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Maritime Transformable Area Systems:
Towards Sustainability in Factory Planning and Development

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ABSTRACT

Transformable area systems (TASs) offer new possibilities for sustainable factory planning and development, notably as regards maritime structures. This is of relevance to factories of the future and could constitute a major influence in future factory planning and operation (i.e., the way in which factories are planned, implemented, transformed, relocated, used, and managed). Floating pontoon islands with solar systems already exist, and so much more is possible with similar but more complex structures. This article explains the basics of the TAS concept, assesses its potential, and discusses the future possibilities. It concludes that lack of knowledge and awareness about TASs and their potential is holding back their application in practice. Omnipresent short-term thinking and short-term profit expectations are further hurdles that are limiting the further development of TASs at present. TASs could nevertheless contribute to the improved functioning, sustainability, and future viability of factories, other structures, and their development.

KEYWORDS

Circular Economy, Factory of the Future, Fourth Industrial Revolution, Sustainability, Sustainable Development, TAS

INTRODUCTION

We live in a dynamic world, but use static and immobile physical structures, with many consequent disadvantages. The core problem is that terrestrial areas are non-transformable. This is especially relevant in the case of factory transformations, leading to cost-intensive and time-consuming demolitions, reconstructions and new constructions, which make existing factories antiquarian, as they are neither sustainable nor efficient. One way forward is to build transformable structures, located at sea in marine environments or other water bodies. For these structures, the term Transformable Area Systems (TASs) is used. Diverse TAS-like developments, such as floating solar systems, exist (ABB 2017, 2019) and the growing concerns for the environment (Rueff, 2020) are bringing the feasibility of using TASs more into view, as does Oxagon, the "world's largest floating structure" (Neom, 2023). The main objective of this article is to introduce and discuss the TAS concept and its potential, for which Scanlan (1974), Hernández (2002) and (Sredić, 2018) are notable sources.

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The non-transformability of terrestrial areas is the underlying problem that leads to diverse negative factory developments and characteristics throughout factory lifecycles, and this is scarcely recognised in factory planning theory and practice. It is important to recognise the significance of area transformability facilitated by TASs. A TAS needs to be modular, mobile, pluggable and scalable, provide additional spaces, and have at least one functional layer for substructures – for example for the housing of supply and disposal infrastructure. Compared to terrestrial areas and terrestrial area-based factory structures, TASs can achieve a significantly increased area, substructure and superstructure transformability. The TAS concept is not only a potential opportunity for factory development, but also for many different structures and uses, and their combination.

Following this introduction, the literature review explores relevant sources from several disciplines and fields of knowledge. Then, the research methodology is discussed, which is mainly based on an integrative literature review and the analysis of real-world factory developments. As part of the findings from this research, the basic concepts and features of TASs are outlined, and the current potential and issues for the future are discussed, building upon the views of different authors of relevance. Finally, the conclusion pulls together the main themes of the article, looks at possible areas for future research, and provides an outlook to a possible future.

RELEVANT LITERATURE

Non-recognition of the transformable area concept: Even though flexibility, transformability and modular factories are discussed in factory planning literature (Wirth, 2000; Schenk et al., 2014; Wiendahl et al.,2015; Grundig, 2018), most of the factory theories, models and concepts do not consider transformability requirements: the problem of non-transformable areas and their impact is generally not recognised. Similarly, the recent literature on industrial engineering, Industry 4.0, and the "factory of the future" (including the "smart factory") does not adequately consider factory developments and lifecycles. The active transformability of areas and the necessity that factories should have this capability are not considered.

Factories that are constructed upon terrestrial areas are restricted and currently barely transformable. Numerous demolitions, reconstructions, new constructions, and thus continuous destruction of usable structures and tremendous waste of resources are consequences. Furthermore, most factories and production networks are inefficient for the large part of their lifecycle, while the use of synergies is very limited. The loss in efficiency of today's automotive manufacturing plants throughout their lifecycle through remodelling, suboptimal operation and complex management is high. Such factories and production networks are unsustainable, and environmental destruction occurs as a consequence. The transformability and transformation velocity of today's factories are low and decrease throughout their lifecycle, while complexity increases. Numerous transformation requirements occur and increase throughout factory lifecycles, but the possibilities of meeting these requirements are limited, and decrease (Sredić, 2018).

The impact of non-transformable areas: Existing literature concerning factories of the future discusses a range of themes, including "adaptive and smart manufacturing systems", "highly competitive distributed manufacturing (flexible, responsive, high speed of change)", "lowest resource consumption energy – lean, clean, green", and "sustainability in material, production processes/ workers" (EFFRA, 2013, pp. 28–29). These aspirations do not match the reality of today's factories and will be difficult to achieve with terrestrial area-based factories alone. Figure 1, for example, depicts a construction site in the city of Karlsruhe, Germany. Such structures are anything but transformable, and diverse requirements and negative effects occur, for example, on traffic. The question is not only "what should be done and how?", but rather "what could be done, and how if transformability is to be achieved at a new level?".

The significance of transformable areas: Factories need to be viewed as living organisms, allowing them to change their position, be extended, exchanged or otherwise transformed. Movements and

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