Objective of the project Every week we hear about events such as: **natural disasters, humanitarian and man-made disasters**, in particular **terrorist attacks, mass migration**, etc. During such unexpected situations, the time is the most precious, and services provided by deployable and reconfigurable structures are invaluable. Rapidly deployable structures can save lives, health and improve human comfort in several ways:

- in case of **disasters** they can serve as **escape routes**, also for
- creating **infrastructure**:
  - for **temporary** use such as **connector sleeves** which can also serve to allocate persons according to the condition, contamination, religion, sex, age, formal status, etc., as shown in Figure 1.
  - for **semi-permanent** use such as **refuge shelters**, infirmary, etc.

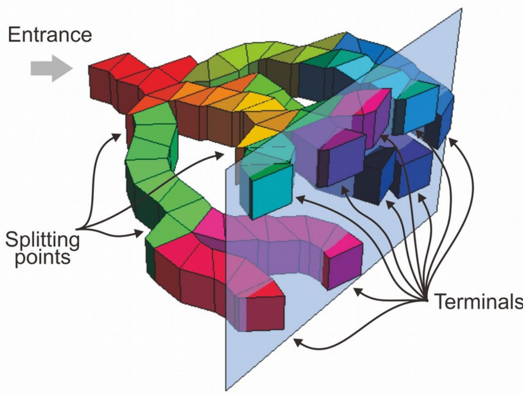

Fig. 1. An example of a spatial pedestrian connector sleeve based on Truss-Z splitting the pathways from 1 entrance to 9 terminals leading to isolated rooms.

- In case of settlement **habitats** in **extreme situations** such as war, or **extreme environments** such as undersea, arctic, or outer-space outposts. In such cases, due to the harsh environment the assembly must be as simple, quick and robust ("error-proof") as possible.

This research project proposes development of reconfigurable and robust **Extremely Modular Structures** (EMS) serving as temporary or quasi-permanent **habitats** and **infrastructure constructions** considering: topology, geometry, mechanics, crowd-structure interaction, functionality, ergonomics and structural safety.

The research to be carried out The proposed research will be realized mostly by **numerical modeling** and **computer simulations**. The results will be cross-validated by various methods and evaluated against representative **physical models** and **prototypes**. After the **creation of new concepts of EMS**s, the **encoding** of their entire structures, and implementation of: the **expert knowledge**, **functional** and **strength** constraints, modern algorithms (mostly graph-theoretic and heuristic), etc. will be implemented. Specifically, algorithms taking in account coupling at multiple levels and different characteristics will be developed:

- Modeling and **local discrete-continuous optimization** of EMS modules considering: topology, its members shapes, thicknesses and choice of materials for fabrication.
- Numerical model of EMS structures based on **bottom-up and top-down coupling**; i.e. the relationship between the response of entire EMS construction under loads (dead, structural, environmental) and stress state of its modular sub-structure.
- **Dynamic modeling** and analysis of behavior of entire EMS structure **during deployment** considering e.g: its natural frequency.

The reasons for choosing this topic

1. **Exploration of modularity**. Prefabrication and modularity are common ways of minimizing the construction cost of. However, they also substantially limit the diversity of possible shapes of structures. There is a number of modular systems, where high modularity results in trivial, repetitive forms. The **approach of EMS is different**: here any shape, i.e. simple or complex, are non-trivial assemblies of not-oversimplified modules. The underlying principle inspired by Nature is that no shape or direction are preferred, e.g. a straight line is only one of many possibilities of linking two points in space, not "the best" by default. Figure 2 shows EMS invented by the applicant – Truss-Z. In this project the concepts of modularity will be further developed for creation of: modular networks, surfaces, and solids to serve as temporary and semi-permanent deployable and reconfigurable constructions. This part of the research will contribute to **engineering and architectural design theory**.

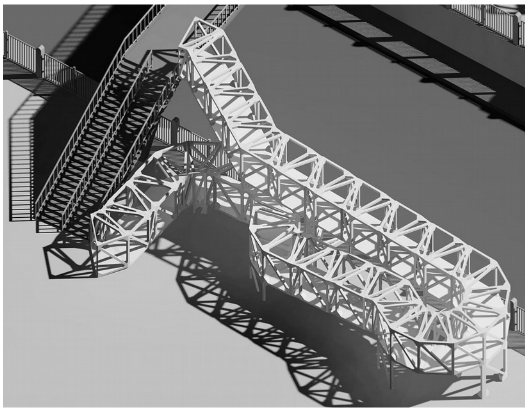
Fig. 2. Truss-Z (TZ) structure (shown in white) is comprised of a single type of module; it can have practically any shape and its gentle slope allows for safe crossing of wheel-chair users, persons with strollers, bicycles, etc.

2. Previous research by the applicant was relatively conceptual. In this project various types of **mechanical analysis** is intended to move these ideas toward reality. This part of research will contribute to the **applied sciences, in particular – engineering**.
3. The ultimate objective is to **improve safety and comfort in built environment**, especially in **crisis situations**. Thus it will contribute to the **safety and well-being** in society.
4. Lastly, the applicant has extensive **experience in interdisciplinary projects**, this project is a rational continuation of his academic activity*. Successful completion of the challenges listed above are within his capabilities.

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* Presently a monograph: M. Zawidzki "***Discrete Optimization in Architecture***" in three volumes: i. Architectural & Urban Layout, ii. Extremely Modular Systems, and iii. Building Envelope is being published by Springer-Verlag.