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TECHNOLOGY TRANSFER: CURRENT TRENDS IN INCORPORATING NEW TECHNOLOGIES INTO HOUSING INDUSTRY

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In current world technological improvements and innovations are inseparable from everyday lifestyles everywhere around the world. There are some obvious and not so obvious correlations and analogies between approaches to sustainable living in space and on earth. These environments have many similar kinds of technical and operational priorities. Key among these are needs for appropriate transportation and construction systems, efficient energy, effective and environmentally-responsive waste management and life support systems, maintenance and repair provisions, and emergency accommodations. Space technologies have been and continue being implemented in housing and construction industry. Understanding current problems and challenges in construction and housing helps to form and outline strategies and techniques those industries require to be developed and implemented in order to meet sustainability criteria and help to shape responsible living practices. This paper investigates levels of feasibility of making cutting edge technologies be a part of our everyday life. To do so several common for space applications techniques are compared and analyzed.

I. INTRODUCTION

This paper is a pilot study report that outlines observations of current trends in housing industries and potentials for incorporating cutting-edge technologies into them with focusing on the following approaches:

- Enabling sustainability;
- Merging multidisciplinary approach into design process;
- Transferring knowledge between disciplines;
- Needs and constraints in housing (challenges are good for you!);
- Making living environment interactive to offer learning experience become more than just operative knowledge;
- How to encourage and stimulate people to expand their knowledge;
- Creating awareness of evolution of man-machine relationships and influences.

Conclusions summarize design and housing applications considerations, and future directions of research development.

Understanding Technology

It is important to look at the history of human race developments in order to understand the role of technology in everyday life and how it affects us. Philip J. Vergragt characterizes it by three major meanings: tools and instruments, knowledge and culture [(1)].

Each of these three meaninings or facets influence one another and technological innovation can not be successful unless all three are worked together and are equally represented at the time of implementation.

Technology transfer often faces barriers in many sides of life: social, economic, individual, cultural, and political and depend on five important characteristics [(2)]:

- Relativity;
- Compatibility;
- Complexity;
- Trialability;
- Observability.

These attributes are common for technology transfer in many if not all industries and spheres of human life. However, housing industry may be unique because it includes not only technological aspect but also psychological and behavioral aspects of life.

This paper investigates technological possibilities and psychological aspects of implementing them into design and everyday lifestyle.

II. TECHNOLOGIES ENABLING SUSTAINABLE LIFESTYLE

Providing the crew with housing during space missions especially long duration missions requires a multi-disciplinary and comprehensive design approach. Sustainability during those missions is more a necessity rather than a popular trend. Some common and very well-known technologies span-off from space applications. Recycling air and water systems, re-usable packaging, zero-G pen, Velcro and many more others

contribute to more efficient and convenient life on Earth in nowadays.

Space systems and habitats analogs on Earth have a long history of providing valuable and unique experience that can be analyzed prior to space mission occurrence. Although none of them can adequately cover all aspects of living in space in full, they are good platforms for testing technology and operations. Nevertheless, that fact does not mean that all technological successful practices and attributes can be directly applied in everyday life and housing.

Terrestrial Space Analogs

In January of 2008 combined efforts of NASA Johnson Space Center (JSC), the National Science Foundation (NSF), and ILC Dover of Frederica, Del., resulted in design and deployment of an inflatable structure in McMurdo station in Antarctica [3]. The project was conducted under development of the Constellation Program and aimed to investigate behavior of inflatable structure under harsh conditions of Antarctica (Figure 1).

Fig. 1: Inflatable habitat deployed in McMurdo station, Antarctica. Credit: Peter Rejcek.

One of critical elements of the design was a system of sensors and devices to monitor and maintain habitable environment of the structures in autonomous regime and maintenance-free (Figure 2).

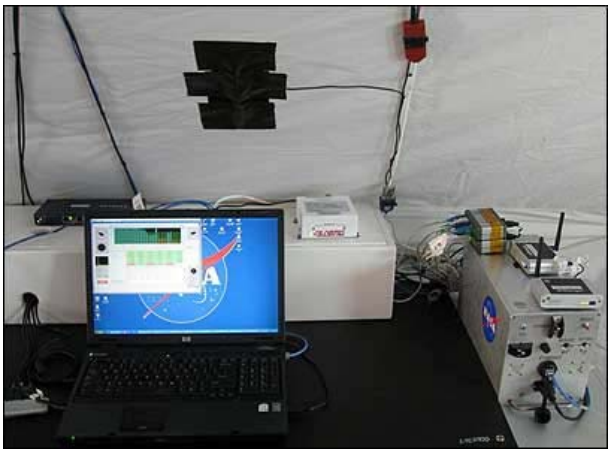

Fig. 2: Interior of the inflatable habitat. Credit: NASA.

Another important feature of the development included required researchers to be able to monitor the structure and its interior environment remotely and directly from Johnson Space Center (JSC) in Houston [4].

Fast-deployable, easy to monitor and maintain structures of habitats like the one assembled in McMurdo are perfect candidates for terrestrial applications in remote and harsh locations where supplies and resources are limited, transportation means and availability depend on weather and climate conditions and infrastructure development level either minimal or not present at all.

Psychological Aspects

Similar sensor and monitoring systems can be applied in housing and building industries enabling sustainable practices and helping to enhance responsible behavior amongst inhabitants of the building.

One of such examples is the LivingLab (LL) project at Chalmers University of Technology (Sweden) that investigates conditions for enabling sustainability by exploring new building and construction ideas and concepts, new materials implementation, design solutions testing, developing new technologies and adapting products and systems innovations to local context culturally, economically and socially [5]. The project also includes an educational aspect or approach in the form of a design studio that is concentrated on developing and supporting true sustainable living practices. The project is a multi-disciplinary initiative with an architectural input that is focused on definition of sustainable living environment and design practice, exploring students' interactions in design process, construction and use of housing units while efficiently

optimizing consumption of energy and other resources. The project includes investigations of affordable practices to adopt space technologies in sensing, managing and recycling resources, and providing means to inform residents of consequences of their lifestyles (Figure 3).

Fig. 3: Prototype of a washing room of the future which is part of the LL study. Credit: HSB and Riksbyggen.

Informational environments for forming sustainable practices

Technology, through creating informational environment, can contribute to developing sustainable housing and generate sustainable behavior. Informing a resident about his/hers consumption rate and conservation of resources is only one aspect of making technology serving sustainability – it does not assure that the particular resident will choose and follow a path leading to sustainable behavior. The process is much more complex than that, although it may require that technology to be part of it.

One of the major goals of connecting informational and built environments is to produce knowledge to advance and shape new sustainable lifestyles. Several strategies can be used in order to achieve that:

- information distribution;
- goal orienting;
- individual or group commitment obtaining;
- feedback on individual or group performance.

In spite of the common belief in power of information and informative means, some psychological theories emphasize that informative techniques are not very effective if used alone [6]. Therefore a combination of strategies tend to be more effective in promoting sustainable behavior.

An important part in the process of shaping a sustainable lifestyle is creating a collaborative strategy towards optimized resources utilization practices. Implementing advanced technology in design affords a means for informing and coordinating residents' responsible efforts helping people to make conservative choices to become a part of their everyday routine.

Figure 4 depicts basic level of essential relationships between an individual and a group, some of them may be present periodically while others belong to common attributes of human behavior [7].

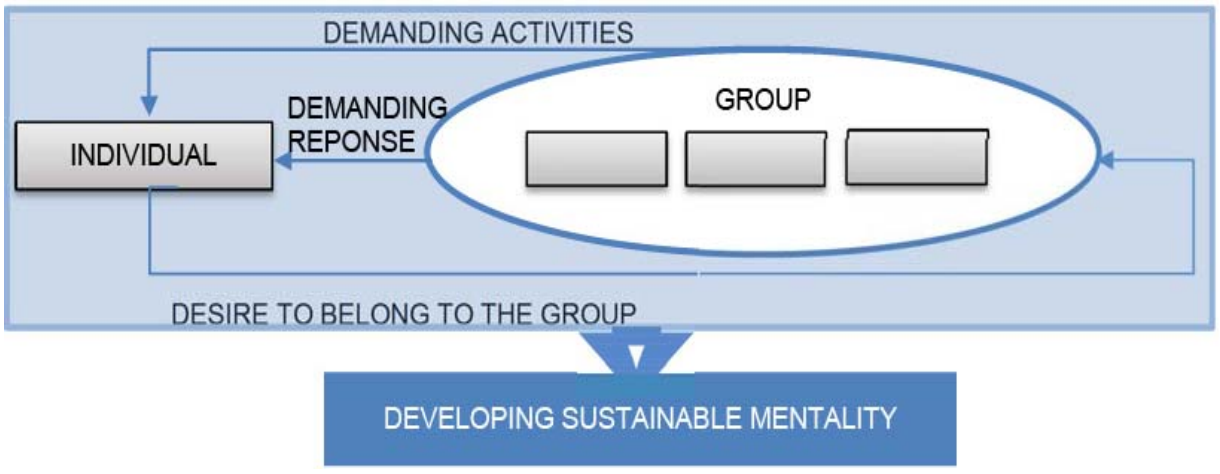

Fig. 4: Individual and group relationships shaping sustainable behavior. Credit: Olga Bannova.

II. LIFESTYLE AND TECHNOLOGY

Housing industries are trying to follow trend of modern lifestyles making living environment "smart" and "responsive" to its habitants, but how "smart" ones' house should be? According to Liam Tung, an Australian business technology journalist, "…the 'mature smart home' is still a decade away when the market does mature - which the analyst predicts will be around 2020 to 2025 - homes probably be hooked up with over 500 data-driven smart devices." Although the market is not there yet, there are indicators that number of devices will be growing exponentially each year. "The broad categories these fit into include power and utilities, lighting, media and entertainment, security and sensors" and more – according to Tung [8].

According to the report published by Goldman Sachs Equity Research analyst Simona Jankowski and her colleagues, there are "five key verticals of adoption — Connected Wearable Devices, Connected Cars, Connected Homes, Connected Cities and The Industrial Internet." The report suggests that the companies that offer web-enabled devices will be benefiting the most in the future [9].

The Figure 5 represents the Internet of Things (IoT) landscape where housing can be viewed as a transitional or connecting stage between individual (private) and global scales.

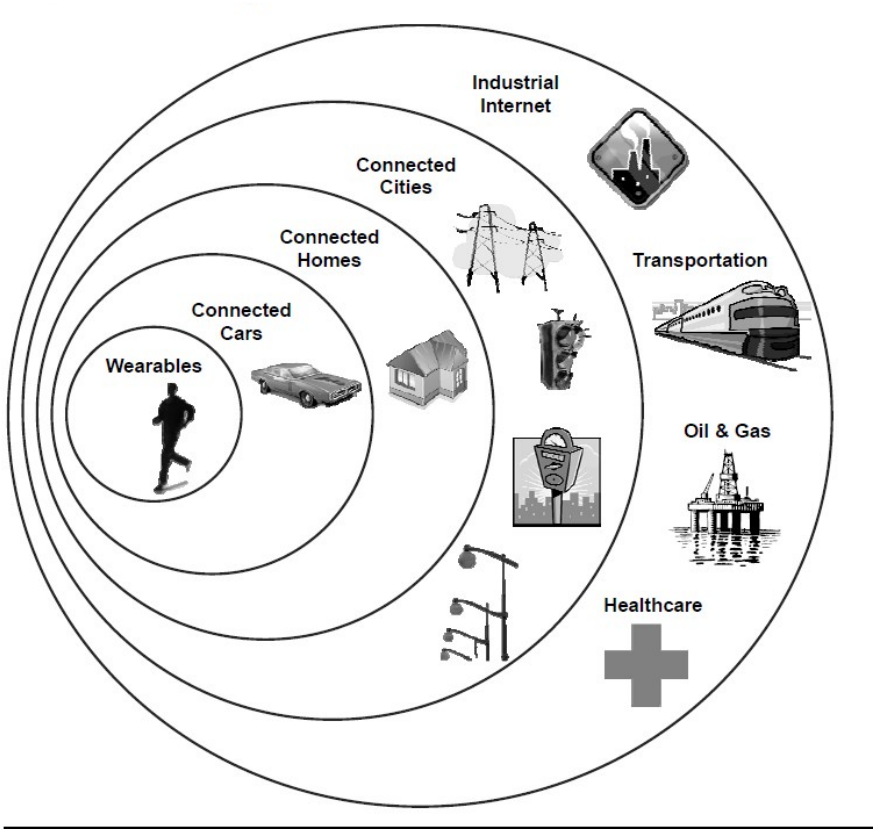

Fig. 5: The IoT landscape. Credit: Goldman Sachs Global Investment Research.

An ideal home becomes a platform for connecting to outside world through systems and devices that relay information between themselves, other homes, and the Universe. Although there are obvious benefits of home automation and monitoring of resources, there is still a question about how intrusive advanced technology of a smart home can be and how the level of interference will affect psychological climate and personal health. (Figure 6)

Fig. 6: Power-efficient Wi-Fi platforms to expand the internet of everything of a smart home. Credit: http://www.qca.qualcomm.com/thewire/new-power-efficient-wi-fi-platforms-to-expand-the-internet-of-everything/#sthash.zdkmtwNH.dpuf. http://insideproperty.com

NASA's Space Human Factors Engineering (SHFE) Standing Review Panel (SRP) recommended increased use of computational models by NASA [(10)]. Therefore there is a need of data collection techniques to be developed to collect flight data that will be used for creating and validating computational models and improve design and layout of habitats for long-term space missions. Those techniques should be unobtrusive as much as possible to secure crews' psychological comfort and safety. Same requirements should be applied to modern housing "smart" devices and equipment.

III. CONCLUSIONS: DESIGN AND APPLICATIONS CONSIDERATIONS

It is important to understand market and client demands in order to successfully incorporate space technologies in terrestrial applications of housing industries. Few important design and technology application considerations should be used as guidelines in housing design, building and construction:

1. Decide what information to be shared and how much of it can be displayed: informing or not? – in relation to usage of recycling systems in the house;
2. Create environment that provokes a user to make choices;
3. Enable means to stimulate learning about consequences of decisions made;
4. Provide a Safe Haven – not from radiation hazard but from informational and technological load – potential application for long-term space missions (providing psychological escape for the crew).

Criteria for evaluating implementation of space related sensing and informative technologies into terrestrial housing applications needs to be developed. Such criteria can include and be based on determining the following levels:

- Level of demand;
- Level of effect on household outcome;
- Level of dependency;
- Level of intrusiveness;
- Level of required or desired privacy.

Implementing such evaluation criteria into housing design and building practices at all stages of development will provide a solid foundation for reasonable technological intrusions while offering necessary information resources to enable sustainable design, building, lifestyle and household practices.

This paper outlined general aspects and concerns of transferring space technologies into housing industries. Future studies have to include reviews and surveys of terrestrial analogues and already implemented techniques, interviews with industry professionals, engineers, cosmonauts and astronauts.

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