Mitigate, Adapt, Sustain: Emerging Workflows and Design Protocols for Carbon Neutral Subtropical H2 Cities

Thomas Spiegelhalter
Florida International University

Worldwide, coastal regions in hot and humid climate zones are in particular vulnerable to risks imposed by humanity's GHG's emissions. Natural oscillations such as sea level rise, storm surge, land use changes and infrastructure losses, migration, freshwater shortages and water-borne diseases will continue to impact coastal societies. Question is how can we prevent the tendency of climate-induced sea level rise and how can we adapt better to these unstoppable changes? Can we mitigate the impacts and sustain in our built environments?

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There are some answers for the building sector: the mandatory European Union's nearly Net-Zero-Energy-Building 2018-2020 regula-tions for all new public and private owned buildings and the voluntary U.S. American Institute of Architects 2030 carbon neutral building challenge mark a change toward various educational and practice oriented resource tools that address minimizing GHG's emissions. All these initiatives try to reverse the negative impact of temperature increase and climate change. We know the need for change is crucial despite conflicting goals in developing long-term core tasks for governments, society, and business. Another challenge is that the divide between sea level rise adaptive planning, real estate losses and re-adaptive infrastructure economics, has resulted in increased policy and master planning delays and costs. Another reason is that the lack of participatory information processes with scenarios modeling and prognostic design coding techniques are not well integrated or are missing.

This essay explores parallels between computational, immersive and performance based developed urban design and nautical engineering practices in the subtropics– here represented by successful projects of leading architecture and engineering firms specialized in sea water level rise adaptable H2O carbon-neutral city design coding and flood mitigation.

The essay interprets how the future of computationally developed H2O carbon neutral architecture will affect and assist policy making, life-cycle design and industrial practice through parametric-topological and/or algorithmic 'what-if" scenario modeling of new coastal cities and buildings. The examples will demonstrate that a paradigm change to view water as a 'site opportunity' will help to identify adaptive re-use stra-tegies and will envision how to accommodate adaptable structures for (sub-) tropical living and working within flooding and tidal inundations.

THREE DECADES AGO VISONS FOR ADAPTIVE DESIGN FOR AMPHIBIOUS ENVIRONMENTS

"Architecture is a tool", the philosopher Vilém Flusser once wrote for the first Intl. Symposium on "Intelligent Buildings" in Germany, 1987. "Tools change our thoughts, feelings, and desires". Flusser's thesis is, „We are governed by our tools even though we design them ourselves." [1] He emphasizes, that we can look at the anthropological history of cultural techniques as a feedback process between humans and tools. Today, we create parametric-algorithmic simulation tools and master models to help to solve society's problem of diminishing resources and sea level rise. A world so overwhelmingly dependent on destructive fossil fuels requires immediate utopian environmental designs, practical ideas, dramatic shifts in thinking and adaptive planning, and action without delay. The change to a renewable world of floating and amphibious carbon neutral water cities is inevitable along vulnerable coast lines around the world. (Figure 1)

FLOATING, DIVING, PULSATING, INTELLIGENT H2O ARCHITECTURE

25 years ago at the first symposium on 'Intelligent Buildings' at the University in Karlsruhe, Germany, Vilém Flusser proposed that the "computer culture will dominate all aspects of civilized life and that this domination has to be counterbalanced by inter-subjective values." [1] Flusser argued that a more inter-subjective and centered body-experience and vision of computation is needed for a more clear understanding of the fields of collective cultural cognition and human-computer-interaction. Flusser believed that the computer on the one hand will establish a technocracy of scientists, a new authority. But this could also be used to set up inter-subjective relations and to overcome the authority of monological narrators (market dictators). Flusser envisioned a new non-cartesian designed,

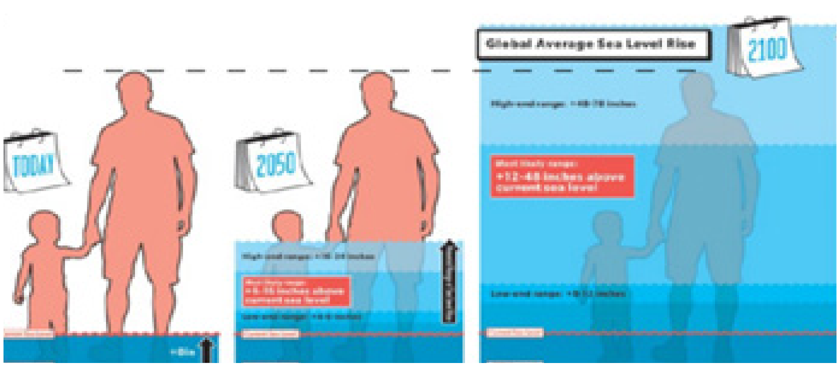

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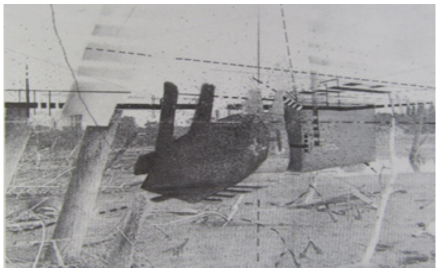
Figure 1: Sea level rise with human proportions for today, 2050 and 2100 according to the IPPC report scenarios in 2007. Collage: T. Spiegelhalter, 2013.



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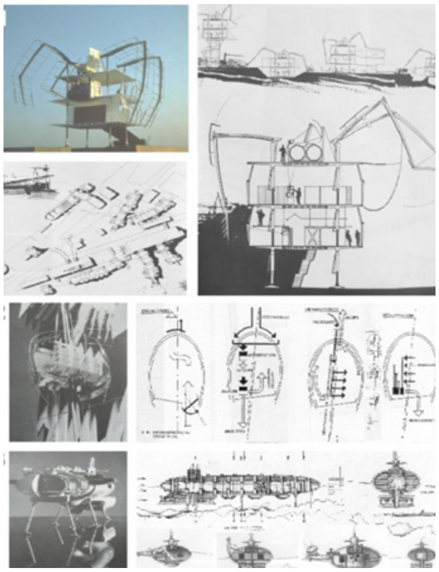

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Figure 2: Floating Inhabitat Egg Shells. Drawing and source: Thomas Spiegelhalter: Mediatecturen und Deponiekoerper, Projekt Bery A, Gravel Pit Architecture, Volume II, (Publishing House Juergen Haeuser,Darmstadt), 1992, pg. 31

Figure 3: Intelligent Buildings Studio Thomas Spiegelhalter. No.1.: C. Beck, H. Weber 'Adaptive Hybrid-Amphibia'; no. 2: C. Forcht, O. Wollowski 'Research Station Tschingelgletcher'; no.3: M. Unterreiner 'Naupilos-Submarine'. Source: Authors. Intelligent Buildings, Climate Tool Architecture, Design Projects at the University of Kaiserslautern, (Publishing House Juergen Haeuser, Darmstadt), 1992, pg. 12-32.

biologically self-reproducing world of intelligent architectures: "The industrial revolution was based on scientific theories in the manufacturing of tools, but there were then no employable theories in existence relating to living matter. Now we are beginning to have the rudiments of such biological theories at our disposal. We can now, for instance, simulate the functions of the nerve system in non-living matter." [2] Flusser argues that machines and computers are becoming more intelligent: "All this is just the beginning stage, and soon we shall also be able to produce viable tools, artificial living beings. Up to now buildings were non-viable machines, but with time they will become more intelligent. One will become aware of the fact that they can assimilate the skin's functions, and artificial sensory and motor nerves, and will probably, sometime in the future, even build a central nervous system into them. And even further into the future one may perhaps inhabit artificial living beings." He argued that "the communications revolution basically consists of the fact that the receptors of information no longer need to go to the disseminator, but that the information is directed straight towards the receptors." [2] Flusser stated in his prophecy that "public buildings, the city, and politics as such, have become superfluous. And thus, material and immaterial cables, wireless data have reached the private building. It has become flooded with the public sphere. ...Just how these buildings will look in the future, whether they will be like floating egg-shells or pulsating microbes, or even like central nervous systems sheathed in an electromagnetic skin is at present difficult to imagine and not all that crucial" (Figure 2).[2]

TWO ACADEMIC CASE STUDIES OF ADAPTIVE H2 ENVIRONMENTS

Based on Flusser's 'intelligent tool theory' the author conducted with students at the University of Kaiserslautern in Germany a one year research studio called "Climate Tools Architecture – Intelligent Buildings" from 1990 to 1991. Climate-sensitive and user dynamic 3D building form modeling using the latest parametric computation technologies at that time were included in the environmental designs. Individually chosen assignments that are focused on different interrelated coastal threatened climate zones and altitudes in Europe from the Atlantic and Mediterranean Ocean to the Alps. The students were engaged to model and calculate self-organizing, adaptive buildings that adapt, swim, dive, drive and float. The design parameters and calculations included the change of inundation height due to coastal storm surge events with potential sea level rise of two meters. Some of the typical challenges were to tackle with problems related to the topologising of dynamic form variations and parameters, as well as the associated environmental design processes and spatial exploration to arrive at highly adaptable carbon free off-the-grid powered buildings (Figure 3).

The project, publication and traveling exhibition through Germany was supported by Schueco International, Bielefeld, Publishing House J. Haeusser, Darmstadt and HL-Technik AG (CEO Prof. Daniels, ETH Zürich), Munich.

Eighteen years later another graduate design studio project at the Florida Intl. University in Miami participated in the 'The USGBC's 2010 Natural Talent Design Competition' in New Orleans. Our award winning projects focused on 3 to 4 metres elevated housing typologies as an aftermath consequence in response to the devastating impacts of Hurricane Katrina in 2005 (Figure 4). Katrina was the most memo-rable storm in New Orleans history. Though, the incongruity between our adaptive carbon-neutral student project and the fact that New Orleans is artificially kept free from floodings through immense fossil fuel based pumping demonstrates the viscous circle of all these efforts. On September 10, 2005, for example, there were 148 fossil-fuel based operating pumps in the New Orleans area being worked, with an average of 26 permanent pumps operating, pumping 9,125 cubic feet per second and 39 portable pumps were operating, pumping 723 cubic feet per second. In addition, nine of 26 existing pumps in Plaquemines Parish reported operating at 1,360 cubic feet per second. The equivalent to an Olympic-sized swimming pool was being drained every two seconds and contributes significantly to GHG's emissions which then trigger climate change and sea level rise and again more pumping demand. [3]

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PARADIGM CHANGE: SOFT BLUE-GREEN INFRASTRUCTURES VS. GREY AND HARD INFRASTRUCTURES

For centuries, spatial planning in the low-lying Netherlands (like in many other countries too) has been an issue of a grey infrastructure planning by separating land and water. These engineered hydraulic conduits have replaced the complex fluviomorphology of natural flood plains. The decrease of water and alluvial sedi-mentation has led to the deterioration of fragile ecosystems and accelerated coastal erosion.

Fourteen years ago, the Dutch Ministry of Transport, Public Works and Water Management and the Association of Water Boards declared in its 'Water Management Policy in the 21st Century' report that a change in water management policy was required, involving relinquishing space to water rather than winning space from it. [4] Ever since spatial planning in the Netherlands is widely abandoning the compulsive control of water while taking full advantage of the dynamic relationship between land and water, to generate flexible living environments accepting of climatic influences, tides and seasons. Rather than simply elevating buildings or increasing the stability and quantity of urban ground, these projects do the inverse by incorporating calculated mixtures of flow and storage into their design parameters. The concept is to work with nature and not against it. Spatial planners and architects realized the reoccurring problems of working against nature and develop now master plans of adaptation which integrate the natural regenerative potential of these marginal territories. Typical examples include designs for folded water-walled levees, floating and energy-producing occupiable beachscapes, and rhizomatic hydrogen-generating aquatic living networks with alluvial sponge combs to mitigate floods. This design tendency demonstrates mixed-used amphibious zones between land and water within the dynamic hydro geographies in which they are immersed. To encourage a more synthetic relationship between architecture's artificial containment and the ever dynamic flux of its natural fluid environs.

In summary the concept of soft green infrastructure as a network of green and blues spaces in and around urban areas, give emphasis to green space planning. This includes the delivery and maintenance which should be equally important to that of other types of infrastructure such as transport, communications, water supply etc., as an integrative part of coastal cities.

THE SUPREMACY OF THE 2007 IPPC REPORT SCENARIOS FOR NEW POLICIES

The 2007 Intergovernmental Panel on Climate Change (IPCC) AR4 report

Figure 4: Emerging Green Builders South Florida Chapter Awards. Elevated, carbon-neutral houses (above) and section (below) of the city of New Orleans ground elevation from Canal St. at the Mississippi River to the Lakefront at U.N.O. by Katiuska Merino and Mabel Lanza, FIU, 2010.

MATERIAL IMPACTS
Damage to:
- residential, commercial and public buildings, space and assets;
- transport infrastructure;
- public utility objects and networks (electricity, communication, gas, water);
- other vulnerable objects, e.g. petrol stations.

ECONOMICS IMPACTS
- Disruption of electricity network;
- disruption of communication network;
- disruption of traffic: Motor vehicles, public transport, bicycles, emergency services;
- loss of business.

HEALTH IMPACTS
- Death;
- health impacts due to contact with contaminated flood water;
- health impacts due to damp and associated fungi;
- citizens' experience of all relevant impacts in a flood event — post traumatic stress disorder due to dislocation and loss.

EMERGENCY ASSISTANCE IMPACTS
- Fire department services;
- policy department services;
1 • sewer management services

METEOROLOGICAL FACTORS
- Rainfall
- Storm surges
- Temperature
-

HYDROLOGICAL FACTORS
- Land-use changes (e.g. surface sealin due to urbanisation, deforestation)
- Inefficiency or non-maintenance of sewage system; river margins clearin
- Building in flood-prone areas
- Reducing/cutting off retention areas

HUMAN FACTORS AGGRAVATIN NATURAL FLOOD HAZARDS
- Soil moisture level
- Groundwater level
- Presence of impervious cover
- Channel cross-sectional shape and roughness
- Topography, slope, basin geometry
- Presence or absence of over bank flow channel network
- Synchronisation of run-offs from vario parts of watershed
- High tide and heavy swell impeding drainage

Table 1: Urban adaptation to climate change in Euro-pe - Challenges and opportunities for cities together with supportive national and European policies, Euro-pean Environment Agency, EEA Report, No. 2/2012. Source: Adapted from van Riel, 2011.

estimated that there will be a 1°C increase by 2020 in global atmos-pheric temperatures. Beyond 2020, IPCC cites several emissions scenarios that could result in a global temperature increase ranging from 2°C to 4°C through 2100. We know, as air temperatures rise, there are likely to be changes in water temperature with thermal expansion, sea level rise, availability, quality, and chemistry on global, regional, and local scales.

The IPPC describes three key factors of the hydrologic cycle, i.e.: evapora-tion, transpira-tion, and atmospheric humidity. All three key factors will amplify with increased atmospheric temperature and trigger socio-economic, politi-cal changes that contribute to higher urban, industrial and agricultural water demand. Increased water temperature reduces dissolved oxygen content and the combination of higher temperature and lower oxygen levels causes surface waters to be more sensitive to eutrophication and algal blooms. Aquatic flora and fauna are sensitive to temperature, oxygen level, and aquatic chemistry and will dramatically change as well. The resulting effect of temperature and sea level rise will also impact groundwater and surface water flows. In particular this will happen in most tropical coastal regions where high rates of precipitation and aquifer recharge is inevitable and close control of the water table is essential to prevent flooding of the low terrain. Groundwater flow rates are relatively high due to the aquifer's permeability, which also makes the aquifer more susceptible to saltwater intrusion.

Furthermore, the IPPC predicts that climate change will increase future Atlantic and Pacific tropical cyclone and hurricane activities. [5]

There will be coastal flooding with deep inland penetration along rivers and canals. For example the storm surge associated with Hurricane Andrew reached almost 6 meters in south Miami-Dade County in August 1992.

The table on the right shows typical potential flood impacts in urban areas. The table is adapted from van Riel in 2011 and published in the European Environment Agency Report, No. Feb., 2012:

THE INTERDEPENDENCIES BETWEEN AMPHIBIOUS BLUE-GREEN INFRASTRUC-TURES AND SMART GRIDS

Hydrological "what-if" scenario modeling for subtropical coast line cities is sub-stantial to understand the interdependencies and needed re-planning measures for soft, blue-green and grey infrastructures. Multi-scale approaches will be nec-essary to also manage the overwhelming data flow for resource and energy peak loads and storage management of driven Smart Grids.

For example, as sea level rises, increased ocean hydrostatic processes will cause the saltwater interface to migrate inland, especially if the water table is held constant, as has been historically assumed in hydrological modeling to date. In addition to increased saltwater intrusion, groundwater flow and water table height will approach new equilibrium values that depend upon the extent of sea level rise and the rates of rainfall, evapotranspiration, well field with-drawals, storm water drainage, and lateral groundwater flow in or out at the boundaries of cities. Sea level rise is also expected to compromise the effi-ciency of the primary drainage canals and flood control structures. Extreme events in particular stress the interdependencies in infrastructure as they are accountable to trigger cascade failure. This occurs where the collapse of one system of an infrastructure can cause others to fail. One example of this could be "flooded power stations leading to power cuts thereby affect telecommunications networks, the pumping and treating of drinking water and control systems." [6] Practical examples of Siemens' engineering shows the use of proprietary algorithmically operated power calculator tools that take into account dynamically changing, regionalized energy distribution peak loads and cost trends, anticipated start-up volumes, and diurnal flow patterns within blue-green and grey smart grid infrastructures along coast lines. Siemens uses biologically inspired process-optimization 3-D-learning programs that evaluate specific peak load and cost factors such as energy and drink water distribution use, labor and disposal. The program integrates several key hydraulic scenario features with urban planning parameters as drink water, wastewater treatment, biological operations and solids separation, to significantly reduce energy costs and carbon emissions. [7]

COLLABORATIVE ENVIRONMENTS: HUMAN COMPUTER INTERACTION HCI) AND SWARM INTELLIGENCE (SI)

The cooperative activities of individuals belonging to a community stimulates information sharing and engages individual performance just as by Vilem Flusser envisioned with his call for intersubjective relations to overcome the authority of market dictators. In this case of sea level rise, communities should be able to create cognitive, collective entities that exceed the limits of individual capacity to adapt and mitigate the impacts of climate change.

But what are the main issues, demands and expectations which make collaborative formulations, presentations and the adoption of design protocols, legislation and the frameworks successful?

It seems that we can no longer think of the future of collaborative design with digital planning tools without retooling the profession. It is noticeable that professional practice and architectural academia have developed diverging positions about the present and future of the human-computer action (HCI) in 3-D-design and presentation of 'What-If' scenarios to adapt to climate change.

With games engines, such as Quest3D® fed by 3D-data resulting from multiple scenario inputs of Built Environment Modeling (BEM) tools, we can create navigable, immersive integrated 3D urban models that illustrate potential flooding, adaptable infrastructures and buildings, cities, storm, humidity and air movement, and people or vehicle circulations using false color. [8] Based on information from Geographical Information Systems (GIS) databases and accurate physical analyses, these quantitative interactive 3-D environments provide unified, multidisciplinary representations of proposed urban developments (Figure 5).

BEM offers excellent opportunities to make meaningful stakeholder and public engagement not only possible but also cost effective. Participatory processes with accessible data exchange are essential for getting necessary change and radical design innovations adopted.

"Abstract, static computer representations and physical mock-ups are useful for studying mono disciplinary computation results within one designer's realm of expertise. However, these forms of representation are inadequate when several designers are asked to (develop and) explore interdisciplinary computation results and uncharted design territories." [8]

Now designers have the opportunity to create models with interrelated data that

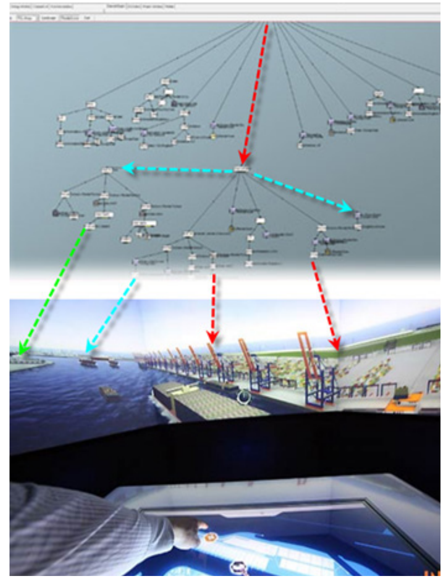

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Figure 5: Quest3D Real time animation of Future Land, which is an area of 4500 acres being reclaimed off the coast of the Netherlands for the Port of Rotterdam. The Future Flight Experience shows what this area will look like – including sea level rise -when it is finished in 2033. The Quest3D graphical programming allows quick testing and modification of imported 3D models in DXF, 3DS, OBJ, DAE and FBX formats. Source: http://quest3d.com/showcase/

are interactive and immersive– including a mix of real and symbolic representation – that facilitate experiential design and 'what if'-scenarios. These virtual models enhance designers' perception by allowing them to explore experientially hundreds of potential multidisciplinary design combinations, both qualitatively and quantitatively, in a practical, collaborative and cost effective way.

DESIGN CODING WITH IPCC AND SMART GRID DATA

However, the sheer amount of information that is required to effectively re-design, to manufacture, assemble and operate amphiphous carbon-neutral infrastructures and buil-dings is overwhelming. Today, thanks to 3-D/4-D design modeling and intuitive computer interfaces that are easy to use, it is possible to achieve the rapid conceptualization of different carbon-neutral building designs at minimal time. These scenario features enable the user to simultaneously conceive, simulate, validate and present to the audience several alternative solutions though the entire life cycle of a building or city. There is no longer a need for extensive and repetitive coding and scripting for this Intelligent Information Flow Management of reusable parametric models and creative design processes.

The design coding and simulation of any product, infrastructure or city on computers can be achieved long before anything is built. As mentioned before these parametric 3-D/4-D or even 5-D virtual models contain thousands of associated parameters, most of which are from real infrastructure or building models. Many leading software companies such as SIEMENS or Dassault Systèmes are developing these parametric-algorithmic tools and processes beyond meta-heuristic techniques for Environmental Design in order to augment the traditional analog heuristic methods or practical rules of thumbs used by project teams in academia and the profession.

Digital Mock-Up (DMU) studies of an entire building or a city can be virtually assembled in order to visualize the interaction of all production processes using an integrated data model. A complete city infrastructure, factory, production plant, container, cruise ship or aircraft can be modeled with millions of parts designed and envisioned individually and designed in dynamically changing contexts. Parts of the design process, such rehabilitating and retrofitting aging water infrastructures for improving drink water and waste water systems, that were once performed through extensive physical mock-ups are developed through digital mock up studies. [9]

For example the parametric-algorithmic developed scenario models of the The Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO) can be embedded in any kind of master models as digital mock-ups for the adaptation and mitigation design of the consequences of sea level rise. With that said, architects, designers and engineers can become topological operators with unlimited capability to optimize and test multiple scenarios.

SWARM INTELLIGENCE SCENARIOS AND MASCHINE LEARNING LIBRARIES

The Competence Center for Learning Systems at Siemens Corporate Technology (CT) in Munich, Germany, develops for this kind of scenarios software solutions based on the 50 year old idea of neural networks and pattern recognition for autonomous and automated design processes. These algorithmically driven networks tend to perform best when combined with other procedures, such as fuzzy logic, for example, which recognizes not only binary values but also intermediate ones. The statistical methods then generate predictions on the basis of probability theories and are assembled in the so-called Siemens Machine Learning Library (SML). Neural networks are genetic algorithms that are modeled on the human brain and assist learning software to control or predict almost any kind of dynamic processes in climate change design processes, including decision making processes for the politics, culture or economy. Each parametric value can be changed with just the push of a button. It is simple to run through various scenarios.

Another used technique includes so called generative-algorithmic modelers that contain specific topological Swarm Intelligence (SI) capabilities. The Swarm intelligence is a collective behavior of decentralized, self-organized systems, which could be fused to a worldwide network of design and engineering, allowing for all kind of scenario developments of climate change mitigating designs. These participatory 'what if' scenario tools offer new visions and workflows in the Human-Computer-Interaction (HCI) with Swarm Intelligence (SI) driven sensor infrastructures and manufacturing systems for designing, fabricating, assembling, and benchmarking new, adaptable, amphibious carbon neutral cities.

CONCLUSION

SIEMENS' expert's project that the highest form of linkage that we are trying to achieve is a mechatronic simulation in which an architectture's coding, mechanics, electronics and software interact in real-time with other compatible imported data. "Experts predict that by 2015 there will be virtual engineering at all levels from nanostructures to complex 3-D imagery in real time." [9]

It is inevitable that collaborative design will play a strategic role in developing this complex 3-D real time imagery with data interchangeable scenario techniques. This will also include forms and statistics of stakeholders, communities, helping us to think together, concentrating our intellectual energies, multiplying experiences and imagination, and negotiating viable solutions to complex problems of best adaptive practice strategies.

Recently, Prof. Martin Greiner, a physicist at Siemens Corporate Technology, envisioned a form of distributed optimization in which complex networks function as if they were intelligent societies. Greiner recently patented an invention that will allow the rotors in wind parks to optimize the positions of their blades in response to information provided by the first towers affected by a change in wind speed or direction. He emphasized that this instan-taneous learning process assists the reduction of power fluctuations and allows an entire wind park or any other infrastructure to function as if it were a single entity. [10]

Such collaborative networks, whether made up of a mix of renewable generating energy systems and their users in an amphibious city environment or molecules in biomass production with algae, will learn from experience and will become interconnected in a virtually biological and social alliance.

The profession and the academia have to recognize that these adaptive networks, their dynamics and architecture will be a major focus of learning systems and neural networks and will help to retool the profession and academia. Ultimately the designers aim is to achieve an integrated environment where – during the design process, including the early stages – one can generate

3-D-/4-D/5-D design scenarios, set up interrelated analysis and optimization routines, protocols and receive meaningful real-time feedback for collaborative data sharing with all participants. These virtual models enhance designers' and clients' perception by allowing them to explore interactive and immersive, experientially hundreds of potential multidisciplinary scenario combinations, both qualitatively and quantitatively, in a practical and cost effective way. Since millions of years, these forms of environmentally and adaptive driven collaborations take place in cells, or among ants or wasps. Learning from these processes will have implications for our data exchange, for traffic management, for logistics, and self-organized city or building infrastructures. As we continue to learn to extrapolate knowledge from natural systems, we will optimize human behavior, patterns and systems in the built environment.

In memory of Vilem Fusser's stimulating visions of the natural world in 1991, the inter-subjective cybernetic one, and the virtual tools that connect them seem to channel directly into today's reality and future of collective intelligence. However, the need for a more clear understanding of the fields of collective cultural cognition and human-computer-interaction has not yet reached its full peak. We are still in the baby steps and much more needs to be done!

ENDNOTES

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