Less Is More Intense

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All serious art, music, literature is a critical act. It is so, firstly, in the sense of Matthew Arnold's phrase: "a criticism of life." Be it realistic, fantastic, Utopian or satiric, the construct of the artist is a counter-statement to the world.[1]

A few months ago, I stood in front of one of the world's most augmented buildings, or, at least, one of the buildings that has housed the most augmentation throughout its life. The Vehicle Assembly Building (VAB) at the John F. Kennedy Space Center on Merritt Island, Florida, is a hobbyist's back-garden shed transposed to the science fiction-tinged, hyper-professional mega-scale at which NASA operates. It is, in fact, the fourth largest building by volume in the world, superseded only by the Boeing Plant in Everett, Washington, the Jean-Luc Lagardère Plant in Toulouse-Blagnac (where the new Airbus A380 airliners are put together), and the Aerium in Halbe, Brandenburg, which used to be a hangar housing the construction of giant airships, but has now been turned into an indoor, artificial tropical resort.

The VAB is a big building for people with big ideas.

With a footprint of 218.2 x 157.9 meters, and a height of 160.3 meters, it encloses some 3,665,000 cubic meters of space. That's enough to hide the Great Pyramid of Cheops, in Egypt, or to tuck away nearly four Empire State Buildings. To describe it as massive is a bit like saying Arnold Schwarzenegger has decently-sized biceps; the doors alone are 40 stories tall. Made from 89,421 tons of steel, 49,696 cubic meters of concrete, and 100,800 square meters of insulated aluminium panel, the interior of the 52-story building is so vast, it creates its own weather, and needs a moisture reduction system to minimise the impact of interior rain clouds forming below the ceiling on warm days.

The late, prolific architect of US government buildings Max Urbahn, who headed the team of architects and engineers that designed the VAB in the early sixties (construction work began in January 1963 and was completed in late 1965), had no illusions that the building would be remembered for anything but its size. Interviewed by the New York Times during construction, he called it "little more than a slick, polished box." To the Saturday Evening Post he admitted that it was the most frustrating building he had ever designed, while he told Astrobiology Magazine that the VAB "is not so much a building to house a moon vehicle as a machine to build a moon craft. The Launch Control Center that monitors and tests every component that goes into an Apollo vehicle is not so much a building as an almost-living brain."

Originally constructed for the assembly of Apollo spacecraft and Saturn launch vehicles (operating roughly between 1961 and 1975), NASA's Vehicle Assembly Building was later modified to support Space Shuttle operations (from around 1969 until 2010). Though the exterior has largely stayed the same for almost half a century (the 64 x 33.5-meter-large flag with accompanying bicentennial emblem was added in 1976, adorning the façade with almost 30,000 litres of paint; the north entrance was widened by 12.2 meters and slotted at the centre to allow entry of the towed orbiter; about 820 panels were torn off the VAB and had to be replaced in the aftermath of Hurricane Frances in 2004), it is the building's interior that has been evolved, extended, expanded—and thereby augmented—the most.[2]

There is a—probably apocryphal—story about John F Kennedy touring Cape Canaveral in the early—1960s, right around the time the VAB was being built, and asking one of the janitors scrubbing the floor what he was doing. The janitor turned to Kennedy and replied proudly "Mr. President, I'm helping to put a man on the Moon."

The VAB is a building that helped put several men on the Moon.

The "machine to build a moon craft" can be defined according to its spatial characteristics: a simple shell to house the most advanced, evolving technologies of man, a rectilinear mass devoid of any features to indicate human scale, or an exaggerated volume celebrating hubris on a planetary level. Or it can be perceived in program: the terrestrial component of our space exploration as a spaceship built on top of Spaceship Earth launching other, smaller spacecraft into orbit. The VAB is an ever-changing building that has been constantly refurbished to adapt to new technological challenges, its 141 cranes endlessly hoisting scaffolding up and down around its innards, rebuilding, restructuring, recombining, remodelling and reinventing its architecture.

Augmenting it.

Augmentation is an interesting concept in architecture. In its simplest sense, the word means to enlarge, increase, or make bigger, the way that the VAB has been made bigger in order to house ever-larger rocket ships. To augment can also mean that something grows or intensifies, or that something (such as the tempo of a musical piece) slows down for dramatic effect. In architecture, however, augmentation can also be a viewed in more abstract terms as the action of adding something to increase a structure's volume or subtracting something to—perhaps paradoxically—increase its intensity.

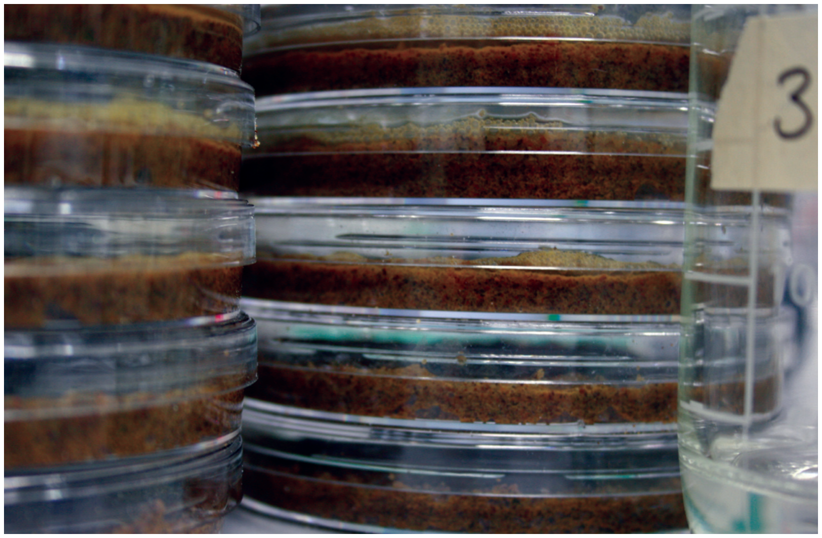
Less is more intense.

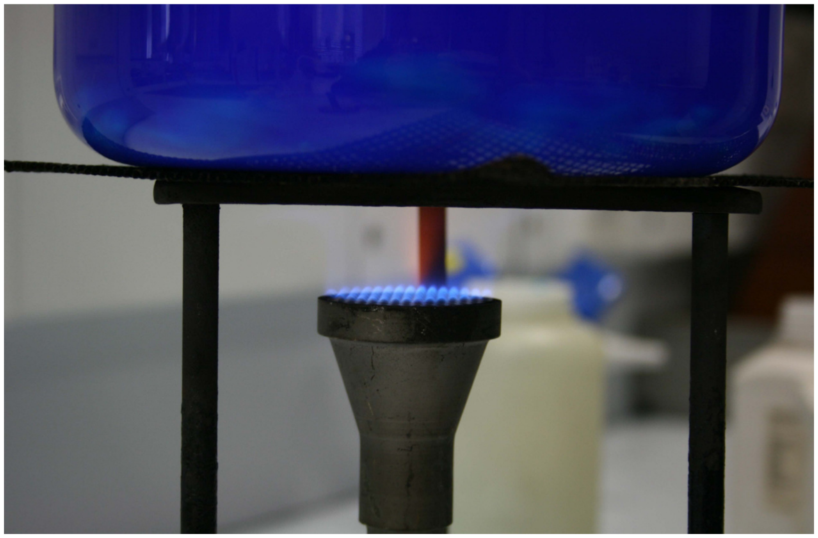
This view of architecture, as the augmenting power that addeth and taketh away, as controlled aggregation and erosion, the increasing/intensifying augmentation of densifications of matter, lies at the heart of one of my studio's areas of interest. We tend to call this research, informally, the Beyond Biomimicry part of our output. The idea being that we can augment biomimicry-inspired architecture to arrive at processes that not only passively imitate but actively har-

ness nature's own *modus operandi* in order to arrive at new materials, forms, construction methods, and phenomenological/architectural experiences.

Recent developments in consumer technology have seen a rise of the idea that we can use digital displays in the analogue world to provide real-time guidance and explanations to the surrounding physical environment. But in an architectural sense, "augmented reality" suggests actually using data to change the physical makeup of the world around us, not just overlaying it with information. If we view the design of our built environment as an accretive process extending across different scales—cellular accumulations becoming material articulations, that become constructed artifacts, that become spatial enclosures, that become manipulated landscapes that become urban fabrics—the parameters (whether a volume is solid or void, for instance) cease to be mere projections and instead become an indispensible set of instructions controlling the resulting structure itself. Information goes from being an overlaid projection to being an underlying assumption, just as the presence of geometry is assumed in architecture, the presence of mathematics in physics, the presence of letters in words.[3]

The most exciting topic in architecture today is biology. This shouldn't surprise us too much. Arguably, the most interesting evolution of society today is happening in biology and in particular, within the emergent field of synthetic biology. Architecture takes its cues from prevailing scientific and cultural movements, and at the moment we're working within a veritable explosion of new biology. This naturally shapes today's (or at least tomorrow's) architecture, much as the explosion of data and comput-





ers shaped architecture throughout the latter half of the twentieth century.

Architecture is changing, and change itself is changing. We have known this at least since 1938, when Buckminster Fuller started to talk about ephemeralization—the trend of "doing more with less" in different fields such as chemistry and industry—an idea that was later, perhaps in an unrelated way, extrapolated by renowned Polish mathematician Stanisław Ulam, who, in 1958, became the first to apply the mathematical term singularity to the notion of an accelerating societal change. Social theorists such as Gerald S. Hawkins, Lewis H. Morgan, Leslie White, and Gerhard Lenski have all declared technological progress to be driving the evolution and development of the human race. In his 2001 essay "The Law of Accelerating Returns," American inventor, entrepreneur, and author Ray Kurzweil controversially extended Moore's law (a description of an exponential growth pattern in the complexity of integrated semiconductor circuits) to describe such a Malthusian growth model for technological progress.[4] Together with mathematician, computer scientist, and science fiction author Vernor Vinge, Kurzweil is the main proponent of the technological singularity, the hypothetical point of no return when technological progress becomes so rapid and the growth of artificial intelligence so great that our post-singularity future becomes qualitatively different and harder to predict.[5]

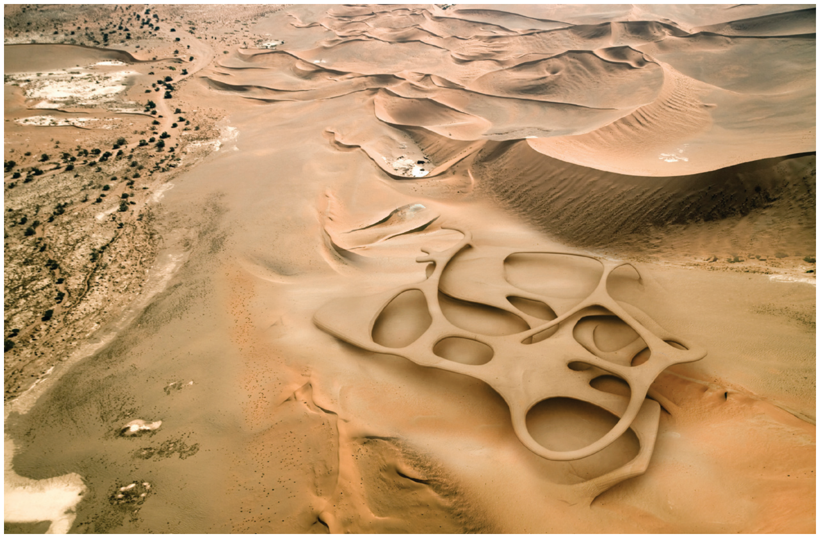
Whether this critical moment will arrive within the foreseeable future is beyond the scope of the present article, but the result of the acceleration (exponential or not) of technology and many associated scientific fields is already augmenting architecture as an academic and practical field, in ways that will probably only become clear to us several years or even decades from now. Part of this acceleration, itself, is becoming our tool for augmenting the discipline, which in turn becomes a starting point for the investigation of new materials, novel haptic experiences, and original formal studies.

Let us return for a moment to Max Urbahn's view of the VAB being, "not so much a building...as a machine...an almost-living brain," and see how this biological-machine metaphor leads to new attitudes, new concepts, about what architecture is and what the role of the architect should be, as considered by and reflected through my practice. Le Corbusier talked about the house as a machine for living in.[6] Ray Kurzweil named one of his books *The Age of Intelligent Machines*,[7] while leading theorist, author, and founding editor of *Wired Magazine*, Kevin Kelly, pronounced the future of machines to be biology.[8] Just a few months ago, on 13 January this year, *Nature* magazine published a paper by professor Christopher Voigt and colleagues in which they explained how recent advances in multicellular computing make it possible to write software that controls the creation of genetic circuits in microbes – essentially giving bacteria senses (touch, sight, smell) and then programming them to perform complex, coordinated tasks based on their newly-gained understanding of the world around them—programmable biological intelligence, microbes as memory devices, biological computers. What is this if not a vision of an almost-living brain like the one Urbahn mentions?

Since bacteria can also be used to create building materials (we'll continue this discussion in a moment), it seems inevitable to me that there will come a time in the near future when the two worlds collide. It will become possible to add new parts to our environment using abstractly-programmable, biological building blocks that can process information and change their properties accordingly. If architecture will soon be about designing intelligent biological machines for living in, then what does that make the architect: a combined designer-bioengineer-material scientist? Or simply a more consilient architect, capable of directing people from disciplines that have traditionally not been associated with architecture (or which didn't even exist before)?

Whatever it is we're becoming, we're adding to, or augmenting, the discipline through our experimenting with different material manipulations that lead to structurally, formally and hopefully even phenomenologically logical buildings and landscapes. We're intensifying, or augmenting, the resulting materialities and turning them into structures through different formal strategies (ranging from recursion via different kinds of branching to growth along trajectories based on crystal geometry). This is our "criticism of life," our "counter-statement to the world," the outcome of which, to speak with famed literary critic George Steiner, I would argue is realistic, fantastic, Útopian, and possibly even satiric, all at the same time.

Yet another way in which we're augmenting architecture is through the strategic shift of scales, from the inner-body, medical nano scale to the astronomical scale of future space



architecture—another result of our age of rapid technological advancement. At least since Larry L. Hench's groundbreaking work in the late sixties, which led to the invention of bioglass, the medical profession has been able to design for, and implement, structures within the human body. Setting out from the VAB, humankind has ventured to the Moon and is preparing to go even further into space. Architecture is what keeps those astronauts alive and functioning. No landscape or site could be more interesting, no architecture more mission critical than that which exists in outer space.

Three landscape projects currently in progress can serve to illustrate our attitude towards this evolution and some of these scales. The hitherto most widely published of these is the Dune—Arenaceous Anti-Desertification Architecture proposal, based on the novel process of engineered architectural lithification.

Dune

Without sand there would be no brick, no concrete, no glass. Even wooden structures are sanded down to smoothen their edges. Sand is an incredibly renewable material: one billion grains of sand come into existence around the world every second through a cyclic process that sees entire mountain ranges weather and release miniscule splinters. Some of those fragments lithify (from lithos, Greek for "stone" or "rock"), into a clastic sedimentary rock, a sandstone. As that sandstone weathers, new grains break free. A typical mountain will be lowered by a few millimetres every year.

That amounts to a lot of sand. Dry areas cover more than one-third of the earth's land surface, and desertification—"the diminution or destruction of the biological potential of the land"—is a major threat on all continents, affecting more than 100 countries in the world. Spread out across 35 percent of the Earth's land surface, some estimates suggest that the livelihoods of 850 million people are at risk.

The idea of introducing a barrier of greenery in order to halt the shifting sands, building a "Green Wall for the Sahara," was first proposed by former Nigerian president Olusegun Obasanjo in 2005. The initiative originally called for 23 African countries to come together in order to plant trees across a 15-kilometre-wide stretch south of the Sahara in order to stop the dunes from migrating.

The Dune project would turn 6,000 kilometres of sand into a pan-African sandstone city that supports this Great Green Wall through a localised cementation of desert sand via microbially induced carbonate precipitation (MICP) using the bacterium *Bacillus pasteurii*, which is capable of producing enough calcite to technically turn sand into sandstone in a very short space of time. The spatial pockets created within the resulting solid rock structure would help retain scarce water and mineral resources, while also serving as programmable spaces—a habitable wall straddling an entire continent, binding villages, people, and countries together.[9]

While we have yet to explore this potential, future programming of the bacteria using methods similar to those of professor Voigt could potentially add another dimension to the strategy of using the existing sand dunes as granular ready-made structures, working within the material volume itself, controlling the bacteria to augment the loose sand into solid structures.[10] This strategy has been imaginatively compared to "a kind of infection of the earth... a vast 3D printer made of bacteria (that) crawls undetectably through the deserts of the world, printing new landscapes into existence over the course of 10,000 years."[11]

Moon Dune

The Moon Dune project translates the Dune project into a space architecture context, constructing a lunar cratertecture out of a new (thus far theoretical) material, made from bacteria and regolith, which we call bacillith. An alternative to existing proposals for in-situ resource utilisation (ISRU) is a proposal based on the growing and farming of building materials in outer space—a radical departure from sintering or bulk-regolith applications from the past.[12]

Getting building materials and elements into space is an expensive and cumbersome affair. A bacillith-based strategy could keep the distribution costs down, as sending vials of propagative microbes to the Moon is arguably a less burdensome method than moving larger volumes of building materials or elements. The initial strains could be made to reproduce when they arrive at their final destination. As synthetic biologists become even better at programming bacteria, the microorganisms can be much more precisely deployed, perhaps even robotically controlled from Earth. Entire structures could be created inside of the existing lunar craters in a similar way to the sand dunes on this planet.

Crystal Lines

Crystal Lines explores a different neighbouring field, venturing into inorganic chemistry and investigating the concept of growing both material and binding agent at the same time—taking us one step further towards a truly programmable, extreme minimalist architecture, in which less is truly more intense. In our crystal structures, different densities and molecular or cellular arrangements within the same material mass differentiate wall from aperture, membrane from surface, and so on. Substrate structures are seeded with crystals and grown within liquid baths. Over and above the shape of the substrate, three control factors influence the form of the resulting structure: the chemistry of the fluid, the conditions under which it is being solidified, and the ambient pressure it is under. As in musical augmentation, time becomes a critical design factor.

While still a work in progress, this scheme is the latest of our excursions into the largely unchartered territory that lies at the intersection of architecture and contemporary science. This might be the first design experiment that has been aimed at growing actual crystals into architecture (Roger Hiorn's prize-winning 2008 art installation Seizure was an interior; Tokujin Yoshioka's Venus chair from the same year was a piece of furniture). If the Dune project is an experiment in biological landscape architecture on the continental scale and Moon Dune a scheme that stretches across the heavens towards an astronomical scale, then Crystal Lines is a return to the human scale, with some designs conceived as individual buildings. Although, we are also investigating concepts based on the seeding of entire Endorheic drainage basins with crystalline structures that could slowly emerge as water is channelled away from the basin walls. Theoretically, such an engineered landscape could be endlessly augmented as the basin is drained and filled anew, with new substrate structures and crystal seeds being added with each water cycle, turning the organic tectonic patterns of the surrounding mountains into vertical foundations for semi-controlled outgrowths of atoms, molecules, and ions arranged in the orderly repeating patterns of crystal geometries, nature giving birth to culture, expanded and intensified through the creative process of augmentation.

Architecture uses two simple augmentation mechanisms to create different spaces: addition (an increase in volume or size) and subtraction (an experiential intensification brought on by the removal of matter). The new marriages between disciplines, and—as in the case with architecture and synthetic biology—the new marriages between older and exceptionally young disciplines, open up never-before-seen possibilities for designers to experiment with processes that go beyond the mimicry of biomimicry, toward the kind of biological machines for living in discussed above. To speak with George Steiner, we are right now given new means with which to criticise life. We invent new ways of constructing counter-statements to the world. Working within this context of novel architectural augmentation can be frustrating. We're designing not only a building and usually a new construction method with entirely new materials, but also the arguments needed to convince the world that our explorations are valid. It's hard work. At times, we feel like the janitor at Cape Canaveral: scrubbing the floor, but perhaps, just maybe, also helping to put a man on the Moon in the process.

Notes

1. George Steiner, Real Presences (Chicago: The University of Chicago Press, 1989)
2. Patricia Slovinac, Historic American Engineering Record: Cape Canaveral Air Force Station, Launch Complex 39, Vehicle Assembly Building (John F. Kennedy Space Center) HAER No. FL-8-11-B (July 2009)
3. Cf. Robin Evans, The Projective Cast (Cambridge, MA: The MIT Press, 1995), p. xxvi
4. Cf. R. Buckminster Fuller, Nine Chains to the Moon (Southern Illinois University Press [1938]1963), pp. 276–79, and Gerald S Hawkins, Mindsteps to the Cosmos (HarperCollins, August 1983)
5. Ray Kurzweil, The Law of Accelerating Returns (published on Edge.org and KurzweilAI.net on12 January, 2004)
6. Cf. Vernor Vinge, The Coming Technological Singularity: How To Survive in the Post-Human Era (1993) http://www-rohan.sdsu.edu/faculty/vinge/misc/singularity.html, and Ray Kurzweil, The Singularity Is Near: When Humans Transcend Biology (New York: Viking Press, 2005)
7. Le Corbusier, Towards a New Architecture (translated by John Goodman, Los Angeles: Getty Research Institute, 2007; Vers Une Architecture (1923), first English translation (Towards a New Architecture) 1927)
8. Ray Kurzweil, The Age of Intelligent Machines (Cambridge, MA: The MIT Press, 1990)
9. Kevin Kelly, Out of Control: The New Biology of Machines, Social Systems and the Economic World (Reading, Massachusetts: Addison Wesley, 1994, New York: Perseus Books, 1995)
10. Magnus Larsson, Dune – Arenaceous Anti-Desertification Architecture in V. Badescu and R. B. Cathcart (eds.), Macro-engineering Seawater in Unique Environments, Environmental Science and Engineering, DOI: 10.1007/978-3-642-14779-1_20 (Berlin Heidelberg: Springer-Verlag, 2011)
11. Geoff Manaugh, Sand/Stone (BLDGBLOG, 19 April 2009)http://bldgblog.blogspot.com/2009/04/sandstone.html
12. Marc M. Cohen/Haym Benaroya, Lunarbase Structures in A. Scott Home/Brent Sherwood (eds.) Out of This World: The New Field of Space Architecture (Reston, Virginia: American Institute of Aeronautics and Astronautics, Inc., 2009)