

Performing Sustainability: Life Support Inside Biosphere 2's Glass Box Theater, 1991-1993

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ABSTRACT: Recently, the term Performative Architecture has been increasingly used as a pseudonym for sustainable design. In the case of Biosphere 2 (B2), performative architecture became not only a service oriented container for long-duration life support, it became the stage on which multiple sustainability narratives were played out. Perhaps unconsciously achieved by the project's architects, Phil Haws and Margaret Augustine, the functional form of B2 provided the front-of-house and back-of-house venues that propelled the operation, and the perception of sustainable life-support during Mission 1. This paper defines the troupe of performers: ecology, ecotechnics, Biospherians, scientists, tourists, and popular media, and utilizes their performances upon the B2 stage to unpack the ensuing drama of Mission 1 through the lens of this glass box theater architecture, while speculating on the value of the lessons learned for today's performative architectures.

Here, conventionally understood quantitative aspects of performative architecture link the eco-technological design and operation of B2 to qualitative humanities based frameworks of Performativity such as theater, service oriented design, and object studies. Through the case study of B2, it becomes apparent how and why these coupled quantitative/qualitative understandings are critical to the future success of performative architecture in the Anthropocene, at a time when adaptive architectural strategies for sustaining and enhancing global life support, which supplements diminishing ecosystem services during rapid climate change, are becoming more ubiquitous. Ultimately, we can utilize the performative architectural apparatus of B2 to develop a more sophisticated understanding of trans-disciplinary architectural design and its operational implications, which will ultimately facilitate the design and performance of more productive constructed eco-techno-socio environments.

KEYWORDS: performative, sustainability, Biosphere 2, ecological systems diagram, environmental ethic

1.0. MUD WRESTLING IN A GLASS HOUSE

On July 20th, 1992, in celebration of Biosphere 2's (B2) crew member Taber MacCallum's birthday, a Mud-wrestling Olympics was performed. *Terrible Taber* faced off against *Sly Wiley Coyote*, Roy Walford, from a drained rice patty, adjacent to B2's glass envelope, which had just been harvested (Walford and Rowland 2005). From inside B2, the crew participated with delight, and outside, members of Mission Control and the design team watched the performance from the south viewing plinth/walkway, faces pressed up against the glass.

Gaie announced the start of the fight over her two-way radio and Roy leaped from the spaceframe, knocking Taber down in the gray mud. They rolled, they threw each other, they headlocked with great showmanship, until finally Taber flung Roy over his shoulder and slashed him facedown in the mud to claim his victory. It was completely staged, but the crowd went wild as the victor, dripping with watery grey mud, waved and beamed (Pointer 2009, 219-220).

Many performances of various kinds permeated Mission 1. The crew was comprised of individuals, hand selected from an independent group of *total systems ecological managers* who designed and inhabited B2. Theatrical performance was embedded within their alternative lifestyle. Prior to the advent of B2, when they were not practicing ecological restoration, they were traveling as members of a theater troupe called *The Theater of All Possibilities* performing original works (Reider 2010). Mark Nelson, one of the crew members and head of the Institute of Ecotechnics, described the dynamics of this alternative group:

We do whatever we need to do, and play what roles we need to play, to get done what we need to get done (Pointer 2009, 237).

Performance had become a way of life for the crew, blurring lines between dreams, realities and fictions. This state of perpetual performance not only brought B2 into being, but also assisted the Biospherians in managing not only socio-cultural stresses that arose from life within the fully enclosed architecture of B2, but the ecology itself.

2.0. BIOSPHERE 2 AS BUCHNER FLASK

B2 sits outside of Oracle, Arizona, about one hour drive north of Tucson. It was designed by a trans-disciplinary group of environmental managers, architects, ecologists, engineers and visionaries eager to test the plausibility of biodiverse closed-loop polyculture life support for space exploration. Their inspiration, and ultimately the diagram of the building, came from Exobiologist Clair Folsome's ecological samples containing "... complete functional suite[s] of microbes together with [water and air]...inside a closed laboratory flask..." (Allen 1990). Resulting in a 3.15 acre spaceframe megastructure that operated as an ecotechnical instrument "...for materializing anthropocentric/anthropogenic change on an ecosystemic scale" (Luke 1997, 113), it operated as the tightest envelope ever built, exchanging only ten percent of its atmosphere with earth's annually (Dempster 1999). The surrounding complex of engineered architectures included B2, two redundant *Lung* structures that mitigated air-pressure, a power generation station, quarantine and lab facilities, and an external Mission Control.

B2 operated as a materially closed but energetically open system, analogous to the earth and sun. The above ground *biosphere* consisted of rainforest, wetland, ocean, savannah, and desert wildernesses, agricultural, and human habitat/mini-city *biomes*, enclosed in glass to ensure maximum solar exposure, and a basement *technosphere* (Pointer 2009). Sandwiched between them was a carefully controlled photosynthetic datum of soil, water, nutrients and life, penetrated by mechanical and digital systems sensing and servicing it from below. This datum cycled atoms through augmented ecosystem service provisioning landscapes.

B2 was the ultimate embodiment of ecology, the perfect expression of the word's etymology: the study of the house. In this case, the house was designed as a performative model of planet earth, scaled down by a factor of 23.3 million. A systems infrastructure, in productive tension between scales of planet, mega-structure, humans, and microorganisms that required the creation of unprecedented technologies for its operation: energy powered hybrid electronic/mechanical/biological feedback infrastructures, serviced by humans, which manufactured and regulated carbon, oxygen, water, and nutrient cycles necessary for human survival. B2 demanded the development of some of the most sophisticated hybrid digital/environmental control systems and synthetic ecologies of the time in order to intensify earth systems processes that typically perform invisibly in space and time. Through the design, construction and operation of these, invisible processes, such as carbon dioxide residence times, which accelerated to a maximum of ten days inside B2 (Cronise, Noever and Brittain 1996), were revealed and aggressively manipulated. These invisible processes took the forms of eco-technological constructions, sensing and surveillance equipment, and management protocols and regimes.

2.1. A Culture of Ecological Performance: Noösphere

Long before B2, the Biospherians utilized a holistic, service oriented approach to restore diverse degraded landscapes they amassed across the globe. They took inspiration from geochemist Vladimir I. Vernadsky's biogeochemical theories of the *biosphere*. Vernadsky defined *biosphere* and *noösphere* as the two *spheres*, or systems of influence, that affect the qualities and performance of life on the earth's surface. He describes the *biosphere* "...as the domain of life on Earth [that] is a *biogeochemical* evolving system..." (Grinevald 1998, 26), and the *noösphere* as

...a new geological phenomenon... [where] Man becomes a great geological force for the first time. He can and must reconstruct the realm of his life with his work and mind." (Vernadsky 2007, 415).

In 1944 Vernadsky outlined *noösphere*, an ecological ethic that the Biospherians modeled themselves after (Fig. 1), which resembles the recent definition of the emerging geologic age of the Anthropocene (Zalaziewicz, et. al. 2009).

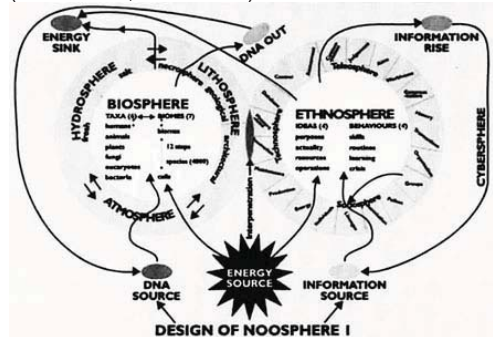


Figure 1: Noösphere of B2. Source: (Me and the Biospheres, 2009)

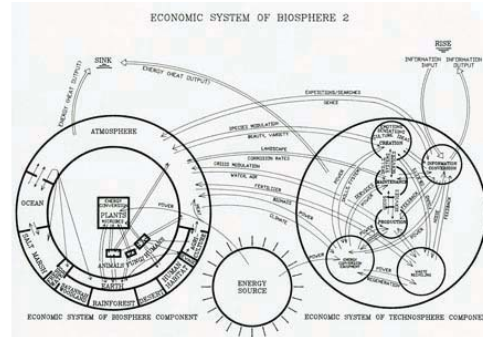


Figure 2: Economic System of Biosphere 2: Biosphere and Technosphere. Source: (U of A B2 Archives, 1987)

The Biospherians utilized Vernadsky's writings on the *biosphere* and *noösphere* to structure their understanding of the relationships between earth patterns and processes, and the evolution of human ethics. They added a third *sphere*, the *technosphere*, in order to specify the mechanism of human action and agency that can create the *noösphere* from the *biosphere* (Allen 2003). This duality of *biosphere* and *technosphere* was utilized to generate their own ecological systems diagrams which they employed in the design of the eco-technical architectural systems of B2 (Fig. 2). Thus, the ultimate goal of B2 was the creation of a *noösphere* prototype, an enlightened ecologically driven society that would

...produce understandings to assist in the creation of a transformative culture where Homo sapiens become creative collaborators with ecological earth systems...[to]...create living art forms that champion life and space exploration (Allen and Nelson 1989, 55);

a synergistic blend of the quantitative sciences with the qualitative humanities that resulted in an ecotopia experienced through the coordinated performance of technology, ecology and ethics.

2.2. Scripting the Invisible

The creation of ecological system diagrams that communicated flows, behaviors and quantities comprised the pre-schematic programming phase of B2's design. Systems diagrams identified the performative relationships and constituents (the script and cast of characters) necessary to construct B2's operation. But these diagrams are not easily deployable design tools because they lack of spatial explicitness. Their

...boundary and network structures are topological and functional duals of each other. The boundaries define a space of containers and places (the traditional domain of architecture), while the networks establish a space of links and flows" (Mitchell 2003, 7).

The Biospherians, with their interdisciplinary team of expert scientists and engineers, manifest the design of B2 by translating and mapping their systems diagrams into adjacencies and scales of space, built form, building control systems, and biotic habitats. These diagrams manifested a top-down operational space of known quantities which theoretically would operate as a seamless choreography of *biosphere*, *technosphere*, and *noösphere* idealized by the Biospherians. However, throughout the design process, tension between *top-down* and *bottom-up* control heightened as designers brought multiple disciplinary understandings of ecological performance into the mix.

The highly quantifiable *systems* approach facilitated schematic design, despite the fact that it favored a "technological and scientific view of *nature* and *humans* at the expense of wider social and cultural values" (Anker 2010, 127-8). This scientific view ignored the Biospherians humanist bent. This bias was continually reasserted via calculated relationships between human beings' survival requirements and the earth's biophysical carrying capacities (Luke 1997). Ultimately, it was facilitated by B2's *Nerve* monitoring and communications system. Within the *Nerve*'s operation humans were

...reduced to differentiable but integral engineering functions. Caught in the grids of scientific surveillance, the ecological interface of human organisms and biological environments [were] transformed into technological design criteria..." (Luke 1997, 103).

The Biospherians were able to reconcile their place within the larger system, in part, because they understood the ecological performance of B2 as a dramatic play, within which they each would perform their scripted role, as they had done in their Theater of All Possibilities productions.

They simultaneously anticipated that the performance of their script would be subject to massive change as the ecological systems of B2 struggled to mature and ultimately find equilibrium. In this way, they would be living in a highly uncertain post-normal science constructed environment (Kay 2008), in dynamic tension between recitation and improv. They looked to Zoologist G. Evelyn Hutchinson writings, particularly his book *The Ecological Theater and the Evolutionary Play* for insights into how to manage the ecosystem recalibration that would begin upon enclosure. They anticipated massive extinctions, and ultimately endured significant hardships to prevent their own, in order to prevent a premature termination of their mission.

2.3. Performing the Invisible

The first experiment, Mission 1, began at 8:00 am on September 26, 1991. Eight people were sealed inside this 5.15 acre biotectural mega-structure, commencing the two year and twenty minute (Pointer 2009) ecological theater performance. Once inside, the Biospherians began to experience the ecological systems script, how it drove ecosystem service performance, and facilitated management decision making. It troubleshooted feedbacks, ensured redundancies, and facilitated trans-disciplinary communication. Most importantly, it checked and balanced energy-matter exchanges. The photosynthetic *biosphere* surface required significant energy inputs, unnecessary on earth-scale, to maintain functionality. Because the biomes were enclosed in glass, heat gain was a significant problem. Massive inputs of energy were required to cool the structure to prevent flora mortality and ensure photosynthesis functionality. Energy was also necessary to power basic building usage, environmental control systems (including rain and ocean wave-making), hybrid eco-technical systems that provisioned life-support services, and the *Nerve* communications system that monitored and facilitated the entire system. The systems diagram feedback loops kept the

Biospherians inside alive. Because of this, much time was spent within B2, and Mission Control, crunching numbers and balancing budgets.

Simultaneously, reports from inside B2 glorified the qualitative, haptic experience of the ecological systems diagram. Biospherian Jane Poynter described it as:

“... technically beautiful, with the mechanical and life systems working in concert to maintain a functioning biosphere...it seemed that technology and humans had found their rightful place, working hand in hand to maintain and enhance life...” (Pointer 2009, 139).

Indeed the idealized stable systems diagrams that facilitated the design, construction, and operation of B2 functioned, at times, as an overarching synergetic “...logic of Bios (bio-logic, biology)...uniting the organic and the mechanical” (Kelly 1994, 165), the quantitative and qualitative. Ultimately, this resulted in a Biospherian experience of embodied cognition of their *biosphere*, creating an operational consciousness of their “Molecule Economy” (Kelly 1994, 159) and actualizing a version of *Noösphere* in the process:

“... [We] reveled in the experience of being consciously a part of the day-to-day biospheric cycle. As [we] stood in the grass, [we] knew [we were] breathing the oxygen the plants produced and they were absorbing [our] carbon dioxide...Our relationship with the other living organisms in our Biosphere was equally symbiotic. While it seemed we held dominion over them by our ability to turn the rain on and off and rip out unwanted plants, our lives depended on them...We were in fact on equal footing...experience[ing]...a direct connection to [our] life support system...” (Pointer 2009, 291-2).

It was through this embodied experience that invisible earth systems processes became visible and tangible, and moments of *noösphere* were actualized. This message was regularly relayed through teleconference calls to school children, interactions with tourists, media relations, and scientific symposia during Mission 1.

3.0. BIOSPHERE 2 AS GLASS BOX THEATRE

B2 was essentially designed from the inside out. Much preliminary design work was focused on structuring the internal ecotechnical systems, and ensuring that there would be enough daylight penetration to support photosynthesis. The project architects, Phil Hawes and Margaret Augustine, looked to multiple global architectures to inform B2's form, but ultimately performance inside the envelope dictated the project's parameters. B2 quickly evolved into a spaceframe structure that could support the uninterrupted longspans and glass envelope necessary for the biota inside. Ultimately, the image of the form of the building itself evolved into not only a brand, and symbol for the operations within, but also a physical stage set for tourists to view the Biospherians inside. Because of its form, B2 operated as a glass house, the ultimate glass theater for the *Theater of All Possibilities*. Only the Human Habitat biome was clad in opaque material. Programmatic elements inside this *back-of-house* biome included a Magic/Wardrobe room stocked with fabric and sewing machines, an Art studio stocked with materials, and a Media suite, further reinforcing the projects theatrical undercurrents.

As the programmatic needs of the site developed, the design focus flipped to the spaces surrounding B2's envelope: accommodations for visiting scientists, educational facilities, and tourist attractions. Viewing platforms and pathways almost completely wrapped B2's transparent skin (Fig. 3), and visitor centers with outdoor amphitheater spaces were designed (Fig. 4). In 1990 the surrounding land was master planned to include an 18 hole golf course and convention resort, all of which were designed to educate and entertain.

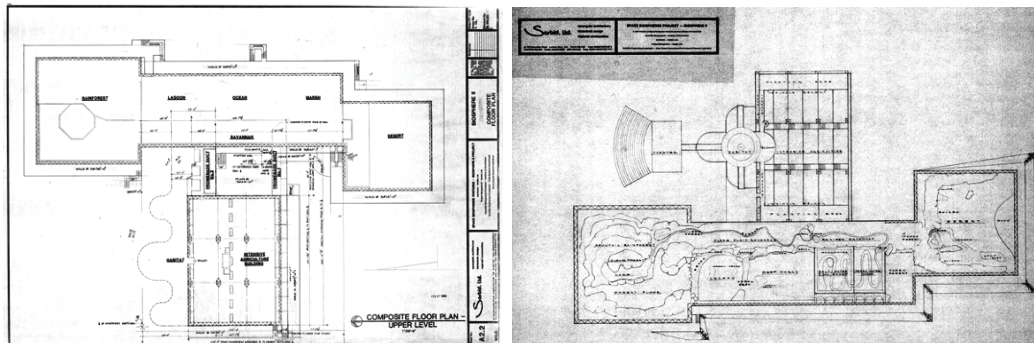


Figure 3: Plan of B2, see exterior viewing plinth/walkway surrounding much of the structure. Source: (U of A B2 Archives, 1990)

Figure 4: Schematic B2 plan, see outdoor amphitheatre on upper left, on axis and across from entrance/Human Habitat. Source: (U of A B2 Archives, 1988)

3.1. Locating Front and Back of House

The project designers had some awareness of the implications for the residents of the emerging glass house they were creating. In response, there were private zones designed into B2 wilderness biomes, such as the rainforest Cloud Mountain, which included a small waterfall and watering hole called Tiger Pond that was used extensively for skinny dipping. And as the rainforest and mangrove tree canopies matured, it became easier to *disappear* into the forest. But for a group of environmental managers who were accustomed to having free reign over large tracks of land, the surveillance through the glass, and the cameras and sensor systems inside, proved tiresome. Their duties did require spending significant amounts of time working in back of house spaces such as the basement *technosphere*, communication bridge, labs, and their living quarters. Nonetheless, they quickly found they were living their roles as Biospherians full time, and that these roles were becoming increasingly complex as the audiences grew more diverse and sophisticated.

3.2. Playing to Multiple Audiences Simultaneously

These audiences radiated out from the B2 building in concentric circles. The innermost was the eight Biopsherians playing to each other. They cooked for one another, played music together, created performance art, and celebrated birthdays and other events with elaborate themed costume feasts. Roy Walford and Lazer Thillo made documentary films, and Roy shot a performance art music video titled *Ecological Thing* (Walford and Rowland 2005).

They also played to the Biosphere itself and to Mission Control through the performance of scripted protocols, in order to keep B2 operating. Eventually, this scripting functionally reprogrammed the eight Biospherians of Mission 1 as "...spatially extended cyborg[s]" (Mitchell 2003, 39) which were seamlessly dissolved into the operational body of B2, despite their rebellious attempts to resist. Similar phenomenon have been observed on early space missions. Historian Walter McDougall described NASA's space age treatment of astronauts as an "individualism...subsumed into the rationality of systems" (McDougall 1997, 449). Astronauts' bodies, similar to those of the Biospherians, were eminently at risk, yet they surrendered much of their control, autonomy, and ultimately privacy to Mission Control, who was tasked with managing the system. In the case of B2, the Biospherians bodies were physically extended and simultaneously emotionally reduced to extensions of the *Nerve*.

Once sealed inside, the Biospherians gentle rebellion began: during their first non-regulation mission they dismantled several surveillance video cameras (Arrington 2011). Soon after, they agreed to take days of rest from response to relentless system alarms and mission control video-conferencing. They quickly realized, barring sudden major mechanical failure, the *biosphere* would survive without their management for 24 hours per week. Nonetheless, the Nerve Center was not only their savior and master, it was also increasingly becoming an appendage. They were physiologically merging with it as they were physically merging with the "natural" system of molecule exchange which fed them oxygen, calories and nutrients. Their bodies mirrored the sensors, transducers and actuators of their augmented reality, each picking up on the phenomena, and labor, the other wasn't designed for. They were literally becoming one with the *technosphere*, rendering themselves spatially dispersed cyborgs. B2 became

...not only the domain of [their] networked cognitive system, but also—and crucially—the spatial and material embodiment of that system (Mitchell 2003, 19)

rendering the less idyllic realities of life inside ecotopia visible.

Given their diminishing oxygen and food resources the Biospherians' physical bodies were taxed to the limit. Increasingly they needed rest and psychological recuperation time. As Mission Control increasingly assumed responsibility for function inside B2, the Biospherians perceived they were losing control of their life support system, as "the Mission Control support team perform[ed] maintenance and control[led] changes from outside Biosphere 2" (Allen and Nelson 1999, 24). One of the more dramatic examples was the removal of the analytical lab from the facility a little over a year after closure. Less visibly and more invasively, Mission Control monitored the Biospherians e-mail and tapped all phone lines inside B2 (Pointer 2009).

The next concentric ring of audience was comprised of visitors to the site. Scientists, tourists, and the media came to glimpse and interact with the Biopsherians through the architectural glass. One product of the reality of transparent enclosure was the Biospherian handshake, the lining-up of palms on either side of the glass pane (Fig. 5). Another was a growing confusion between the relationship of actor and audience. At times, the Biopsherians appeared more as a captive audience through the glass than as the actors they were trained as (Fig. 6). There were times when Mission Control brought performances to them, such as the first anniversary of enclosure when a country band serenaded them and there was a simultaneous cake cutting on both sides of the glass (Walford and Rowland 2005).



Figure 5: Biospherian Handshake: Mark Nelson, John Allen, Visitor. Source: (Life Under Glass, 1993)

Figure 6: Biospherians of Mission 1 looking through the viewing window at Closure. Source: (U of A B2 Archives, 1991)

Beyond that was the audience of the Space Biosphere Ventures (SBV) Scientific Advisory Committee (SAC). This audience was grappling with the scientific legitimacy of the B2 experiment; attempting to lend it credibility among the intellectual scientific community. The SAC was an interactive audience attempting to restructure experiments within B2 while simultaneously restructuring perception outside of B2 (Pointer 2009).

Next was the media, who initially responded overwhelmingly favorably to the Biospherians' project. But as word got out about their alternative society, and questions arose about the scientific validity of the project, the tables turned and the media utilized B2 as an almost endless source of dramatic entertainment. The more the Biospherians attempted to play to the media, seemingly the worse the situation became (Reider 2010). The final concentric ring of audience consisted of the general public who watched the project predominantly through the eyes of the media. The Biospherians ultimately were unsuccessful in maintaining control of the content of this performance.

3.3. Which Performance?

Because of the nested complexity of the performer/audience relationships that the Biospherians maintained, it proved difficult at times to keep the roles separate and hierarchized. Among these, the performance of work, particularly hard manual labor necessary for maintaining life support, was eminently present. Maintenance of the digital and mechanical components within B2 was endless at the points where its sensors caressed the *biosphere*. This work could only be accomplished from inside. It consumed approximately ten percent of the Biospherians time (Allen and Nelson 1999), time increasingly needed for agricultural production. The Biospherians were steadily being reduced to manual laborers in service of the *Nerve* and its shifting hierarchy of control. Even as the technology facilitated the shifting power dynamic, "nature" was challenging the technology, creating a positive feedback loop resulting in even more manual labor:

The sensors for temperature, humidity, light, energy, gas concentrations, water quality, and soil conditions were industrial grade. Although they were seal-tight terminal boxes and conduits covered with silicone, the most difficult problem was corrosion of electronic equipment because of humidity or the use of dissimilar metals. Most of the maintenance hours were spent on the data acquisition system, calibrating and replacing corroded sensors or terminals (Pointer 2009, 24-5).

As agents in the mechanical mastery of B2's Gaia body, and by implication their own bodies, the Biospherians obeyed orders from their *Nerve* like slaves: when carbon dioxide levels skyrocketed, they harvested biomass by hand, and dried it to halt decomposition (Pointer 2009). They played simultaneous conflicting roles in their experiment: ecologists, naturalists, gardeners, explorers, prisoners, guinea pigs, gods, laborers, survivors. They acted as gods when determining the change of seasons, and with the push of a *rain button* they accomplished their will (Pointer 2009). They were simultaneously objects and subjects of experimentation and study. As an embodied script within the systems diagram they became embodied systems of control: they *managed* the system that was managing them, playing to an audience that was playing right back at them through feedback loops.

3.4. Performing Survival as Cyborg

Because the ecologies were synthetic and immature, and their behavior triggers poorly understood, the overarching bio-logic feedbacks facilitated by the communication *Nerve*, and augmented by redundancy, were critical for life support within B2. As these synthetic ecologies were increasingly understood as experiments, not guarantees of life support,

"surrendering control became one of the 'Principles of Synthetic Ecology...We ha[d] to accept the fact that the amount of information contained in an ecosystem far exceeds the amount contained in our heads. We

...[would] fail if we only tr[ie]d things we [could] control and understand.' The exact details of an emerging Bio2 ecology...were beyond predicting" (Kelly 1994, 165)

Sniffer sensors detected patterns of molecule concentrations not apparent to human bodies, cameras detected movements, environmental control equipment reported its own usage, all of which were communicated as messages (Wiener 1956) to the Biospherians, and to Mission Control through *The Nerve*.

The Nerve facilitated ecological production under challenging conditions, but the technical and ecological systems proved mediocre partners without human mediation. Growing plants and salinity would regularly damage sensors (Alling and Nelson 1993), computer programs were too slow and didn't correspond to social rhythms or sick days. On average, Biospherians spent up to twenty-one percent of their time tending their technological control system, (performing sample and data collection, sensor repair/calibration, infrastructure maintenance, and technical tasks), in comparison to eleven percent on wilderness biome management (Allen and Nelson 1999).

Every valve, every pipe, and every motor of the infrastructure was simulated in a software network. Very little activity in the ark, either natural or man-made, happened without the distributed computer knowing about it. Bio2 responded as if it was one beast (Kelly 1994, 162).

One beast that carried within it the power to transform itself through surveillance feedback loops. *The Nerve*'s sensors, transducers, and actuators became real-time decision making devices as they managed the range of tolerances acceptable to human and biome environmental conditions. Because the Biospherians had been scripted into this set of protocols, their performances were predetermined, offering little room for creativity or inspiration, until the system threw them a curve ball, at which time they were forced into an emergency improvisational mode. This proved to generate a stressful version of *noösphere* for the Biospherians.

4.0. THE PERFORMANCE OF SUSTAINABILITY

4.1. Post-Normal Science at Play

Today's Sustainability Revolution, often defined by the 3E's (ecology, economy, equity) might be more productively redefined for designers as the performance between *biosphere*, *technosphere* and *noösphere*. Like the Biospherians, we currently struggle with the post-normal scientific conditions of elevated atmospheric carbon levels, increased toxicity, loss of biodiversity, and declining health of basic regulating and provisioning ecosystem services (MEA 2005). These require increasing deployment of complex management and adaptation strategies to maintain human homeostasis conditions globally, a task with which architecture is already deeply implicated. We are already seeing comprehensively service oriented and managed projects like Masdar City come online. Like B2, Masdar was designed from a series of systems diagrams, and forces its occupants to leave the outside world at the gates (read as *system boundary*) by leaving their normative consumptive behaviors, including their carbon spewing vehicles, parked outside. We are also keenly aware that curbing downstream energy consumption within buildings requires first and foremost, reductions in consumption patterns, only then followed by increases in the efficiency of equipment, and finally utilization of alternative energy sources (Addington 2007). Reduction in consumption is primarily reliant on *occupant/user performance*, not *technological performance*. The implications of B2's scripting of human performance, and the lessons learned from the Biospherians experience of object-subject control, are now becoming urgent.

Given this context, it is logical to assume that a performative ethic that encourages more consciously considered actions and deeper relationships between *biosphere*, *technosphere* and *noösphere* would prove beneficial. However, these relationships and actions must be carefully designed into the constructed environment in order to be effective. As we have seen in the case of Mission 1, despite this considered design, the unintended consequences of synthetic ecological architectural top-down systems of control can be devastating. B2 demonstrates how these unanticipated products of entwined relationships between atoms, bits and humans reveal contradictory dynamics of power and control, which have dramatic implications for people, and therefore, the future success of the complex integrated biotectural sustainable life support systems increasingly needed to mitigate and adapt to global climate change.

As architects it behooves us to take valuable lessons from B2: understandings of how to better address weak points of contact between seamless bio-technological infrastructures, methodologies of discerning the deployment of top-down (authoring) vs. bottom-up (adaptation) design approaches, and ways to link scales and durations (human brain-body to Gaia-body) within resilient architectures. Through an examination of the eco-architectural forms that embody these lessons, and their deployment within the B2-body, we extract critical lessons for the creation of future *noöspheres*, take them back to the drawing board, and iterate again. Today, we are increasingly tasked with the mission of creating eco-technical net-zero theatres within which we can all perform. Twenty years after the conclusion of Mission 1, it is imperative that our discipline recognize how essential it is to engage deep practices of research, exploratory design, and post-occupancy

analysis in order to mitigate the risk of perpetuating post-industrial paradigms to the point of collapse. A leap into the blurred quantitative/qualitative space of performance, where fictions, realities and dreams propel vision into actualization, may be just the space that facilitates the creation of future resilient and performative architectures of *global sustainable possibility*: ecotopic or distopic *noöspheres*.

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REFERENCES

- Michelle Addington. 2007. "No Building is an Island: A Look at the Different Scales of Energy." *Harvard Design Magazine*, 26: 38-45.
- John Allen. 1990. "Historical Overview of the Biosphere 2 Project." Paper presented at the NASA Conference: Biological Life Support Systems: Commercial Opportunities, NASA Conference Publication #3094. accessed September 5, 2012. <http://www.biospherics.org/pubhistoricaloverview.html>.
- John Allen. 2003. "Ethnospherics: Origins of Human Cultures, Their Subjugation by the Technosphere, The Beginning of an Ethnosphere, and Steps Needed to Complete the Ethnosphere," *Ethics in Science and Environmental Politics*, 7-24: 7-24.
- John Allen. 2009. *Me and the Biospheres: A Memoir by the Inventor of Biosphere 2*. Santa Fe: Synergetic Press.
- John Allen and Mark Nelson. 1999. "Biospherics and Biosphere 2, Mission One (1991-1993)." *Ecological Engineering* 13 (1999): 15-29.
- John Allen and Mark Nelson. 1989. *Space Biospheres*. Santa Fe: Synergetic Press.
- Abigail Alling and Mark Nelson. 1993. *Life Under Glass: The Inside Story of Biosphere 2*. Oracle: The Biosphere Press.
- Peder Anker. 2010. *From Bauhaus to Ecohouse: A History of Ecological Design*. Baton Rouge: Louisiana State University Press.
- Robert Arrington, interview at U of A Biosphere 2 Facility, July 18, 2011.
- Raymond J. Cronise, David A. Noever, and Andrew Brittain. 1996. "Self-Organized Criticality In Closed Ecosystems: Carbon Dioxide Fluctuations In Biosphere 2," *International Journal Of Climatology*, 16: 597-602.
- William F. Dempster. 1999. "Biosphere 2 Engineering Design," *Ecological Engineering*, 13: 31-42.
- Jacques Grinevald. 1998. "Introduction: The Invisibility of the Vernadskian Revolution." In *The Biosphere: Complete Annotated Edition*, by Vladimir I. Vernadsky, trans. David B. Langmuir. New York: Copernicus.
- G. E. Hutchinson. 1965. *The Ecological Theater and the Evolutionary Play*. New Haven: Yale University Press.
- Kevin Kelly. 1994. *Out of Control: The New Biology of Machines, Social Systems, and the Economic World*. Reading: Addison-Wesley Publishing Company.
- Timothy W. Luke. 1997. *Ecocritique: Contesting the Politics of Nature, Economy, and Culture*. Minneapolis: University of Minnesota Press.
- William Mitchell. 2003. *Me++: The Cyborg Self and the Networked City*. Cambridge: MIT Press.
- Jane Pointer. 2009. *The Human Experiment: Two Years and Twenty Minutes Inside Biosphere 2*. New York: Basic Books.
- Rebecca Reider. 2009. *Dreaming the Biosphere: The Theater of All Possibilities*. Albuquerque: University of New Mexico Press.
- Vladimir I. Vernadsky, trans. Olga Barash. 2007. "A Few Words About the Noösphere." From *Geochemistry and the Biosphere: Essays by Vladimir I. Vernadsky*. Santa Fe: Synergetic Press, 2007.
- Roy L. Walford and Chris Rowland. 2005. *The Voyage of Biosphere 2*. DVD. Venice, CA: Emergent Properties.
- David Waltner-Toews, James J. Kay and Nina-Marie Lister, editors. 2008. *The Ecosystems Approach: Complexity, Uncertainty, and Managing for Sustainability* (New York: Columbia University Press)
- Jan Zalaziewicz, et. al. 2009. "Are We Now Living in the Anthropocene?," *GSA Today* v. 18, no. 2, accessed August 30, 2012, doi: 10.1130/GSAT01802A.1