KNOWLEDGE TRANSFER INTO A SYSTEM DESIGN PROCESS: THE CASE STUDY OF "S(P)EEDKITS - RAPID DEPLOYABLE KITS AS SEEDS OF SELF-RECOVERY"

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Sommario

Il contributo presenta i risultati del progetto collaborativo di ricerca S(P)EEDKITS, co-finanziato dall'Unione Europea nell'ambito del Programma Quadro FP7, per il settore Sicurezza (attività SEC-2011.4.2-3, grant agreement no. 284931). Il progetto ha coinvolto dal 2012 al 2016, quindici partner europei tra organizzazioni umanitarie, centri di ricerca, accademia e aziende private, per il rapido sviluppo di soluzioni modulari e iper-leggere, per implementare le Unità di Risposta all'Emergenza (ERU) già in uso dalle principali organizzazioni umanitarie.
L'articolo si concentra sul trasferimento delle conoscenze nel partenariato in un processo di progettazione sistemica, grazie a un approccio multidisciplinare e orizzontale. In particolare, si focalizza sulle attività svolte dal Politecnico di Milano, che è stato direttamente impegnato nella progettazione del packaging e della modularità delle nuove ERU.

Abstract

This contribution presents the case study of S(P)EEDKITS, a four-year collaborative research project co-funded within the Seventh Framework Programme, activity: Security (SEC-2011.4.2-3, grant agreement no. 284931). The project involved 15 European partners including humanitarian organizations, research centers, academia and private enterprises, for the development of rapid deployable, modular and lightweight kits toimplementthe Emergency Response Units (ERUs) already in use by humanitarian organizations for emergency response.
This article focuses on the knowledge transfer in a systemic design process, with a multidisciplinary and horizontal approach. The paper goes through in particular the activities carried out by the Politecnico di Milano, which was directly committed in the design of packaging and modularity of the ERUs.

Keywords

Knowledge Transfer, Emergency Response, Long-Term Self-Recovery, Emergency Shelter, Complex Systems Theory.

Introduction

In emergency response, humanitarian organizations (e.g. IFRC) have developed pre-packaged ERUs, ready-to-use and for different specific functions, e.g. medical care, sanitation, energy provision, with trained professionals. Against this background, benefits coming from other expertise are being increasingly recognized as an advantage for the humanitarian sector, such as the experimental innovation of material and technical aspects of shelter and logistics, as the interdisciplinarity of conceptual frameworks and support in terms of methodology and technological innovation, as the development of prototypes and pilot projects.

In this context, the project "S(P)EEDKITS: rapid deployable kits as seeds of self-recovery" was a twofold driver of innovation, pushing forward the performance of current and in-use emergency kits: on one side, the project improved existing ERUs and developed novel kits to support early emergency response of humanitarian organization by reducing drastically their deployment time, volume and weight for transportation; on the other side, the project approached the long-term recovery, designing the kits by their components rather than as closed products, to endorse the shared trend in emergency aid to stimulate as early as possible self-repair and reconstruction by the affected population.

Therefore, the novel emergency kits are *speed* in terms of transport and installation, in order to provide fast and proper solutions when a disaster occurs; at the same time, the novel emergency kits are *seed* for long-term self-recovery after disaster strikes, in a way that its components may be used in the reconstruction phase, according to the occurred needs, either by themselves and together with other components from different kits.

Moreover, the S(P)EEDKITS project was unique in its consortium members, closely pertinent with the project's goals. The partnership included actors from humanitarian sector, industry and research. In particular, the peculiarity of every stakeholder was:

1. Humanitarian organizations: expertise of humanitarian operation execution and management (deployment of humanitarian actions).
2. Academia and Research centres: expertise on innovative systems (materials, structures, recycling) to be tested.
3. Private enterprises: production facilities and technical competencies for the development, testing and prototyping of the kits.

Indeed, the multidisciplinary nature of the partnership assured a mutual contribution by balancing each other operational limits. Humanitarian organizations have operative knowledge but they refer to donors; academia has theoretical knowledge that needs to be validated in the field; private sector is a technology provider that can be limited by market demand.

S(P)EEDKITS: Rapid Deployable Kits as Seeds of Self-Recovery

The complex management due to the technical and formal complexity of the project and, indeed, the nature of the partnership, having actors that had no formal experience in the emergency field, required the set up of a knowledge transfer process at two levels (see Image 1).

On one level, a quality management process was necessary in order to tackle the development of novel emergency solutions, able to speed-up the response of humanitarian organisations (NGOs) during the days following a disaster.This type of information needed a vertical organization in which the boundary conditions had been set in relation to the kits' requirements by the humanitarian organizations. On the other level, the knowledge transfer process was related to the achievement of better coordination and common technical specifications between shelter sector and the other related sectors, such as facilities (water, sanitation and hygiene, communication center) and infrastructure (medical, energy, re-building). This kind of sharing criteria benefited from a horizontal organization of the process.

The Politecnico di Milano was responsible for the latter by providing the packaging guidelines that have played a crucial role for the implementation of the project.The complexity and diversity of kits' size, use, and time of entry in the emergency scenario have been being approached embracing a systemic design, that allowed to map complexities and to enable a functioning exchange of knowledge among partners. In reality, the packaging design was instrumental to transfer knowledge transversally, by virtue of its multidisciplinary impacts: it supported the development of systemic and cohesive kit solutions, that had to be transformational or composed by modular elements.

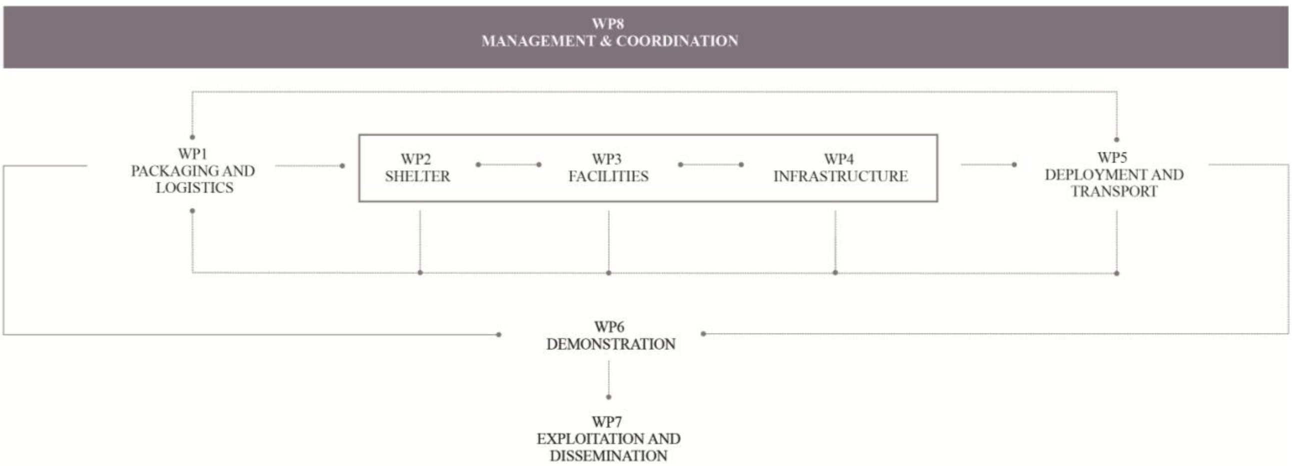
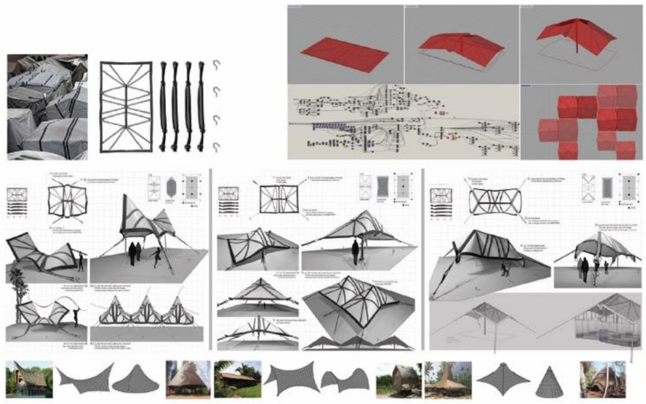


Image 1 –The two levels of the knowledge transfer process: a) the vertical process: Management & Coordination (WP8) / System Design (WP1) / Deployment & Tracking (WP5) / Demonstration

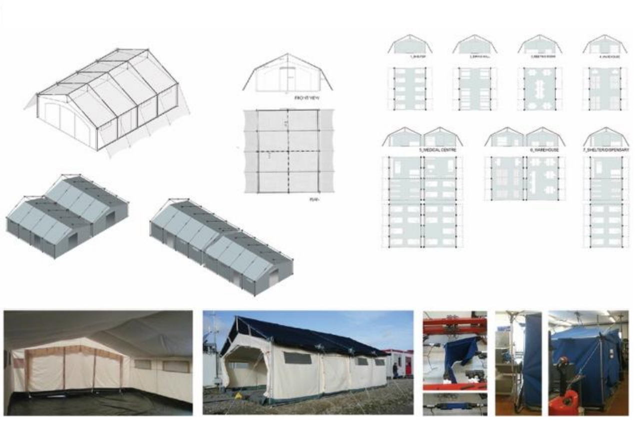
(WP6) / Dissemination (WP7); b)the horizontal process: System Design (WP1) / Shelters (WP2) / Facilities (WP3) / Infrastructures (WP4) / Deployment & Tracking (WP5).

Referring to the operational structure, the outputs of S(P)EEDKITS had being divided into 5 technical Work Packages (WPs) in the following four domains:

1. Shelter (WP2), whose aim was the design and development of novel shelter kits for four different basic shelters: ultralight weight safe house unit; collective unit; the Family Modular Unit (Cocoon);the Multipurpose Collective (Image 2).
2. Water and Sanitation (WP3), whose aim was the research, development and testing of prototypes of flexible sanitation systems, based on the use of “add-ons” for tuning to local needs and future applications.
3. Sustainable infrastructure (WP4), whose aim was the implementation of existing prototypes of container-based command, communication and medical center units; the design and testing of a biogas system for energy working with faecal and household kitchen waste; the development of mobile debris recycling kit for producing usable building materials from debris.
4. Deployment and Tracking (WP5), whose aim was the development of a decision support tool and a tracking system to determine immediately which kits and support has to be deployed.



a)



b)

c d)

Image 2 – The outcomes (kits) of the “Work Package 2: Shelter (WP2)”developed by the Politecnico di Milano: a) the concept of Clever Roof; b) the tested Multipurpose Collective Unit (in collaboration with Ferrino S.p.A); c) the tested Family Modular Unit (Cocoon); d) the tested Textile Wall.

Other 4 Work Packages had been set up to work transversally to the technical WPs reported above, in order to define a common language and manage a complementary direction of development: System Design: Modularity and Packaging (WP1)**,** Demonstration (WP6), Dissemination (WP7) and Management and Coordination (WP8). In particular, the System Design: Modularity and Packaging (WP1), led by the Politecnico di Milano, tackled the (re-) design of existing and novel emergency response kits packaging, with a focus on easy and quick deployment.

As stated, the development of the packaging developed by the System Design (WP1) was planned to begin very early in the project, because it was necessary to integrate functionalities and instructions according to different emergency, climatic and cultural contexts and alternative means of transport. This allowed the process to run in parallel to the kits’ development and it has been instrumental to the definition of requirements and constraints for the kits’ developers. The fact that packaging, did not come as an afterthought, made the process collaborative.

More specifically, these information had been crucial for at least three reasons: i) to improve cross-collaboration alongside the WPs to define new kits, once considering the kits self-contained (speed), once studying their pack as a sub-system itself, which will be able to do an extra-function useful throughout the whole emergency process (seed); ii) to gradually focus the *architecture* of the S(P)EEDKIT system, with the aim to define the hierarchy between kits, sub-kits, pack with extra-functionality and so on, getting as much as possible the optimization of their transportability, based on a *matryoshka concept* (see Image 3); iii) to communicate the S(P)EEDKIT process in a systemic way, as an organic complex of well-designed sub-systems, getting a map of possible interconnection between different kits.

The following table (Table 1) is an example of the coordination activity conducted by the System Design: Modularity and Packaging(WP1)along the implementation of the kits' production.

Working package	**Kit**	**Packing level**	**SC / EP***	**WP1 collaboration***
WP2	T1 – CLEVER ROOF	bag	EP	guidelines
WP2	T2– MULTIPURPOSE UNIT	bag/tank	EP	strong collaboration
WP2	T3 – PROGRESSIVE HOUSE	bag/tank	SC	strong collaboration
WP2	T4 – WAREHOUSE	Pallet	EP	guidelines
WP3 sanitation	RAISED LATRINES	Pallet	-	guidelines
WP3 sanitation	MULTIPURPOSE TOILET	Pallet	-	guidelines
WP3 sanitation	DESLUDGING KIT	-	-	guidelines
WP3 sanitation	SLUDGE TREATMENT (pasteurization kit)	Container	SC	guidelines
WP3 water	WATER TANK	bag/tank	SC	guidelines
WP3 water	WATER TOWER	Container	EP	guidelines
WP3 water	SEMI-MANUAL DRILLING KIT	Pallet	EC	guidelines
WP3 water	SITING KIT	-	-	guidelines
WP4 medical	Autonomous rapid deployment hospital	Container	SC	guidelines
WP4 medical	COORD/COMMAND CENTER	Container	SC	strong collaboration
WP4 medical	TRAVELLING SURGICAL UNIT	Container	SC	strong collaboration

WP4 medical	TRAVELLING SURGICAL UNIT	Container	SC	strong collaboration
WP4 medical	MATERNITY UNIT	Container	SC	strong collaboration
WP4 medical	X-RAY UNIT	Container	SC	strong collaboration
WP4 energy	SOLAR / PV KIT	Pallet /bag	EP	guidelines
WP4 recycling	MOBILE RECYCLING KIT	Container	SC	guidelines

Table 1 – Overview of all kits developed by different WPs and the role of WP1design group.
Legend:
* "SC/EP" = Self-Contained or with Extra-Pack
* "WP1 collaboration": "Strong collaboration" = The Politecnico had been part of the design team since the very beginning) / "Guidelines" = The Politecnico had been developed the general guidelines for the packaging design and the writing of the instruction manual of each kit.

Basic Packaging Design Principles for Emergency Response kits

As a matter of fact, the promptness of the post-emergency response is fundamental. Nevertheless, it is also stressed out that, from the logistics point of view, not every kit is needed in the same phase: indeed, most of the kits must be available as soon as possible (i.e. the communication center, the shelter kits), but others could arrive after few days (i.e. the recycling kits).

The second relevant innovation pursued by the S(P)EEDKITS project was to overcome the different technical specifications and logistics divisions between NGOs, introducing a new packaging model that can be flexible to the different kits' specifications thanks to a system design approach.

A preliminary analysis between different emergency phases was needed in order to plan and send efficiently the different ERUs, according to a modular packaging design. Several researches had been done on the existing disaster phasing methodologies: general theories were compared to the operational methods practiced by some important international humanitarian organizations(namely, ECHO, OCHA and International Federation of Red Cross). In the following table (Table 2), the results of that *knowledge matrix* reports the slight, but consistent distinctions that emerged between the methods:

<table>
<tr><td></td><td colspan="3">Analysis</td><td>Proposal</td></tr>
<tr><td>Emergency management</td><td>EU/ECHO</td><td>UN/OCHA</td><td>Red Cross Luxemburg</td><td>S(P)EEDKITS</td></tr>
<tr><td>Emergency management cycle</td><td>LRRD approach</td><td></td><td></td><td></td></tr>
<tr><td>Mitigation</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Preparedness</td><td>-</td><td>‘Imminent danger’</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Response</td><td rowspan="2">Relief</td><td>Response:
first 48 hours</td><td rowspan="2">Relief:</td><td>Rescue (first 48h<time)</td></tr>
<tr><td>Response: from 48 hours till recovery phase</td><td>Relief (48h<time<2/4weeks)</td></tr>
<tr><td rowspan="2">Recovery</td><td>Rehabilitation</td><td rowspan="2">Rehabilitation and reconstruction</td><td>Recovery</td><td>Recovery (time>2/4 weeks)</td></tr>
<tr><td>Development</td><td>Reconstruction</td><td>Reconstruction</td></tr>
</table>

Table 2 – Phasing of emergency situations (elaboration of the authors).

The *knowledge matrix* of the State of the Art was a fundamental starting point to define the packaging and the modularity between the different production kits – i.e. T1: Clever Roof, T2: Multipurpose Unit (see Tab.1) –. Indeed, the *time of delivery* and the *means of transport* influence strongly the design principles of every kit, which should be different according to the specific post-disaster phase.

In the operational framework of the project thus, the disaster’s management phases had been distinguished in four overlapping stages:

I) the RESCUE, meaning the first 48 hours after the disaster;

II) the RELIEF, after 48 hours;

III) the RECOVERY, within the first 2/4 weeks after the disaster occurred;

IV) the RECONSTRUCTION phase.

As mentioned, the innovative contribution of S(P)EEDKITS to the emergency sector was to design the most flexible and adaptable solutions, so that the affected population will use them during the reconstruction phase. The re-usability of some components of the kits was planned from the very beginning relief phase to the reconstruction phase in which they could become useful building elements. In order to accomplish to this challenging objective, the packaging design was the selected source of information exchange and monitoring mounting strategies along the different emergency phases and kits.

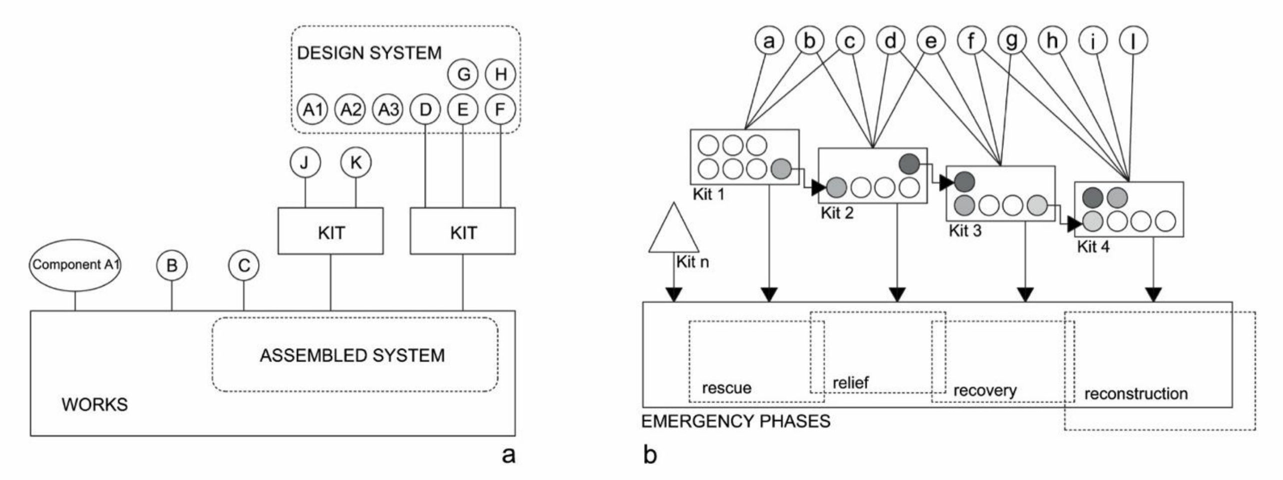


Image3 –The relation between the two following approaches: a) the design system and kit in the Building Sector (Construction Products Directive – 89/106/EEC); b) the system design and the *seed concept* adopted in the S(P)EEDKITS project (elaboration of the authors).

In this sense, the S(P)EEDKITS had worked like a design system(Image 3), based on which all the ERU kits have been developed; each new kit could also be different and adaptable, targeted for a specific emergency phase (meaning different functional/social requirements), based on the best practices, and at the same time the kits needed to act as system, taking into account that the design system allows: i) different combinations of components in customized kits (for their adaptability to different climatic contexts; different cultures; means of transportation); ii) the re-usability of some components of the kit in the subsequent emergency phases as a component of the next kit, which are later delivered.

Modularity and Designing Components: a Systemic Approach

In the specific field of humanitarian first repair and reconstruction, the traditional modular approach may not solve problems that characterized the emergency context, i.e. transitional requirements, and, in some cases, might strongly affect the development and reconstruction phases of a community which may not be able to return to its original condition on his own.

Even if modularity has always been identified as the fundamental principle on which every solution, that aims to fulfill rapidity and efficiency, should be based on, the growing number of humanitarian cases need to take into account potentialities of much more effective alternatives. That is the case of solutions which could perform an implementable and flexible system in contrast with the rigidity and standardization offered by modular-based concepts. As a matter of fact, advantages of modular design are relevant in the design and planning phases where they can be easily arranged or modified according to spatial necessities – shipment, logistics and local transport of building components – but, in construction phases, modular design reveals its limits. On site, local resources and contingency may give precious inputs and may offer even better solutions to the community: therefore, adaptively and compatibility –meaning an "open building model" (Habraken, 1985)– would allow more freedom to set up the best configuration as soon as the boundary conditions become clearer or by adapting to them if anything changes.

The novelty of the S(P)EEDKITS approach had been to design the kits by their components rather than designing them as products, i.e. prefabricated shelters, and to consider the kits as a coherent *unicum*, as a complete set of parts and components that could/should work together as a system.

The main challenge was to determine those special *constant* properties that made the kits being developed in the whole project, reciprocally harmonious and understandable for all users throughout the emergency process. And, going further, to coordinate the design of some components in order to allow them to be reused.

Definition of the knowledge transfer process

Therefore, the main actions of the System Design: Modularity and Packaging (WP1), led by the Politecnico di Milano, had being been:

1. *Setting a common language for all partners, in particular about the definition of the emergency phases and the means of transport.* A widely accepted phasing method was firstly assessed, to define the emergency phases. Each humanitarian organization uses a different disaster phasing methodology. In S(P)EEDKITS, the phasing method of the Red Cross Luxembourg was adopted, combined with the one of OCHA. According to this methodology the "response phase" was divided into two different parts: rescue and relief. Hereby, a distinction was made between the emergency kits and relief kits: most of the kits must have been available as soon as possible, (i.e. life saving and communication infrastructure, although some kits could arrive after a few days (i.e. some shelter kits) or even weeks (e.g. recycling kits).
2. *Understanding the partners' needs for the packaging of each kit.* After a qualitative data collection referring to the needs of different partners, the outputs of each Work Package was set. An assessment of the various kits and packaging concepts was then conducted to eva-

luate them (e.g. needs of kits' developers and advices in further developments of guidelines).

3. *Supporting each partner in the design and setting up of the development of its kits.* A process of cross-collaboration was set up alongside the WPs' production, meaning the Shelter (WP2), Water and Sanitation(WP3),Sustainable Infrastructure(WP4), to develop new packaging kits (e.g. considering the kits self-contained, or studying their pack as a subsystem itself.).
4. *Coordinating the other WPs' kits by defining common design specifications and requirements.* In an effort to bring together different, complex, requirements and needs emerging from the project partners and groups developing the various kits, a set of constraints and guidelines was set up to define basic packaging design principles. In particular, the packaging guidelines focused on three main areas: i) the characteristics of the kits that have to be delivered (i.e. size, weight, contents); ii) the time at which they have to be delivered after the emergency strikes; iii) the best and most appropriate means of transport to be used.

The researches and activities of the System Design: Modularity and Packaging (WP1)can be summarized as follows:

- *The analysis of the State of the Art.* Understanding transport and packaging requirements relating to different kits. The starting point was to collect data and achieve knowledge about the State of the Art (SoA) of existing materials and equipment, used by the humanitarian organizations. Hence, the project had inherited experiences and best practices from humanitarian sector as a premise for implementing the existing emergency response. Those had been critically reviewed from both the material and building construction point of view and a matrix had been developed.
- *Development of modules.* Following this preliminary analysis work, a *matrix* was elaborated outlining the various means of transport and the different levels of packaging (container, pallet, bag) most commonly used that led to modularity and the maximum size of packaging.
- *Development of guidelines*. Guidelines were than developed defining packaging levels with specific dimensions and materials (modular nesting concept), labeling and marking, color coding, packaging and logistic strategies suggestions, manual and instructions framework and guidelines, wiki documentation and online support portal, and suggestions for the integration of packaging with instructions.

- *Monitoring and interaction*. The advancement status of each WP has been monitored from initial requirements definition and concepts till the final product to obtain relevant information and to offer advice to further the development of the concepts.
  A *reference table* of all kits was created, containing all information about the issues of packaging, transporting and deployment of the kits.

*Introducing different kit usability for the same component and multiple users for the same kit.*Approaching the design of innovative packaging for emergency response, the user-centred design is fundamental: *personas* (core users) were introduced to partners as a design tool useful to influence development decisions to make them relevant to different context and users.

Guidelines: packaging and instructions

The purpose of S(P)EEDKITS was to provide kits that can be pre-positioned and transported very quickly and easily, that are modular and adaptable, low cost, high-tech in their conception but low-tech in use. The research focused on the design of optimized strategies targeted at reducing the dimension, managing modular composition of items (based on euro-pallet dimensions) and minimizing voids. To respond to this requirement, a *Modular Nesting Concept*(Image 4) was conceived for the packaging: elements were designed in order to fit different capacities of transport and to combine on any level, whether it is a bag, a pallet or a container.

Partners (kit developers) were provided with guidelines about the reduction of weight and dimensions of the packaging, keeping the maximum kit size fitting on euro-pallet or sub-modules of it and, whenever possible, packaged in bags made of durable technical textiles.

The guidelines were completed with a framework for assembly instructions and manuals, as well as with standardized transport/package labels and color coding(Image 5).

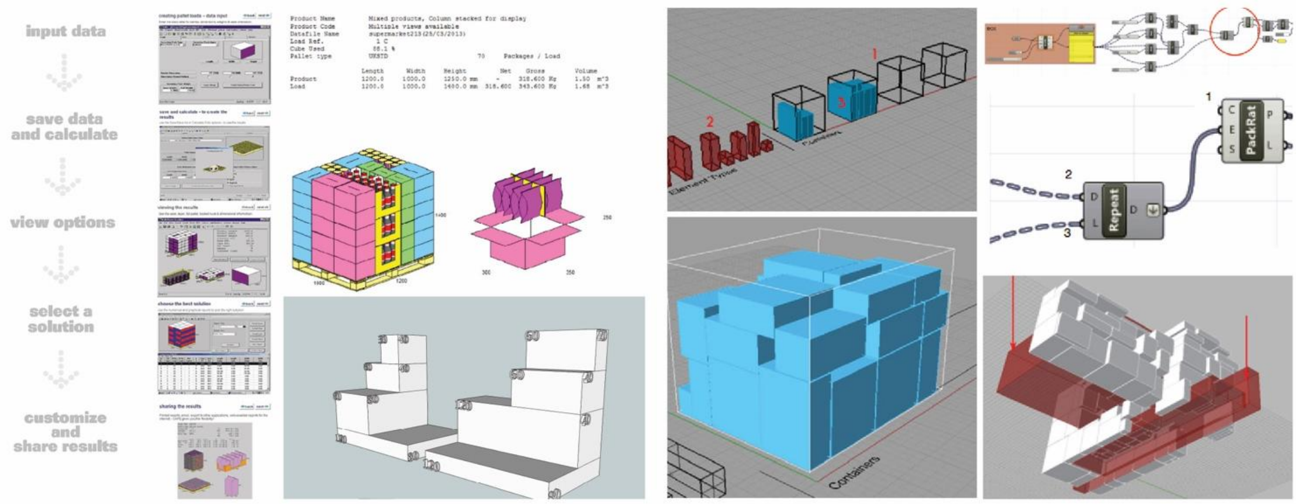


Image 4 – The Modular Nesting Concept.

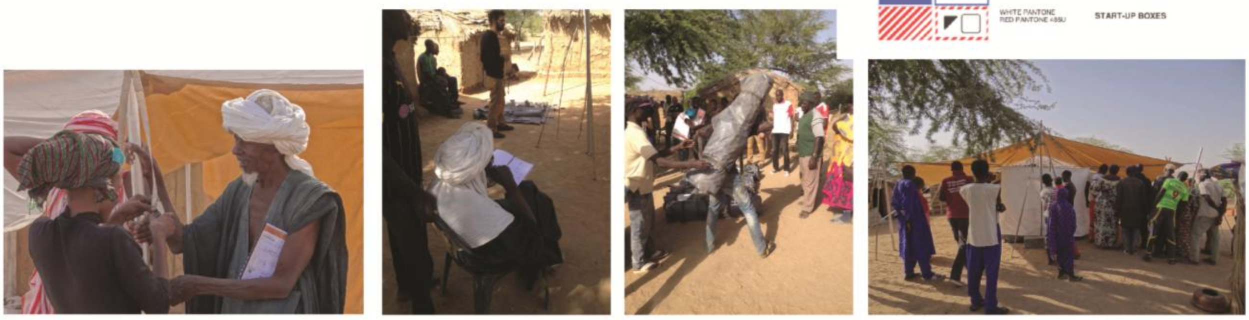


Image 5 – The packaging guidelines provided mounting instructions and tracking system; they were labeled with different colors according to the kit type. The photos show the field mounting test of the T1 – Clever Roof and T3 – Cocoon, in Senegal.

Conclusions and further findings

The article illustrates a case study on a research conducted in the field of emergency response for the development of rapid deployable, modular and lightweight kits. The activities have been conducted within a multidisciplinary partnership with diverse actors.

The contribution focuses on the role of the System Design: Modularity and Packaging (WP1), led by the Politecnico di Milano, in the effort of exemplifying and explaining an effective and useful method to transfer knowledge and make sense of multiple developments with a complex system. What emerged from the process was that by enforcing and enabling a trans/multi-disciplinary approach to design, by being able to interact and include different users and needs in the development of the packaging and its guidelines, the S(P)EEDKITS project have made an advancement toward a systematization of the work conducted in parallel by different teams. Beyond implementing a systemic design approach, the project defined a number of constraints and guidelines that were needed to be able to maximize compatibility of kits, components and packaging:

- the set up of constant properties or elements (e.g. size, weight, content);
- the set up of standard capacity transport (e.g. euro-container and, as sub-systems, euro-pallet and bag;
- the set up of a widely accepted phasing method, according to the different phasing methodologies in use by the humanitarian organizations;
- the drafting of standard guidelines for the packaging of the emergency kits;
- the drafting of a framework for instructions and assembly manuals in order to harmonize and simplify the process to different users.

The broader vision that the System Design: Modularity and Packaging (WP1) have tried to coordinate, through the packaging and logistics, was to create singular items that, each associated with one kit, will work both alone or associated with other kits. The *multiplicity* of the packaging was the characteristic to allow the kits to be used in different ways, after they have satisfied their primary function of transporting the goods to destination. In this way, different structures can be created, with different functions, and finally multiple *seeds* can be generated, that could be open to local adaptation in emergency response. In this context, the knowledge transfer process between partners was essential to define the *constant* properties across the all kits, and it has been enabled within the development of the project by the activities of System Design: Modularity and Packaging (WP1).
Nevertheless, more multidisciplinary research and fieldwork, transversal to diverse expertise and scientific knowledge, is required to develop a deeper awareness on the value and methods of knowledge transfer, among actors attaining at different sectors or institutions, to improve emergency response effectiveness.

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NOMENCLATURE

ERU	Emergency Response Unit
WP	Working Package
NGO	Non Governative Organizations