freeDOME smart mobile office-home. The bio-logic design adaptation to the dynamic evolution of living

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Abstract: The paper explores the phenomena of social isolation due to the changing modern work and life style models and looks for possible design solutions by investigating the insect world and translating this into design principles, from the micro to the macro scale. It empirically investigates the 'anthropological leap' that Homo Sapiens, along with his habitat, is technically making, evolving to “Homo Technologicus” (Longo, 2001) and researches the natural environment for designing his new “technological habitus”. The aim is to discover basic biologic principles applicable in designing both innovative human-centered devices (myPod) and intelligent collective systems (the campUS) where individuals can interact with themselves and their environment, as “Australian Aboriginals” used to do. Finally the project empirically engages with the challenges of designing “freeDOME”: a mobile and autonomous load-bearing shell structure inspired by insects, especially coleoptera, exploiting their structure, the bending properties and the spectacular structural colors of their wings.

Keywords: Telecommuting, Interactivity, Smart mobility, Biomimicry, Eusociality

1. Introduction

“To the glory of the new global era contrasts the common man’s loneliness: ... To put a stop to this process is necessary to find the space in which public and private connect: the ancient agora, in which individual freedom can become collective commitment” (Bauman, 2014).

Can we have a healthier society through self-organised individual performing collective action with a closer relation to their natural environment as social insects teach? Here, bio-logic design can play a new role as an intelligent actor in complex networks, not just giving solutions with a top-down approach, but developing and spreading tools for collaboration.

“Some social systems in nature can present an intelligent collective behaviour although they are composed by simple individuals with limited capabilities. The

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intelligent solutions to problems naturally emerge from the self-organisation and indirect communication of these individuals. These systems provide important techniques that can be used in the development of distributed artificial intelligent systems” (Wilson, 2013).

To rediscover the place in which “public and private connect”, through the empirical project “freeDOME”, the research investigates new design possibilities referring to biology on two different levels, from the micro scale of the product to the macro scale of the territory:

- MICRO: from insect to human self organised individual systems (freeDOME myPOD)
- MACRO: from insect to human intelligent collective systems (freeDOME CampUS)

“freeDOME myPOD” represent the individual embodiment, “the habitus”, where he nourishes his subjectivity, emotion, language, thought and social interaction. The campUS is his way of living the world and socialising through his acculturated body.

Research hypothesis - This paper on “The design adaptation to the dynamic evolution of living” explores the hypothesis that biological principles, such as insect collective intelligence and their kinetic flexible system, can introduce to new self and social-working organisations -more dynamic, flexible and related to the environment- and to new technical applications in bio-design and engineering products. At this purpose the research was conducted in Australia, where the nomadic Aboriginal culture, their relationship with the land and the wild extended territory perfectly favour the hypothesis of new forms of “technological nomadism”.

In chapter 2 the “literature review” aims to introduce the state of art on portable architecture design by understanding how Homo Sapiens, along with his habitat, is evolving into the ‘Homo Technologicus’ and the implications of this social metamorphosis in designing his house (and office). In chapter 3 the “research Methodology” describes the tools and the procedures used to identify and select the information analysed for the research purpose and the inspiration sources that have allowed us to develop the experimental project illustrated in chapter 4. Here all the hypothesis are verified through a practical application at the intersection of product design/architectural design, micro scale urban design, technology and biology.

2. Literature review

“The quality of life and the health of the individual and communities will be improved through the design and creation of persuasive cities, streets, buildings, homes, and vehicles” (Stibe & Larson, 2014)¹.

According to Robert Kronenburg (2014) “Architecture in Motion”, the following analysis compares traditional examples of mobile dwellings with current work of innovative designers, and explores the related philosophical and technological issues by reading through the history and development of portable buildings.

Going across social statistics it is possible to understand actual living and working social trends, anticipate some negative consequences and trying to reshape them by prototyping tools and technologies that support physical, mental, social, and emotional wellbeing.

¹ Kent Larson is Director of the Changing Places research group and co-directs the City Science Initiative at the MIT Media Lab. His recent work has focused on 4 different areas: Responsive Housing/Urban Mobility-on-Demand/Living Labs/Changing Places.
2.1 The development of portable building

Since the 20th century, many architects, engineers and designers have started to experiment with prototypes of mobile dwellings stating the necessity of lighter, less static and impactful houses. Mobile housing was a fertile playground for both practitioners and theorists. In 1920 Le Corbusier stated in L’Esprit Nouveau that “...houses must go up all of a piece, made by machine tools in a factory, assembled as Ford assembles cars, on moving conveyers belts” (cited in Kronenburg, 2014, p. 63). Ten years later, Buckminster Fuller invented a futuristic dwelling, called Dimaxion House, a sustainable autonomous single family dwelling, the living machine of the future that could have been mass-produced, flat-packaged and shipped throughout the world. Antonio Sant’Elia already proclaimed in 1914, “we no longer believe in the monumental, the heavy and static, and have enriched our sensibilities with a taste for lightness, transience and practicality” (Kronenburg, 2014, p.68). Throughout the late 20th century and into the 21st, visionary architects have responded to Sant’Elia’s Futurist claim. Frei Otto with his lightweight and elegant structures inspired by nature, the Archigram experimental project of Plug in City (Peter Cook) and prefabricated transportable capsule-homes Living-Pod (David Green), opened the notion of portable architecture.

Current culture produces a wide variety of portable, relocatable, and demountable building types ranging from health-care to education and commercial facilities. Internet connections favour physical disconnections from stable locations allowing new forms of nomadism through ‘living capsule’ for a solitary lifestyles but still looking for connectivity, as states Lorenzo Imbesi, (2016) in Nomad+Design:

“...they are flexible and transportable capsules... impermanent objects that simultaneously click and flexibly fit to each space, reactively connecting with the individual characteristics of the subject and tuning it on global frequencies” (p.40).

The failure of the previous attempts of mobile life-styles were due to the strong territorial dependence between living-working places. Knowledge technologist (the “homo technologicus”) private life is always more identified in his professional one and home is then becoming his office.
FreeDOME MyPOD aims to bring the previous “capsule model” to a further level of development and make it a place where it is possible to live and work in a unique environment, where private and public connect and through which semi-nomad lifestyles can become a way to live with more freedom and flexibility and create sustainable temporary societies through technological innovations.

For this purpose the interest has been addressed to the theme of interactive bodies referring to the MIT Media Lab researchers on digital revolution and to the Interactive Architecture (IA) research, by Hyperbody, Tu Delft University of Technology, addressed at the level where buildings become dynamic, acting and re-acting in response to environmental and user-specific needs (Biloria, 2015). The hypothesis has been then experimented on a smaller scale, developing a prototype in between the product design and the architectural scale, a new information technology centre that promote learning anywhere anytime for anyone. The focus is on mobile tools that empower users to live freely and think creatively, collaborate broadly, and develop product and services that are useful to themselves and others around them.

As statistics shows, by 2050 cities will account for nearly 90 percent of global population growth, 80 percent of wealth creation, and 60 percent of total energy consumption (Singapore Smart Cities World Congress, 2006). However, today’s desire to escape from the urban sprawl, the need of more adaptable environments, the willingness to travel and to self-organise their work, seem to be widely supported by the majority of modern workers, even for short but constant periods (3-4 days a week) as telecommuting allows.

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2 Dr. Nimish Biloria is an Architect and an Assistant Professor at Hyperbody, Faculty of Architecture, TU Delft, The Netherlands. His research space between Emergent Technologies and Design, real time adaptive environments, intelligence aided relational networks and more.
2.2 Telecommuting or tele-isolation?

Knowledge technologists are likely to become the dominant social force over the next decades. Teleworking and telecommuting (all types of technology-assisted work conducted outside of a centrally located work space), have been growing for years, with recent polls putting the proportion of teleworkers at 37% in the U.S. (GALLUP, 2015) and 31% in Australia, (ABS, 2008). From the last recent surveys, (Il sole 24 Ore, Impresa e territorio, 25 Nov. 2016): 95% of workers between North and South America, Europe and Asia Pacific say to be ready to work anywhere in the world; 79% believe to carry out their tasks by simply connecting to a mobile device. Furthermore, researching specifically among the latest Australian lifestyle trends: 1 in 5 Australians work already in 3 or more different remote locations and 1 in 16 would even be willing to compromise 20% of their pay in exchange to the opportunity to work remotely or from home (McCrindle Research survey, 2013).

Housing is no longer about shelter but it is also used for running small businesses, shopping, studying on line. It is becoming part of the economic infrastructure of our countries. Are our old dwellings adapted to this new functions and dynamics?

Nowadays more than ever, the individual is identified with his profession and job. With the new scenarios of individualistic organizations of work, the risk of isolation, as Bauman (2016) stresses in "Liquid modernity", is very high. However today “the need to develop social and emotional skills is becoming more and more a requirement for survival and success in life and work. And this is true both for people and organizations” (Goleman 2007).

The research assumes that telecommuting will be part of the next “Homo Technologicus Habitus” and the experimental project represent a better model for his “biological embodiment”, where private and public connect, where he can finally satisfy his needs of freedom, self expression and sociality without incurring in isolation consequences.

At this purpose it explores insect colonies collective behaviour - in entomology called eusociality - as fundamental source of inspiration for a new self and social work organisation proposal.

2.3 Eusociality, new habitus and new habitats

For decades entomologists have known that insect colonies are capable of complex collective actions, even though individuals adhere to straightforward routines.

“In essence, we believe that social insects have been so successful and they are almost everywhere in the ecosphere—because of three characteristics:

- flexibility (the colony can adapt to a changing environment);
- robustness (even when one or more individuals fail, the group can still perform its tasks);
- self-organisation (activities are neither centrally controlled nor locally supervised)” (Bonabeau and Meyer 2001:108).

Furthermore, as insects teach, the community life requires a higher intellectual capacity comparing with the choice to lead a solitary life:

“It seems that in the insect universe there is a correlation pretty evident among sociality and intelligence: ecological niches, architecture, sociality, speciation, and knowledge interact with each in a complex way, that has amplified the benefits, driven innovation, raised Intellectual capabilities and brought to huge diversity” (Gould, J. L. & Gould, C.G. 2008, p.95).
Through an empirical case study of both individual and social organisations, freeDOME “myPod” and the “campUS”, the experimental project intend to verify the applicability of the eusocial model in designing smart human collective systems: here, as in the insect social groups, individuals follow simple rules (through their ecological and technological shelter -myPOD-), and interact in a complex way through innovative collective systems (the campUS). By an interdisciplinary cooperation between different expertise -as biologists, sociologists, engineers, architects and designers- for example, the collective system can combine research, development and production of innovative design products or services, driving innovation and rising capabilities by following the same eusocial sustainable principles.

The research-project is aimed to verify this hypothesis.

3. Methodology: Bio-logic inspirations

“I’m not trying to imitate nature, I’m trying to find the principles she’s using”. - Buckminster Fuller, (cited in Schleicher, 2015).

The research has been developed between Australia -where extended territories encourage nomadic lifestyles- and Singapore -where contrarily “Excellence is needed to solve the challenges caused by shortage of land, water and energy” (Tripathi, 2016)³.

The creative method reflects its central relevance in biomimetics. Gaining inspiration from nature isn’t a novel concept but a repeating theme in human history. However modern biomimicry is far from just copying nature’s shapes. It includes systematic design and problem-solving processes, which are now being refined by scientists, engineers and designers worldwide. Prof. Simon

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³ Professor Anshuman Tripathi leads the area of autonomous vehicles, electro-mobility and grid connectivity at the Energy Research Institute at Nanyang Technological University, in Singapore.
Schleicher (2015)\textsuperscript{4}, with his interdisciplinary research focused on bio-inspired compliant mechanisms for architectural design, has been fundamental in inspiring the biologic approach to solve the Pod’s kinetic structures issues.

The goal of this research project is not merely to copy the aesthetics in nature but instead to establish a systematic knowledge transfer between biological behaviour and social working organisations, biology and technology.

The broader view of biomimetic demands integration not only within biology, but with sociology, engineering, technology, architecture and design. An interdisciplinary vision is a must for this research. ‘Comparative biomimetics’ is here uniquely positioned to serve as an exemplar of this integration to investigate the following topics:

1. Time (evolution)
2. Organisms (insects, with focus on coleoptera)
3. Levels of organization (from organisms to eco-systems).

4. THE RESEARCH PROJECT - freeDOME -

4.1 Biocreativity on the road - living architecture -

"In case of need I’ll take my territory on my body, I will territorialise my body: the house of the turtle, the hermitage of the crustacean, but also all the tattoos that transform a body in a territory" (Deleuze & Guattari, 1987, cited in Imbesi, 2016).

\textsuperscript{4}Dr. Simon Schleicher is an architectural designer, researcher and educator from Germany, actually assistant professor in the Department of Architecture at the University of California, Berkeley. Currently he is also a member of “Design Innovation from Nature” at Berkeley.
The project model lies at the intersection of design, engineering, and biology: it is a shell built around the “homo technologicus” body and adapted to its changing needs: therefore, as the turtle shell protects the reptile from danger and weather, allowing it to cross territories and oceans for hundreds of years, would a fairly solid armour allow the individual to live outdoor and move with suitable protection levels and sizes?

By researching among flexible and robust structures in nature, the analysis also explores the insect’s wings motion principles, in specific in coleoptera, as creative inspirations that offer an alternative to the prevailing paradigm of rigid-body mechanics, allowing a different level of flexibility in the Pod design, as explained in the next paragraph.

It seems now more and more necessary that our living and working environment become smarter, more responsive, more flexible, adapting to the new social and technological changes. The mobility challenge opens therefore, together with the issues of flexibility, interactivity and sustainability, the new scenarios of the future living. This research is aimed at offering an experimental proposal to meet this challenge by combining this characteristics into a unique design product.

**Mobility: -myPOD allows a more fluid and flexible lifestyle-**

It is a minimal living/working technological unit on wheels (W2.5*L3.0*H3.0 meters) perceived for one to two people. It is smaller than 7 sq.m complete with a bedroom, a kitchen, a living/working area, a bathroom and also a deck - thanks to its expandability. Conceived as a towable device the Pod is progressing to a further level of development and innovation. Together with Anshuman Tripathi, we pointed out the need of adapting the device to the latest innovation in the field of transportation, in favour of an autonomous and electrified vehicle. Further progressions are investigating the possibility to develop a remote autonomous living-workplace where telecommuters can travel while...
working by optimising their commuting time. This will allow to travel for longer distances but then stop for few days in different locations.

Figure 5. The Pod features: a) Mobility; b) Interactivity; c, d) Flexibility; e) Sustainability; f) 3d study model; g) 3d printed prototype.

**Interactivity:** *the pod interior changes based on the user's emotions*

“Monitor touch screens and mouses have changed upon the tangibility of objects and sensorial stimuli they cause. We are, after all, biological creatures, equipped with body, arms and legs. A huge part of the brain is occupied by sensory systems, in constant exploration and interaction with the environment. The best products use a maximum of such interaction” (Norman, 2014).

FreeDome My POD allows this interaction physically connecting people with their own and with the environment stimulating their senses through interactive body-house connections: a wearable system reaches the user emotional sphere and through specific algorithms adapt the environment to balance his feelings through images, perfumes, sounds, colours. Despite FreeDOME allows a deep level of individuality and “self-connection”, his kinetic system, inspired by coleoptera’s wings, permit also a 360 degree opening to the natural environment and connection possibilities with the other Pods and members of the community.

**Flexibility:** *The pod configuration changes based on the user’s physical needs*

Today people look for a higher level of flexibility, in search for adapting the space to their changing needs. Its volume is a minimal capsule, sized and adapted to an average size person movements but it can adapt to any users, including people with disabilities, and uses, from home/office to show room,
meeting room, cafe and more. The volume is dynamic and in continuous state of change: compact when in motion it can be tripled when stationary.

Figure 6. Cross folding in the beetles wings (1-2) and biomimetic design application (3).

Analysing the Coleoptera elytra structure (external wings) and the hindwings bending mechanism, gave interesting inspiration in solving some Pod’s mechanical and technological issues. The elytra primarily serve as protective wing-cases for the hindwings underneath, which are the only one used for flying. Alike a coleoptera, also the Pod is equipped with a dual system of opening wings which here performs the dual function of electric power supply and protection of an inflatable/expandable underlying membrane that, when open, triple the indoor volume protecting from the external environment.
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**Sustainability:** -a self-sufficient and eco-friendly device- Light materials and renewable energy sources will make the device weigh less on the environment, both in terms of physical weight and energetic consumption. As in Coleoptera, FreeDOME’s spherical shape is aimed to reduce thermal dispersions and to favour the efficient collection of rain water for personal use. The inclinable roof and wings allow the best solar collection to the photovoltaic films they are covered with (12 sq.m producing nearly 1,6 kw) and the energy storage makes the energy available when the exposure is reduced. This, with the high capability water tank hidden in the tile, allows complete self-sufficiency for few days. The Pod water collection system reflects the insect waterproof shell and its ability to gather water from the fog.

As water accumulates, gravity overwhelms the electrostatic attraction and it runs down the bump, through a hydrophobic trough, and into the beetle’s mouth”. In the Pod alternating layers of glass and nylon thread mimic the hydrophilic and hydrophobic properties of the beetle’s shell, directing water into the tail (fig.8a), which works as a water collector for human use (the Biomimicry Institute, a 501(c)(3)). At an average temperature of 25 degree and relative humidity of 50%, we can produce 100 L of water by consuming 0,20 kw/h. (Basic water requirement standard for human needs is 50 L per person per day - Tab.1 in Basic Water Requirements for Human Activities - Pacific Institute).

4.2 Coleoptera elytra - biomimetic applications

The structural and material properties of insect exoskeleton (cuticle) remain largely unexplored, even though they comprise the majority (approximately 80%) of animals. It serves many functions, including protection against predatory attacks, supports the body, maintains the shape, and provides waterproofing. It also has mechanical properties such as high plasticity, adhesiveness, wear resistance, and gas diffusion control capacity. In addition it is very light. Nanofibers similar to chitin are being considered for the design of composite material of a high quality. However, optimal design for materials based on all aspects of the insect cuticle has not yet been established. It can represent a challenge for a further research investigations.
Furthermore studying biomimetic applications of the beautiful structural colors and texture of beetles forewings would allow high level of customisation and camouflage for the Pod surface coating.

Figure 10. Different structural colors and microstructure of the forewing found in several types of beetles (J. Chen et al./in Materials Science and Engineering C 55 -2015/ 605-619).

4.3 From Smart Design to Smart Communities

The freeDOME project addresses a social problem through a wide range of investigations, ranging from the micro scale (myPOD) to its applicability on the macro scale (smart-tech green-campUS).

Smart Cities use innovative technology and the willingness to change behavior related to energy consumption in order to tackle climate goals. Based on the insect ‘eusocial’ communities and on the ‘new nomadism concept’, further investigations are focused in developing a sustainable community model for smart cities that can be applied locally and globally: the smart-green-tech campUS. It is a sustainable-social organised system based on the 3+7 Permaculture principles (an ecological self-organised method developed from the 70’s in Australia by Bill Mollison, which perfectly advocate and allow a balanced coexistence between culture, art, innovation and design, craft and entrepreneurship, community living, ecology, sustainability and healthy life), where the individuals can express their culture and produce collectively innovation by connecting to their natural environment through the Pod.
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![Organizational diagram](image)

Figure 11. “Smart-tech-green campUS” organizational diagram (a) based on the Permaculture principles spiral (b) - the Pods are part of the ecosystem (c).

Organised following a radial system for allowing a more regular distribution of the resources and better people connections, the smart-green-tech campUS is based on the mobility and flexibility of the Pods which are the main element of the eco-system: they use its resources - solar energy, water, heart products - and give them back in terms of soil nutrition, carbon dioxide absorption and land care with a considerable saving of energy and pollution comparing with traditional offices. Furthermore, this system will give individuals the ability to live interactive-interconnective and co-creative experiences by travelling worldwide with their own shelter (private or rented) through an international connecting system.

The smart-tech campus aims to become a universal approach for designing and developing a sustainable, economically and viable program for making many old surrounding areas of the future cities user-friendly and enjoyable places where to live, work and interact by contributing in cities carbon footprint reduction. Learning the aboriginal capability of “Living with the land, not off it” (Tom Dystra, Aboriginal elder. Cited in Korff, 2016).
5. Conclusions

“I might have nothing, but I’m proud of my shell” (African Vodun, Blier, 1995).

The main premise of this research-project is that we are an organism within an environment that continuously evolve and self-organize itself and, established that old stable models are not suitable anymore, it is necessary to build a better model for our “biological embodiment” where the cultural environment cannot be separated by the natural one.

Considering a new design for a modern self and social organisation of individuals inspired by nature is the ultimate result the research aim to achieve, a deeper understanding of biological integration in technological design solution is in progress. To meet all the complex requirements for an autonomous and flexible human/biological shelter for the external environment, which allows to work and travel simultaneously, a new biomimetic research direction is proposed by deeper investigating the effective applicability of the exceptional coleoptera’s cuticle properties (as kinetic, resistance, hydrophobic and spectacular structural color).

The personal and international experience as “nomad architect and designer” and the further study in Business and Entrepreneurship, have conferred a more interdisciplinary approach and global vision to the project. A start-up based in research, development and production of human-centred design products, has been established between Sydney and Singapore with the aim of further interdisciplinary co-operations between international networks of Universities (as [BLANK] in the Netherlands - Dr. [BLANK], [BLANK] in Singapore - Prof. [BLANK] and the University of [BLANK] in California - Prof. [BLANK]), governments, non-governmental, business, and international agency partners motivated by the prospect for a sustainable and humane urban/social development.
Promoting better strategies for the creation of new small scale-city organisations, is therefore a global imperative, also thanks to the availability of new strategies for smart city interventions that are enabled by emerging technologies. Experiencing an intelligent collective and international research system, globally applicable, is the proposed instrument.

Figures 13. Coleoptera (Coccinellidae Latreille) - modified colour.

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