Conceptual design of a telecommunications equipment container for humanitarian logistics

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Abstract

Preparedness addresses the strategy in disaster management that allows the implementation of successful operational response immediately after a disaster. With speed as the main driver, product design for humanitarian aid purposes is a key factor of success in situations of high uncertainty and urgency. Within this context, a telecommunications container (TC) has been designed that belongs to a group of containers that serve the purpose of immediate response to global disasters. The TC includes all the necessary equipment to establish a telecommunication centre in the destroyed area within the first 72 hours of humanitarian operations. The design focuses on defining the topology of the various parts of equipment by taking into consideration factors of serviceability, functionality, human-product interaction, universal design language, energy consumption, sustainability and the interrelationship with the other containers. The concept parametric design has been implemented with SolidWorks® CAD system.

Keywords: case study, design, telecommunications container

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1 INTRODUCTION

Since the 1970s, disaster management thinking and practice has evolved into an all-embracing approach called disaster risk reduction (DRR). According to the United Nations International Strategy for Disaster Reduction, DRR is the conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) adverse impact of hazards, within the broad context of sustainable development (UN/ISDR & UN/OCHA, 2008).

Relief response to natural and man-made disasters is expected to be fast, dynamic and agile. The delivery of the critical supplies to the theatre of disaster is a significant challenge for post-disaster humanitarian logistics (PD-HL). In this light, agile and effective capabilities that encounter current and emerging threats are vital for any crisis situation. Even the best systems can default in emergency situations in the absence of proper and effective tools. Common systems rely on everyday technology like e-mail, attachments and short messages to communicate and manage disruptive events. Unfortunately, these systems were not built for mass special emergency notification and often make navigating the rough waters of an unplanned crisis more difficult than it has to be. For the past years, extensive research has provided a vast amount of knowledge on how good practices of humanitarian logistics and effective supply chain management can improve the efficiency of relief programmes (Kovács and Spens, 2012). Thus, emergency preparedness has the serious possibility to become a transformational power and modify the methods the aid system addresses crisis (Kellett and Peters, 2014).

According to the International Federation of Red Cross and Red Crescent Societies (IFRC), disaster risk reduction policies are highly cost-effective. In Kellett and Peters (2014), the authors estimate that US$3.25 of benefit is generated for every US$1 spent, which can reach US$5.31 of benefit for every US$1 spent in the least conservative. Therefore, further investment in preparedness strategies will heavily affect not only the efficiency of the humanitarian response mechanisms, but will also subdue the natural disaster costs, which the IFRC predict to be US$ 300 billion per year 2050.

All disasters have a common factor, besides the loss of life and panic; they are immediately followed by loss of ability to communicate with the outside environment. Telephone services are discontinued and GSM services are either non-existent or is so congested. The creation of a communications zone facilitates crucially the management of humanitarian aid that ultimately lead to successful emergency response operations. The appropriateness and functionality of the supporting infrastructure is of equal importance when such programmes aim for effectiveness.

There is a variety of mobile structures that are used in humanitarian efforts. However, the conditions in the theatre of disaster can hinder the mission teams from transferring the equipment as well as from setting up the infrastructure because of the bad weather conditions, the bad terrain status or the destroyed surrounding transportation network. Therefore, there is need to design products that can respond to extreme situations and accelerate the disaster relief missions.

Applications from the emerging field of shipping container architecture suggest that transforming a container into a mobile response unit is attainable and can offer a sustainable solution into establishing emergency communications quickly in the area of disaster. Shipping containers are a low-cost building and architecture resource. An ISO container is a large reusable standard size box made of corrugated weathering steel, a corrosion resistant material. The standard size enables the safe and easy transport by sea, rail, track and air ("Residential Shipping Container Primer (RSCP™)", 2013). The reference size is the 20-foot box, 20 feet long, 8'6" feet high and 8 feet wide, or 1 Twenty-foot Equivalent Unit (TEU) (Rodrigue et al., 2017) When the structure of a modified container is closed, it can maintain the strength and the dimensions of the original shipping container (Nellemann, 2009). One characteristic example is Weatherhaven's seminal 'Mobile Expandible Container Camp' (MECC). The modified ISO containers can change modes of transport within the global freight transport system until they reach their final destination, while protecting their contents (Kronenburg, 2013). As a result, modified containers can offer a space with environmental management capabilities that can be inhabited by people and used for storage or operational requirements (U.S. Army Natick Soldier RD&E Center, 2012).

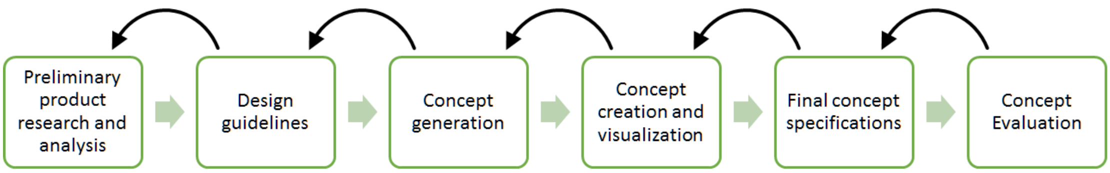
Raising the question in the field of design for humanitarian relief operations, the current research is concerned with the concept design of an ISO container that can carry the necessary telecommunications equipment for the infrastructure restoration. The design explores ways to pre-install the necessary equipment in the interior space of the container and to make it ready for use once the container is placed in the designated area, requiring minimum preparations. It also examines ways to make it functional in the harshest environments and comply with standard living conditions while providing its users with easily operable facilities. The concept development is based on established product design methodologies and the final concept is visualized using the Solidworks® CAD (Computer Aided Design) program.

This paper is organised as follows. Section 2 presents the methodology followed for the concept development. Section 3 provides an overview of the application of the selected methodological approach, followed by the presentation of the proposed design in Section 4. Section 5 concludes this paper with implications and outlook for future research.

2 METHODOLOGY

Our study focuses on addressing the research aim with an early concept that can understand the users' needs and offer a preliminary design solution with CAD with features that can justify the launch of a product development project. Our concept development methodology of the ISO container with telecommunications equipment, hence referred to as 'Telecommunications Container' (TC), is in line with the user-centred approach as defined by Nieminen and Mannonen (2006): *an iterative process starting from understanding the context of use and specifying the user and organizational requirements, to producing design solutions and evaluating them against requirements; this cycle is iterated until set requirements are satisfied*. The phases and iterations of the concept development process are illustrated in Figure 1.

Figure 1. The concept development process



Preliminary product research and analysis

The preliminary product research and analysis phase consists of the user and technology research, which were conducted in parallel. It is associated with gathering data on the context of use and the potential industrial solutions that can be included in the design. The methods used for collecting information about users and the product-user relationship were interviews and scenario building. Lead users from four associations and organisations with professional training and field experience on using emergency communication systems were invited via email to participate in the interviews. One of the four teams responded. The interviewees were informed of the research theme before the interview and a more detailed briefing occurred during the meetings. The interviews were conducted in the operational base of the team, were unstructured and included open-ended questions that gave the participants the opportunity to ask questions themselves and encouraged conversations. The scenario building method was used to generate hypothetical user interactions with the conceptualised product. The explorative scenarios were based on the potential stakeholders' stories, on data from interviews and information from literature review, and allowed the creation of ideas in a pragmatic context.

The technology research goals of the study were the exploration and analysis of successful technical applications in related products along with good practices in containers and mobile shelters for other purposes. The research material also included product marketing materials, published books on human factors and technical journal and press as well as information on technology trends supplied by experts in fields of building construction, energy supply and telecommunications equipment. An important part of our technology research was a detailed tour of the mobile operational centre of the lead users' team, a van that has been modified to suit the needs of the team during rescue missions. The deliverables from this phase are the mood-board, the scenarios and the user characteristics. In this paper, we present the user characteristics in Section 3.

Design guidelines

Design guidelines depict in detail all the parameters, characteristics, functional requirements and limitations in a design project and illustrate the desired relation between the user and the product. They have a direct impact on the design strategy and are of great importance when selecting the design solutions during the concept generation and evaluation phases. The design guidelines were created based on the data findings of the research and analysis phase and decomposed the problem into smaller problematic areas. In every design iteration of this project, the guidelines directed the concept selection and validated the chosen solution.

Concept generation

In concept generation, all the possible solutions that can satisfy the design guidelines were examined. Since the concept is designed for future development and implementation, supplemental technology research was performed in this phase. Extensive electronic searches were conducted for gathering information on existing techniques and industrial products that can satisfy the user needs. The key solutions, their alternatives and main findings were combined with ideas that emerged from extensive brainstorming sessions. All findings were discussed with the lead users and field experts to obtain constructive feedback and define directions for further research. The generated ideas and solution concepts were either described in words or illustrated in sketches in a non-linear, iterative process.

Concept creation and visualisation

The most suitable ideas from the previous phase were combined into a concept in the phase of concept creation and visualisation in a top-down design strategy. The main goal was to capture the form and function of the elements of the design and not the aesthetical appeal. An assembly of products and technical solutions were visualised in a 3D model using Solidworks® CAD. Rough geometric layouts were created to represent each of the TC components and determine the dimensional relationships between the elements. Any clustering or incompatibility issues that appeared during this phase led to another design iteration.

Final concept specifications

Snapshots, wireframes and photorealistic renderings were used to describe the selected sub-solutions of the concept in the final concept specifications phase. The morphological elements of the design were also explained in this phase, using published literature in ergonomics and anthropometric data. The deliverables include all the relevant details and functional characteristics of the concept.

Concept evaluation

In the last phase of the development process, we evaluated the concept to ensure it meets all the constraints and the design requirements. The assessment was performed analytically, where drawbacks and possible omissions were evaluated. The final concept was presented also to the lead users and other stakeholders involved in strategic planning for disaster mitigation. The concept evaluation concluded with proposals for further development or redesign of certain solutions.

3 APPLYING THE CONCEPT DEVELOPMENT PROCESS

Figure 2 depicts the design brief used in our study. The design brief (Fig. 2) acts as a simple and straightforward guide to those involved in the product development. It helps to define a more coherent definition of the project goals and sets the framework of the assumptions for the development process (Ulrich and Eppinger, 2012).

Figure 2. The design brief

Product description	• A self-sustaining intermodal container that can provide telecommunication services in any destroyed area
Project goals	• Serve as the telecommunications hub in the group of containers that are sent in the destroyed area • Support the communication needs of the response teams and facilities • Offer a comfortable environment for the operating team • Minimize the setup time for fully operational status
Assumptions and Constraints	• Easily transportable • All the necessary equipment is preinstalled in the interior of the container (Plug & Play specifications) • All the components are existing technologies and current market

	products • Suitable for extreme weather conditions in arid, mediterranean, temperate and tropical climate zones • The included equipment weighs less than 28230 kg • There are no alterations to the overall geometric shape of the container • Maximizes the use of the interior space
Stakeholders	• Emergency and Disaster response organisations • Organisations developing products for disaster preparedness • Telecommunications business sector • Construction companies

Any mobile operation unit requires 2 or 3 people for handling the communication equipment, due to high traffic in radio bands in emergencies. Each operator is capable of supervising maximum 3 missions at the same time, on the condition that each mission uses a unique communication channel. Operators should be equipped with headphones, and when possible, be in an isolated space, away from commotion from other people. The team also needs a chief operator that will have the overall management and decide on the team actions.

In any emergency response mission, there are three categories of people that might use the facilities and services of the TC; (a) Operating team of the telecommunications centre (minimum 2 operators and the team leader), (b) the various humanitarian response teams (rescuers, medical team, engineers, logisticians and technicians) and (c) local authorities from the affected area, where all communication means are out of order. It is important to exclude the affected community population from the above categories for operational reasons. It is assumed that they will have access to communication means from another post, in a respective distance from the TC.

In emergency cases, the response teams need the rapid deployment of the available infrastructure in order to meet the complex telecommunications requirements of the situation effectively. A real-time response depends on the quality of the equipment and the technological capabilities of the integrated systems in the mobile unit. The military, fire departments, emergency management agencies, law enforcement and investigation (police, FBI, etc.) as well as news broadcasters have invested in acquiring units that are fully integrated communication suits with robust networks that can quickly connect the response teams in the area of interest.

Typically, the telecommunications inventory consists of a satellite system, workstations, network systems, portable base stations and repeaters for radio communication, telephone systems, antennas, televisions, fax machines, printers, and the respective gadgets that complement them (Bieltz, 2012). Most mobile emergency communications units are in the form of transformed vehicles as well as shipping containers.

User Characteristics

The user characteristics address all the actions, elements and values that define the three different groups of users. Therefore, they are presented in three respective groups. The features that appear in more than one group are noted with '*' at the end of each line.

Communications team (chief and operators)

- Are experienced communication systems professionals
- Setup and control all communication systems
- Establish the communication systems that interconnect the various teams when they are in the field
- Support the communication needs of the teams surrounding them
- Know how to recover from infrastructure failures and error situations
- Respond to various requests from inexperienced users
- Want the network operation equipment to be fully adapted to their needs
- Want equipment that is comfortable to use and repair
- Want to set the equipment in working mode quickly and easily
- Expect the communication systems to be reliable with minimum to zero breakdowns
- Require constant power input for their systems without failures
- Know how to repair most damages to the equipment

- Need to work in front of monitors for many hours without breaks
- Work more effectively when they avoid distractions and commotion in their working area
- May need to concentrate on a certain task for a long time
- Are expected to be very calm and composed during emergencies *
- Contact other teams/ authorities/ organizations
- Try to contact and locate possible victims
- Scan for other communication points outside their area
- Manage critical situations *
- Respond quickly to emergencies *

Various teams
- Are professionals or volunteers in their field of expertise
- Require constant communication support
- Are constantly/ usually on high alert
- Manage critical situations *
- Are expected to be very calm and composed during emergencies *
- Their performance is affected by the quality of the communication services
- Might use means of communication in extreme weather conditions *
- Require continuous access to information related to their tasks
- Need reliable communication systems and networks for their tasks*
- Should be able to communicate anytime from their location in the affected area surrounding the container
- Might need to charge their personal communication products (tablets, mobiles, laptops, radio receiver)
- Might require special communication support for some tasks (victims rescuing, medical procedures, etc.)
- Might need guidance and support for using communication equipment *
- Might have difficulties in using complicated systems and products *
- Respond quickly to emergencies *

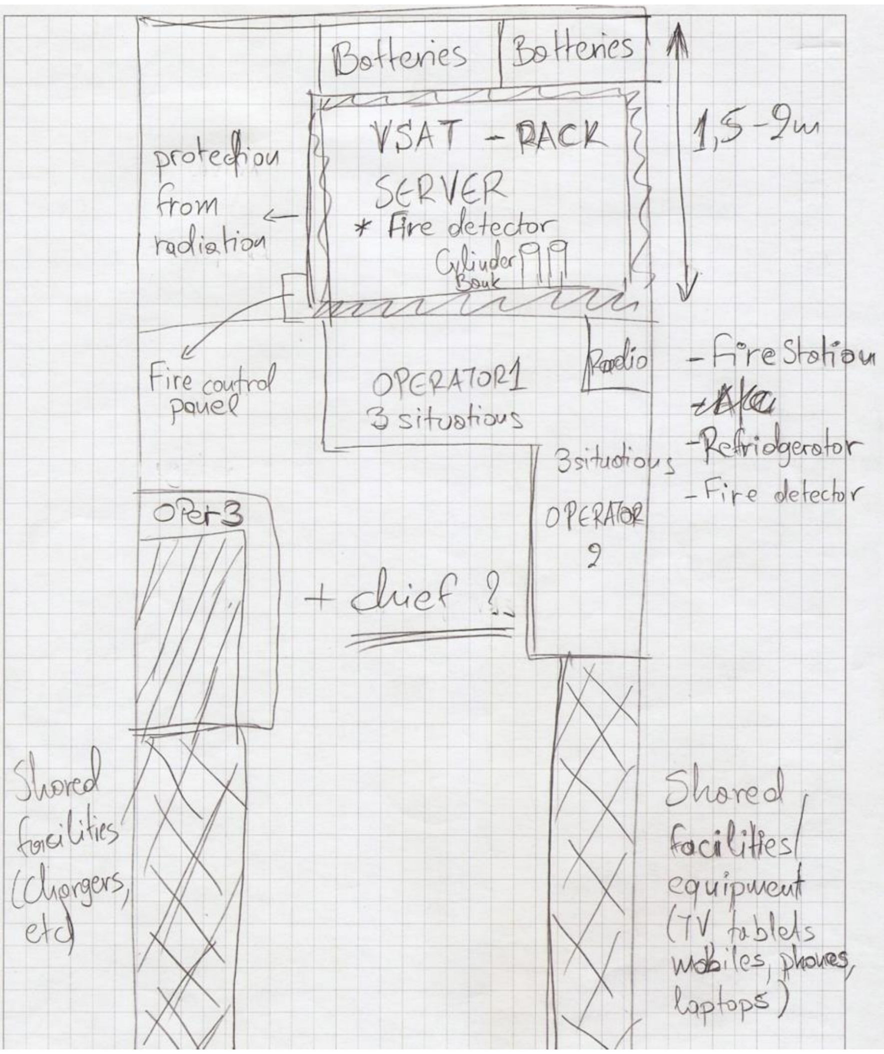
Local authorities
- Are of various ages and backgrounds
- Are expected to be very calm and composed during emergencies *
- Their psychological state may be fragile
- Their self-composure may falter
- Manage critical situations *
- Might need guidance and support for using communication equipment *
- Might have difficulties in using complicated systems and products *
- Might use means of communication in extreme weather conditions *
- Are responsible for informing the local population and other authorities
- Want to gather reliable and plenty of information
- Want to use their mobile phones for communication
- Need reliable communication systems and networks for their tasks*
- Require at least one way of communication available when they are in the affected area close to the container
- Might need to charge their personal communication products (tablets, mobiles, laptops, radio receiver) *

4 DESIGN PROPOSAL

The design guidelines have been organized into primary and secondary requirements. The secondary needs express the primary needs they are associated with in more detail. The brainstorming phase offered a variety of solutions for the 15 primary design requirements and their sub-requirements. The ideation step started with the examination of each of the guidelines separately and the generation of a range of sub-solutions. A rich pool of creative and evaluated ideas were developed in cooperation with the involved stakeholders. The detailed design guidelines of the proposed TC are presented in Parisi (2014).

A first attempt to visualize the arrangement of users and their positioning in the TC is illustrated in Fig. 3. This is the first rough sketch during ideation after determining some of the basic components.

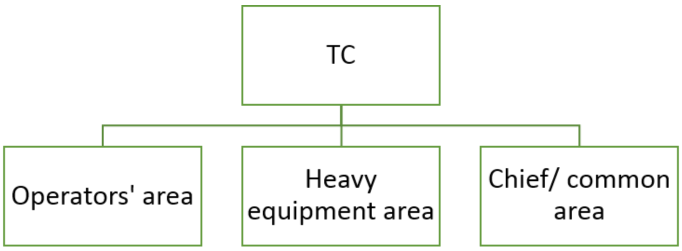
Figure 3. The first sketch of a top view of the internal space



The first step in the visualization process in Solidworks® was to create a frame along with the floor, the roof and the side walls, based on ISO container drawings for container manufacturers. The limitations from the basic construction features dictated the available space left for the implementation of the concept as well as the construction features that affect the positioning of the features and the door opening constraints.

The container is separated in three basic space areas, the operators' workspace, the common area where the chief has his/her own work post and the heavy equipment area. Following the selected design approach (Fig. 4), the main infrastructure in the operators' area, the heavy equipment in the back side and the chief/common area were designed in the respective order.

Figure 4. The top-down design process



All the featured pieces of equipment were visualized based on specifications from existing commercial and industrial products. The dimensions of the designed components were taken from the product datasheets. During modelling in Solidworks®, concise design details were applied to help in the overall visualization perception and easy recognition of the features. The design of the workspace area proved to be challenging and an extensive ergonomic study was performed to determine the dimensions of the equipment that could satisfy the design requirements. The calculations of the dimensions were based on anthropometric data of European population. Fig. 5 – 10 show the final results of the visualization process in Solidworks®. The detailed design of the proposed TC is presented in Parisi (2014).

Figure 5. Ground view of the interior with perspective

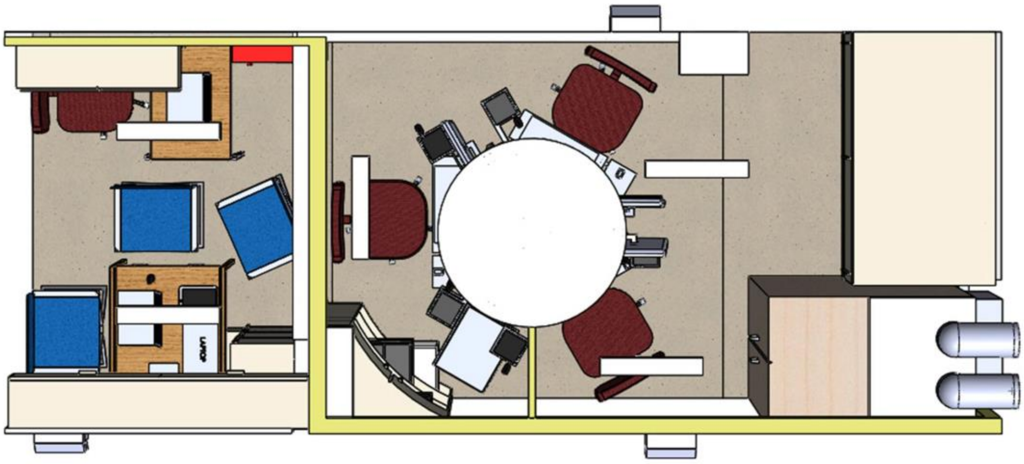


Figure 6. Left side view of the interior with perspective

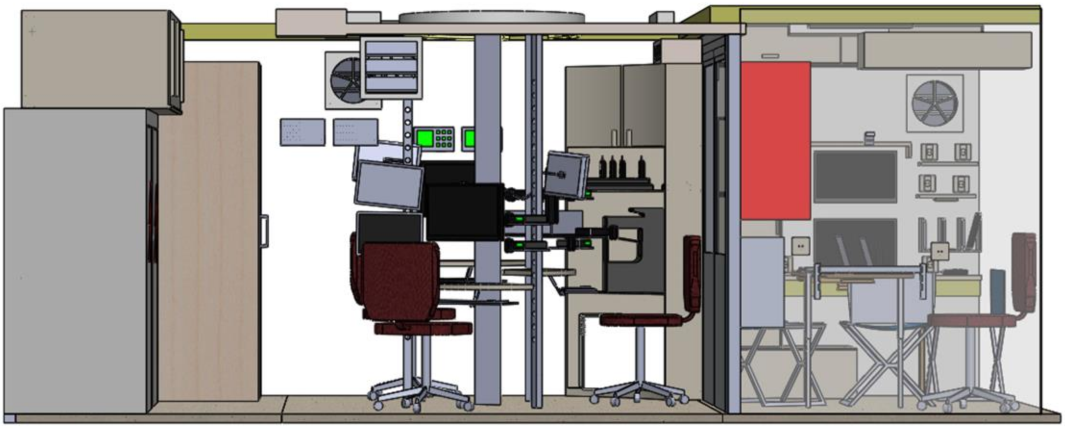


Figure 7. Section view of the operators' area

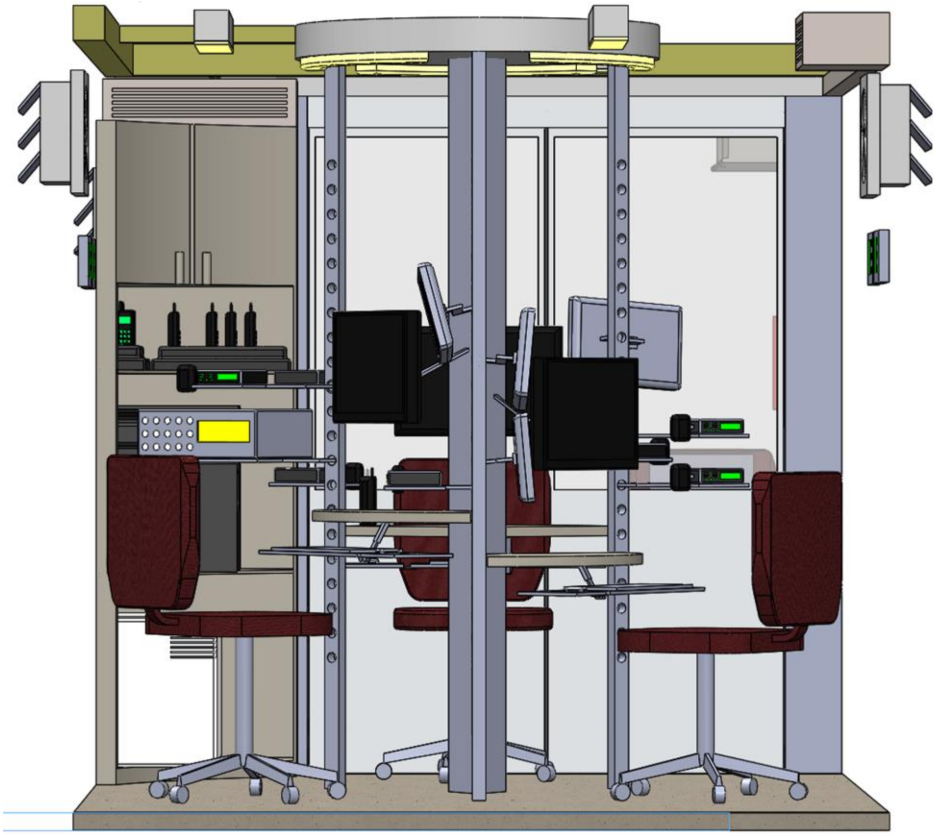


Figure 8. The TC container and the satellite dish in deployment

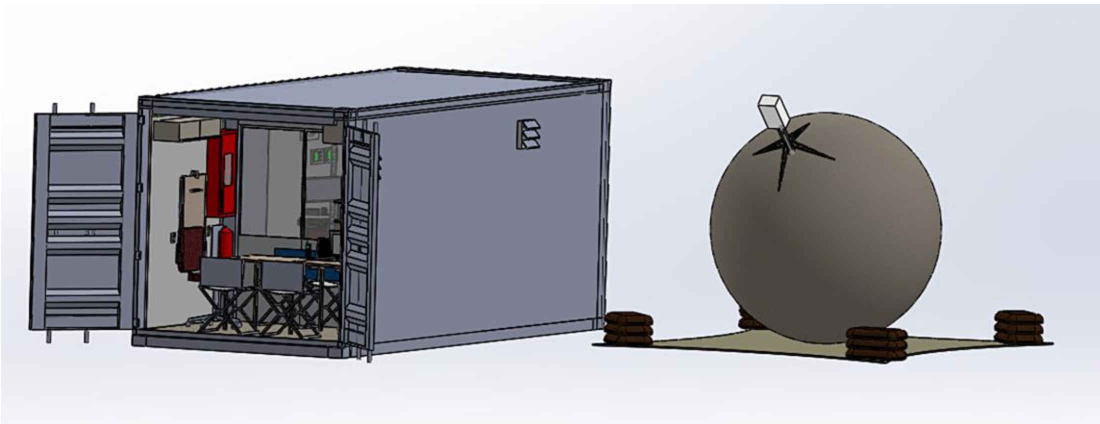


Figure 9. Ground wireframe view of the operators' workstation complex

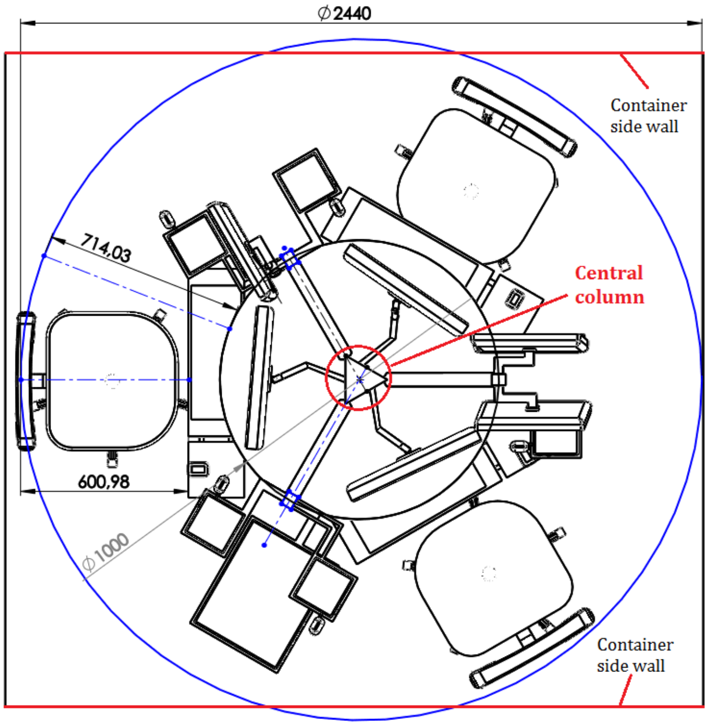


Figure 10. Photorealistic image of the proposed concept

5. CONCLUSIONS

Container constructions have a growing potential for mobile working spaces that can be comfortable, safe and functional at the same time. They provide an effective solution for a rigid shelter of people or equipment that can be used multiple times in various relief missions. Their ease of transport makes them one of the quickest deployable solutions on disaster response efforts. Transformed shipping containers are valuable resources that satisfy needs without having to compromise on the quality of the services or the infrastructure they can offer. In the available interior space, almost any kind of system can be installed by using available compact solutions or by applying modular design principles. Their conversion to a sustainable solution that responds to the surrounding environment is possible and offers great results. Their customization and their easy installation can create a small community in any location, where everything and everyone can be connected with each other.

During the concept generation process, there were conflicts of early concept ideas that resulted in broadening the technology research, until an acceptable design solution that did not violate important user needs could be met. Therefore, researching for technical information became a recurring procedure up to the final selection phase. Some redesigns resulted in a domino effect that changed other features. As a result, some design improvements were not examined to avoid a possible endless loop of design iterations.

The proposed TC fulfills the requirements set in the initial stages of its design and the end-product offers a “ready-for-use” solution that minimises response time, setup workload, setup problems, and maximises transportation safety and operational preparedness. Its design is viable and can be implemented, since its development is based on actual construction methods and market products. Nevertheless, further research can be conducted on issues, such as extruding spaces that implement automated solutions can isolate specific equipment (e.g. generators, rack cabinets) and expand the available space, hence making the interior more comfortable. Moreover, the cost of such a project needs to be detailed in the case that the concept proceeds to the implementation phase. The suggested design can be also used (with slight modifications) for non-emergency situations, where communication systems are not working properly, i.e. big sports events, demonstrations, large-scale cultural events, summer holiday resorts, etc. As a future challenge, the authors also envisage the design and development of a cluster of containers that could restore all basic needs for a camp and constitute an integrated operations centre for providing agile humanitarian assistance. More specifically, the TC herein presented could play the role of a camp’s command centre in the effort to improve the strategic and operational efficiency of public administration and public services in managing natural disasters, while supported by more containers required for covering other needs such as medical treatment, hygiene, waste management, water sanitation, energy production etc.

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