remain unaltered. The first phase ended therefore with the export of a model in a universal format.

Step 2) Importing the geometry. Importing the model into the online software, activating its operability. Cloud technology is an integral part of the software and is an indispensable element to exploit the full potential of the program. Generative outputs cannot be created in offline mode. Before importing the model into the Generative Design software it is necessary to convert the mesh and/or nurbs into solids. 3D modeling allows to create, within the program itself, the study models to be imported later into Generative Design. The toolbar offers a series of options – Design, Generative Design, Render, Animation, Simulation, Manufacturing and Design – which, once selected, vary the interface of the program. The resources provided by the software are: the Design interface that allows to work on elementary solids, surfaces, nurbs and meshes; the Generative Design Workspace interface, that is the virtual place in which to load the model, made suitable to generate the outcomes (the first operation is to select the faces of the model that are intended to remain unchanged and indicate instead the spaces to be exempted from the calculation, while as an optional option it is possible to assign a basic geometry, useful to the program to start the algorithmic calculation); the Render interface that allows photorealistic renderings; the Animation interface, which allows to produce videos, as well as the management of key frames, allows to control the scenes of moving objects; the Simulation interface, which allows to choose the type of simulation that the user want to perform (the choice falls between: Static Stress, Modal Frequencies, Thermal Stress, Structural Failure, Non Linear Static Stress, Form Optimization); the Manifattura interface, which allows the creation of tool-paths to optimize the manufacturing phases, whose functions include the simulation of the nozzle movements, speed and inclination, essential aspects for the creation of the components of a product ; the Design interface, which allows to draw shapes in space starting from a product or animation.

Phase 3) Assignment of geometries, forces and pre-check. Within the Generative Design Workspace the model is managed not only from a geometric point of view, but also on the data required by the Pre-check, an activity that the program performs to verify that all the phases preceding the generation of the outcomes have been correctly completed. Assigned to the model the geometries that we intend to keep in the final form: in this phase it can be assigned more than one geometry at a time. Define the geometries to be eliminated during the calculation phase and which therefore represent the spaces that are intended to be kept empty. Finally, the last step provides for the optional assignment of the 'starting-shape': this geometry is considered by the software to be the starting point for processing. Specify the areas of the model subjected to stress, indicating the physical variables of force, pressure, rotational moment and loads, an operation to be carried out in parallel with the choice of the axis. operation to be repeated for each component The program offers three modalities of optimization of the model that allow to decide, which will be the criterion used for the final generative design. If user wants to give shape to the model in rapid prototyping, he/she must use the type of manufacturing (additive), the minimum thickness, the inclination of the work surface and the orientation according to the axes. These data prevent a possible collapse of the artefact during the additive molding phase. User select the material from the library, with which he/she want to generate the outcomes. The software has the ability to create online libraries to load the most used textures. The calculation procedure is online, with a saving in terms of calculation memory for each computer.

Step 4) Exploration of the outcomes. Once the calculation phase is complete, the generated models remain on the cloud. The software provides the designer with four different types of visualization of the model and another visualization mode for the technical characteristics, defining the ranking of the concepts closest to the set requests. The displays show the results graphically and each material uses an identifying colour. On the abscissa axis are shown the values of Mass (lb) and on the coordinate axis the values of the Minimum Security Factor, which ranges from 1,999 to 2,001. Each outcome is accompanied by a technical sheet with all the dimensional, material and performance information of the model. User can view the models produced on the cloud in 'free orbit' viewing, including the 'stress reference'. This visualization mode shows the chromatic variations ranging from red to blue: the maximum and the minimum stress value. At the same time, it is possible to observe the starting geometry and the consequent evolution carried out following the algorithmic calculation. The software also allows the two models to be compared simultaneously – the starting and the ending – to appreciate the differences and/or similarities.

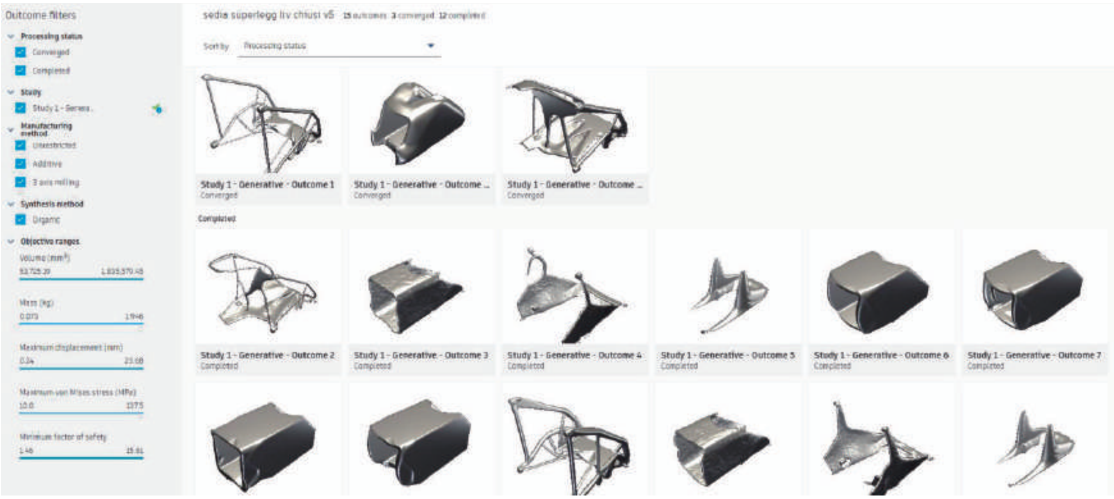
Step 5) Export. Once the concept is chosen, it can be exported in STL or SAT format. Given the universal nature of the file, it is possible to complete the model using any 3D modeling software, the generative design process is completed and it is possible to work on the model or implement it in rapid prototyping.

Results – The tests were performed with the aim of testing the potential offered by the generative software, orienting the generative experimentation on iconic Italian design products, starting from 3D models. The software synthesizes the Starting Shape, creating connections with the parts of the model that are wanted to remain unchanged, then the algorithm eliminates the excess material and optimizes the model. Once the Superleggera model was created and the constraints assigned, the software calculated surprisingly unusual formal and structural solutions (Fig. 1). Despite the inclusion of all the required constraints, the algorithmic calculation has not always produced profitable and advantageous results. In particular, with reference to the generative experimentation on the Superleggera, the proposals taken into consideration concerned only 26% of the totality while for the Invisible sandal 90% of the outcomes proposed by the software were interesting and plausible solutions (Fig. 2).

During the outcomes generation phase, the software developed a finite number of concepts on the cloud platform, developed simultaneously to optimize waiting times. Sometimes ineffective cases may occur, that is when the software produces outcomes that are extreme syntheses of the model; this phenomenon does not derive from the type of input inserted but from the type of calculation – subtractive – that characterizes the software. It is possible to retrace the 'interaction levels' to reach the result that best meets the expectations: a process that also allows the evolution of the algorithm to be viewed step-by-step. In the specific case of sandalwood, the chronology of the interaction levels was analyzed identifying the most interesting solutions in the early stages of

Figg. 1, 2 - Next page. *Preliminary outcomes of the* Superleggera *chair by Gio Ponti;* Invisible sandal *by Ferragamo, evolution of the heel and sole structure in relation to the reduction of material and weight.*

calculation compared to those developed at the end of the generative process. Once the outputs have been obtained from the software, it is essential to take into consideration the morphological aspect relating to the form-structure link which is the most satisfactory of the solutions. Finally, the output must be processed by the designer, who ultimately uses the model's own knowledge, skills and sensitivity, also based on his own culture and places. Three possible product typological classes have been identified elaborated by the algorithm on which the designer intervenes. It is possible to define the degree of intervention of the designer according to whether the transformation of the post-algorithm is Low, Medium or High. These classes can provide various types of products within the Generative Design.



In the case of low post-algorithm transformation, the Product is configured as belonging to a class of contemporary artefacts necessary, capable of producing unitary solutions for a diversified public, adaptable to any context. The strength of design lies in the study of the generated form, in the relationship between ethical, social and environmental aspects in which the design culture is called to define a new form of beauty. Products determined by the mastery of the designer who knows how to operate in the parameters, in the constraints and who, through his sensitivity, imposes the solution he prefigured, to the algorithm. In the area of Medium post-processing algorithm, once chosen the best solution among those proposed by the software, the designer defines the shape of the product. It could be argued that this result represents the outcome of the joint work between designer and algorithm, in which both parties contribute to the determination of the result. The product of the post-algorithm medium transformation is an elaborate, detailed, reasoned artefact in which the designer's own knowledge is essential to define the study of form: defining the aesthetics of the product and giving shape to emotions is the exclusive task of the designer. Without doubt the great advantage given by Generative Design is the ability to generate many varieties of functional concepts very quickly, which the designer would not be able to summarize in such a short period of time.

In the case of post-algorithm High Transformation, the product represents the perfect combination of refinement, taste and quality, elements that characterize Made in Italy, which stands out through the relationship between executive care and formal innovation. It is believed that the generative design of the products belonging to this typology should contemplate the broader "post-algorithm" transformations. The internal structure, generated through mathematical calculations, must in fact serve as the foundation on which to base the development of the product. The care of the aesthetic component, in this particular class of artefacts, remains the dominant task of the designer and very often the resulting product is the synthesis between design and the virtuosity inherent in the value of artisan know-how. This value is exactly what the global customer looks for when choosing the Italian product.

Without a classification that can distinguish the different categories of products, one would be led to consider the results given by Generative Design as effective and sufficient, and this could be translated into a 'cultural and creative globalization'. Furthermore, there is no doubt that the greatest advantage of Generative Design is the possibility of obtaining a large number of functional proposals, something that the human designer would not be able to synthesize in such a short time. However, by examining the activity of designer 4.0, a series of critical issues emerge that could occur during the use of Generative Design:

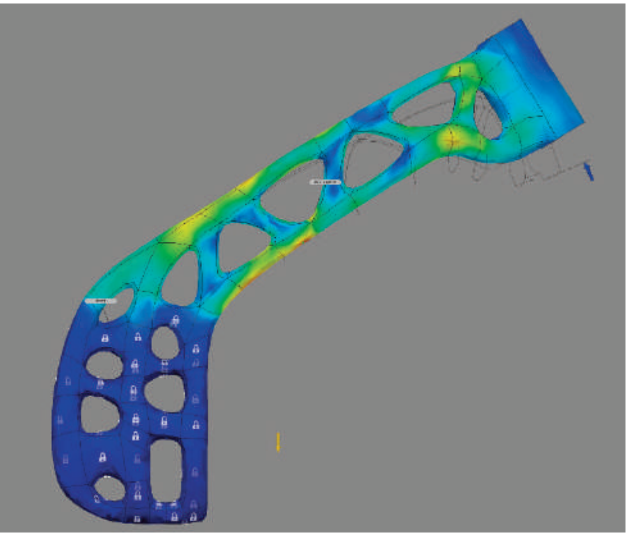
1) given the ease with which the products with 'low post-algorithm transformation' are produced, there is the risk that these will free human creativity from the conception of artefacts, relegating the designer's task to that of a mere data manager to be introduced in the software;

2) What would happen if in a contest of ideas two participants produced products with a 'low post-algorithm transformation' (with outputs not subsequently elaborated by the designer) that are similar? Since the morphology of a product varies based on the inputs that the designer inserts into the software, what would happen if one or more users entered the same inputs provided by the same brief?
3) What would happen if two designers with different degrees of skill on Generative Design software would compete in creating a High Range product? Would it be possible to 'circumvent' the result by limiting human interaction and replacing it with more targeted inputs thanks to optimal software management?

The challenge in experimentation – Once the first experimentation phase was completed and the degree of intervention between the algorithm and designer was defined, the team entered a second phase dedicated to some types of vehicles destined for the Italian high-end manufacturing system. The types of products are a motorcycle and a bicycle; these are objects with different degrees of complexity through which the research team intends to verify the modes of action in the high post-algorithm transformation. The morphological studies on the single components have assumed as 'generative models' of the bionic models to be processed through the generative software. The formal inspiration for the frame and the fork of the bike comes from a spider web that has become a three-dimensional structure with a variable section (Figg. 3, 4), while the bicycle designed for urban use is composed of a frame in fiber profiles of carbon with constant section in which the junction points of the parts are generated by portions of exoskeleton of some insects and designed to be made of aluminium alloy (Fig. 5). The study of the shape managed in real time with respect to the mechanical checks allowed us to check weights and quantities of material to definitively configure the mono-material components, hierarchizing the assembly and disassembly phases.

Conclusions – The results given by the Generative Design appear to be different each time but are identifiable in the same process and undoubtedly provide the designer with suggestions. The research wants to underline that the generation of the form is not entrusted to the digital: it is only an assistant, which optimizes the 'time to market' of the design process and the passage from the concept phase to the product development phase. Generative Design, from a first phase dedicated to the engineering field, goes into the creative field of design, offering innovative solutions in terms of performance, lightness, strength, resource savings, use of new materials, and formal innovation. Generative Design in fact, is not only to be understood as a software but as a modeling procedure of the form in which the designer can control the meanings, performances and material characteristics simultaneously. The study of the form is enriched with further solutions: all the possible variations produced by the algorithms, the designer finds himself in real-time possession of variants that only software is able to achieve.

The difference between the algorithm and the human mind therefore lies in the design



Figg. 3, 4 - Moto Bora*, design by Lapo Corenich: View 3/4 in which it is possible to observe the frame and the fork as connoting elements; Detail of the frame in the generative software environment.*

Fig. 5 - Overall view of the product with a frame made of constant section carbon profiles and joints made looking for the lowest possible weight and a shape that gives the product its identity.

method. While the designer conceives ideas drawing on his knowledge, experience and field research, the software calculates only the inputs. The designer, on the other hand, through his skills, helps to define a formal hierarchy and to determine the meaning, the identity of the products and therefore of the brand through a matrix of signs. As John Maeda (et alii, 2017) recently stated, it seems that the figure of the designer will inevitably have to evolve in a 'computational' sense, so the designer will have to become familiar with the use of codes for the design of products in continuous evolution. Therefore, in this vast panorama of algorithms it is believed that the role of the designer is not destined to become extinct but that it will be more and more incisive in the decision-making, elaboration and finalization phases of the project proposals. The figure of the designer is not destined to change: what will change will be the design process that will therefore require new skills, and in which the generative software will become advantageous tools in concrete support of the designer.

Finally, the team asked a question about the possible repercussions that Generative Design can have on the Made in Italy system and what it means to innovate in the Industry 4.0 era. Italian companies, in fact, produce their own products and services for customers who represent the wellness society, in which not only mere needs must be met. It is therefore considered necessary not only to define more specifically an Italian 4.0 model, but that it is also fundamental to redefine the purpose of the Italian product itself. The 4.0 era is an opportunity for the Italian System, in which innovative processes are to be found in the meanings (Verganti, 2016) that the products or services take and no longer in products that satisfy mere needs. It is therefore believed that the Italian Design System is facing new avenues to be taken to bring formal innovation to the product by interpreting the new 'qualia', qualitative aspects of the experiences that have always identified the Made in Italy product and that cannot be totally delegated to the digital technology inherent in the product/service.

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[a] *Elisabetta Cianfanelli, Architect and Industrial Design Specialist, she is Associate Professor at DIDA (Architecture Department) of University of Florence (Italy), Design Campus section. Chairman of the CdLM in Fashion System Design, and scientific director of the DIDA Lab REI (Reverse Engineering & Interaction Design), she carries out research related to the world of SMEs concerning the development of new products and technologies applied to design and production. Mob. +39 335/70.43.214. E-mail: elisabetta.cianfanelli@unifi.it*

[b] *Lorenzo Pelosini, Designer, graduated from the Master of Science in Design at the University of Florence (Italy). Mob. +39 334/97.83.756. E-mail: lorenzo.pelosini@stud.unifi.it*

[c] *Margherita Tufarelli, Designer, she is PhD student in Architecture curriculum Design of the DIDA (Department of Architecture) of the University of Florence (Italy), Design Campus section. Coordinates the DIDA Lab REI (Reverse Engineering & Interaction Design). Her research interests concern the application, the impact and the relationship between digital technologies and cultural heritage. Mob. +39 340/59.14.514. E-mail: margherita.tufarelli@unifi.it*

[d] *Maria Luisa Malpelo, Designer, graduated from the Master of Science in Design at the University of Florence (Italy). Mob. +39 328/77.85.815. E-mail: marialuisa.malpelo@stud.unifi.it*

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SIMCENTER
GUIDELINES TO DEVELOP A MEDICAL SIMULATION CENTER

Mario Bisson [a], *Alessandro Ianniello* [b], *Stefania Palmieri* [c]

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DESIGN

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ABSTRACT
Simulation techniques are an essential tool, to allow learners and operators to develop hard and soft skills simultaneously. Emerging technologies in the field of sensory perception will improve training and emergency management. The combination with virtual reality technologies will allow the development of complex systems, more realistic, allowing an effective and targeted training. They will allow the monitoring of training sessions and the collection of useful data for the generation of a standardized, efficient and unambiguous practice of action. The Design takes on the role of facilitator and manager of the system constituted by the different actors, with the mission to design and indicate the guidelines for setting up an innovative simulation center.

KEYWORDS
medical simulation, training, design guidelines, simulation center, simulation network

Simulate, simulate, simulate! This seems to be the slogan that the medical world has given itself as a mission and as one of the founding values for the professional training of health subjects. This trend is the result of a multiplicity of technological, but also ethical and social factors, which have pervaded the world of medicine in recent decades. First of all, it can be said that simulation is becoming a pervasive phenomenon. Secondly, the widespread use of simulation in medicine is meant to be a necessity, hence the idea that simulation is not only a pervasive phenomenon, but it is also a necessary phenomenon. Thirdly, the diffusion of simulation's techniques and the need for their use, open the door to another aspect of the phenomenon, namely its organizational dimension.

This research is based on the integration between medical knowledge and the know-how of the SIMNOVA simulation center system, the technological means offered by LogosNet and the design and management skills of the Design Department of the Politecnico di Milano. The mingling of these three entities has led to the creation of an open-source, cooperative Co-Design network (Fig. 1), strongly committed to creating guidelines for the development of a Simulation Center. The objective of the contribution is to draw up guidelines, from a technical-technological, managerial, ergonomic and proxemic point of view, which allow the development of a Center for medical simulation, which can become an example of excellence and the first node of over-state network constituted by the different Centers activated after the first one.

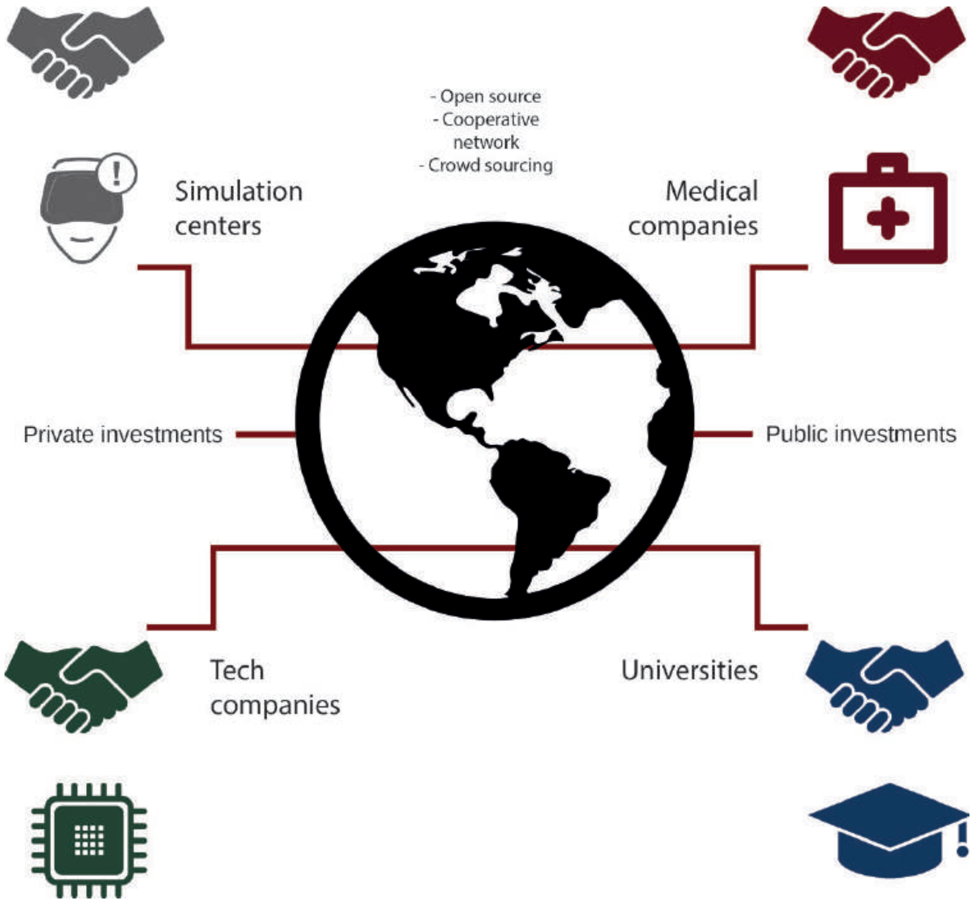


Fig. 1 - Co-Design network scheme.

Medical simulation's state of art – Simulation as a didactic tool knows its origin in the aeronautical and military field, to arrive in the medical sector during the 70s, with a full diffusion only twenty years later (Aggarwal et alii, 2010). The use of human mannequins, known as simulators, actors who play the part of the sick, was spreading in the field, but also the use of 3D virtual reality systems which reproduce various types of interventions on computers or in dedicated environments, had become to spread. Every doctor needs to practice to learn and/or maintain patient-centered skills (care, communication, information gathering), process skills (group management, information) and environmental skills (cultural skills, administrative and leadership matters). It also must be added the cyclical updating of health procedures, the increase in medical knowledge and the widespread use of minimally invasive surgical techniques.

Until now, attention has been given to the ability that the dummy has to transmit feedback to the student, related to the behavior of the simulated patient and the interaction that occurs between the student and the dummy. The first human simulator appeared in the 1960s: it was Resusci-Anne and marked the beginning of the era of simulations in the health sector (Good, 2003). The dummy had to guarantee the simulation of the ABC (Airway, Breathing, Circulation) of cardiopulmonary resuscitation (CPR). Today the evolution has led to several high-fidelity simulation mannequins that, through the interaction with the control room, allow a dynamic simulation experience. Maneuvers, procedures and interventions have almost immediate answers that the mannequin sends back to the student. Simultaneously with the development of mannequins, PC simulators appeared at the beginning of 2000.

Modern simulators are programmed to interact with the user, responding to his actions and combining both visual and tactile stimuli, as the aim is to obtain increasingly realistic simulated experiences. The simulation would require three fundamental elements: 'realism, realism and realism' (Ingrassia et alii, 2014, 2014a). Health professionals need to interact with an anatomically realistic scenario, but at the same time the environment must adapt in response to it. Giving importance to ergonomics means problematizing, for example, the professional needs of the organizational subjects and then the translation of them into satisfactory environments and experiences. This does not mean, however, only to provide comfortable environments that are compatible with the physiological characteristics of people, but also to promote the communicative exchange between these (Shams and Seitz, 2008). The surrounding work environment is also recreated in detail to make the experience more real. The reproduction of the environment must not be seen as a static representation, but the environment itself must stimulate the student and it must also change according to the choices made by the learner (McGaghie et alii, 2010). The more senses are activated during the execution of the action, the greater the storage of the experience that results from the action itself.

Technology's state of art – With the advent of new technologies the possibility of accessing a patient's and environment's simulation much more realistic and usable by a large number of people, assigned to the services, has opened up. Currently we can talk about three different types of 'parallel' realities: virtual reality, augmented reality and mixed reality. Virtual reality is an environment simulated through a series of technologies, which, combined with other techniques, such as the projection of a scene, generate a context in which the user is able to perform different actions, receiving an answer from it. A person who experiences this type of experience will be able to look around, move and interact with the features or objects present within the scene. Looking at the existing, both in terms of research and product development, it is clear that the technologies related to virtual reality, allow at this time to reach a level of immersion unthinkable until a few years ago. It is also true that, compared to the two 'realities' described below, it also has disadvantages, linked to the complexity of the system and consequently to the higher costs.

Augmented reality consists of a vision, direct or indirect, of a real environment, whose elements are increased or modified, by sensory input, such as audio-visual stimuli, graphics or GPS data, generated by a computer[1]. Unlike virtual reality, its use turns out to be simpler and requiring a less complex system, relying on the real environment, on which digital increments are represented; however, this implies an adherence to reality and an immersive experience of lower quality, having to rely on what really surrounds the user and therefore not being able to completely simulate the scenario. On the other hand, with current developments, it allows the necessary system to be leaner and exportable in different contexts of use.

Mixed reality is the fusion of the real and virtual worlds to produce a new environment and a new visualization, where physical and digital objects coexist and interact in real time. Among the presented realities, the latter is, without a doubt, the most recent and innovative: it is possible to have images at better resolution, compared to virtual ones, and of considerably higher dimensions; it can be used with different types of devices. The presence of several people in the same co-environment, real and virtual, and the interaction between them and the virtual elements present on the scene, is possible, even allowing the presence in the virtual world without having the need of physical presence in the place. Being comparable to an evolution of augmented reality, it is endowed with more performing characteristics, eliminating that aura of immobility, thanks to the interaction in real time, between virtual and real components[2]. It has the same advantages of augmented reality with respect to virtual reality, even if its development is further behind the other two technologies, and therefore it has lower reliability. Looking in the future, however, it could be the technology to focus on. Given the design requirements, among the three technologies presented, two are convincing and valid to use, even if the choice of one instead of the other will lead to significant design and use changes. They appear to be virtual reality and mixed reality. Currently the best choice, especially for the degree of development achieved, is virtual reality, but, looking at a development in the next decade, the reality to focus on will be the mixed one.

The Internet of Things represents an extension of the Network (Jayavardhana et alii, 2013): objects become recognizable and acquire intelligence, managing to communicate data about themselves and to access aggregated information from others. The goal of the Internet of things is to make an electronic map of the real world, giving an electronic identity to things and places in the physical environment. MEMS (Micro Electro-Mechanical Systems) are a set of devices of various kinds (mechanical, electrical and electronic) that constitute intelligent systems capable of combining electronic, fluid, optical, biological, chemical and mechanical functions in a very small space, integrating sensor and actuator technology and process management functions. The integration of this type of technology within the simulated training tools system, can be useful to achieve the before mentioned objective, which is to map and regulate the behaviors and actions to be performed during the actual aid, to succeed in creating a univocal practice of intervention (Fig. 2).

SIMNOVA – The Interdepartmental Center for Innovative Education and Simulation in Medicine and Health Professions (SIMNOVA)[3] is established with the aim of carrying out higher education, research and service activities in the health field, with particular attention to the use of simulation as a tool to innovate programs training, to improve the quality of care, to reduce clinical risk and increasing patient safety. It was created to make the spaces welcoming and functional in order to reproduce highly realistic scenarios, which recreate the natural environments of health care in different phases of the hospital and extra-hospital process and where students, doctors and health personnel can face the diagnostic-therapeutic and interventional routes on patient-simulators. The latter are the tools used by teams to simulate the human patient. During the activities the unit can use different types of dummies, depending on the course and the procedures that must be implemented. The simulator can faithfully reproduce the human body from a physical and physiological point of view, responding to different types of stimuli and being able to undergo surgical or administration operations, thanks to the use of dedicated software.

Inside the Center there are a series of equipment for training in maxi-emergency scenarios, such as the XVR© simulator, the ISEE© simulator and the Disaster Simulation Suite (DSS©). Thanks to the collaboration with LogosNet[4], an Italian company that deals with the design and the use of virtual and augmented reality systems, an immersive simulation environment has recently been set up, consisting of three spaces (simulation room, debriefing room and control room), within which it is possible, through the video projection on white walls, to reproduce high-fidelity environments, within which to carry out the practices. Another feature of this space is being equipped, thanks to technologies provided by LogosNet, of capacitive walls, with which it is therefore possible to have a tactile dialogue, useful during the debriefing phase or for certain types of scenario.

The role of Design – The complexity and the interconnected nature of today's projects necessarily require a deep and multipolar exploration, rather than an approach devoted to the immediate search for a solution (Cross and Dorst, 2001). In addition, Mozota (2006), while stating the four strengths of Design (Design as a differentiator, Design as an integrator, Design as a transformer and Design as a business model) concludes that each of these four elements contributes to creating value, while problems and solutions

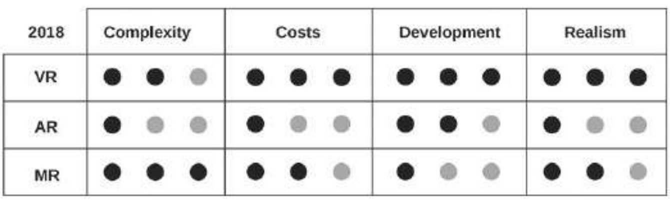


Fig. 2 - Comparison scheme of the three realities.

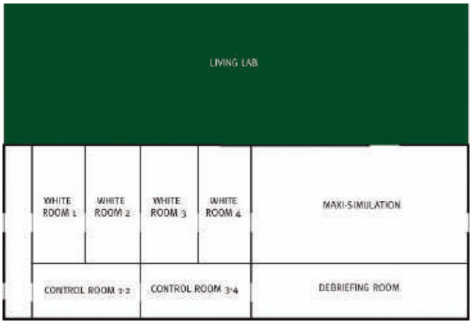
are fragmented. In the literature concerning Design-driven innovation, the importance of the involvement of different stakeholders within the project, is repeatedly emphasized. Some conclude that the major discriminant for the success of this methodology lies in the co-development model, facilitated by Designers, which involves various stakeholders during all the project phases (Bailey et alii, 2018).

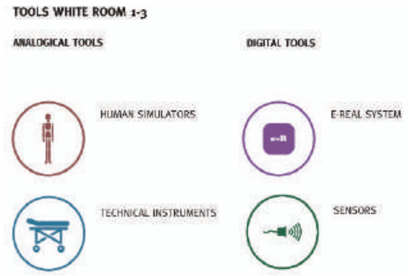
Some authors promote the involvement of external stakeholders, who nominate 'performers', in order to feed disruptive innovation (Norman and Verganti, 2014). Manzini states that Design can take on different roles in a context of co-planning, both as an activator of the innovation process and as a facilitator of co-creation activities. He also denotes the great importance of the involvement of different actors, affirming that the designer's role is to 'make things happen' (Manzini, 2015). In the literature of the sector it is repeatedly emphasized that the value of Design is fundamental to innovate sectors other than the reference one: Martin, Yee and other authors present cases of companies and organizations that have been able and far-sighted enough to use typical Design methodologies to innovate their business sectors (Martin, 2009; Yee et alii, 2017). Design, therefore, in such a context, where actors with different competences, from different sectors coexist, must be able to act as a catalyst for innovative design processes, continuously stimulating the various stakeholders, and as a facilitator of the design practice, allowing the best exchange of information possible within the co-planning network established.

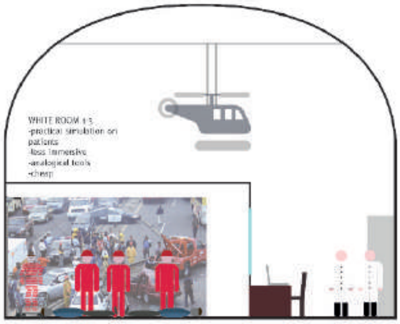
Design guidelines – The objective is to develop a set of toolkits to set up a highly performative simulation center, given the technological development of certain sectors. In this section the simulation environments will be described in detail, the guidelines to set up the environments will be defined and a series of hardware, software and tools necessary for the correct functioning of the Center will be listed, in relation to the objectives to achieve, always trying to provide more viable solutions (Figg. 3-13). The proposed set-up model must be open, exportable and replicable, in order to create an accessible and democratic network, based on principles that determine the standard of admission to the network itself. There will be four main simulating environments in the Center. The number of environments was chosen, basing it on the various simulated experiences that want to be proposed, which can be grouped into four sets: medium-level simulation of realism, with few users; high level simulation of realism, with few users; maxi-simulation in the interior and maxi-simulation in the exterior.

The first two environments will consist of three spaces, interdependent with each other: the simulation room, where the team training takes place, the control room, where the instructors and managers will assist the practice and will actively intervene in modifying the parameters of the simulated scenario and the debriefing room, where the teams and the instructors will discuss what happened during the training session, reporting impressions and feelings and highlighting the strengths and weaknesses of the team members, in order to conclude the training activities in a profitable and constructive manner.

The proposals of setting up for each of the three rooms can vary according to the







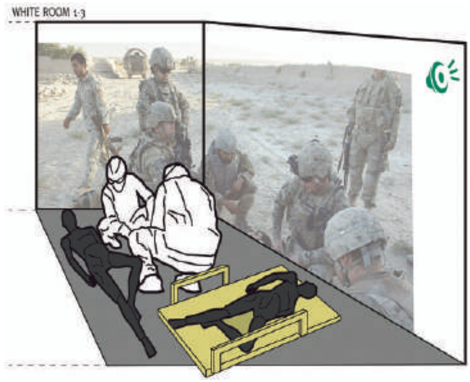
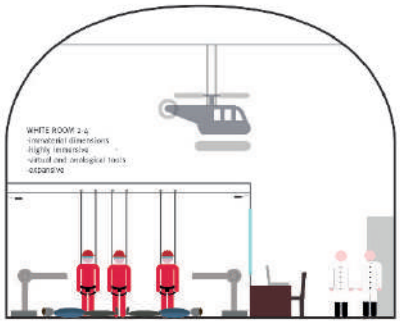


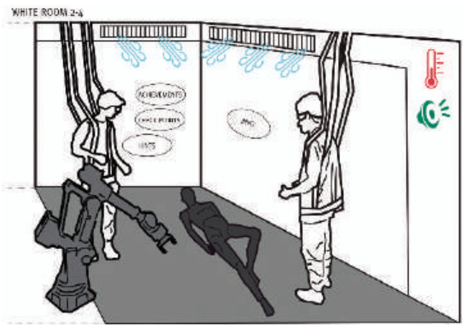
Fig. 3 - Top view of the Center.

Figg. 4-6 - Tools, prospectus and axonometry of white room 1.

simulation needs of the activators and the managers of the Center. Each room can be set up with independent packages, which, installed in their entirety, will make it possible to satisfy a wide range of needs and to achieve important objectives, both for the single Center and for the network. The simulation room is the environment where students carry out practical training activities, according to the learning by doing methodology, through simulation techniques.

By combining different types of technologies, hardware and tools, and using software to allow the system to function, highly immersive scenarios, which allow learning and the development of hard and soft skills, are recreated. The space must meet certain requirements, so that the training can be really effective and formative, it must: allow to adhere to the standards of real practice; allow the simulation of numerous types of scenarios, from the simplest to the most complex, combining virtual-digital and physical-environmental elements; be an easily reconfigurable environment based on the simulation that is carried out; the activities and practices carried out within it must be able to be monitored and analysed, in order to generate an important amount of data which will lead to the identification of best practices; be connected to other space envi-





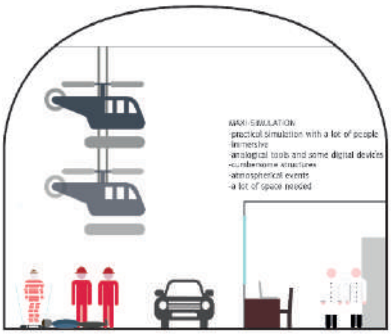
Figg. 7-9 - Prospectus, axonometry and tools of white room 2.

ronments, through an IoT system, so that it is possible to remotely manage some elements of the room and get feedback in real time.

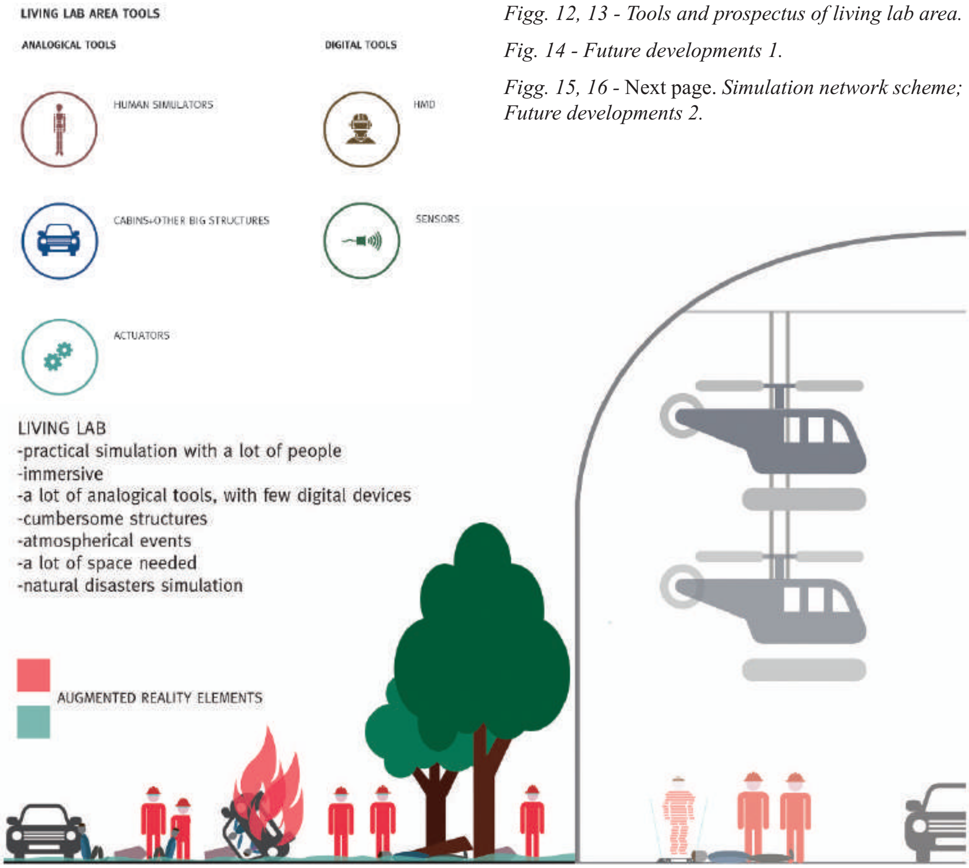
The high and medium immersion simulation room has three walls painted in white and it is connected to the control room by an environmental division glass, which allows the supervision of the practice by the instructors. Activities are carried out by teams of 3-5 people. There are four solutions packages that can be installed inside. Each of these packages consists of different hardware that allow to achieve the different features mentioned before: the first one allows a generical kind of simulation, which is useful to train managerial skills. The second one is designed to train the hard and soft skills in the clinical field. The third one allows to recreate atmospherical events in order to train the extra-clinical skills of the students; and the last one is the one that make possible the tracking of the movements done by the learners, inside the simulation room in order to obtain a high number of useful data.

The control room, which is used by the instructors and supervisors of the teams involved in simulation sessions, has a fundamental importance due to allowing them to have clear, objective, methodical feedback focused on checkpoints and training objectives. The space must, like the previous one, comply with some requirements, so that the transmission of concepts is effective. It must: allow to observe what happens in the simulation room, without influencing the learners; allow video and audio recording of simulation sessions and other forms of data collection; allow the insertion and management of variables in the scenario, in real time; allow the observation and monitoring of the status of the simulation room; being able to communicate directly with the simulation room; allow the supervision of action checklists and scenario objectives; be connected to other space environments, through an IoT system.

To create a protected environment that does not influence learners in practice, it is necessary that the instructors can observe the practice without being noticed: for this reason the two rooms, the simulation and the control rooms, are adjacent and connected by a glass of environmental division. Based on the packages installed in the simulation room, the control room will present several elements within it. The debriefing room is the environment dedicated to the last moment of a simulated training session, where teams and instructors will discuss the ended practice, covering the recordings and trying to share impressions and feelings, points of strength and weakness demonstrated, good deeds and errors, so as to conclude the activities with profit. The requirements that the room must satisfy, so that the practice has really educational effect are: to be a comfortable environment that facilitates sharing and constructive discussion; to allow another/two other non-practicing teams to attend the current simulation session; to allow the review of the session just ended; to provide interactive tools for the activities performed within it; to provide educational tutorials related to the mistakes made to be connected to other space environments, through an IoT system. The room is designed to accommodate up to two teams of learners (6-10 people) and the team of instructors (2-4 people). It can also be configured as a white room, having three walls painted in white. The hardware and tools that can be installed inside it are not dependent on those of the simulation and control room.



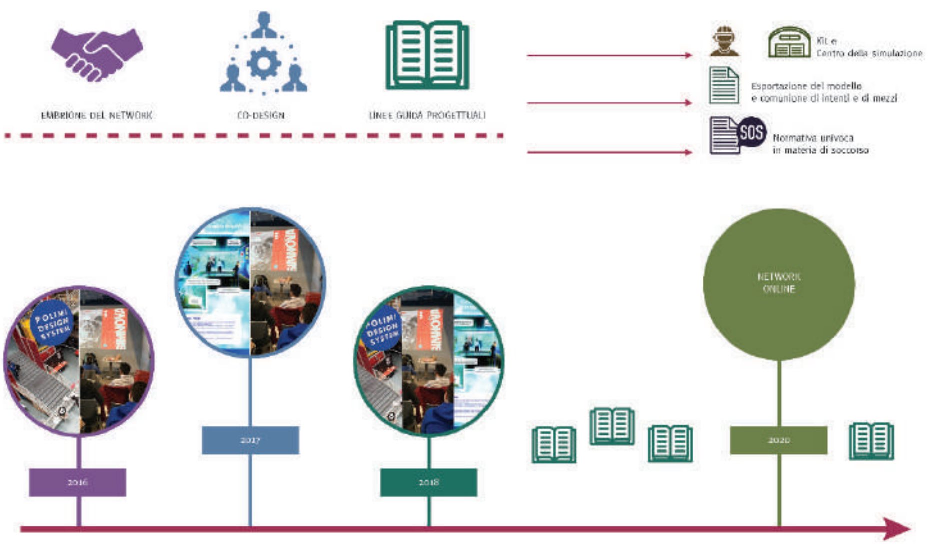
Figg. 10, 11 - Prospectus and tools of emergency area.

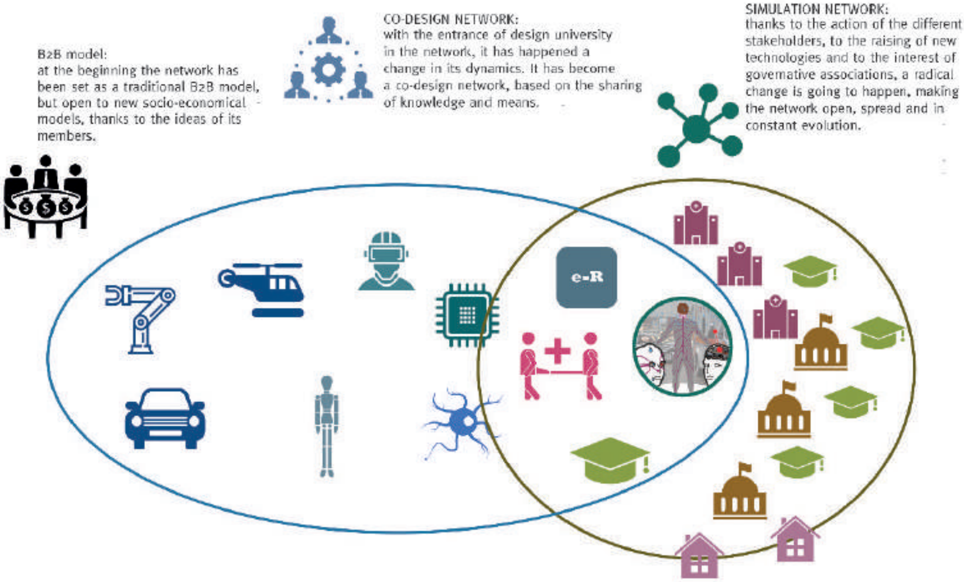


Figg. 12, 13 - Tools and prospectus of living lab area.

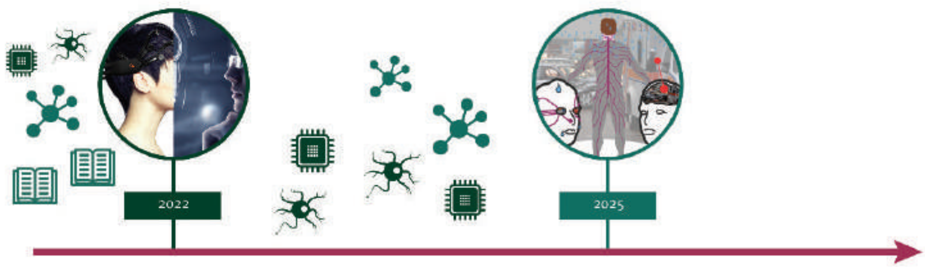
Fig. 14 - Future developments 1.

Figg. 15, 16 - Next page. *Simulation network scheme; Future developments 2.*




B2B model:
at the beginning the network has been set as a traditional B2B model, but open to new socio-economical models, thanks to the ideas of its members.
CO-DESIGN NETWORK:
with the entrance of design university in the network, it has happened a change in its dynamics. It has become a co-design network, based on the sharing of knowledge and means.
SIMULATION NETWORK:
thanks to the action of the different stakeholders, to the raising of new technologies and to the interest of govemative associations, a radical change is going to happen, making the network open, spread and in constant evolution.
e-R


NEW TECHNOLOGIES/
DEVELOPMENT OF THE EXISTANT ONES
DEVELOPMENT AND SPREAD
OF THE NETWORK
International cooperation
Democratization
of the processes
Network accessibility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The other two environments inside the Center are the internal area for maxi-simulations and the living lab in the external area: the first is equipped with mannequins, nacelles or other large structures, actuators for different atmospheric or extraordinary events; as regards the digital pull, various types of sensors are found and the system offered by LogosNet that relies on e-Real software. Finally, the living lab must be equipped with dummies, cockpits or other large structures and actuators to simulate atmospheric events, as well as visors for augmented reality and a sensor system.

Through the kits and guidelines, the goal is to set up a simulation Center that can become an example of excellence, exportable and replicable in as many places and countries as possible. Medium-immersion white rooms are used for direct patient training, involving few people; given the high level of immersion of the other two rooms, they will be used for the training of emotions and operational stress. The environment dedicated to maxi-simulations is used for a practical training that involves a large number of people, also allowing a good level of immersion, although it requires a large space. Finally, the outdoor space is used to train practical situations that, like for the internal area, will involve a large number of people, managing to guarantee a high level of immersion, using the surrounding environment. It must be used often for the reproduction of catastrophic atmospheric events.

The commissioning of the Center will enable the network, which will be much more devoted to horizontal collaboration between the different actors, mainly the various Centers that will be built after the first one, to be activated. Once online, the network will allow the supervision and sharing of data and scenarios, produced by the high number of simulations carried out, practiced identically in different areas of the globe, in order to generate innovative, but unambiguous, rules and practices. in the matter of rescue. A first embryo of the simulation network was born during 2018, with the activation of an Interdepartmental Center within the Politecnico di Milano, established by the Department of Design, by the Department of Chemical Engineering and Materials, by the Department of Electronics Engineering and the Department of Mechanical Engineering, to which SIMNOVA and LogosNet have been added. It consists of two environments, within which it is possible to live experiences of virtual reality, in the context of white rooms, where virtual environments are projected to encourage immersive practice. Simultaneously with the creation of the space within the Polytechnic, a similar environment for conformation and application possibilities, was created at the SIMNOVA site, in communication with the Center at the Politecnico, establishing a first form of simulation network, capable of sharing the scenarios created and the experiences lived within them.

Conclusions – The presented project constitutes the first step for the realization of what has been conceptualized and designed, providing specific guidelines that indicate how to set up the spaces and which hardware must be used to activate a Center. Software development will be the second milestone to be reached, to ensure that the model becomes operative and sharable. Simultaneously with the development of the software part, the network's activation processes must also be stimulated, acquiring a cloud platform, a website and other necessary digital applications, so that the network can be online in a short time. When these two steps are going to complete, it will be possible to make the replicable and exportable model available to the public and to activate the network, to achieve the goals set (Figg. 14-16).

Defined the design guidelines for development in the near future, it is also interesting to define a visioning operation for the year 2025. Medical simulation in 2025 will allow total experiential and sensorial immersion, facilitating and making training absolutely true and effective for the teams; this will be possible thanks to a series of studies and technologies being developed today, such as haptic and neuro-device technologies that will allow to actively interact with intelligent interfaces and machines, generating dynamic simulations, modifiable at will in real time and therefore highly formative especially as far as concerns problem solving skills. A fundamental point will be the accessibility to the simulation, which will become the fundamental tool for training in all medical fields. Another main objective is the creation of a norm of behavior that doctors and all operators will have to follow in order to be highly efficient; this will be possible by mapping those who simulate and crossing the data obtained, so as to go to identify the correct positions, movements and actions to perform, depending on the situation in which one will find oneself.

NOTES

1) Pokemon Go, a famous game for mobile phone, is an example of augmented reality. [Online] Available at: https://www.pokemongo.com/en-us/ [Accessed 28 January 2019].
2) The start-up Magic Leap, purchased by Google in 2016, is one of the companies promoting mixed reality technology. [Online] Available at: https://www.magicleap.com [Accessed 25 February 2019].
3) For further information cfr. web-site: https://www.simnova.unipo.it [Accessed 12 January 2019].
4) For further information cfr. web-site: https://www.logosnet.org [Accessed 12 January 2019].

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[a] *Mario Bisson, Architect, he is Associate Professor at the Design Department of Politecnico di Milano, Scientific Director of the Interdepartmental Laboratory E.D.M.E, Scientific Director of the Color Laboratory, Founder and Scientific Director of M.D.A., Member of the Board of Directors of PoliDesign scrl. Mob. +39 331/72.65.620. E-mail: mario.bisson@polimi.it*

[b] *Alessandro Ianniello, Product Designer for Innovation, he is a project researcher at UPO SIMNOVA. Mob. +39 338/53.81.248. E-mail: alessandro.ianniello@mail.polimi.it*

[c] *Stefania Palmieri, Architect, PhD in Industrial Design at the Design Department of the Politecnico di Milano, where she is a permanent researcher. She is Head of Business Relations and Professions for the School of Design. Her teaching, research and management activity aims to create a network of collaboration with the world of production at 360°, aimed at strengthening and stabilizing synergies between University and Enterprise for the creation of cultural and interchange networks. Mob. +39 335/67.59.314. E-mail: stefania.palmieri@polimi.it*

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SUSTAINABLE PRODUCT-SERVICE FOR CHILDREN'S SOFT MOBILITY
FLURRY, THE INDOOR-OUTDOOR BIKE

Arianna Vignati [a], *Benedetta Terenzi* [b]

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Abstract
The collaboration between Italtrike, an Italian company producing ride-on toys for children between 1 to 6 years of age, and a group of researchers from the Politecnico di Milano gave rise to the design of a new product system capable of encouraging, promoting and facilitating motricity in preschool children, through play and digital technologies. The modern day challenge is that of responding to the demands of design and innovation generated by digital transformation and not losing sight of the child's values and needs from the emotional, physical, cognitive and relational perspective. During a Design Laboratory involving a number of researchers from the Politecnico di Milano and expert designers of Design for Kids & Toys, it was possible to delve into the theme of Sustainable Product-Service for Children's Soft Mobility by developing an innovative product, both on the level of response to children's specific needs and from a technological point of view.

Keywords
soft mobility, playful experience, phygital product, kid-centred design, product-service for kids

Digitisation has led to profound changes in the behaviour of adults and children. Between apprehension and opportunities we are living through a sense of confusion and uncertainty on how children of the future will engage with products and services: first and foremost, toys. Between digital fans and analogue nostalgics, there lies a schizophrenia which makes it difficult to work uniformly on the 'product system'. Everything is more complex but there are tools to successfully deal with the contemporary challenge that sees a demand for innovation and cultural quality as superior to the offer that is present on the market today. This contribution presents the results of an initial research involving collaboration between universities and businesses in developing an innovation design capable of responding to the modern world challenges of digital transformation in the toy sector. Through a path of analysis and research, the foundations were laid for the development of a product designed to encourage, promote and facilitate motricity in preschool children, accompanied by playful activities supported by digital technologies.

This work primarily gave rise to an in-depth analysis on child motricity, going on to define the state-of-the-art from the point of view of scientific research and the production sector, and the classification of the types of products present on the market which nowadays affect child motricity. In fact, according to the genetic epistemology theory of Jean Piaget (1962), motricity is the basis for the development of the human being and as demonstrated by many studies (Bruner, 1968; Calabrese, 2001; Zoia, 2004; Boccia, 2008; Di Tore et alii, 2012; Babaglioni, 2014), physical activity affects cognitive development in childhood and increases its potential. In parallel, the role which digital transformation covers in various fields related to childhood was analysed, particularly in the moments of play and free time spent with family members. This was finally followed by an analysis of the literature concerning the use of screens and devices by children.

The results of a study[1] coordinated by Martin Paulus of the Laureate Institute for Brain Research in Tulsa, Oklahoma and the study conducted by the Canadian Pediatric Society (2017) shed light on how the digital scenario is evolving very rapidly and how 'screen time' is also increasing in preschool children. Today's children can no longer be referred to as digital natives (Prensky, 2001) but rather as 'mobile born', that is, children who learn the use of devices before learning to walk and who expect that everything can be implemented with software. The infant neuropsychiatrist Bruce D. Perry (1996) stated «different kinds of experiences lead to different brain structures» referring to the minds of the new generations, structured in a different manner with respect to the old generations, characterised by constant sharing of information from a multitasking attitude and by the continuous connection with others through social channels. The various actors that gravitate around the Kids & Toys production sector must, therefore, be aware of the fact that they have to interact, communicate and work with the children who will exploit all the connection possibilities and that the IoT will dominate the market in the coming years (a research published by Accenture in 2019 estimates that by 2022 at global level, also due to 5G technology, at least 50 million objects and devices will be connected to the network with a market value of 600 billion dollars), inevitably also influencing non-digital natives. These data suggest a tendency for children to be increasingly connected and already sedentary in the first years of life.

On the basis of this research of reference (in a psychological and market opportunity context), the objective of the applied research activity was to create a product system which, through play, enables children to regain possession of movement (attempting to respond to an increasingly widespread problem concerning the lack of opportunity to play in large spaces on a daily basis). The design of a tricycle for outdoor use stems from these assumptions, to which is added a base (to secure the tricycle to the ground) and a controller: the product system allows the child to also pedal when stationary and to connect to a video game console to use multimedia content that encourages learning. In fact, the design developed allows for playful motor activities in small indoor spaces as well as outdoors, and in different contexts of use in which children, by interacting with a screen, and therefore with the specially-designed pedagogical content, increase their cognitive abilities through their physical movement and manage to also improve the learning of educational content.

The contribution thus illustrates the methodology used in the product's development, the results achieved and the possible implications that this type of product can have in the Kids & Toys sector. It is therefore intended to highlight the role of design in terms of tools, methods and support to companies to promote motricity in preschool children, focusing on the assessment of the main drivers which are today driving the revolution of products for children, in line with the changes that digital transformation fosters in the behaviour and in the response to the needs of children and the adult community around them.

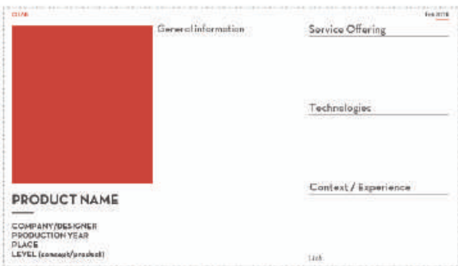
Motricity and cognitive development: literature review on the challenges in the world of kids – Although physical movement is a natural aspect of a human being, children are inserted from a certain age into a social system in which a lot of time is spent stationary and seated, starting from school. In addition, a key concern which generally surrounds the exponential increase in the use of media by children is that this involves a displacement in time – screen-time – which could otherwise be spent on other more traditional activities considered to be more child-friendly, including physical activity, sleep, reading and practical educational activities. Many studies show that good physical activity in children improves learning (Erickson et alii, 2015), increases concentration and attention, and reduces stress, anxiety and depression. In one study (Jäger et alii, 2014) carried out by researchers from the Department of Psychology and from the Institute of Sport Science at the University of Bern, investigated the effect that good physical activity produces on the cognitive performance of primary school children aged between six and eight years. Specifically, the study had the objective of verifying whether motor activity modifies the executive functions of children, and whether and what such modifications are in relation to the variations in the level of cortisol produced from the same activity.

With regard to motor activity, a study by Diamond (2012) already demonstrated that executive functions in children can be implemented by practising sport. An increase in these functions results in the development of the capacity for selective attention and reasoning, responsible for an improvement in school learning. Executive functions can be defined as cognitive procedures that have the purpose of planning and organising an individual's behaviours and emotions at the moment in which new particularly difficult contextual realities are faced requiring the mobilisation of adaptive strategies (Owen, 1997). According to the model produced by Miyake (et alii, 2000), executive functions consist of three skills – inhibition, the working memory and the flexibility of cognitive response – used in problem-solving strategies. Inhibition is represented by the ability not to let impulses and non-pertinent information interfere in the task that is being performed and which could exert the role of distractors.

Another study conducted by two Finnish Universities (Haapala et alii, 2013) examined the relationship between cardiovascular activity and motor skill performance in children in the first year of primary school, by comparing the reading and arithmetic skills of 174 Finnish children from the first to the third year of primary school. Children who obtained unsatisfactory results in agility, speed, manual dexterity tests and poor overall motor skill performance in the first year of school obtained lower reading and arithmetic scores in subsequent years, compared to children with better performance in motor skill tests. It was also demonstrated (Röder et alii, 2013) that physical exercise improves the neuroplasticity of certain brain structures and consequently cognitive functions, affective and behavioural responses. Specifically, in another study (Budde et alii, 2016) researchers used various methods – including brain scans, EEG recordings, and blood and saliva sampling – to study the effects of different physical exercises (dance, play and cycling) on brain activity and the consequent volume variations in different areas of the brain (the frontal and central regions, the hippocampus, the cerebellum and the motor cortex).

Case studies of products and services for motor development in kids – Based on the literature review's theoretical premises, an analysis was then conducted on the case studies of products and services available on the market which innovatively interpreted the relationship between technologies and solutions for motor development, using a specially-prepared analysis fact sheet (Fig. 1). In addition to a focus on products and services for children, effective solutions were explored for adults with a potential transfer scenario in the world of childhood. Cases were organised according to different categories and contexts of use (Fig. 2). Data collection considered three key aspects: the relationship between the product and service offered; technologies used (with particular reference to digital technologies); the types of context of use envisaged and considered for the product system.

Five case studies were analysed which made it possible to identify the framework for a subsequent design development phase. For each case, different variables were evaluated and assigned a value linked to presence and importance (Fig. 3): the dimension of the service associated with the product; the versatility of indoor and outdoor use; the presence of enabling digital technologies; the simplicity of use/interaction; the possibility of customisation; and, correspondence with target children in the age group between 2 and 6 years. An area of opportunity emerged from the evaluation of collect-



Figg. 1, 2 - Case study data sheet; Summary fact sheet of the types of case studies highlighted.

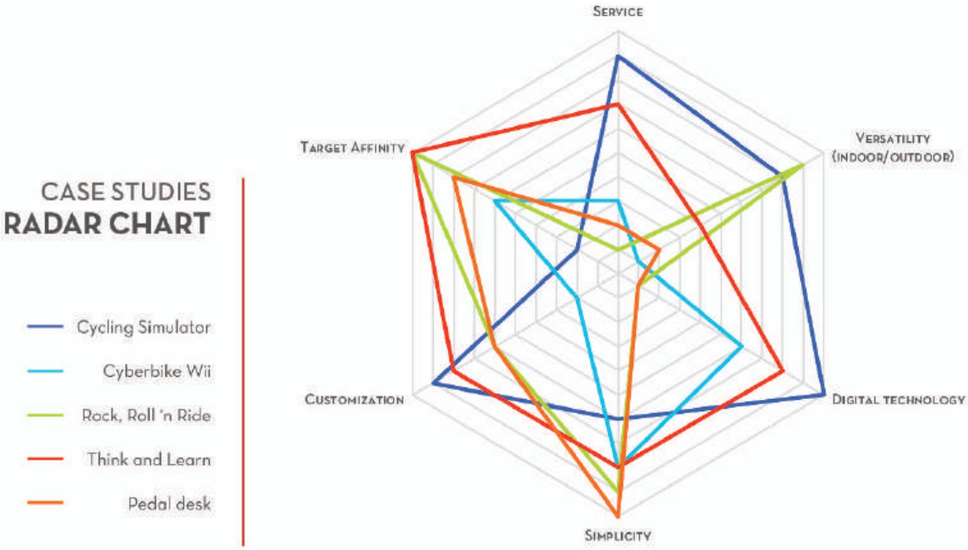


Fig. 3 - Radar chart of the variables collected through the case studies.

ed variables, which combines the dimension of service, versatility of use and use of digital technologies.

A second evaluation phase of case studies enabled the crossing of insights relating to the literature review with the areas of opportunity determined through the cases to identify five macro areas of design development for a new product system: the development of 'smart' accessories connected to sport; the development of games/toys capable of combining analogue and digital in an original and engaging manner; the development of accessories and tools of a pedagogical nature aimed at educational environments such as schools and educational centres; the development of hybrid solutions for indoor and outdoor motor skills activity; the development of product systems capable of adapting to private and public contexts.

The collection of various cases studies highlighted that there is an opportunity to develop a versatile product-service that is capable of integrating the digital component in the experience of children's physical movement. This phase of analysis underlined that: no similar products currently exist for kids; all case studies taken into consideration are inadequate from the point of view of the service's integration; versatility, which makes it possible to use the product both indoors and outdoors, is a strong point for a design that wants to be seen as innovative; the digital component is not always present in the case studies or, in any case, not well-integrated.

Enabling Technologies – Once case studies were evaluated, the project's preliminary research phase deepened the scenario technological aspects for product system in-

novation in the world of kids. Research on existing technologies focused on the following four areas.
1) Use and exploiting movement. There are some devices that convert the kinetic energy of movement (for example, through walking) into electrical energy and storing it in a battery. These devices utilize a process called Generative Braking similar to the processes of braking systems which can be found in hybrid cars – the movement of walking is very similar to the stop-and-go process of driving. Regenerative braking is a technology that is used in electric vehicles to capture the energy that it produces through its movement or, in other words, its kinetic energy which would otherwise be wasted at the moment when the vehicle decelerates or stops. This was widely developed for the car and locomotive sector (Doyle et alii, 2016). In recent years, interesting systems and products were implemented which directly capture the energy from man's movement (Starner et alii, 2004) or, for example, through the use of paving capable of creating clean and fully recyclable electric energy, simply by utilising the kinetic energy produced by walking pedestrians (Elhalwagy et alii, 2017).
2) Eco-sustainable batteries. Organic molecules derived from biological sources are an economically-viable alternative and ecologically favourable to electrodes based on metals widely used in current energy storage technologies. Research carried out by Schon (et alii, 2016) led to the discovery of a polymer-based cathode for lithium ion batteries. The redox part is flavin and is derived from riboflavin (vitamin B2). This work provides a basis for the use of sustainable and high-performance bio-based pending polymers in lithium ion batteries. The battery was tested and demonstrated optimal performance in terms of duration – a key success factor if one considers its possible applications in the Internet of Things.
3) Wearable technologies. There has been a rapid increase in the development of smart wearable systems in recent years, that is, those wearable devices modelled around the human body with the purpose of making the greatest possible use of the least invasive technology at the service of the user. A fundamental characteristic is that the human body can be used as a natural support for their functioning. Today, wearable devices are becoming increasingly comfortable, also thanks to the development of new flexible polymers and to the progressive miniaturisation of sensors and electronic circuits. The fields of application are also varied, ranging from entertainment, to the control of physical activity and biomedical monitoring. Most innovative examples include the case of e-skin, developed by a group of researchers from the University of Tokyo. This is a thick electronic skin less than two micrometres, to which transparent ITO electrodes (indium tin oxide) were attached. Starting from the latter, the Japanese researchers succeeded in creating polymeric LEDs only three micrometres thick (PLED) and organic photodetectors (OPDs) to be applied directly to the skin (Yokota et alii, 2016).
4) Products that integrate analogue to digital technology. OSMO is an innovative example from among current trends in the toys sector. This is an innovative product capable of changing the way in which children interact with digital devices transforming

them into manual games, combining creative tools, games and state-of-the-art technology to encourage creativity and problem-solving skills. The children become increasingly tech savvy; for this reason, games that can be adapted to various devices with a playful approach and with content suitable for the age and cognitive abilities represent the most promising scenario of innovation in this context (Terenzi, 2018). In this regard, the design of devices and Apps is expanding which, through the aid of the playful approach, integrate technology for the logopaedic treatment of children with learning disorders (Cianfanelli et alii, 2019).

Results have shown that the utilisation of kinetic energy can be easily transferable to the design of a new product system. Moreover, the environmental sustainability of many of these technologies is capable of creating further appeal in the products to which they are applied. Equally interesting scenarios are also opening in the applications of products that integrate analogue with digital functions (phygital) in the care design and medical sectors, in general, a potential trend for this sector.

Phygital Products – Human-computer interaction is today widely regarded as being an integral component of many educational and training systems at various levels of access to technology (Lin et alii, 2017) and many studies show that positive interaction increases motivation, attention and participatory learning in children (Parker and Lepper, 1992; Liaw, 2008). It is increasingly clear that the nature of play in the digital era is changing in terms of resources available for play and the way in which these resources are distributed in the different types of play (Bird and Edwards, 2015). A further aspect of contemporary play is the relationship between online and offline spaces. In the last few years we have seen various developments in relation to the way in which toys and other artifacts for children are mediated by digital interaction (Burke and Marsh, 2013; Vignati, 2017). This is leading to a type of communication and play that moves through physical and virtual domains and integrates tangible and intangible methods (Marsh, 2014).

It is generally possible to classify the use of technology applied to toys as follows: AI (Artificial Intelligence), that is, toys with special features such as visual perception, voice recognition, translation, etc.; Machine Learning, that is, toys that can learn, behave according to patterns, change their actions according to stimuli and adapt to the player's ability; Internet of Toys (IoToys), that is, toys connected wirelessly to the Internet, to other toys and/or to database data; Virtual Reality, that is, toys with computer-generated simulation of a three-dimensional image or of an environment with which one can interact in real-time or physically by using special electronic equipment (helmet, glasses, gloves, etc.); Augmented Reality through the use of a smartphone or tablet's camera which provides a level of information, including text and/or images, that goes beyond the real world's vision.

By play interaction, we mean an activity in which an effort is required by users who are rewarded with a pleasant improvement in their skills. The process is also characterised by the presence of emotional responses stimulated through and due to the use of a product (physical or digital). Play activation replaces basic interactions with small challenges that are intended to increase the user's attention and interest. Finally, playful-type assistance to activities enables important learning and support because they are integrated and just-in-time, and also due to the presence of assistance and rewards for satisfactory results. The sector's trend is, in fact, driven by highly innovative companies and start-ups which are presenting products that, at various levels and with different formulas, expand the physical product with one or more of the techniques described above, with very interesting results (Mascheroni et alii, 2017).

From research to design – Starting from the results emerging from the state-of-the-art analysis phase, as a result of the collaboration between Italtrike, an Italian company producing toys for children between 1 to 6 years of age, and a group of researchers from the Politecnico di Milano, with the involvement of a group of young professionals, the new project was created that is capable of encouraging, promoting and facilitating motricity in preschool children through play and digital technologies. Italtrike is an Italian company which, since 1983, has produced tricycles, ride-on toys, balance bikes and wheel vehicles designed for children and their recreation (particularly for kindergartens and nursery schools). 'Kids on wheels' is the slogan of Italtrike, whose mission is to encourage children's mobility to promote motor skill and psycho-physical development. Products are 100% made in Italy.

During a design laboratory coordinated by researchers from the Politecnico di Milano and involving young Kids & Toys Designers, it was possible to delve into the theme of Sustainable Product-Service for Children's Soft Mobility by developing an innovative product both on the level of response to children's specific needs and from a technological point of view. In fact, the project responds to both the contemporary need of motor play and the interactive experience made possible by digital technologies. It is based on needs and specific skills and on the target's stages of cognitive development taken as a reference, that is, for children between 2 and 5 years of age. Important changes that occur in children of this age, not only with regard to the body's growth but also the personality and the relationship with others, where play is a fundamental accompanying tool, were taken into consideration in the project's development and analysis phase.

In children, imaginative play shows up at around two years of age. This involves imagination, simulation and imaginative activities in general. These stimulate divergent thinking and problem-solving abilities – two important aspects for the linguistic component. Constructive play asserts itself at around three years of age. This is expressed through the shaping, for example, of clay, salt dough, plasticine, paper, etc., as well as with the use of building blocks and graphic activities using pencils and colours. These types of activities promote the acquisition of motor skills and lateralisation (defining the body's right and left), develop fine motricity, the sensory understanding of objects and reinforce exploratory and cognitive sensations.

Socio-dramatic play emerges around four years of age. The child enjoys changing roles or characters, pretends to be someone and identifies himself: participation in socio-dramatic play allows the child to shape his personality, express desires, dreams, talents, to control instincts and frustrations, and manipulate them to his advantage. Symbolic play also forms part of socio-dramatic play. Symbolic play has the function of representing a reality that is not present in order to reinterpret it from a subjective point of view. This includes listening and observation games, such as listening to stories, nursery rhymes, poems and decoding images, for example, when using books. Cooperative play and play linked to cognitive learning also develops in children at around five years of age. Often in these cases, the children who act as leaders are usually those that have developed more manual skills. Furthermore, between 4 and 5 years of age the development of motor skill activities is completed, that is, to run, climb, skip, throw the ball, play with sand, ride a bicycle and swings, go on slides, etc.

In summary, the development of the physical product, its recreational component and the video game took into consideration the main stages of motor skills and cognitive development in target children between 2 and 5 years of age: mastering language through conversation and asking questions; improving the ability to solve simple problems; socialising with adults and children of the same age, carrying out activities in conjunction with a recognition of the rules; first development of empathy and recognition of emotions and mental states; combination of shapes, recognition of colours and parts of the body, telling short stories or parts of a story; understanding numbers and perception of the time factor; improvement of the motor skills that make it possible to jump and stand on only one foot for a few seconds, cycling and to catch a ball in the air. The project's development was therefore divided into three different work phases.

– Phase 1) Research and scenario building. From the preliminary research results 4 key themes were identified: customisation, cooperation, new contexts of use and sharing. 4 development scenarios for new product systems emerged from each macro theme.

– Phase 2) Concept generation. In the second work phase, different concepts were developed that are capable of interpreting, in a different and broader manner, the key elements emerging from the research and scenario-building phase. Four product system concepts were drawn up, each of which emphasised one of the four macro themes identified.

– Phase 3) Product system development. The third work phase involved a convergent activity of choosing a promising concept and a subsequent phase of technical development for all the product system elements. This phase enabled the development of an innovation project capable of responding to the contemporary needs of motor play and interactive experience made possible by digital technologies.

The three phases of the design process saw the fruitful synergy of all the actors involved. The Politecnico researchers developed research tools and gathered insights useful to the project's development. In the concept generation and product system development phases, they oriented the design process thus allowing for the substantiation of choices with data and information collected in the scenario-building phase. The company's technical team followed all the project's development phases providing important support through guidance for the balancing of strategic guidelines, on the one hand, and the organisational boundaries and skills available internally or externally to the company, on the other. The toy designers worked in close contact with researchers and technicians, translating the research results and the reflections on strategic positioning operated by the company into product design aspects.

Originality of the developed project – The product system developed in the third phase of the design process consists of an indoor and outdoor tricycle (Fig. 4). The project's innovative component is the synergy between product and service: the technological base acts as the tricycle's base to be connected to a console that allows the child to interact with an educational video game activated and guided by the movement produced with the tricycle's pedalling. The product system is therefore an original combination of physical product and educational content representing the vision of developing new services for a company, which up to that point in time, was totally oriented toward the product. Content activated through movement made with the tricycle allow for motor play activities in small indoor spaces and outdoors, in different contexts of use. By interacting with a screen, and therefore with the specially-designed pedagogical content, children increase their cognitive skills in combination with physical movement, and manage to improve learning.

Conclusions – In Design Driven innovation, there is talk of design's strategic role in defining innovation processes (Verganti, 2009; Manzini, 2015) that have an impact on new forms of organisation and innovative forms of value co-production. It is, therefore, innovation that is principally focused on the significance (process or product) wherein technologies are tools and ways to enhance the user experience and to respond to new behaviours generated by digital transformation. In this scenario, the core of the design process is an integrated system of products, services and communication, to capture new value systems and new market opportunities. Today, children are growing up in a constantly-changing environment; digital transformation is opening up new opportunities for designing new products and services that are able to support their creativity, their self-expression and play according to an ever-growing innovation potential. In this perspective, the key element of the developed project is the ability to provide the child with challenging and fun movement that is capable of stimulating fundamental skills for correct growth from a sensory-motor point of view, such as balance and stability, wherever the child is to be found and by exploiting the possibilities offered by digital innovation.

The product system, which can fall within the scope of Care Design, is useful for children to fight all those pathologies that can be connected to life habits that are too sedentary, such as childhood obesity. In addition, physical exercise stimulated by the new product system, increases children's cognitive skills through the integration of a

Fig. 4 - Flurry's setting in indoor game mode.

playful approach and specially-designed educational content. The new product thus provides children with the possibility of moving constantly through the tricycle in every context, both indoors and outdoors, and can treat motor coordination disorders. It is also a valid ally in fighting obesity and the phenomenon of child depression.

A first innovative product capable of responding to the contemporary needs of motricity and interactive play experience which, however, opens up to a broad scenario of future developments: if we, in fact, consider the needs that it intercepts and the technological potential that it includes, this first product may be followed by a broad system of solutions that explore the phygital theme to promote motor function and the ability to control and coordinate movements (also covering medical or paramedical areas). We can summarise the benefits of the new product-service by breaking them down into direct benefits (facilitates the development of physical activity for children; can be used by children with reduced mobility; can be used for physical rehabilitation; allows the indoor use of an outdoor game; adapts to different ages through adjustments and the updating of games; has a small footprint; is equipped with installation and connection to the intuitive platform) and indirect benefits (fights a sedentary lifestyle and child obesity; actively involves the child; helps with the development of coordination; is a learning support through interactive games; stimulates social interaction in multiplayer mode). In order to appreciate the product system's degree of innovation, a prototype is being built with the support of the company's know-how.

This will be tested on a panel of children. Through the compilation of data sheets, both the physical product and the video game application will be checked and assessed for certain fundamental aspects which are: the level of general usability, ease of interaction, the degree of adaptability and the capacity to promote physical activity.

However, the limitations of the applied research activities are also to be considered. Primarily, those linked to the team's expertise. In the product system's development phase, the project team came up against the absence of specific expertise in the development of IoT solutions and App programming. Access to external expertise required important investment for the company. Research and development activities were therefore accompanied by strategic development activities and the formulation of a business model for the project (with the assumption of partnerships with companies in the digital field and in the production of educational content on Apps and video games). The research activity's second limitation is linked to the development period (partly due to the absence of expertise): today, time to market is one of the most important variables for a novelty's success. The company's lack of internal expertise in the digital field and the need to identify and involve partners with a credible business model definitely conditioned the design development period. While considering the limitations described above, the applied research project presents itself as good practice for Design for Kids & Toys in the contemporary backdrop of changes generated by digital transformation.

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NOTE

1) The ABCD (Adolescent Brain Cognitive Development) Trial aims to recruit 11,500 children of 9 and 10 years of age, follow them for a maximum period of 10 years and collect detailed information on the use of media crossed with data of the scans carried out every two years through cerebral magnetic resonance imaging (MRI).

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[a] *Arianna Vignati, Researcher at the Department of Design of the Politecnico di Milano (Italy), is co-Director of Creative Industries Lab (Cilab) and Director of the Kids & Toys Observatory of the Politecnico di Milano which studies the needs of children and parents in the digital era to improve the design of products, services and spaces for kids. She is a lecturer in various courses and Masters programmes in Italy and abroad. Mob. +39 347/52.91.167. E-mail: arianna.vignati@polimi.it*

[b] *Benedetta Terenzi, Architect, PhD, Researcher at the Department of Civil and Environmental Engineering of the University of Perugia (Italy). She carries out research on the role of digital innovation in the areas of product design for children, retail and communication. She forms part of the research group of the Kids & Toys Observatory of the Politecnico di Milano and of Creative Industries Lab (Cilab). Mob. +39 393/44.17.696. E-mail: benedetta.terenzi@unipg.it*

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INNOVATIVE RESTORATION
PROCESS FOR THE PRESERVATION OF NAUTICAL HISTORY

Giulia Zappia[a], *Maria Carola Morozzo della Rocca*[b]

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Abstract
Nautical Heritage, a new discipline dedicated to historic boats, has developed as a topic of study in the field of Nautical and Naval Design with research and didactic headquarters in the University of Genoa's Architecture and Design Department (dAD). At present this includes two complementary fields of research: the cataloguing of Italy's boats and the definition of methods for their preservation. The purpose of this paper is to present the studies conducted and results achieved in the latter field of research. Specifically, this article falls under the heading of Process Innovation and demonstrates a new design tool for the restoration of still-functioning historic boats: the 'guidelines for the process of nautical restoration'.

Keywords
process, innovation, guidelines, nautical restoration, new professions

Restoration, as a field, came about and was developed, in Italy as well as in the rest of Europe, after a lengthy 19th and 20th century debate and, historically, it was considered a discipline related to the field of architecture before it was eventually applied to those pieces of Cultural Heritage which are today widely recognised and shared as much by the scientific community as by the general population. Today the primary law that safeguards these objects in Italy is the Cultural Heritage Act – Leg. Decree no. 42 of 2004 and subsequent amendments and integrations – which also includes means of transportation and historic vessels with certain specific characteristics[1]. Nevertheless, this law, created for other categories of historical objects, has proven on multiple occasions to be incapable of safeguarding and facilitating the recovery of those which we refer to today as floating Nautical Heritage (Rosato, 2011; Morozzo, 2014; Zappia, 2017). Meanwhile, according to a more recent timeline that begins in the mid 1990s and extends to the present day, at the University of Genoa the role of the designer, much newer as compared to that of the engineer or the architect, has been asserting itself in academic training[2] and has progressively acquired its own professional dignity, replacing the architect in many fields of design. While the Masters of Design at the time that the Weimar School was created, and due to the logic of a developing historical process, were invariably primarily artists or architects, today, exactly one hundred years after the birth of Bauhaus, the various skills of these two distinct figures, which have often overlapped or have been separated by a fine line, are now clearly established. Industrial and, by extension, nautical products now pertain overtly to the field of Design. Meanwhile, the contemporary effort which the Società Italiana di Design and the Icar/13 scientific Community have invested in the creation of a new design identity has introduced new areas of experimentation to our discipline which transcend the industrial product as it is traditionally understood to appear in fields of research that can be classified under the category of Design and Other Know-How[3], in which we can reasonably include all of the research activities conducted in the field of valorisation of Cultural Heritage from 2004 to the present day (Celaschi, 2008; Lupo, 2008; Bozzola, 2009; Irace et alii, 2014).

Based on this simple premise, the valorisation and preservation of Nautical Heritage currently tends to be the responsibility of a nautical designer rather than an architect, and finds practical feedback in Italy in those shipbuilding enterprises that, on the one hand, adhere to an artisan tradition that still exists but that is in crisis and, on the other, to a style of shipbuilding characterised by an industrial logic which is now outdated in terms of the practices that, not even a century ago, gave birth to the vessels of Italy's Nautical Heritage. Professional figures from the worlds of design and construction that co-exist and cooperate with one another to restore or preserve valuable vessels, work within a scenario whose historical context has yet to be studied to the same degree as other categories of Cultural Heritage and, as we have seen, with legal regulations that inadequately guide or direct the entire process of the valorisation of historical nautical objects.

There was no interest in Italy's historic naval vessels until 1982, a symbolic year (Zaccagni, 2007) after which the phenomenon slowly and painstakingly developed along two parallel trajectories. The first within a small circle of admirers of primarily privately owned vintage vessels; the second within several museums dedicated to the valorisation of publicly owned traditional crafts (Panella, 2014; Morozzo, 2018; Zignego, 2018). Currently, those who work in the field of vessel recovery base their work on personal capabilities and sensibilities which they have developed through direct experience and, lacking guidelines that can be applied to the entire restoration process, possess a freedom of action and interpretation that is not present in other sectors (Giacinti and Marino, 2006; Giacinti, 2008; Gnola, 2008; Morozzo, 2014). Furthermore, the gradual loss of traditional 'know-how' connected to the legendary figure of the 'shipwright' in favour of an industrial production of nautical vessels that, since the 1970s through to the present day, has developed with no regard for the field's origins, contributes to an increased degree of freedom of action (and uncertainty) for those who operate in the sector (Morozzo, 2017).

The dAD research group inserts itself within this context through ongoing research activities begun in 2012[4] and with methodological contributions which can be traced back to the modus operandi typical of designers. In particular, the line of research that is the subject of this paper is based on critical analysis of the sector[5] with a particular focus on the professional roles (old and new) that contribute to the recovery of historic vessels, the tools (traditional and contemporary) now used in shipyards, and the methods and processes that are primarily used today (often subconscious or not particularly evident). The phases of preliminary research aimed at a critical summary of the scenario referenced have made it possible to identify what is lacking and what is needed within the sector (Morozzo, 2014; Bellia, 2014) in order to subsequently offer solutions and define a new and innovative tool capable of 'scientifically guiding' the restoration process for nautical vessels (Zappia, 2019). One 'methodological' tool that has been developed under the rubric of 'guidelines for the process of nautical restoration' has been created for the designer, or for anyone who intends to undertake the restoration of a vessel, starting from the initial research phase, all the way through to its new launch and ongoing maintenance.

The degree of innovative contribution made to the context into which the guidelines insert themselves is apparent in how the phases of the process of nautical restoration are managed, as well as in the proposed manners of integrating them so that they may be easily applied. In this sense, the way indicated by the 'guidelines' determines a 'radical' innovation of the process, introducing an all-new 'scientific' methodological and operative approach to a sector that is still principally, if not completely, self-referenced. Furthermore, though the 'guidelines' are inserted within a primarily Italian context of research and experimentation, the work carried out has permitted comparison – during both the definition and experimentation phases of the process – with various European entities and a deeper contextualisation with respect to the Anglo-Saxon state of the art of restoration. This is recognised as an absolute benchmark for European good practices in the sector, not only due to the strong and enduring nautical cultural tradition that characterises it, but also and above all as regards the activities of National Historic Ships UK, an advisory committee that safeguards British Nautical Heritage. In this sense the 'guidelines' not only follow the 'Decision-making process for nautical vessels from the National Historic Ships UK patrimony' (National Historic Ships UK, 2010), integrating it and rendering it complete, but are also the connecting link to the studies and practical proposals of Leonardo Bortolami (2018) which focused on a responsible approach to the recovery of wooden nautical crafts.

The research project that led to the creation of the 'guidelines' is currently in a phase of experimentation which has responded positively to the initial tests on several case studies presented in the doctoral thesis which illustrates them (Zappia, 2019), an activity which continues to involve the highest calibre of professional figures currently present in Italy, with the intention of fuelling the spirit of inclusion and collaboration within the sector of interest. Further applications will contribute to honing and redefining them in accordance with the results achieved once the current phase of experimentation is concluded.

Foundations of the Study and Method – The activity that was conducted predominantly, but not exclusively, uses Design Thinking as the preferred approach to the study and to the project, obviously considering it to be appropriate for the field of Design and unique (in that it has never before been used) for the field of interest. The use of a tool that is typical to Design in a sector such as that of historic vessels, which is far removed from specific and rather 'conservative' rules, has made it possible not only to come up with solutions to complex problems, but also to examine the reference scenario using an approach that is unconventional in the world of historical vessels. Brainstorming and Lateral Thinking then assisted in the design phase, which led to the definition of the 'guidelines for the process of nautical restoration'.

The study is rooted in Genoa's academic environment, inserting itself in a field that is already active and whose previous inquiries have made it possible to easily define the broad landscape of Nautical Heritage in Italy, as well as the additional research that is still necessary. The work, which developed from this starting point, was structured into three main sections that trace the typical organisational sequence of Design Thinking: Understand, Explore, Materialise (Fig. 1; Zappia, 2019a). The first of these is, in turn, subdivided into one phase that is aimed at identifying and becoming comfortable with the context (Empathise), and a second one that is strictly aimed at defining the problem that needs of answer (Define). In order to carry out each phase, careful observation (both passive and active) of the sector was necessary, using tools that are typical of Design research (bibliographic sources, local analysis, mapping of shipyards and of ship design and recovery studios, meetings and interviews with professionals and experts from the sector, participation in seminars and conferences, etc.). Once the state of the art and the trends in the restoration of Italy's boats were identified, it became possible to recognise the lack of a methodological design approach that was 'strictly scientific' and shared among those who at present, in Italy, work on recovering these vessels. The subsequent Exploration phase, divided into Ideate and Prototype, has contributed to the application of the good practices which are currently found in the field of historic ship recovery, as well as to the rejection of incongruous design approaches and the identification of approaches that are absent or missing.

The specific parts of the recovery process were defined through study of the manuals[6] and of what happens not only in the sector's shipyards, but also within its design studios. Furthermore, the ongoing dialogue with experts has made it possible to draft a series of actions that are more or less recurrent in the procedures carried out by single operators during the restoration of a nautical vessel. For example: 80% of those surveyed identify, during the course of the restoration, a phase prior to the design and to the work in the shipyard which could be defined as research, analysis, or evaluation. To this end, four individuals out of five talk about historical research; two out of five talk about analysis of ships' construction categories; three out of five talk about analysis of the disrepair; and four out of five mention a dialogue with the shipowner as an important phase of the restoration. 60% of those surveyed then identify a design phase in which only one expert out of five talks about preliminary design, evaluation of the time frame, and the final project, while four out of five of these take into consideration an evaluation of the costs, and three out of five an evaluation of the craftsmanship and the labour. An additional phase identified by 100% of experts pertains to the work done in the shipyards (Zappia, 2019).

The complexity of adapting these phases under the umbrella of a single and shared operative model is, therefore, apparent and also corroborated in four case studies of vessels analysed (Zappia, 2019) following direct interviews. The units examined are

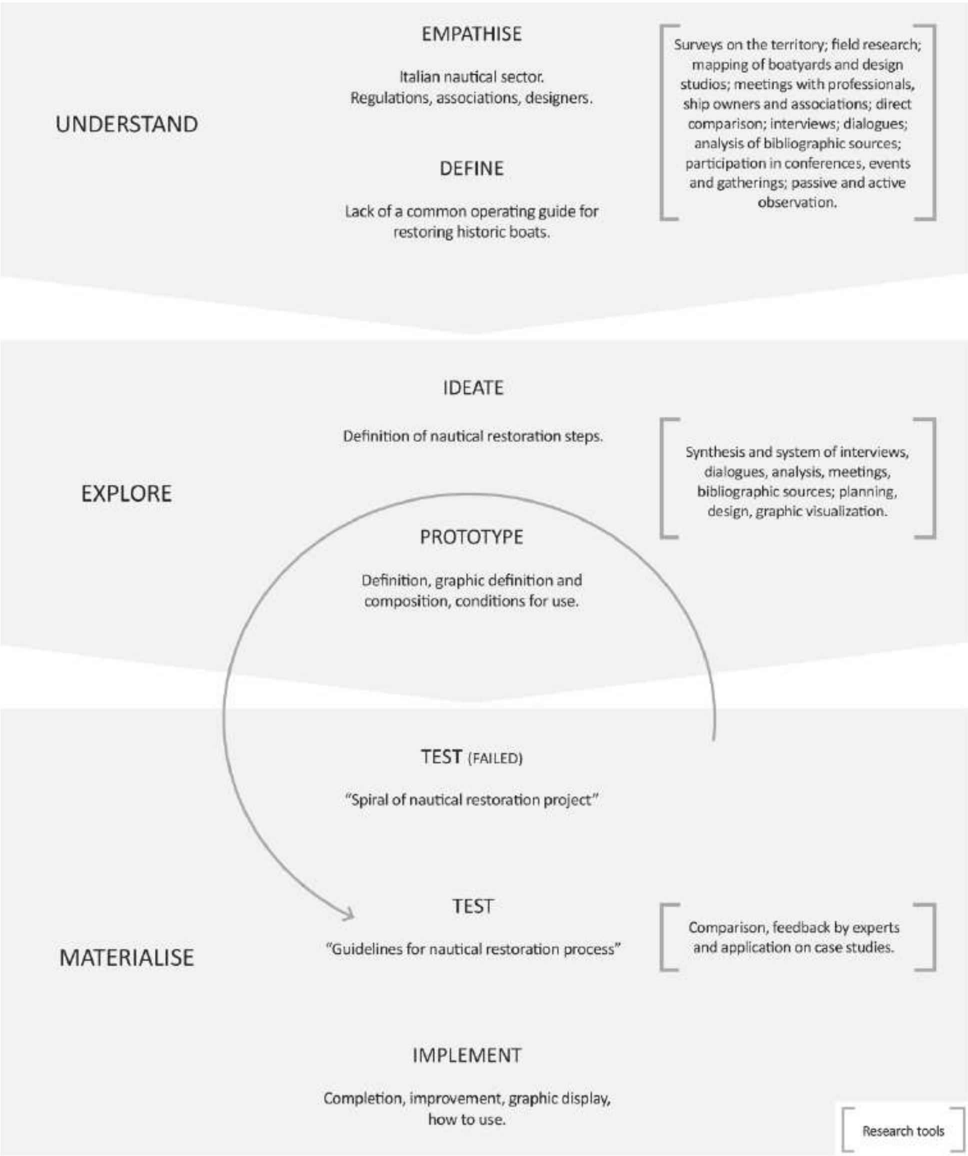


Fig. 1 - Design Thinking methodology applied to the research (credit: G. Zappia, 2019.)

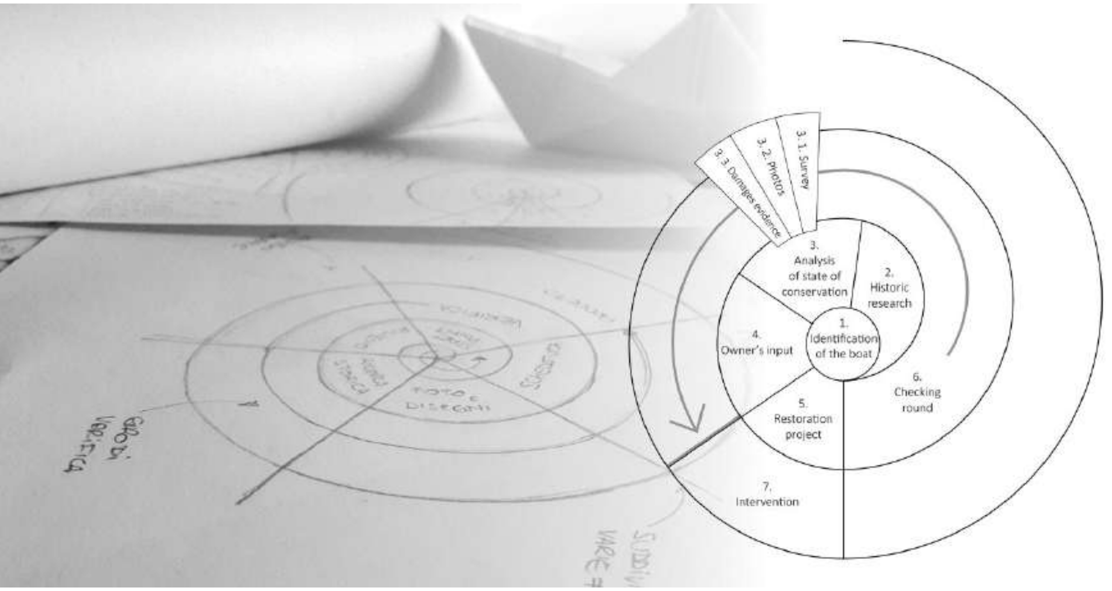


Fig. 2 - The spiral of nautical restoration. Sketches and graphic visualization (credit: G. Zappia, 2019).

representative of a wide range of possible restorations and are differentiated by the type of vessel as well as by the type of intervention. The only thing they have in common is that they all received awards and recognitions for being outstanding examples of recovery[7]. Subsequently, research activity has led to an attempt to establish a complete process for nautical restoration, 'saving' and organising the good practices found in the sector and inserting the phases that were considered to be missing. The first trials resulted in a unique graphic composition, in the form of a prototype, called 'spiral of the nautical restoration project' (Fig. 2; Zappia, 2019a). The spiral, thus defined because it was inspired from a project methodology that already exists in Naval and Nautical Design, was tested with unsatisfactory results as compared to the specific context of reference. Consequently, it was necessary to revisit the Materialise phase of the applied research in order to arrive at the definition and design of a new prototype capable of including and weighing as much as possible all of the phases identified, this time under the guise of a sequence diagram.

The organisational model proposed in the second instance, called 'guidelines for the process of nautical restoration', was, in its most current form, an object of comparison for experts from the sector and was newly tested on several case studies, both in 'reverse engineering' and in real time. Finally, following the positive outcome of the prototype's tests, upon completion of the entire design and adopted research sequence, the Implementation phase is currently underway, during which the results of the study are expected to be completed, refined, and implemented.

Guidelines for Nautical Restoration: Structure, Experimentation, and Optimisation – The 'guidelines for the process of nautical restoration', the result of the whole research project, is an entirely new tool for this sector which introduces process innovation. Primarily intended to be used by nautical designers and restorers, they insert themselves within the life cycle of an object, providing a guided design path which makes it possible to register the historical, cultural, and material value of the object, to adequately restore its operative functionality, and to keep it functioning through a perpetual cycle of checks and maintenance.

The structure of the 'guidelines for the process of nautical restoration', in its final form, characterised by a linear process flow diagram (Fig. 3; Zappia, 2019a), is made up of a first part called Research, the objective of which is to identify the historical and cultural value of the boat, describe its constructive forms and characteristics, and get a grasp of its condition at the moment it was found or at the start of the restoration. After this comes the phase known as Design, through which it is possible to identify the objectives of the restoration, choose the operative methods and the materials considered most appropriate to the specific case, and, lastly, draft, hone, and complete the design itself. The third part, Interventions, identifies the physical activities of the shipyard and allows for the timely monitoring of work with relation to the objectives established in the previous phases and the historical and cultural value of the boat. Finally, Post-restoration includes not only the planning of the maintenance necessary for preserving the working order of the boat over time, but also the cultural valorisation and dissemination of the material and immaterial value which the vessel, as a piece of Cultural Heritage, can convey.

Specifically, the part related to Research includes the identification and initial survey, through which the boat's data, such as name, category, type of propulsion, and affiliation are collected; the historical research, which makes it possible to collect historical information like the year and place of construction or launch, the designer, and any change in the boat's ownership, name, registration number, or use; the survey, in which all of the vessel's dimensions and material characteristics are defined; and the analysis of the state of preservation, which is necessary in order to document the boat's condition and any damages it has suffered (Fig. 4; Zappia, 2019a).

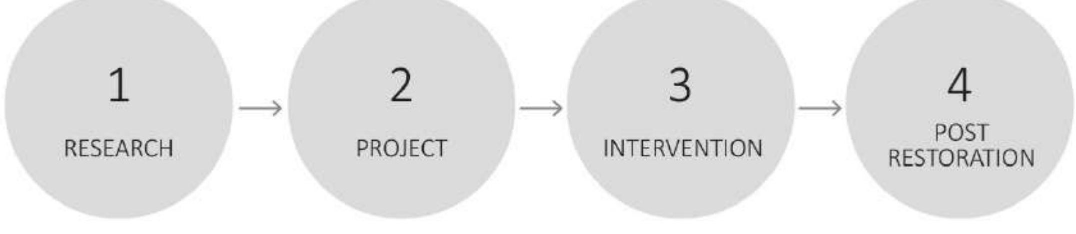


Fig. 3 - General structure of the 'guidelines for the process of nautical restoration' (credit: G. Zappia, 2019).

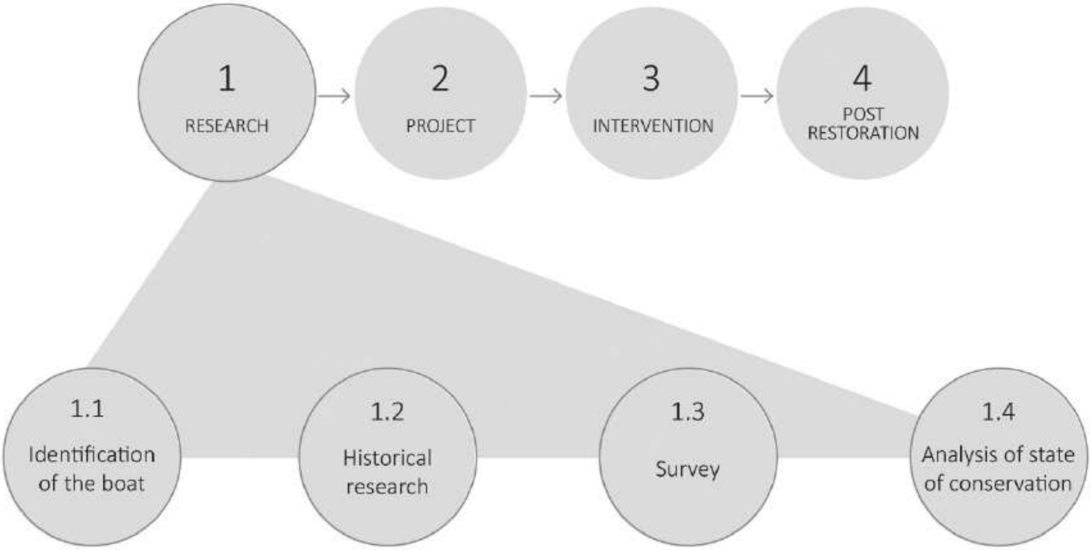


Fig. 4 - Composition of the 1st area of the 'guidelines for the process of nautical restoration' (credit: G. Zappia, 2019).

Meanwhile, the part known as Design is made up of five main steps. An initial phase of evaluation and assimilation of the history, the shipowner's input, and the available budget, followed by the definition of the objectives and goals of the restoration in order to develop an initial design proposal and, finally, the constructive and material technical evaluations. This stage includes numerous considerations and a lively and ongoing debate regarding the possibility and legitimacy of using modern building techniques and materials in the restoration of vessels, or, on the contrary, of using only techniques and materials that were in use at the time in which the boat was constructed (given the extent to which this is still realistic in practice)[8]. The final phase of Design is the completion and drafting of the project (Fig. 5; Zappia, 2019a).

The Interventions part is next, for which the structure of consecutive steps is maintained, but implemented. Here the boat is subdivided into different parallel work areas depending on the specific needs of the type of intervention, the shipyard, or the labour. For every area of the boat consequent activities are carried out: preliminary work, meaning work that comes before the actual restoration (for example: dismantling, sanding, stripping); verification, in which it is determined whether or not, after the preliminary work, the project still corresponds to the requirements or if new elements have emerged that require the project to be re-examined; execution of the project, in which the actual steps in the restoration process are identified; and finishing, which entails completion of the final construction activities on the vessel (for example: lacquering, sealing, painting). It must be emphasised that oversight of every phase in the restoration process is guaranteed by continuous and constant supervision which permeates the entire process and that, from a practical standpoint, is identified by a series of questions aimed at verifying that every step complies with the objectives determined in the first phase, with the historical and cultural value of the boat, and with the shipowner's input. Finally, the part related to Post-restoration can be carried out by the designer himself via indication of the checks and maintenance cycles that are necessary for the specific vessel.

In Fruitful, a traditional Scottish vessel first launched in 1955, this process as just described finds the most complete application of 'reverse engineering' encountered during the research project (Zappia, 2019). Fruitful was built as a motorised fishing boat in Scotland's Millers shipyards in St. Monans. Following a series of vicissitudes that saw it dock in numerous ports around the country, accompanied by ten different owners, after sixty years it returned to the same area of the coast from which it first launched. Here, in 2016, within the shipyard of the Scottish Fisheries Museum, it began its restoration which was concluded nearly two years later.

The Research phase was conducted simultaneously by the designer and the shipowner who, through comparative analysis of historical photographs of the boat

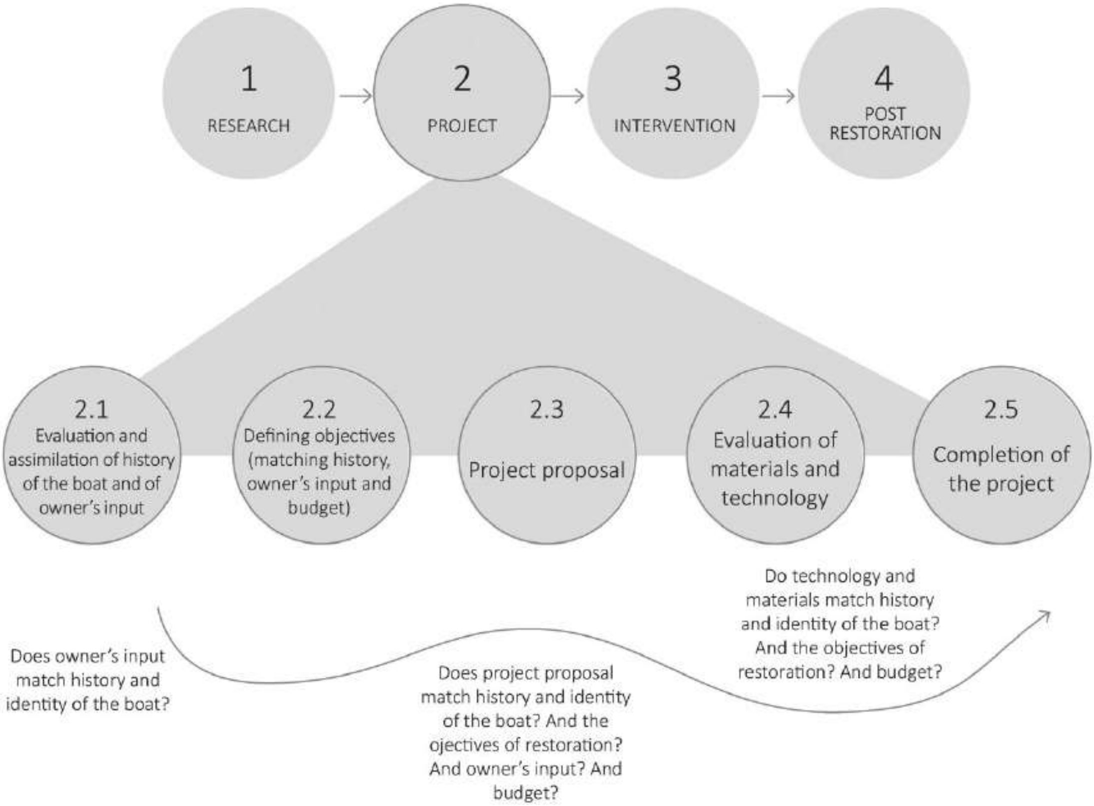


Fig. 5 - Composition of the 2nd area of the 'guidelines for the process of nautical restoration' (credit: G. Zappia, 2019).

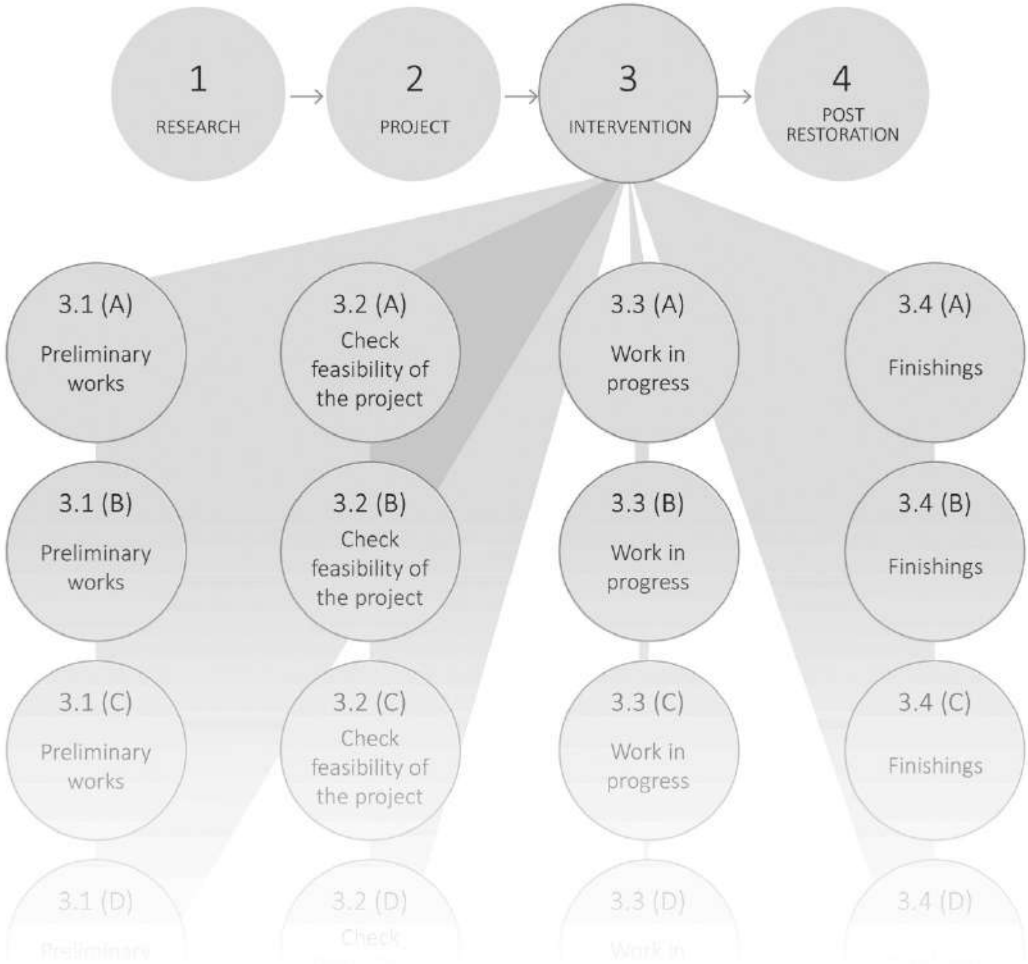


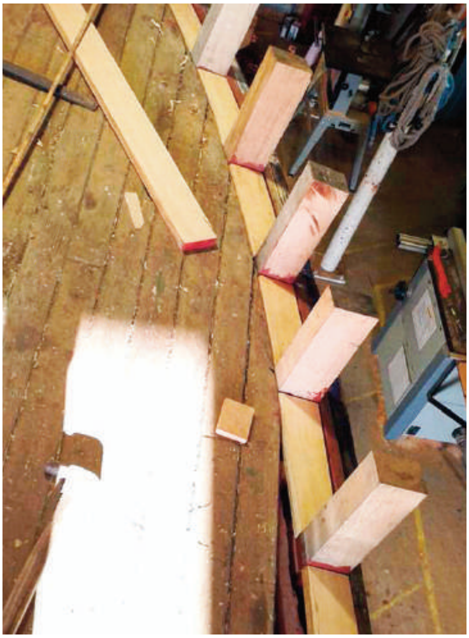
Fig. 6 - Composition of the 3rd area of the 'guidelines for the process of nautical restoration' (credit: G. Zappia, 2019).

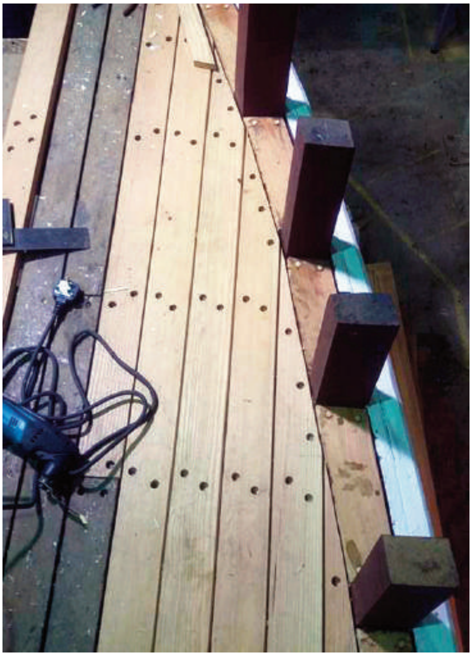
and drawings of vessels from the same shipyard as Fruitful and constructed in the same year (given that the vessel itself was entirely without documentation) and following the evaluation of its condition and the assessment of its damages conducted by the designer and subsequently documented, defined the objectives of the restoration. «Considering the modifications made over the years to be historically irrelevant interventions which had a considerable impact on the shape and aesthetic of the vessel, and given, on the other hand, the important historical testimony of this kind of vessel in its original state, the project intends to return the boat to its original conformation, even taking into consideration the necessary compromises made to ensure the navigability of the boat and its use for private recreation» (Zappia, 2019, p. 292). The Design phase was completed following the enumeration of specific steps subdivided by area of intervention (ex. bulwarks, deck, interiors, etc.). Regarding the evaluation of construction techniques and materials, implicit in the shipyard's typical operative methods is the use of traditional techniques and materials that can be easily found in the area, with the occasional use of modern technologies when these represent a necessary compromise between preserving the boat's historical accuracy and ensuring an easier, more appropriate, and longer lasting restoration.

With respect to the interventions (Fig. 6), an initial attempt to simultaneously conduct phases 3.1 for all of the areas (A, B, C, etc.), and to then proceed with the subsequent phases only once the previous ones had been completed, had a negative outcome. In fact, the vessel was subdivided into 14 areas and certain limits could not be perfectly defined. This meant that while for the preliminary work it was possible to proceed simultaneously as suggested by the 'guidelines', for the restoration (phase 3.3) of certain areas (for example certain specific activities in the 'deck' area) it was necessary to wait for other areas to be finished (in this case the 'bulwarks') in order for them to be carried out and completed (Figg. 7-9). This situation demonstrated the impossibility of establishing strict rules and overly restrictive limits. Therefore the subdivision into steps and the configuration proposed by the guidelines' remain valid, taking due account however of the freedom of choice between the option of following the suggested steps simultaneously (first all of the 3.1 phases, then all of the 3.2, etc.), or, depending on the needs of each intervention, of the organisation of the shipyard, and of the labour, opting for a crossed sequence that is determined depending on the situation (for example, one could proceed with phases 3.1 and 3.2 for area A and subsequently begin phase 3.1 in area B before proceeding at the same time and concluding simultaneously with all of 3.4), while still maintaining the overall sequential nature: first 3.1 then 3.2 then 3.3 and finally 3.4, without ever proceeding backwards.

Ultimately, Fruitful was a verification model for the Post-restoration part as well. The designer drafted a chart containing the sequence of checks and maintenance specific to the boat while, in terms of cultural valorisation and dissemination, the shipowner actively participated in the organisation of gatherings of traditional vessels and historical-cultural events in which Fruitful was always front and centre (Figg. 10, 11).

Critical Considerations and Conclusions – Following the optimisation obtained by testing the 'guidelines' on Fruitful, additional trials were conducted in Italy with the dual objective of improving the process and getting those national entities that oversee the recovery of Italy's Nautical Heritage newly involved (once the process was defined). This inclusive approach, which has always been a part of the way in which the research project was conducted, brought to life a lively and well-rounded debate in the sector (Morozzo, 2018, 2018a) which nourishes the cultural aspects at the basis of the project (like the comparison with architectural restoration) as much as the practical-logistical aspects (like, for example, the operative activities of the shipyard). Both the scientific





Figg. 7-9 - Scottish Fisheries Museum shipyard, Anstruther, UK: Intervention on waterways, area 'bulwarks'; Completion of waterways intervention, area 'bulwarks'; Intervention on the deck (credits: L. Bortolami, 2017).

Fig. 10 - Fruitful at Anstrhther Harbour Festival, Anstruther, UK (credit: R. Wemyss, 2018).

Fruitful	1 week	2 week	3-4 months	6 months	1 year	1.5 year	2 year	6 year
Wet the deck with salt water	x							
Starting the engine		x						
Bilge cleaning			x					
Deck oiling				x				
Interior ventilation		x						
Painting with antifouling					x			
Check and possible change of anods					x			
Check and possible reset of pitch					x			
Painting								x
Mast oiling					x			
Sanding, primering and painting of metal components							x	
Cleaning or possible replacing of water pump impeller					x			
Cleaning or possible replacing of water and diesel filter					x			
Oil change, check and possible change of the oil filter							x	
Checking engine liquids						x		

Fig. 11 - Ordinary maintenance timetable of Fruitful (credit: G. Zappia, 2019).

community and the sector are demonstrating substantial interest in the process that has been defined and illustrated by the 'guidelines', recognising the innovation and benefit to the sector of historical nautical vessels.

With respect to the current scenario and to the approval with which they were met in the community of application, in the near future the popularisation of the 'guidelines for the process of nautical restoration' will contribute to establishing all-new professional figures capable of bringing together great design capability and skills that incorporate both tradition and innovation and both the material and immaterial culture of historical nautical vessels. It will also encourage the consolidation of good practices in nautical restoration, confining and limiting incongruous interventions and, finally, will contribute to the strengthening of a collective awareness of the actual 'value' of historical nautical artefacts. Furthermore, their widespread use will facilitate the simplification of certain phases of the process itself, which at the time of this study may seem complex or difficult to use, but which through practice and redefinition will certainly benefit from the experience acquired through use. Finally, it is possible that, once the use of the 'guidelines' as a tool for restoration projects has been strengthened and completely absorbed by the sector, their use may over time spark virtuous mechanisms capable, in turn, of determining production or product innovation, reflecting positively on the more specific activities of the shipyard. This final aspect is certainly of interest and relevance, and therefore we hope to be able to examine it in the future as a further development of our research activity.

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NOTES

1) Art. 10 and 11 of Leg. Decree no. 42 dated 22nd January 2004 – Cultural Heritage and Landscape Act (in accordance with article 10 of Law no. 37 dated 6th July 2002) and subsequent amendments and integrations. For additional information see: Morozzo della Rocca, 2014.
2) Genoa's School of Design was established in 1996 and went on to develop and structure itself over time, ultimately arriving at its current form of: a three-year bachelor's degree program in Product and Nautical Design, a master's degree program in Products and Events, a master's degree program in Naval and Nautical Design, a doctorate program in Architecture and Design, and an interdepartmental doctorate program in Maritime Science and Technology. For additional information see: Aa.Vv. (2006), *10 indesign. Dieci anni di progetti e prodotti della scuola genovese*, Alinea, Florence; Spadolini, M. B. (2009), *Design Scuola Territorio*, Alinea, Florence; Aa.Vv. (2015), *Design Navale e nautico dieci anni magistrali a master's decade*, Publisher goWare, Florence.
3) This refers to what has become an incredibly active debate in the scientific community and which is embodied once again in the topics of the 2019 National Assembly of the Italian Design Society. See: Società Italiana di Design – SID. [Online] Available at: http://www.societaitalianadesign.it [Accessed 23 April 2019].
4) University of Genoa, Architecture and Design Department:
- University research projects: URP 2012 – Restoration for Nautical Artefacts, Methodological and Disciplinary Observations, research director M. C. Morozzo della Rocca; URP 2013 – Strategies for the Valorisation, Safeguard, and Recovery of Historical Vessels, research director M. C. Morozzo della Rocca; URP 2016 – Nautical Heritage, Digital Tools for Understanding and Promoting Nautical Patrimony, research director M. C. Morozzo della Rocca; URP 2017 – Maritime and Sea Museums: Networks for the Consolidation and Cultural Growth of Nautical Heritage in Italy, research director M. C. Morozzo della Rocca; URP 2017 – Associations and Organisations for the Safeguard of Nautical Heritage: Networks for the Cultural Growth and Consolidation of Nautical Patrimony in Italy, research director M. I. Zignego.
- Research Agreements and Contracts: 2019 Three-Year Memorandum of Understanding with the Ministry of Defence – Italian Navy – Northern Naval Command for « […] the development of activities for the valorisation and recovery of Nautical Heritage, also through research projects applied to specific case studies. A research project that explores the topics of historical analysis and of strategies, methods, and protocols that are useful to the recovery and valorisation of the San Giuseppe Due motorsailer [...]», research directors M. C. Morozzo della Rocca, M. B. Spadolini, and M. I. Zignego; 2019 Research Contract with Yacht Club Italiano (Genoa) for «study and research activities relating to the valorisation and recovery of nautical culture and of material and immaterial Nautical Heritage, also through research projects applied to specific case studies. [...] Study of the Bigrin vessel [...]», research directors M. C. Morozzo della Rocca and G. Pellegri.
- Doctoral Thesis: Bellia, S. (2014), *Il Restauro Nautico. Criteri metodologici e scenari per la valorizzazione e il recupero delle imbarcazioni storiche*, Doctoral Thesis (cycle XXVI) in Nautical Design

and the Sustainable Product, University of Genoa; Ferrando, L. (2015), *Cultural Heritage, tutela e valorizzazione del Patrimonio Nautico*, Doctoral Thesis (cycle XXVII) in Nautical Design and the Sustainable Product, University of Genoa; Zappia, G. (2019), *Tutela, valorizzazione e recupero delle imbarcazioni del patrimonio. Linee guida per il procsso di restauro nautico*, Doctoral Thesis (cycle XXXI) in Architecture and Design, University of Genoa.
5) Ibidem, see: Research Projects URP 2012 and URP 2013.
6) The study of the manuals focused primarily on: the Barcelona Paper (EMH, 2003); the Regulations for the Tonnage and Racing of Classic and Vintage Yachts (CIM, 2018); the ASDEC Nautical Historical Registry (ASDEC); "Imbarcazioni in legno, il restauro consapevole" (Bortolami, 2018); "Yachts Restoration" (Morozzo, 2014).
7) The case studies examined are: the Barbara yacht, restored by E. Zaccagni, expert project manager in the field of refitting and restoration of vintage vessels assisted by R. Valeriani, Vice-President of Viareggio's Historic Sailboats Association and by the workforce of the F. del Carlo Naval Shipyard; the recovery of Big Class Lulworth, undertaken by the Faggioni Yacht Design Studio, for the past two generations committed to the recovery of classic or vintage sailboats; the auric cutter Star 1907 restored by its owner, P. Sivelli, with the help of Verbano's Vintage Sailboats Association; the dragon Acanto, restored by designer L. Bortolami for the development of his doctoral research.
8) The objective of the 'guidelines' is, specifically, to see this phase as a necessary point to reflect upon. It is not the intention or objective of the 'guidelines' to indicate which operative methods should be applied to the restoration of the vessel. Please refer to the recent publication entitled "Imbarcazioni in legno, il restauro consapevole" (Bortolami, 2018), which integrates and completes, from an operative standpoint, the 'guidelines for the process of nautical restoration', created to satisfy a methodological deficiency in the process.

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[a] *Giulia Zappia has a master's degree in Naval and Nautical Design and is PhD in Architecture and Design at the University of Genoa (Italy), Architecture and Design Department (dAD). She conducts research activities in the field of preservation and valorisation of floating Nautical Heritage and Nautical Design. Mob. +39 340/32.41.933. E-mail: giulia.zappia@fastwebnet.it*

[b] *Morozzo Della Rocca Maria Carola, Architect, PhD since 2003 and Associate Professor of Industrial Design since 2014 at the Architecture and Design Department (dAD) at the University of Genoa (Italy) where she conducts didactic activity and research in the traditional fields of Nautical Design. She is a member of the Doctoral Panel in Maritime Science and Technology. Mob. +39 338/76.49.223. E-mail: carolamorozzo@arch.unige.it*

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The beginning of the third millennium has marked a period of unprecedented change for cities, architecture and product/visual design. Over the last two decades, economic, social and environmental causes have stimulated and conditioned research and production, directing them towards substantial paradigm changes, proposing new challenges to create more smart, more resilient, more responsive and adaptive, more efficient and more sustainable urban systems, buildings and objects – from nearly Zero Energy Buildings (nZEB) to Positive Energy Architecture (PEA) – designed and built faster, with lower costs and with a positive effect on the environment, society, health and productivity: more innovative, in a nutshell. It is a common knowledge that innovation is, now more than ever, the tool needed to recover from the global economic crisis, to aim for economic prosperity and quality of life improvement, to increase productivity, to foster competitiveness, to support the challenge of globalization and environmental sustainability, both at an 'incremental' level (improvement of an already existing production process) and 'radical' (to create a new unmatched method or production system).

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Francesca Scalisi, Architect and PhD, she is the co-founder and Research Manager at DEMETRA Ce.Ri.Med. (Euro-Mediterranean Documentation and Research Center), Palermo (Italy) She is a member of the Editorial Board of Agathón | International Journal of Architecture Art and Design; she is a member in several International Steering Committee as well as a Reviewer for various scientific Magazines. She carried out research on Green Materials, Innovative Materials for Architecture, Nanomaterials, Energy Saving in Buildings. Her main Research Projects are 'Natural and artificial innovative materials for architecture', 'Nanotechnologies for unfired clay bricks (tradition, innovation and sustainability)', 'Recovery and conservation of Architectural Heritage using nanostructured materials and innovative technologies'.

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