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# FLEX-HAB

## Executive summary

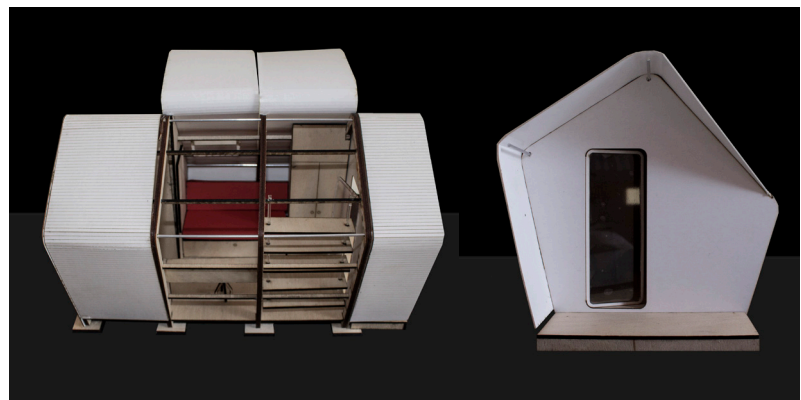
FlexHab project investigates a possible field of application for a new composite material, the MadFlex, and develops a specific construction technology regarding flexible housing solutions. The material has been developed by Composite Research srl: it is a lightweight composite panel sandwich-like structured. It has two innovative features, from a mechanical point of view: it is flexible and rollable on one side, while it is stiff and crushproof on the other; from an energetic point of view it has good thermal performances in relation to its thickness.

Concerning the different possible fields of application, from the preliminary analysis emerged how the potential of MadFlex is addressed to the critical context of disaster management and can be efficiently deployed for the construction of emergency shelters. In the Italian context, the "Recovery period" is conventionally split into "Medium-term supplementary reconstruction sub-period" and "Definitive reconstruction sub-period", in which shelter solutions employed are wooden houses, containers and SAE (Soluzioni Abitative di Emergenza meaning "emergency housing solutions"). The FlexHab project proposes a solution able to eliminate the first sub-period and to significantly reduce the overall timing of the "Recovery period".

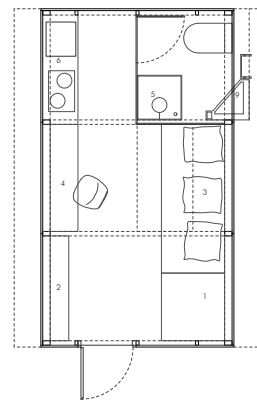
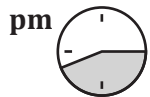
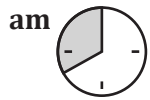
Some crucial points of the research were how to approach an innovative material and which constructive and technical systems choose according to the materials properties and the specific requirements of the emergency shelters topic. The main goal of FlexHab is to conceive a shelter solution for both private and public market, allowing for a revolution of the disaster management processes and combining the requirements of comfort, flexibility, affordability, smart technical solutions and life cycle sustainability.

## Keywords:

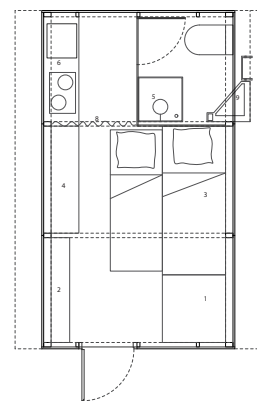
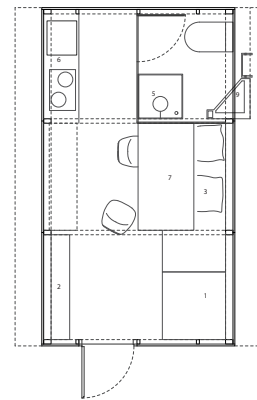
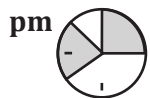
Emergency shelter  
Madflex  
FLEXible HABitat



Final solution, model 1:20



- 1 Closed wardrobe
- 2 Hanged shelves
- 3 Sofa-bed
- 4 Flap desk
- 5 Shower
- 6 Kitchen forn
- 7 Flap-table
- 8 Curtain
- 9 Washbasin



0 10 50 100

Rendering and plants of the shelter interiors depending on daily activities

**Project description  
written by the  
Principicipal Academic  
Tutor**

The project will be concentrated on creating a technology push for a new material. The MadFlex (PCT WO2016120785 A1) is a lightweight asymmetric composite material panel, having a sandwich-like structure. It exhibits two order-of-magnitude difference in bending stiffness, depending by the direction of the applied bending moment, thanks to a reversible buckling phenomenon of one of its skins: it is flexible, even rollable, on the one side, while it is rigid like a traditional sandwich panel on the other one. In addition, its foam core confers to the MadFlex good insulation properties.

The design and development of a novel flexible habitat starting from the potentialities of the new material will face a multiplicity of research needs which will be integrated into a systemic approach and organized in four main steps:

1. The requirements identification: at the material / building component / habitat level. The new material will be tested and its characterization will orient the right matching with a set of technical requirements for adaptive structures and flexible skins.
2. The form + structure integrated design process: supported by advanced form-finding design tools and performance-based modelling tools.
3. The experimental phase where a first demonstrator of the new adaptive skin will be installed and tested to validate the behavior of the new habitat and to optimize its final design.
4. The study of different application of the novel habitat solutions and the evaluation of social, economic and environmental impact by using multi-criteria analysis, Life Cycle Cost (LCC) and Life Cycle Assessment (LCA).

**Team description by  
skills**

The FlexHab team is composed by five students from the field of architecture, engineering and interior design. To each component a specific role was assigned in order to develop a strategic topic:

Edoardo Marcandelli: (MSc. Degree in Building Architecture, Politecnico di Milano) study of details of mono-material and/or hybrid structural solutions, study of the thermal performances.

Francesca Perego: (MSc. Degree in Building Engineering Architecture, Politecnico di Milano) optimization of the packaging and transportation issues, study of environmental and economical sustainability of the solution (LCA and costs survey).

Roberto Rossi: (MSc. Degree in Civil Engineering, Politecnico di Milano) structure optimization.

Eleonora Teruzzi: (MSc. Degree in Interior Design, Politecnico di Milano) study of the interior spaces, space optimization through the use of furniture considering the user perception (user friendly solution).

Eleonora Valle: (MSc. Degree in Architecture, Politecnico di Milano) morphological study, settlement and architectural composition strategy, design of interior spaces and functions.

## Goal

The FlexHab project goal is to design and develop of a novel flexible habitat starting from the potentialities of the new material, the MadFlex.

The main objectives are:

1. Apply a multi-functional, flexible, “aeronautics-derived” composite material (MadFlex) to figure out futuristic habitat solutions.
2. Improve a revolutionary approach to the building system introducing an innovative technology
3. Envision an innovative building skin, seamless and integrated with the structure, considering the industrial production requirements.
4. Satisfy user needs through an economical and social sustainable solution.
5. Investigate performances and the economic feasibility of a basic adaptive habitat.

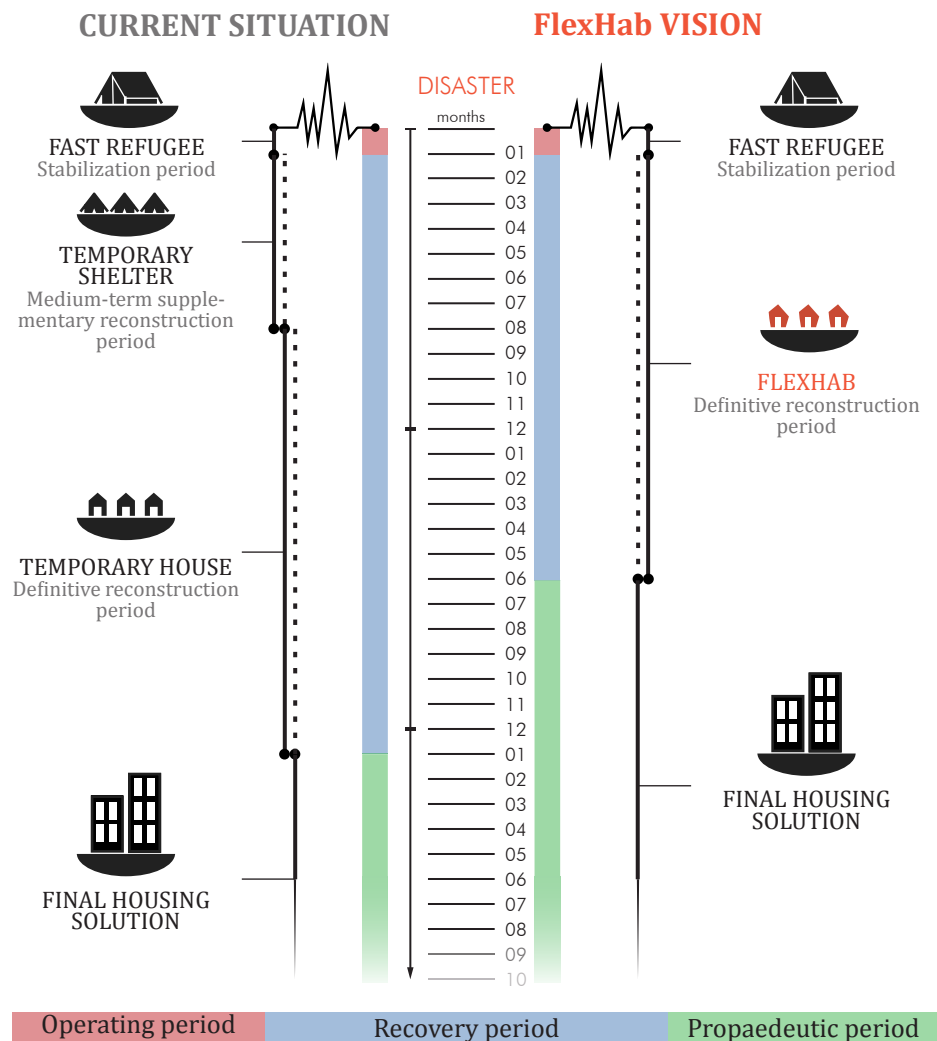
## Understanding the problem

The MadFlex (developed by Composite Research srl) is a composite material panel with a layered structure, practically a sandwich-like structure. The uniqueness of the MadFlex consists in its mechanical feature: the panel of MadFlex is flexible, even rollable, on the one side, while it is crushproof on the other. Investigating the possible scenarios where MadFlex properties could be determinant to perform a revolution inside the market, emerged that the Emergency Shelter field was the most suitable to develop new innovative solutions. In fact, in the Emergency field the more relevant requirements are: transportability, MadFlex is rollable and lightweight; constructability, MadFlex is lightweight and could be equipped in the production phase; performances, MadFlex has good thermal and mechanical performances; customizability, MadFlex could be customized with different finishing.

Looking for possible stakeholders involved in the Italian scenario and analyzing their needs, the main requirements were outlined. Victims of calamitous events demand an increasing of comfort and quality of life inside the emergency shelters as well a more user-friendly solution closer to their houses. Institutions as government and Protezione Civile department require a decreasing of costs and time of the solution and an increasing of performances and social sustainability. Finally stakeholders interest in trade, production and advertising of the FlexHab proposal are in concern about competitiveness of the project solution that must be more sustainable, in terms of cost and social impact, of the existing ones.

In Italy, the management period of post calamitous event is conventionally split in different phases to which correspond different emergency housing solution. Firstly, temporary shelters as containers and wooden houses are used to provide an immediate aid; nevertheless, they are not positively evaluated by the population because of the lack of comfort and security. Meanwhile, SAE (meaning “emergency housing solutions”) are built to host the disaster victims. They are well appreciated because of their tendency to look like as permanent houses, on the other hands they are available too far from the catastrophic event.

Therefore, the FlexHab project proposes in a unique solution the positive aspects of the existing solutions: the “just in time” deployment of the shelter and the high level of comfort.



The emergency management process, Current situation applied in Italy and FlexHab innovative scenario.

## Exploring the opportunities

The potential of MadFlex is better addressed to the critical context of disaster management and can be efficiently deployed for the construction of emergency shelters, thanks to many peculiarities intrinsic in the material. For instance being flexible and rollable on one side, and stiff and crushproof on the other, it allows both an easy and efficient transportation/stock, and a rigid livable skin. In consequence one of the main assets was design a shelter that would be easily stocked in a FlexHab-kit that, as for common tents kits, is easy to transport, built and dismantled for future uses. Moreover, conversely to many composite materials, MadFlex can be moulded and accessorized in a continuous flow process, saving up to 50% of the cost spent with a warming process and meanwhile, addressing constructive needs as introduction of joints, during the production phase. Facing the emergency shelter issues, low cost, easy and fast implementation are fundamental requirements. In consequence, modularity becomes a smart answer to fit industrial production necessities as well for the settlement and the architectural composition of the artefact. Furthermore, from an energetic point of view it has good thermal and acoustic performances in relation to its thickness guaranteeing good thermal level of comfort for the shelter.



## Goal

The FlexHab project proposes an efficient solution to manage the “Recovery period”. This revolutionary impact on the disaster management is allowed by the integration of the tent technology, as easy and fast to deploy, with the home archetype, as private and human scaled space, in a unique FLEXible HABitat.

“Flex” as flexible, since the initial point for the project has been the innovative material of MadFlex and its main peculiarity. Its morphology mirrors some of the potentialities of the materials. Flexible both for the material’s behavior and for the internal space’s conception: in fact the design of the furniture integrated in the structure allows for a different arrangement of the living areas according to daytimes and night-times. “Hab” refers to habitat, the space of domesticity, a new and starting living fulcrum to heal the loss of a house.

Thanks to the pentagonal modular design and innovative joints introduced in the production phase, the whole envelope can be set up through a single construction gesture. No specialized craftsmanship, specific tools or heavy machineries is needed: only a complete “kit” with assembly instructions and technical support would be provided.

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