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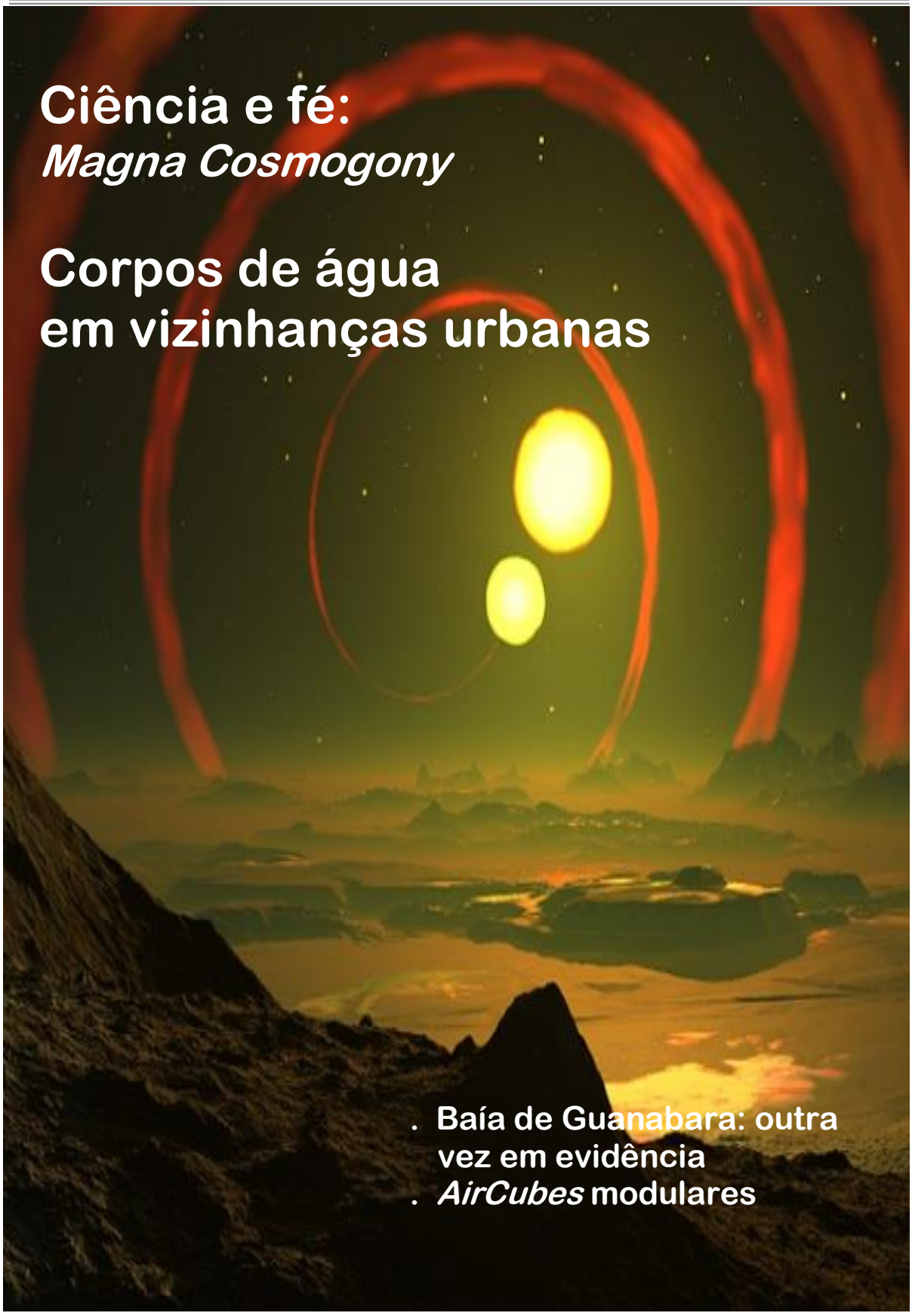

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ARTIGOS ORIGINAIS

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TECHNICAL REPORT

Magna Cosmogony

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To Saraswathi Natarajan Balasubrahmanyam*, in memoriam*…

Abstract: This article aims to show that science and faith have always walked closer than is usually thought, and that they can even coexist harmoniously in the same individual. It also seeks to show the sterility of the debate that puts both in direct confrontation, evidencing the often prejudiced and disdainful position of current science towards faith as a characteristic of the human condition, whether or not it is associated with a religion. In a broader approach, it discusses currently existing beliefs about the existence of intelligent life outside the Earth in contrast to the possibilities that science offers in our actual state of technological development. In addition, the work intends to convey the perception that it would be much more constructive to accept faith as a natural manifestation of consciousness that recognizes the limits of knowledge, rather than rejecting it through scientific arguments that, being faith, is manifestly inapplicable.

Key-words: science, faith, cosmogony, cosmology.

Resumo: Este artigo tem como objetivo mostrar que ciência e fé sempre estiveram mais próximas do que normalmente se pensa, e que podem até coexistir harmoniosamente no mesmo indivíduo. Também busca mostrar a esterilidade do debate que as coloca em confronto direto, evidenciando a posição muitas vezes preconceituosa e desdenhosa da ciência atual em relação à fé como característica da condição humana, associada ou não a uma religião. Em uma abordagem mais ampla, discute-se as crenças atualmente existentes sobre a existência de vida inteligente fora da Terra em contraste com as possibilidades que a ciência oferece em nosso atual estado de desenvolvimento tecnológico. Além disso, o trabalho pretende transmitir a percepção de que seria muito mais construtivo aceitar a fé como manifestação natural da consciência que reconhece os limites do conhecimento, do que rejeitá-la por meio de argumentos científicos que, para ela, sendo fé, não se aplicam.

Palavras-chave: ciência, fé, cosmogonia, cosmologia.

From Left to Right: R.B. Cathcart, N. Serpa and S.N. Balasubrahmanyam, 2021.

Prolog

A few months ago, I received the sad news of the passing of my dear colleague, Professor Saraswathi Natarajan Balasubrahmanyam (1932–2021), an eminent physical organic chemist. His kind and generous style, together with the quality of his scientific production, made him the model of the true man of science. It took me some time to think about how to honor him within the modest limits of my role as a theoretical physicist and cosmologist. Finally, bearing in mind that organic chemistry is a fundamental discipline for its implications on exobiology, and the fact that his also late wife, Chanchal Uberoi, was a distinguished mathematician and astrophysicist, I decided to write this brief cosmogony, inviting my dear friend Richard Cathcart to participate.

As we know, apart from the mythical sense and by adopting an erudite view, cosmogony is a literary genre that reigns between belief and science. Indeed, not so long ago, cosmology was closer to belief than to science[1]. It was the dizzying advance of observational technology that definitely elevated it to the status of a discipline of falsifiable propositional content. However, when cosmology touches on the study of life as a phenomenon conditioned to universal constraints of physical nature, we return to the sphere of speculation and to the region of beliefs. Again, it is hoped that at least some of these beliefs can be tested in the future as long as we have enough technology to do so. However, we have no way of knowing how far our technology shall go, nor how to foresee all the limitations imposed by nature itself.

Discussing some thoughts on science and faith, the final purpose of this article is to moot ideas regarding our current beliefs on the subject of intelligent life outside Earth (if we really have cosmically wise intelligent life here!), as this theme has gained renewed attention with the discovery of numerous planets outside our solar system. I hope this work lives up to the legacy of that man, affectionately called "Bala", whose intellectual gap left shall be difficult to fill.

Anyone who honestly devotes himself
to the study of cosmology never
abandons the daily exercise of
contemplating existence.

Nilo Serpa

Scientific Editor

[1] In the award-winning movie *A Theory of Everything,* the young genius Hawking introduces himself to his wife-to-be Jane as a cosmologist, explaining to her, by a quip, that cosmology "is a kind of religion for intelligent atheists". In fact, that statement cleverly summed up sarcasm and reality, for in the 1960s, it has to be admitted, cosmology came much closer to faith than science.

1 Introduction

> "The problem of the totality of things and that of the provenance of this whole arise from the most naive intention: to see what would have preceded the light." (Valéry, 1945).

Looking back at the so-called "new physics" in its evolution since the beginning of the 20th century, we see that astronomy — and cosmology, in particular — was the last sub-area to develop significantly among the most important specializations of natural philosophy. The construction of orbital telescopes and the sending of probes to the most distant regions of the solar system reaffirmed indisputably what Nigel Hembest and Michael Marten had early called "The New Astronomy" in 1983, long before the advent of Hubble. This new astronomy has advanced a lot and consecrated Peter van de Kamp's legacy with the discovery of so many extrasolar planets. Cosmology has also achieved a high level of precision and power of elucidation with detailed studies on galaxy clusters, type I-A supernovae and gravitational lenses. In addition, the interstellar space proved to be much more active and "alive" than was imagined until recently, full of clouds of gases — that "sing" through magnetohydrodynamic waves —, hyper-fast stars and wandering binary worlds.

From the first years of the 21st century, the discovery of exoplanets has become commonplace, bringing new challenges for astronomy, such as the identification of extravagantly and oddly configured solar systems and exotic worlds. Our instruments are very precise and keep advancing is precision, so that the list of planets, already in thousands, tends to grow even more. The study of the composition of these planets is at the top of the list of commitments in space science, since, from such a study, we shall be able to estimate the possibilities for the existence of life outside Earth, a crucial question for humanity, as yet unanswered. More than that, other correlated studies will show us the prospects of finding complex life in our mysterious galaxy enveloped by an incalculable cosmos poorly defined by anyone, composed of epic dimensions and energies.

Even so, despite all this newness brought into public exhibition over the last few years, particularly since the inauguration of humankind's self-dubbed Space Age, little has changed in our expectations about intelligent extraterrestrial life. Aside from some eccentric speculations, based on questionable arguments, and the rumored ET-military co-op reverse-engineering fanciful programs, no concrete evidence was presented to us amidst the spurious ufological-conspiracyist content that today has social networks always at disposal with fake news (they cause more harm-than-good and probably explain why so many people believe in the presence of aliens among us; fiddle-faddle!). On the contrary, the scenario that is becoming more and more clearly outlined is that we are most likely alone as sentient beings, at least up to the current limits of our technological capacity for observation. So, discovering intelligent life off Earth at a relatively close distance, say within a radius of ~250 light years at most,

would be a surprising and disturbing fact, as nothing registered so far suggests that this is possible. As painful as it may be, there seems to be nothing but cold spatial emptiness, hot objects and gases as well as a disappointing silence or, at least, so far undetectable emissions that is not classed as noise, blips or "WOW' readouts.

Of course, it is possible that we are looking for signs of alien intelligent life by overly restrictive means based on the logic of human communication. On the other hand, it is very difficult to admit that an advanced civilization, or even at the level of ours, would despise such an obvious and simple form of communication as the emission of coded signals by means of radio waves. As much as we wish to find sentient beings similar to ourselves in intellectual capacities, this seems impossible in our galaxy. It may well be that, by some cosmic evolutionary mechanism of constraint, only one civilization can flourish in a galaxy, so that there would be no possibility of inter-species warfare or undesirable contacts that could cause biological risk to the species; the survival of the species would depend on itself, since the distance between galaxies is, to say the least, "unimaginable". In particular, with regard to survival, it is interesting to take into account the discussion made by Serpa (2019) about the so-called "Restraint Orders", and the work of Ćirković (2018).

In fact, this uniqueness proposition lies right halfway between belief and science, since very high-precision deep space scans are feasible and could bring us closer to an answer in the relatively near future. However, an alternative to the conjecture of a one-to-one relationship between civilization and galaxy could be that almost no civilization would live long enough to evolve to the point of acting in deep space in a meaningful and detectable way. So it's possible that we'll never be sure if we're really unique[2]. It shall be more or less a matter of personal

[2] There is an even more cosmogenic alternative. An ongoing study carried out by Serpa proposes that the emergence of complex life is only viable at a very narrow range of rates of space-time expansion. The fundamental thought is that, if the expansion rate is out of this narrow range, the primordial building blocks of life — namely the long-chain molecules required for the chemistry of life — may not have been formed, resulting in sterile galaxies. This idea stems from the fact that everything is made up of expanding space-time, including biological beings (it would be very superficial a model that ignores the role of something so intrinsic to the structure of the universe as the space-time expansion!). Rates beyond a certain threshold would not allow higher levels of matter organization, just as rates below this threshold. Assuming that the expansion rate is not isotropic, as suggested in recent works (MIGKAS et al, 2020; MIGKAS et al, 2021), and that, furthermore, they must change over time (whilst after long periods of stability), intelligent life would indeed be a rarity. To avoid controversies about imprecise expressions such as "complex life", "simple life", "intelligent life" and others, in present context a being endowed with complex life can be succinctly defined as a thermodynamically open system capable to 1) self-regulate internal electrochemical energy levels; 2) physically reacting to the environment; 3) process and interpret information through a neurocognitive kernel; 4) reproduce by dissemination of encoded biological material and evolve in the elementary Darwinian sense. To reach the subsequent stage in the evolution of complex life, *viz* "intelligent life", the being must be able to 5) evolve through adaptive artifacts (culture).

Serpa's conjecture derives from his own theory on the structure of the space-time, with the premise of an inhomogeneous universe, now reinforced by the apparent anisotropic expansion rate pointed out by Migkas and colleagues (2020-2021). Migkas and his team were very meticulous. They were exhaustive concerning all possible biases involved. Combining data from the galaxy cluster surveys available, they mapped the expansion rate, indicating it in terms of the Hubble constant, as shown in Figure 1 bellow (purple hues denoting slower rate; orange/yellow hues denoting faster rate). Although they have tested a large number of potential X-ray and cluster-related reasons and

preference to believe in either alternative. In any case, perhaps the concept of intelligence based on what we know about humanity needs to be carefully revised.

The evolution towards complex life is a theme closely linked to the necessary distinction between "origin of the universe" and "beginning of the universe", two expressions that address different issues. This is a very broad discussion, so that we have no intention of exhausting it in our approach. The implicit purpose of the present cosmogony is to expose the fragility of the human intellective condition when placed in check in face of crucial issues such as the origin of the universe and our apparent loneliness as sentient beings, and to discuss how faith, born from a tenacious philosophical introspection about existence from the cosmological point of view, can converge with the objectives of science, even becoming present in some of its choices.

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systematics that might cause the observed anisotropies, they emphasized that more studies are needed to definitively rule out the possibility of an overestimation of the anisotropies due to the combination of systematics.

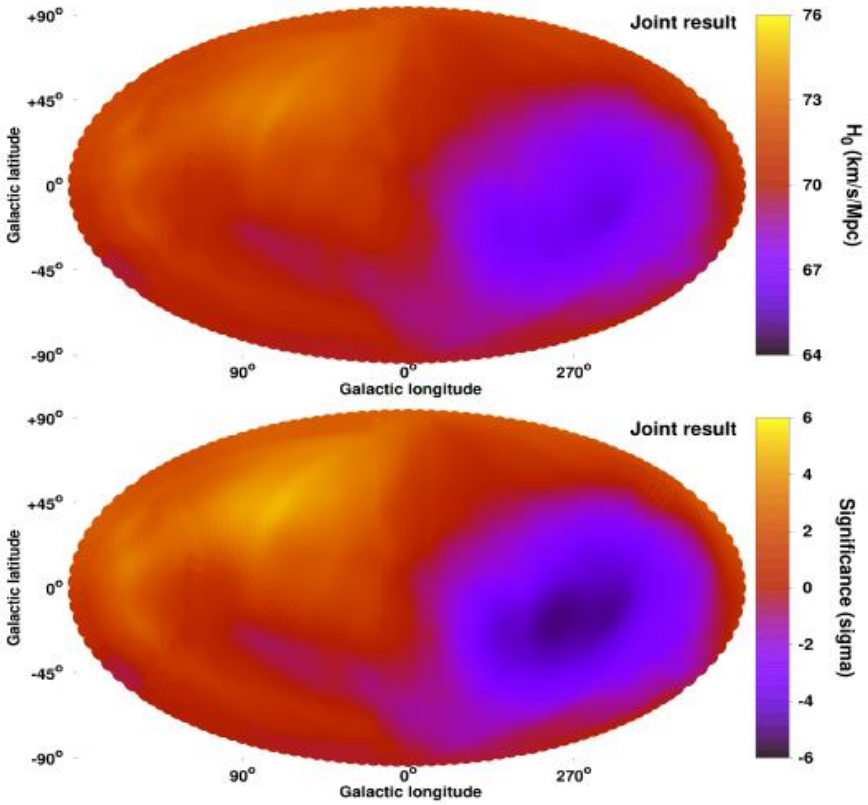

Fig. 1 - H_0 anisotropy map as derived from the combined data analysis (courtesy of K. Migkas, *Astronomy & Astrophysics*, 2021).

Certainly there are many constraints to the emergence of complex life, and we are in process of testing them from increasingly precise observations. For instance, in addition to the well-known features relating to the habitability of a planet, such as the existence of a protective magnetic field, positioning within the "Goldilocks zone", existence of liquid water, etc., regarding the proximity between galaxies a denser universe could expose worlds potentially favorable to biological evolution to lethal gamma-ray bursts.

2 Science and faith: ignorance and disdain in the civilizing process

Are we really an intelligent species? Scientists who still waste time rejecting the erudite faith — that is, faith from the perspective of deep theology — in the light of the rationality that originated the most significant theories for accumulated certain human knowledge do not seem, to us, to show much intelligence with this attitude of curtailment. For faith can only be dealt with in the encompassing realm of theology; it is a human manifestation and, initiated as an educated guess, it is the first step in asserting a promising intuition. There is no point in confronting it with a practitioner-limited non-envelopment science. William Stoeger, a Jesuit priest who was a staff scientist for the Vatican Observatory Research Group in Tucson (Arizona, USA), specialized in theoretical cosmology, high-energy astrophysics, and interdisciplinary studies relating to science, philosophy and theology, in his brilliant approach to the subject, pointed that

"[…] it is crucial to recognize the competencies and limitations of each [science and theology] […]. Obviously, theology is not equipped to, nor even interested in, describing and modeling the laws of nature more accurately at their various levels of operation. This is the realm of the sciences. Nor are the sciences capable of dealing with questions of God and of ultimate value and meaning. These are the objects of theology and philosophy. Furthermore, the languages used by the natural sciences and by theology are very different not only in what their terms signify, but also in the context within which they are to be understood." (STOEGER, 2007).

Faced with such a crystalline truth, we must admit that it surprises us to hear some scientists repeating the obvious as if they had attained superior knowledge: "Science doesn't need God to describe the universe"; it is true, of course! Now, descriptions of nature are representations created by consciousness, by the "knowing self" endowed with the ability to inquire about its place in the universe, which is quite different from asking why the laws of nature are as they manifest in our universe; the latter is indeed a matter of faith's interest, giving rise to the plausibility of God as a transcendent and hidden creative agent, outside the scope of science. As Monseigneur Georges Lemaître said,

"I think that everyone who believes in a supreme being supporting every being and every acting, believes also that God is essentially hidden and may be glad to see how present physics provides a veil hiding the creation." (LEMAÎTRE, 1931).

The immensity of the universe, in size and variety, is rivaled only by our own ignorance. Even crucial assumptions at the foundations of observational science, such as the isotropy of the universe, are being challenged. As Migkas (2021) said, "[...] assuming it [the universe] to be isotropic is almost a *leap of faith* for now." (italics ours). We are constantly led to believe in preposterous ideas at the heart of science, making us question whether the ancient rigor of science remains today, and whether we are putting science on a much higher pedestal than it should, unnecessarily complicating our models of reality. Since science, among many guesses, has considered explaining our universe by the existence of other inaccessible universes, which is absolutely unsatisfactory and purely

fictional[3], let us not waste another second with the so-called expressions of the obvious and with empty disputes; let us have faith that the simplest answers shall bring us closer to understanding the whole[4]. Much of science has become, especially since the 1960s, a doctrine which resembles formations of early religions; so, it is our view that much of science as currently practiced seems to be trending toward a copycat version of very limited faith, which means that such science may well be a delaying social movement rather than a progressing social movement for our species.

2.1. Faith and finalism

The conjecture of a civilization per galaxy can lead one to think of a mysterious design. We don't think this naive impression survives reason. Nature is full of self-regulating mechanisms, such as the dynamic predator-prey relationship. Hawking, for instance, didn't like the idea of time travel at all, and seemed to think there's something he called "chronology protection", a kind of natural "prohibition" that would prevent disastrous paradoxes. In fact, our conjecture is based on facts that indicate, whilst partially, the extreme rarity of complex life. If one looks for weaknesses in science, we recommend, for example, theories built on inaccessible dimensions[5]. In the field of astrobiology, technology is in our favor. We are dealing here with an increasingly observable universe, however, bearing in mind that technology fits the limitations imposed by cosmic nature. This is an important warning for those who think that everything is only a matter of technological advancement. Many of our well-designed creations in imaginative planning may never come to fruition.

Indeed, the idea of a one-to-one relationship between civilization and galaxy as a form of species preservation brings out the old doctrine of finalism, but as Valéry observes: "[...] the notions of cause and adaptation almost inevitably lead to it" (VALÉRY, 1945). This is not to say that we must rescue finalism in a renewed teleological

[3] The idea of the "multiverse" is an ingenious curiosity from a cosmological point of view, but it is vastly speculative. As Ellis noted, “that multiverse proposals are good empirically-based philosophical proposals for the nature of what exists, but are not strictly within the domain of science because they are not testable.” (ELLIS, 2004). In this field of speculations, it is often hard to distinguish a fictional boast from something that has any basis in reality. Of course this is not the way science is properly done. Some have offered even more radical offshoots of the basic notion of multiverse, and the story along these lines morphs with time. Surely, in this whole manner of thinking nothing out-of-the-ordinary happened last decades.

[4] Post-modern physicists are piling conjecture on top of conjecture. For instance, there are many theories on how gravity works, with most being conveniently untestable. As a curious and fun activity we believe to be valid, but is it science?

[5] We are aware of the current submillimeter tests for extra dimensions since the early 2000s. But, it is essential to take into account that to say there is a physics in 10 dimensions would imply that we know there are 10 dimensions. But, unfortunately, we do not. There is no physical evidence for this, and not all mathematics is realized as a description of a objective physical phenomenon.

vision. However, it must be understood that finalism is simply the projection of the human spirit on how things simply are in fact, more or less like the tendency we manifest to see human faces in natural accidents (cloud formations, landscape similarities to life-forms, star patterns); there are no faces, just as there is no finalism (which does not exclude the consideration of "a supreme being supporting every being and every acting")[6].

2.2. The witchhunt

It can be said that there is an "aesthetics of belief" when one recalls Einstein's Spinoza-like belief:

"This deep intuitive conviction of the existence of a higher power of thought which manifests itself in the unscrutable universe represents the content of my definition of God." (WHITROW, 1967).

Therefore, we need to distinguish faith from superstition. The latter is a bizarre construction of the psyche, apparently separate from the action of the intellect, free from reasonableness and causal nexus, being fueled by ignorance or by primitive impulses and passed on through generations. Certainly, in relation to faith, we are referring to belief governed by a long-term contemplative reflection on existence, not popular belief in fantastical things; a belief that even favors keen insights into complex matters. Most critics of the faith do not make this distinction and dive all in the same well of lost souls. They wander off on many tangents and are frequently and demonstrably wrong (they are wrong in the sense that they don't appreciate the human essence). In some more extreme cases, outside the governmental funding insiders "club" of undisputed authorities, everybody else is

[6] Biologists have a serious problem with the idea of a superior creative force; they think that to sustain it it's necessary to deny evolutionism and natural selection. In many cases, the innate exercise of thinking about the meaning of existence was blocked due to the bad habit of dismissing anything their theories cannot envelope. This way of trowing stems from the almost complete absence of philosophical refinement. So, our intention here is to alert to the common bias of wanting to discuss faith with the logic of scientific rationality. We know that several natural factors may conspire favorably for the course of evolution; for instance, a small portion of the cosmic rays that cross the atmosphere can cause changes in the genetic material, characterizing mutations that may have survival value for a given species. So, the focal point is not evolution, but the driving force behind natural selection. Indeed, natural selection works by preserving the characteristics that prove useful for survival. The interesting question then is: why does nature operate in this way, selecting mutations favorable to survival? In fact, this question is a particularization of the major question about the laws of nature being as they manifest themselves and not otherwise.

So it's not about denying evolution; on the contrary, it is the very necessary realization of the creative force. Thompson's gazelles have developed extraordinary escape adaptations, but not enough to be fully unreachable by cheetahs; cheetahs, on the other hand, have developed equally extraordinary abilities for hunting gazelles, but there are not enough of them to threaten the gazelle population. The predator-prey model describes this dynamic very well, but why is it so? The alternating black and white stripes of zebras act to perfectly regulate their temperatures under the strong African sunstroke, while other animals lack this feature; why? These are the themes of faith, far beyond institutionalized religions, themes that awaken in some individuals the supreme desire for communion by contemplating the universe, that is, by the "breath-of-the-soul" which leads to the essence of all things. According to our way of seeing, there is no contradiction between contemplating existence through faith and representing our simple hopes for knowledge through art, physics and mathematics.

branded a "crackpot" or worse (also, there are reports of acidic-abrasive "bedside manner" of debating) . Not long ago, Pierre Teilhard de Chardin was the target of a kind of modern inquisition, combining clerics and academics. His original and innovative thinking was widely attacked by radical minds who simply refused to even try to understand his philosophy.

Teilhard de Chardin tells us about an “attractor” of the evolution of consciousness, the “Omega Point”, the apex of his *noogenesis*, that is, the integration of all human thought into a single conscious network (CHARDIN, 1955). According to his belief, God and the universe (the universe as a material expression of God) have a creative and dynamic relationship of progressive evolution. Although this idea appears to conflict with the Second Law of Thermodynamics, there is no way to deny the visionary nature of the concept of the *noosphere*, the abstract layer created by the conscious network covering the physical layers that make up the Earth. Interestingly, however, the prevalence of the Second Law is not necessarily an obstacle to the Chardinian conception, since, as analyzed by Serpa and Fernandes (2020), the Second Law encompasses an intrinsic creative process based on the interaction between regions of different states of decelerated entropy. We understand that the search for a convergence of science and faith is nothing more than an investigation that seeks to show that both can coexist harmoniously in the same individual. It's not about meddling with each other; it is, rather, the coexistence of these two forms of knowledge acquisition. After all, there is nothing paradoxical about creatures made from matter produced in the stars to seek some kind of communion with the cosmos, since we shall return to dust! Whether this communion is sought and expressed through equations, allegories, poems, paintings or music it is a matter of personal temper that cannot be discussed in a destructive way, just as it is not the role of science to discriminate the ideas of faith as meaningless (indeed, a contemplative quest for eternity, with a bit of symbolism, arises: could a Chardin’s “Riemannian” *noosphere* to be extended in some way to the whole cosmos as the final purpose of God?).

At this point, it is worth remembering Bohm's thinking in terms of enlivening consciousness regarding the fact that our ways of thinking not only fragment reality, but, in a way, induce the thought habit of considering reality as we exactly describe it[7]. Admitting that the ultimate substantiality underlying matter and thought is nothing more than a process, that is, the "becoming", the flux beyond simple transformation, then the fragmentation of the world is simply the result of a confusing fad that is rooted in the mechanical and fragmented way in which pre-intelligence

[7] The attitudes of clear persecution that humanity’s history is full of show how much the exercise of science is contaminated by ideologies and political trends, tearing the nobility's cloak with which scientific circles have always been covered. David Bohm has also been one of the targets of a general vociferous criticism (an evident product of controversy which was permeated by social influences) on the theory of hidden variables in quantum mechanics, in the 1950s and early 1960s, a fact that in 1973 deserved a striking counterpoint by Jauch:

“. . . the discussions which surround the quest for hidden variables in quantum mechanics have, on both sides of the camp, often been conducted in a spirit of aggressiveness which resembles more the defence of orthodoxy of one ideology than a spirit of scientific objectivity.” (JAUCH, 1973).

thinking organizes memories. In fact, what we create are visions of reality. Bohm emphasizes that it is not, therefore, about imposing a unity or integration, which in itself would already be a form of fragmentation, but about embracing at a single stroke all the different visions of reality within their respective domains (BOHM, 1980). We think science and faith fit perfectly into this understanding of the world. However, these ideas were systematically misinterpreted and viciously taken up by acid critics as very close to oriental monism for which "all is one", as in Buddhism and Lao-Tzu's philosophical Taoism (remembering that these wisdoms are not really religions, but ways of life). In fact, in the last third of his life, Bohm approached Eastern thought, however, not with mystical intentions as claimed by those who fly the flag of science as a symbol of a comprehension above the common people, but with the unassuming and friendly intention of showing to everyone that the human mind will always create representations of reality that in the end resemble each other in the search for a unified understanding behind the fragmentation that is presented to us, regardless of current cultural influences[8].

Thus, once all is flux with no real fragmentation, this idea is consistent with the notion of the space-time expansion continuum within a finite element — a simple vision of reality — abstracted from the continuum itself (although human understanding continues to weaken in face of the persistent image of an atomized world, the truth is that the concept of particle does not resist an underlying reality that imposes itself as a flux or process). This being the assumed understanding, it seems quite natural and understandable that several beliefs imagine some kind of union with the cosmos, since we are part of the continuum.

3 A better world to come: belief or fact?

We recall with gratitude the persons who have influences our lives because in many ways we have emulated their inspiring best qualities, and we have been fortunate, or blessed perhaps, to share what we have learned over the years with others close to us in our lifetimes. Inspired by oneiric thoughts and their example, we are motivated to act — as in penning this article — through the power of God within ourselves. Our dear friend "Bala", now absent in our everyday lives as an active corporeal form, was imbued with practical creativity, substantial thought-product, wisdom and understanding of life's many facets. Habitually, he treated others with kindness and greeted people with an ennobling smile. "Bala" exhibited affirmative thinking in his relentless pursuit of service, teaching, and useful learning. Surely, there are many "Bala" persons striving to energize and focus humankind's vision of the past, the present-day and the future, even the magna-cosmological?

We think the abstraction of a better world — a world where true faith, as belief in the field of high theology, can play its role with science according to the knowing subject's freedom of choice — in present moment is the basis for a belief to which we cling inspired by individuals like Bala, a belief which in a sense keeps us convinced that

[8] Another interesting example of the quest for understanding a flowing reality is the Sufi conception of a universe in constant creation.

our presence is something worthwhile. A truly better world, as by the true faith we can hope to come, requires so many changes with respect to what actually happens today that it seems unlikely we shall survive long enough for such changes to take place. A good start, however, would be to re-discuss the civilizing process, something that has not been done for a long time. For this, we can dispense those who engage in debates as if they were dancing around a bonfire of vanities (full of themselves, with lack of humility!).

4 How faith and science can collaborate in revelation

Recently, Westby and Conselice (2020) proposed improvements to the old Drake equation in light of the knowledge acquired and accumulated since the 1960s until now. Yet equations of this type initially work much more like expressions of belief, which science translates eloquently as "likelihood."[9] Indeed, such equations cannot be intended to include all the variables involved, but in the near future some factors as the number of rocky planets that have developed a protective magnetic shell against ionizing radiation will need to be explicitly considered based on the ongoing technological improvements. As the truth is revealed through empirical confirmations, the original intuition gradually gives way to adjustments in calculation models athwart reiterated attempts to better approximate reality; it's how human intelligence works.

In view of everything we've said, it is undeniable that the power of intuition in science can lead to a true act of faith when it is directed towards the construction of a conjecture whose hopes for testing and empirical corroboration are beyond practicability. It is a human feature to fight or simply live for what is believed, whether in the field of science or theology. In science, however, intuition comes to revelation through the intervention of artifacts for observation (telescopes, etc.) and devices for phenomenal provocation (particle accelerators, etc.). In theology, revelation takes place through inspiration, through an unexpected and overwhelming cognition incited by the pervasiveness of the cosmos in everything around us, creating in the spirit a full conviction, devoid of parts, therefore, unknowable by the analytical mind. Both revelations seek the truth through distinct and complementary ways. It is really a pity that few realize this, preferring the dissatisfaction of a unilateral choice that only tends to distance us from understanding the whole.

Probably, the difficulty in realizing this complementarity lies partially in the fact that we are "in" the “great complexity”; perhaps, as has been said, intelligence is the way the universe found to know itself.

[9] In the context of science, and, in particular, in cosmology, belief often appears hidden in statistical formulations from which one seeks to extract a "likelihood". It's a kind of "honorable solution" to knowledge at a *cul-de-sac*!

5 Final comments

The option for a highly consumerist market model has proven to be a way of breakdown rather than of human growth. In the trail of uncritical consumption, science as institution and social practice is gradually being replaced by the technology of immediacy, incapacitating the individual for critical thinking. In this downfall, faith turns into superstition exploited by persons who despise and even hate the most basic ethical principles. This global effect is evidenced by the visibly decreasing quality of the intellectual production of the younger generations. Logically, a world centered on trifling and vileness favoring the creation of untold fortunes in the hands of a billionaire minority is not the right place for an evolution with progress. If all the hypothetical intelligent life that might inhabit our universe is based on such limited parameters, it's no wonder we haven't picked up the slightest hint of other civilizations so far.

Howsoever, with an estimated 100 billion galaxies (maybe much more!), imagining a civilization for each doesn't seem outlandish, even if many are presumably sterile. Putting this conjecture alongside speculations about parallel universes and inaccessible extra dimensions, welcome back to beliefs! Intellectualized indeed, but beliefs nonetheless. As Stoeger said,

“The processes of evolution rely on the harnessing of chance within a larger framework of order and regularity. In fact, what has happened in our universe is that each of the hundreds of billions of hundreds of billions of star systems in our observable universe has become a separate evolutionary experiment. How many of them — or even whether or not any of them besides our own — have yielded life and self-conscious social life, we shall probably never know.” (STOEGER, 2007).

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References

BOHM, D. (1980/2008). Totalidade e a Ordem Implícita. São Paulo: Madras, 222p.

CHARDIN, P. Teilhard de (1955/1970). O Fenômeno Humano. Porto: Tavares Martins, 355p.

ĆIRKOVIĆ, M. (2018). The Great Silence: The Science and Philosophy of Fermi's Paradox. Oxford University Press, 395p.

ELLIS, G. KIRCHNER, U., STOEGER, W. (2004). Multiverses and Physical Cosmology.

Monthly Notices of the Royal Astronomical Society 347: 921–936.

HEMBEST, N., MARTEN, M. (1983). The New Astronomy. New York: Cambridge University Press, 240p.

JAUCH, J. (1973/1990). Are Quanta Real? London: Indiana University Press, 130p.

LEMAÎTRE, G. (1931) . The Beginning of The World from The Point of View of Quantum Theory. Nature 127, 706.

MIGKAS, K., *et al* (2020). Probing Cosmic Isotropy with a New X-ray Galaxy Cluster Sample Through the L_X–T Scaling Relation. *Astronomy & Astrophysics* 636 A15, 42p.

MIGKAS, K., *et al* (2021). Cosmological Implications of the Anisotropy of Ten Galaxy Cluster Scaling Relations. arXiv:2103.13904v1 [astro-ph.CO], *Astronomy & Astrophysics*, 39p.

MURPHY, N., STOEGER, W. (2007). Evolution & Emergence: Systems, Organisms, Persons. New York: Oxford University Press, 378p.

SERPA, N. (2019). Fermi's Paradox and Restraint Orders: Why Does No One Respond? CALIBRE - Revista Brasiliense de Engenharia e Física Aplicada, v. 4 Suplemento - Outubro, p. 1-17.

SERPA, N., FERNANDES, G. (2020). The Way of Entropy: From Lagrangian Modelling to Thermal Engineering. CALIBRE - Revista Brasiliense de Engenharia e Física Aplicada, v. 5, p. 1-16.

VALÉRY, P. (1945/2020). A Arte de Pensar. Rio de Janeiro: Bazar do Tempo, 299p.

WESTBY, T., CONSELICE, C. (2020). The Astrobiological Copernican Weak and Strong Limits for Intelligent Life. The Astrophysical Journal 896: 58.

WHITROW, G. (1967). Einstein: The Man and His Achievement. New York: Dover, 94p.

Future Guanabara Bay Clean-up: Rio de Janeiro's Hillslope Favelas Ought to Be its Amicable Pinnacles

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To Alexander Bolonkin, *in memoriam*…

Abstract: This article brings a social discussion about the surroundings of Guanabara Bay, showing that there are technological instruments capable of promoting citizenship and quality of life for the inhabitants of the slum areas. The work is part of the collection of published studies on the Guanabara Bay edited by the electronic journal CALIBRE, integrating a fundamental legacy for future projects in urban ecology.

Key words: *favelas*, escalators, Guanabara Bay, Macro-Imagineering, *asfaltos*, *favelados*.

Resumo: O presente artigo traz uma discussão social acerca do entorno da Baía de Guanabara, mostrando que há instrumentos tecnológicos capazes de promover cidadania e qualidade de vida para os habitantes das áreas favelizadas. O trabalho se insere na coleção de estudos sobre a Baía de Guanabara publicados no periódico eletrônico CALIBRE, integrando legado fundamental para futuros projetos em ecologia urbana.

Palavras-chave: favelas, *escalators*, Baía de Guanabara, *Macro-Imagineering*, asfaltos, favelados.

1. Introduction

Prior to AD 1957 Homo sapiens' Space Age commencement, the "overview effect" generally referred to the human experience of viewing landscapes from above, such as from atop high hills and even mountain summits [1]. A new way of looking at geographical reality assists our individual freedom to choose, reaffirms and amplifies our everyday understanding, and usually motivates people to convert technological innovations into marked visible regional changes driven by public rationality and consent. Obstructionism is the nemesis of constructionism. On 15 February 1875, the blessed populace of Rio de Janeiro gazed at an awesome sky-backgrounded example of an outer space sporadic aurora and, from 28 April 2021 Brazil has begun its national attempt to establish an orbital rocket launch capability at its *Centro de Lançamento de Alcântara* situated on Brazil's northern coast, about 2 degrees south of Earth's Equator. By early-2021 AD, the city of Rio de Janeiro had extended its cooperative disaster preparedness partnership with the NASA twofold: to increase situational awareness and governmental response to environment-related disasters and to foster the propagation of science education throughout local schools and to create an informed public [2]. In childhood, human imagination helped each of us to see fascinating shapes in scudding clouds but, much more than whimsy, many human imaginations used with intention can give shape to dreams and future goals. Perhaps one of the most important experiences people ponder and sometimes heed during life will be to reduce human fixation on highly rationalized, even doublespeak [3], so-called sustainability [4] and, instead focus more on susceptibility, our God-given openness to the beneficial and life-enhancing "overview effect"!

As optimistic coastal planners [5] seeking and fervently desiring to stimulate (after September 2021) all of Rio de Janeiro's existing, inherently green *favelas* built by long-term focused autotelic activities to become more accessible, safer, healthier, infrastructurally efficient, beautiful and resilient, constantly driving these self-built and illegally-established occupations of public and private landscapes usually mapped as unofficial non-jurisdictions — toward permanent prosperity. But, in particular, and chiefly because most of the city waste dangerously deposited in Guanabara Bay (GB) is derived from these densely urbanized but distinctly separated hillslope regions [6], it is hoped to transform (for the better) eight essential municipalities (Rio de Janeiro, São João de Meriti, Duque de Caxias, Magé, Guapimirim, Itaboraí, São Gonçalo and Niterói), a total land area of 2,766 km^2 bordering the 384 km^2 GB! "Pinnacle" means the highest elevation of a topographic place and also a notable capping architectural ornament. Our task of beautifying landscape architecture-focused coastal planners is to generate a feasible Macro-Imagineering project vision for *favela* dwellers — people who have demonstrated for decades competency in determinedly changing their given geophysical and social world as well as the resulting pride achieved through personalized self-efficacy — that is of durable dimensions and obvious affordability.

Accomplished youth native to downtown Rio de Janeiro ordinarily is more likely to achieve positive public recognition than their disadvantaged peers living in the closely adjacent *favelas* — this outcome may be referred to

as the intra-urban “escalator effect” [7]. Improved mobility, sanitation, reliably clean potable freshwater and non-interruptible electricity supply serving favela dwellers could reduce the “escalator effect” impact markedly. The unitized technology of latticed and covered outdoor escalators is symbolic; meant to last for generations after construction, numerous installed mobility devices obviously transcend its everyday freight-delivery and passenger travel function [8]. Cheerfully neon-lit during nighttime, such trip efficient steep incline machines, potentially laid out in a sea-level viewer attractive trellis-like pattern, might overcome some social barriers long-imposed by misinformed or ignorant politicians and sometime unsociable extra-*favela* elites, the most influential citizens of Rio de Janeiro [*asfaltos*] — persons almost limited to exotelic actions only, motivated by an extraneous goal— who evince disregard for self-starters, the decent *favela* residents of high-density, low-cost homes built by hand! Brazil-recorded videos and movie comedies generally feature characters from *favelas*, persons attempting to better themselves, often by currently illegal means; for example, Jorge Alberto Furtado’s ***O Homem que Copiava*** (2003) is a funny expose of the unfortunately too-common “cultural trait” of wealth acquisition based on just social status, unleavened unjust greed and, perhaps, truly malicious public deceit done by clever publicity release specialists-for-hire.

2. A brief social history of the *favelas* in Rio de Janeiro: impacts on Guanabara Bay

The first irregular occupations in the city of Rio de Janeiro occurred from the large number of victorious soldiers from the “Canudos War”, who landed in Rio at the end of 1897 without housing, and the great concentration of Africans and Afro-descendants who filled the city after the abolition of slavery. However, occupations in shacks are still earlier, dating back to the 1850s, as is the case with the historical “Morro da Mangueira”.

The social structure of the classic favelas of Rio de Janeiro is quite complex. By classic *favelas* we mean poverty-stricken communities that have grown since the second half of the 19th century, developing a popular culture largely influenced by the rituals and customs of “Candomblé” and “Umbanda” and, later, materialized in festive manifestations around the themes of "Samba", such as the famous carnival parades and the circles of "Partido Alto". Marked by social exclusion and absence of public power, these communities evolved in disarray, climbing the slopes of the city's several hills, developing their own moral rules shaped by the harsh exercise of survival. Evidently, the abandonment scenario gave rise to criminality, at first characterized by the profile of the "malandro", basically the common thief who is a street robber.

Although social science theorists insist on a simplistic model for analyzing crime — which ignores innate individual tendencies —, the fact is that the number of criminals in the *favelas* of Rio de Janeiro has always constituted a very small part of the population. We must add to this the error of assuming that *favelas* residents want to get out of it. On the contrary, a more accurate anthropological analysis shows that the crystallized social system of the *favelas* not only reflects the cultural identity of their residents, but is not replicable in projected

urban areas (the example of the "Cidade de Deus" confirms this fact!). What residents want is citizenship, that is, social inclusion (in other words, education, security, health and sanitation).

Figure 1 - Surroundings of Canal do Cunha (photo by Elizângela Leite, 2017).

With disorderly growth and continuous distance between public power and *favelas*, crime took the form of drug-trafficking gangs — enticing minors through a regime of terror and exploitation of poverty — and endemic *militias*, both nourished by the government corruption of a pseudo-democracy that boils down to the exercise of mandatory voting. Over time, *favelas* descended the hills, extending along the shores of GB, through the "Complexo da Maré" and "Complexo do Alemão", greatly increasing the load of untreated organic waste and garbage on the edges of the Bay. The “Complexo da Maré”, once the largest *favela* on over-bay stilts in Rio de Janeiro, is now partially urbanized. However, the risk of disease in the region appears to be, more or less, rather permanent, especially adjacent to the exposed tributaries of the highly polluted “Canal do Cunha” (Figure 1), near the “Ilha do Fundão”, whose foreboding dark-hued waters flow into GB’s turbid waters. The accumulation of contaminated materials, solid waste and large volume of domestic and industrial sewage contribute to dramatically increase pollution rates.

Certainly, conventional proposals will not solve the problem of pollution in GB, as we have pointed out in a collection of works on the subject [10]. Common ecological barriers are palliative for a macro-problem whose solution requires infrastructure, social inclusion and innovative thinking in urban ecology. Realizing that extraction of micro-plastics from GB seafloor is currently economically impossible, nevertheless we hope some type of natural means will be fostered — perhaps a kind of kelp which can be harvested? We recently started work on the possibility of setting up small floating plant islands, constituting an auxiliary network for organic renewal of the most polluted areas of GB. This work is in progress and will give rise to new publications.

3. Zen-like approach to a municipality-driven Guanabara Bay restoration

Emphasizing intuition and profession insights, instead of a conventional fixation on timetabled specific goals, the focus of the proposals contained in this brief article is to develop an enduring and prosperity-inducing

reconciliation between ~1.5 million *favelados*, ~25% of the region's residents, unserved by, or comprehensively over-charged for, basic civic servicing infrastructure such as sewerage, freshwater supply and electricity, and their encompassing bayfront-located Rio de Janeiro society living in utility-connected downtown skyscrapers. Bluntly, every person living and working in the area disposing of waste in a careless manner is a desecrator. Since at least 1930 AD, and until circa AD 1980, some heartless or authority-compliant Brazilian urban planners sought the physical eradication of all *favelas*. Later, managerial schemes entailed limited and regularized utility upgrades, as well as stronger economic integration with downtown residences, port facilities, factories and offices. The elite political class representing the formal city — those *asfalto* folks who sought and strived to "obliterate" Rio de Janeiro's informal slums by inducing their Internet "invisibility" (i.e., Google Earth), hidden from potential and camouflaged from view of actual foreign tourists and other hoaxed visitors from afar, especially during internationally celebrated costly symbolic cultural events whilst, at the same time, using the term *favela* as an associated label for an advertised sellable retailed entertainment product! After AD 1988 geographical low-landers voiced some interest in latching the *favelas* more securely to the core district, the downtown, but the key geographical transformation needed by so many persons was never legally accomplished, or financed: the simple organizational recognition by established governmental bodies that effectively administered *favelas* are regions with mapped political borders, entitled to govern themselves through resident-approved advisory groups and specialized councils and constantly trying (as enfranchised Brazilians) at all times to harmonize their community actions with those extant throughout the State and Nation socio-ecosystems [9a-9b].

Nevertheless, only ~30% of the populace of the whole GB-fronting urban region — measuring 52.27% of the State's area — remain unconnected to a unified, government-operated sanitation system, and only ~50% of all State-generated sewage (replete with atrocious volumes of floating litter) is treated before it flows through multiple air-exposed waterways into a disgracefully degraded Guanabara Bay [10]. (Often it is specified that safe sewage systems epitomize human civilization — Chelsea Wald's 2021 tome ***Pipe Dreams: The Urgent Global Quest to Transform the Toilet.***) Rio de Janeiro has more *favelados* that any other urbanized place in Brazil; Rio de Janeiro's first historically recorded *favela* was Morro da Providência (begun circa AD 1897) and its areally most extensive — about 144 km^2 — is Rocinha (begun circa 1940 AD). Rocinha's people can watch a dedicated television station (**TV ROC**) and, probably, ~80% of *favelados* therein have Internet connection! Naturally, a pertinent question arose: exactly when was it that downtown's High-Society first noticed that steep hillside residents enjoy a less expensive life-style and can admire superior vistas of their commonly-shared, but sadly defiled, GB than those working and housed in expensive tall buildings built downtown; perhaps some the basic daily animus toward *favelados* expressed or, oftentimes, hidden by whispering or shouting *asfaltos* simple derives from this singular causal geographical fact of a rocky naturally punctuated landscape. For a moment contemplate the total removal of Rocinha, its veritable erasure from the picturesque landscape by *asfalto*-mandated bulldozers and other industrial-scale object-moving machinery. If the *favelados* exited peacefully they would take much more

than their personal grooming, clothing items and furniture — since they provably built their individually consecrated "dream" homes (including architectural elements such as concrete bricks, wiring, plumbing etc.) then all such materials comprising those homes *in toto* can become mobilized assets taken, shifted elsewhere! Next, macro-imagine the possible post-2010 AD unnatural disasters occurring subsequently — landslides, flash floods, mudslides and much, much more [11-12]. Indeed, mitigation of geological hazards requires experts to properly anticipate, to identify at-risk steep landscape regions, and to effectively inform *favelados* and to recommend design alterations to their present-day infrastructure. Absent such work, in essence, *favela* removals could worsen the existing GB's uglifying and too-evident pollution! Oddly, non-totalistic event-anticipating eager *asfaltos* are busying themselves strategizing a publicly-acceptable landscape plan to successfully accommodate downtown's fixed-in-place capital assets to a postulated future local sea-level rise, including marine-estates, floating aquatic GB seafood production systems, adapted merchant and naval port industries [13], floating shipyards maritime transport developments, post-COVID 19 cruise liners and park-like coastal ecological zones [14].

4. "Disneyfied" Rio de Janeiro favelas? Power from the People!

Uneven geographical development in Rio de Janeiro intrigues Brazilian and overseas landscape planners, drawing some to Macro-Imagineering. As a former Floridian, Dr. Charles W. Finkl knows personally the astounding regional developmental effects of the Reedy Creek Improvement District's establishment during mid-1967 AD, wherein eventually **Walt Disney World** was constructed by traditional means and methods [15]. However, the worldwide milieu of outdoor construction has changed markedly, especially during the early 21st Century. The idea of additive three-dimensional material printing technology dates, approximately, from AD 1983 and the first working printer was assembled by 1984 AD. 3-D printing of buildings, building components and building furnishings are the future of construction, in both robotized mass-market and serendipitous incarnations. "By producing bridges and houses more cheaply and efficiently, 3D printing could reduce concrete's carbon footprint — but it could also just encourage engineers to build more" [16]. Cleanliness symbolizes all Disney theme parks.

Soils — that is, "earth" — is the most ancient as well as one of the most modern ingredients for 21st Century constructions; too, since 'cement" has been useful since olden times it must be included in that category of global things found important to the individual daily lives of millions of human beings [17]. Such manipulable materials are ubiquitous; 3D printing's recent perfection has prompted and hastened major innovations in many other closely associated fields of endeavor, including Art! (GOTO: http://myminifactory.com for a huge selection of open-source digital scans of famous artworks, furniture, house decorations that can be printed by non-professionals.) Even today, as in the past, and known in the Portuguese language as "*taipa*", rudimentary rammed-earth walls are still prominent in Brazil [18]. Regularization and normalization of the technology of large-scale 3D infrastructure printing is Green, entailing no left-over or waste materials, and ought to be insurable since the plans

may be provided by certified architects and macro-engineers! Printed homes have been completed in Mexico (2019) and the USA (2021).

Hundreds of new and replacement homes for *favelados* may, thusly, be fabricated off-the-cuff so to speak. Necessarily, electrical power for the towed trailer-mounted portable printing machines will have to be available 24/7/365. Down-to-earth Brazilian "Slartibartfasts" intending to successfully build bespoke new residences, or upgrade old residences, will take on the aura of Neo-Impressionist pointillistic artists that would make Douglas Adam (1952-2001) proud — each to his own taste. Neighborhoods within each *favela* might collectively decide that a particular style and coloration of home exterior is preferred by the consenting cooperative group! Reliable distributed micro-generated electricity for local consumption may be produced by solar panels or cheaper small wind-turbines [19]. For example, child-safe because the lack of any external moving parts, approximately the size of a standard street fire-hydrant, a 1 kW ***PowerPod*** — designed and put together by Halcium (headquartered in Salt Lake City, Utah, USA: https://www.halcium.com) — are inconspicuously-sized turbines that capture wind from every direction, speed it up to achieve an output worthy of admiration, and can be colorfully paint-coated to reflect local tastes! (Figure 2**).**

Figure 2. A single ***PowerPod*** versus ordinary linked silicon-wafer solar panel, 24-hour average electricity production at Rio de Janeiro. *Favelados* can easily live off-the-grid. That means the makeshift transmission lines now serving such communities, and which pose a life-threat to inhabitance, may be removed permanently. Besides, almost 50% of Rio de Janeiro State's electricity in imported from other States at some considerable expense. This mini-windmill need only be secured to a stable structural surface (roof, wall, platform etc.) and were carefully designed for already developed urban locales such as *favelas*. (Google Images).

5. Escalating the on-going effort to cleanse Guanabara Bay, Rio de Janeiro, Brazil

Rio de Janeiro's most ancient *favela*, Morro da Providência [20], is a fine viewpoint for people wishing to distance-observe the superficially beautiful Guanabara Bay. **Walt Disney World** is located in Central Florida, USA. It features a unique waste disposal system of "utildors" — officially named the "Automatic Vacuum Collection (AVAC)" — which "…pulls trash underground in pneumatic tubes and moves it at…[~98 kph]…directly from the trash cans to a central compacting plant" [21]. Why not use above-ground sited electrified *favela* escalator chute-shaped sub-structures as "utilidors" as well as subterranean conduits for compartmentalized fiber-optic cabling, powerlines, sewage piping and freshwater importation? This extension of "utilidor' uses seems to fit well with the publicly-known climate change mitigation policies currently be formulated for Rio de Janeiro [22]. Outdoor escalators are less costly to construct than funiculars, cog-railways and rack-and-pinon railways (*Trem do Corcovado*) In fact escalators were installed during AD 2003 to move passengers to and from the famed *Cristo Redentor*. Since the first patent was awarded in AD 1892, escalators have been a useful mobility technology for decades, according to editor Alisa Goetz's ***Up, Down, Across: Elevators, Escalators, and Moving Sidewalks*** (2003). Generally, such devices are safe, but escalator-related injuries can result in emergency department treatment [23].

In Columbia, the Mayor of Medellin during 2008-2011, Alonso Salazar Jaramillo, oversaw the installation and first use of a long solar-powered outdoor escalator — in the Spanish language, the *escaleras electricas* — which connects peripheral poor neighborhoods to that city's valley central business district (Figure 3**)**, reducing the travel time from one-half hour to a mere six minutes [24-25].

Figure 2. The *escaleras electricas*.(Google Images).

6. Conclusion

Citizenship seems to have become an inaccessible right for those who constitute the huge portion of excluded people across the planet. This exclusion tends to grow as the billionaire fortunes of men who intend to increase their wealthy by fabricating frivolities such as space cruises and desert blizzards, while humanity suffers from the worst ailments of the globalization. It is difficult to understand that so much greed of the few surpasses the most basic needs of the many, with several simple and economically viable solutions to most social and environmental problems. What a dark power is this that decides who survives and who succumbs!

Favelas are today the hideouts of a crime that finances power in many regions, and therefore, in general, they cannot be targets of citizenship policies. Its inhabitants live at the mercy of a parallel power imposed by fear and intimidation. As we have seen in this article, there is no lack of ideas and technology to support the actions of public authorities in favor of quality of life and dignity for all. It remains to be seen whether at some time there will be those who are willing to invest in the true civilization that we may not even deserve.

References

[1] White, Frank (1987) *The overview effect: Space exploration and human evolution.* Boston MA: Houghton Mifflin. Page 1.

[2] Hurtwitz, M.M. et al. (September 2020) "Earth Observations Inform Cities' Operations and Planning" *Eos* 101: 29-33.

[3] Walker, A.C. et al. (2021) "Controlling the narrative: Euphemistic language affects judgments of actions while avoiding perceptions of dishonesty" *Cognition* 211: 104633.

[4] Ford, A.T. et al. (2021) "Understanding and avoiding misplaced efforts in conservation" *FACETS* 6: 252-271.

[5] Edwards, N. (1 March 2021) "Politics of the coastal professional" *Ocean & Coastal Management* 202: 105419.

[6] Serpa, N. and Cathcart, R.B. (February 2020) "Guanabara Bay Special Edition: Including unpublished PARTS III and IV" *Revista Brasiliense de Engenharia e Fisica Aplicada* 5: 1-36.

[7] Davies, J. Donnelly, M. and Sandoval-Hernandez, A. (13 March 2021) "Geographies of elite higher education participation: An urban 'escalator' effect" *British Educational Research Journal* https://doi.org/10.1002/berj.3711 . 23 pages.

[8] SEE: Townsend, D. (5 January 2021) "Can escalators and elevators solve the last-mile problem?" *City Monitor.* https://citymonitor.ai/transport/can-escalators-and-elevators-solve-the-last-mile-problem .

[9a] Barbosa, L.M. and Walker, G. (2020) "Epistemic injustice, risk mapping and climatic events: analyzing epistemic resistance in the context of favela removal in Rio de Janeiro" *Geographic Helvetica* 75: 381-391.

[9b] Rulim, C.C. and Baptista, P. (2021) "Sharing Lisboa [Portugal]: A Digital Social Market to Promote Sustainable and Energy Efficient Behaviors" *Climate* 9: 1-28.

[10] Serpa, N. and Cathcart, R.B. (February 2021) "The Devil on a Dying Bay: Brazilian Marine Plasticarianism at Guanabara Bay" *Revista Brasilience de Engenharia Fisica Aplicada* 6: 1-24

[11] Tarolli, P., Preti, F. and Romano, N. (2014) "Terraced landscapes: From an old best practice to a potential hazard for soil degradation due to land abandonment" *Anthropocene* 6: 10-25.

[12] Ehrlich, M. et al. (2021) "Triggering factors and critical thresholds for landslides in Rio de Janeiro-RJ, Brazil" *Natural Hazards* 107: 937-952.

[13] Hossain, T. et al. (2021) "Role of sustainability in global seaports" *Ocean and Coastal Management* 202: 105435.

[14] Baumeister, J., Bertone E. and Burton, P. (Eds.) (2020) *SeaCities: Urban Tactics for Sea-Level Rise.* The Netherlands: Springer. 321 pages.

[15] Bezdecny, K. (2015) "Imagineering Uneven Geographical Development in Central Florida" *Geographical Review* 105: 325-343.

[16] Zastrow, M. (6 February 2020) "The new 3D printing" *Nature* 578: 20-23.

[17] Goodbun, J.C. (2016) "Mud and Modernity" *ARENA: Journal of Architectural Research* 1:1-15.

[18] Rauch, M., Heringer, A. and Blair-Howe, L. (2019) *Upscaling Earth: Material, Process, Catalyst.* Gta Verlag: FRG. 170 pages.

[19] Milojevic, M. et al. (2021) "Household's Energy Autonomy: Risks or Benefits for a State?" *Energies* 14: 2026.

[20] Worms, J. and Shuyter, A. (2018) "Conceived versus Lived Social Spaces and the Transformation of the Morro da Providencia Favela of Rio de Janeiro Since 2008" *The Latin Americanist* 62: 545-567.

[21] Mittermeier, S. (2021) *A Cultural History of the Disneyland Theme Parks: Middle Class Kingdoms.* Chicago, Ill.: Intellect. Page 67.

[22] da Silva, T.B., Baptista, P., Silva, C.A.S and Santos, L. (2020) "Climate Change Mitigation in the Transportation Sector in Rio de Janeiro, Brazil" *Environments* 7: 99.

[23] Schminke, L.H. et al. (March 2013) "Riding the Escalator: How Dangerous is it Really?" *Western Journal of Emergency Medicine* XIV: 141.

[24] Naef, P. (October 2016) "Touring the 'comuna': memory and transformation in Medellin, Columbia" *Journal of Tourism and Cultural Change*. Pages 1-17.

[25] Reimerink, L. (2018) "Planners and the Pride Factor: The Case of the Electric Escalator in Medellin" *Bulletin of Latin American Research* 37: 191-205.

ESSAY

Some Thoughts on the Maintenance of Water Bodies Close to Urban Settings

A GIANT TREATMENT PLANT FOR UPGRADATION OF SEWAGE AND RECYCLING WATER

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Editor's letter to readers

This essay was the last writing of my aged good friend in India, Balasubrahmanyam, who has always expressed his strong desire to be addressed informally as simply "Bala". We met briefly, but it was enough to realize that he was an excellent and fine person, and, undoubtedly, a great scientist. From his obituary, with permission of his daughter, Vibhavaree Gargeya, I reproduce here the very significant final excerpt:

> "Twenty-six students received their Ph.D. degrees working under the guidance of SNB. They now occupy prominent positions in academia and industry, both in India and abroad. He lived a contented life, mostly in the Indian Institute of Science campus, with his wife, Chanchal Uberoi, an eminent mathematician and astrophysicist (who died about two years ago). They are survived by their daughter and son, and their respective families.
>
> Overall, the life and times of SNB coincided with the rise of organic chemistry as a central discipline in science with a wide range of implications on all beings in this universe. SNB played his part in promoting this cause."

It is comforting to remember that I was able to address him some words of sincere admiration. I am sure how fruitless my condolences to his family would be, so I leave this Edition as a tribute to my esteemed colleague.

Nilo Serpa

Scientific Editor

1 Synopsis

The traditional system for rainwater harvesting, a matter of wonder, designed to make water available in the dry season in the Deccan Plateau, where rainfall is seasonal, and often ill-distributed, is briefly described. It is shown how the lay of the land and naturally formed drainage were utilized to build storage structures (artificial lakes) using simple but clever engineering. The downstream flow was used to interconnect these storage structures and, most importantly, to utilize the water, thus made perennially available, remained under local control.

The dangers attendant on not stemming abuse and destruction of inexpensively created, ancient storage facilities, not doing anything about setting down practicable wastewater emission standards, and strongly enforcing them, are highlighted. Whatever 'lake development' programs that have been undertaken seem to pay scant attention, if any is attention is paid at all, to how the lakes are going to be kept filled with useful water.

An engineering proposal is put forward in this paper to rejuvenate the ancient system whereby the water from the lake at the lowest level is pumped back into the one at the highest elevation. The many benefits that can be expected to accrue from such recycling are highlighted.

The first step in the proposal is to identify a particular system of serially connected lakes in whatever state of disrepair it may be. As is very likely, sewage ("grey water") would be already polluting the feed of the highest lake. The overflow from this lake would be feeding the next lake that would be already polluted, and so on. All these are surveyed and any repairs, probably requiring only minor engineering interventions, would be carried out. The water in the lowest lake is then pumped back into the lake at highest elevation.

The second step is to set up needed structures in the interconnecting canals for rapid biological clean-up of the re-circulated water through well-researched biological processes. The degree of elevation of the quality of water at every stage is measured by the procedures recommended for standard tests.

The whole proposal, described in some significant detail, is conceived as a gigantic sewage treatment plant. It has the potential to rejuvenate an old, well-conceived system, to maintain water at the requisite purity levels in the lakes, to elevate the quality of sewage close to that of river water, to increase the ground water table level, and so on. It is expected to yield a highly favorable cost/benefit ratio.

2 Ancient history

In a letter to the editor of a prominent Bangalore newspaper, published some time ago, a well-known writer on environmental matters thanks God for endowing a bevy of beautiful lakes in and around Bangalore. God would indeed be embarrassed to take credit for what He would certainly think He did not deserve. For, He intended that there couldn’t be any natural lakes in old geological formations, “yes” in the ‘new’ mountainous regions like the

Alps, the Andes or the ‘newer’ Himalayas or fractures like Lake Baikal caused by tectonic movements, and “no” in the ‘old’ Deccan Plateau, He would rather accept thanks for positioning a civilization on the Plateau that produced ancient and modern visionaries and engineers who created those lakes over there in the last one or two thousand years.

3 The Deccan plateau

The “Deccan Plateau” consists, in the largest part, of that triangle-shaped Peninsular India that juts into the Arabian Sea on its west, the Bay of Bengal on its east and points into the Indian Ocean on its south. No, it wasn’t always here. It was part of Gondwanaland (“the Land of the Garden of the Gonda Tribe” – named after a still extant human tribe living in east-central part of India). It once touched the island of Madagascar which abutted (or was in contact with) the southeastern coast of the African Continent, while the west coast of Australia has been thought to have flanked its eastern edge. Gondwanaland broke up and the “Deccan” moved generally northeastward to meet the “soft underbelly” of Eurasia. I do not know when the collision happened (more likely perhaps it was a plowing-in) and if Eurasia was where it is now or it came there when Pangaea broke up and formed Laurasia. The Himalaya mountains were raised (and are still rising) and the sea lane between the two land masses, called Tethys Sea, was mostly closed off and got filled in to form the alluvial Indo-Gangetic Plain, largely by erosion of the Himalayas. Searching for animations of the break-up of land masses, their movements, and formation of newer seas and oceans, now available on the Internet, gives an interesting experience. Actually, the animations show a roughly triangular piece that was to become the Deccan Plateau as just about the fastest moving land, moving north-northeasterly from where it was and to where it is now. Recent investigations have been interpreted as showing that the high rate of movement of the plate associated with the Deccan is not unique to it but comparable with movements of other plates such as those associated with the Mid-Atlantic Ridge. Whatever may have happened, I feel free to think that the Deccan Plateau represents the top part of a gigantic, plow-shaped, granitic block the lower part of which plowed under (subducted) the ‘soft underbelly’ of the southern coast of Asia, raising up the Tibetan plateau.

Be all that as they may, the Deccan Plateau (“Deccan” is the corrupted form of the Sanskrit word “dakshina”, cognate with the Latin “dextro”, meaning ‘right’, since the south is towards your right when you stand facing the rising Sun. The original corruption happened because the invaders from the northwest, and later the British, could not pronounce Sanskrit words properly). The Plateau must have passed through regions of varied climatic conditions, from near Antarctic cold, to southern temperate, to southern tropical, to Equatorial, and to just northern tropical as it moved, through the eons, on its journey. I wonder if the seafloor spreading associated with that journey, possibly recording reversals of the magnetic poles, has been fully scientifically investigated the way it has been for the Mid-Atlantic Ridge.

The Plateau, as it now exists, has a mountain range called the “Western Ghats” (the local name is Sahyaadri in the northern part and Malayadri in the southern part) runs for about 1000 kilometers, leaving a coastal strip of about 80 to 100 kilometres width, and bounded on the east and by less spectacular hills to its, leaving a broad piedmont sloping down to the Bay of Bengal. The eastern and western ranges meet at a high point formed by the Neelagiri mountains (or Nilgiri, literally, neela - Blue + giri - Mountain), averaging 2500 metres in elevation. The northern part (the base of the triangle) is bounded by the Vindhya Mountains. While much of the water that falls on the Plateau during the monsoon rainy season is wasted into the Arabian Sea through short riverine flows, there are major east flowing rivers, the Mahanadi, the Godavari, the Krishna, the Kaveri, the Vaigai, the Tamraparni (the “flow with copper-red leaves”), and others.

Between the two main mountain ranges lies a rugged region encompassing rocky hills, broad depressions, rock outcroppings, plains regions, etc. It can be classed as semi-arid, with rainfall averaging about 100 mm, ill-distributed from humankind’s viewpoint, between end of June and the middle of September caused by the Southwest Monsoon. A region near southeastern part (the state of Tamil Nadu) receives some rain during November-January caused by the reverse-flowing Northeast Monsoon.

4 Recent history – the traditional system: Artificial water bodies

Water bodies, created as collection receptacles of natural run-off, have served the inhabitants of the Deccan Plateau from times immemorial. The traditional system of rainwater harvesting for making water available in the dry season, where rainfall is seasonal and often ill distributed, is a matter of wonder. More than a millennium ago, the leading forbears of the present population, the Palyagararu and the Gowda Rajaru (nomenclature in the local language, Kannada, for Local Chieftains or Vassal Kings; the most famous of whom was Kempe Gowda I of uncertain date, possibly 12th century), entrusted visionaries and ‘engineers’ of their times with the task of surveying the rises spanning broad depressions, that characterize the Deccan, in order to choose particularly suitable sites for building water storage systems.. Constructing such systems was considered as an act of great merit. Kempe Gowda I and his successors, who also went by the titular name “Kempe Gowda”, had many kere-s (‘kere’ - pronounced ‘kayray’ - is the Kannada word for an artificial water-holding system) constructed in their times.

Those ancient visionaries and ‘engineers’ employed by the chieftains were fully aware of the difficulties of carrying on productive agriculture in a tropical setting, with the seasonal rains confined to only a few months of a year. They visually surveyed (“eyeballed”) the undulating land and identified suitable low lands with seasonal flows, supervised the construction of long earthen bunds (called katte-s in the local Kannada language), revetted them on the storage side with cut granite, built weirs to take care of excess seasonal flow, and so on. The planning was comprehensive: the overflow from a lake at a higher elevation was made to take a natural course to flow into a

lower lake successively until the excess water in the ‘last‘ (bottommost) lake merged with a major flow, a river bound to the Deccan’s base level at the ocean. Most importantly, the water requirement of agricultural settlements could be controlled locally. Sluice gates were installed for the controlled release of water for agriculture and for use by the villagers living nearby - indeed the 'kere-s' were often named after the nearby villages. The water table remained high, and clean water that percolated was taken from stone-lined open wells sunk within the village limits, was utilized for drinking and cooking and other domestic purposes. Certain hereditary officials were appointed to take care of and oversee the repair and upkeep of the embankments and weirs. Siltation, tending to reduce the holding capacity, and that used to happen over some years, was taken care of by using the silt during dry seasons for making baked bricks. Little chapels were created on the bunds and worship, including animal sacrifice, offered to the protective, guardian deities. The occasion whenever the lake overflowed was always joyful …… I could go on in this manner but I shall stop here to ask God why He thought it fit to endow all those descendents of the original constructive people, who now inhabit the Plateau, only with low mental capacity (I avoid using the more appropriate castigate term dimwits’ here) that fails to understand that these water storages are, virtually, living systems.

The command area of each of the storage structures was highly agriculturally productive. The resulting steady availability of life's needs, needless to say, led to a flowering of high civilization, fine arts like music (both the art and its science), classical dance like Bharatanaatyam, folk dance-drama like Yakshagaana-/Bayalaata, artistic painting, the construction of intricately carved temples, the associated metallurgy for making carving implements and for weapons, philosophic speculation, and so on flourished. The sight of a water body is always stress-relieving.

Fig. 1 - General view of the water body showing scrub vegetated hill edging a depression characteristic of the Deccan, water collection, stone strengthened bund and pathway.

Fig. 2 - A vertical stone “scale”, placed in order to gauge the depth of the water can be seen. Clouds gathering at the beginning of the monsoon season over the water body are visible.

Fig. 3 - Strengthening ‘revetment’, made of dressed stone, lines this part of the earthen dam. Wild growth, which may serve to allow rainwater to percolate, can be seen on one side of the kere.

A tourist from Sydney, Australia, who stayed for some weeks in Bangalore some years ago, wrote a letter to the editor of a prominent Bangalore newspaper that he had read about Karnataka's laudable concern over air pollution, particularly in Bangalore but had seen nothing about any attempts to control water pollution. He noted that a flowing stream parallels Mysore Road leading to Mysore, the city of the palace of the old royal family (the 'Maharaja-s' of the state) southwest of Bangalore, before bending away to the south through farmland. "It is a foul, black, stinking stream which, piles up drifts of dirty foam." He wrote. "No doubt it is fed by drains and sewers but, at least as serious, it is fed by industrial wastes as well. In the crowded buses of Mysore Road, you can tell your whereabouts by its stench. Whatever industrial chemicals and other effluents it carries are certainly finding their way into the water table and the sources of washing and drinking water for the communities around. What would study of the health of people over the next few years in such communities as [a locality called] Rajarajeswary Nagar show? When I asked what grand plan was under way to control water pollution, and industrial effluents in general, and to clean up this stream in particular, I am told there is no plan at all!"

Things may change to what can be only be called 'slightly' better, at least towards greater awareness of the problem, since that letter was published. That is, some ten years after that letter was written, a sewage treatment plant was erected, with foreign collaboration, at great cost, over that particular stream ('Vrishabhavati' – river near the banks of which bulls roam – or roamed once). I believe that the plant is functioning even now though the stench appears not to have abated near the entrance to the Bangalore University situated on the Bangalore-Mysore road.

Though most of the good practices of the past continued till about the beginning of the last century a large part of the created system is being actively, almost systematically, destroyed now. Artificially created water bodies designed to collect rainwater ('rainwater harvesting' is the current buzz phrase), the kere-s, commonly called 'tanks' in the type of English used in these parts, are being allowed to die in many ways, not merely by bad planning but also by rampant, deliberate encroachment on the foreshores, obstruction of the seasonal flow channels and downright pollution. Because of urban 'development' on the foreshores that diverts runoff into storm water drains the amount of water that can percolate into the ground from rainfall has becomes reduced. Denudation that accompanies urban development allows silt and debris to be eroded into the 'tanks', quickly reducing their capacity. In most cases, raw sewage is actively diverted into the storages as part of so-called 'urban planning' because it can be done cheaply for the lazy reason that the 'tanks' occupy, of necessity, low areas. Solid waste, including building materials, dumped deliberately into the lakes, not merely by irresponsible citizens and even by municipal street-cleaning staff, compounds the matter so that when they can no longer hold enough water they are declared 'dead' - within a short time the 'tank' "ceases to exist". Land sharks, in connivance with corrupt authorities, who are empowered to give "permissions", soon claim the area for building high-rise apartment blocks whose basements often get flooded during the rainy season.

The present-day water supply to the conurbation of Bangalore depends much on pumping water from the river Cauvery through large diameter pipes. The river flows about 100 kilometers south of the city and one cannot even imagine how much, mostly thermally generated, green-house gas emitting, electric power is wasted in such effort. If anything, the Cauvery is overexploited, leading to inter-state disputes (with lower riparian Tamil Nadu state) over sharing the available water. Though the water supply is augmented with yield from bore wells not all of the needs of all parts of the city can be met. All this may not continue to be sustainable both in the short run because of power shortages and in the long run because of lowering of the water table. It is necessary to be aware that all this is happening not merely in and the vicinity of metropolitan centers but also extending to the countryside. The justification is that an increasing population needs housing. But should providing housing bring down the quality of life below even the ordinarily acceptable norm? How will that “growing population” be supplied with water and be fed?

The so-called lake-rejuvenation programs of the government does not look into wherefrom the lakes will receive water and how the lakes can be kept filled up, an absolute necessity. Rainfall within the spread (water catchment area) of the lake will never be enough and the flow of sewage through what were earlier clean seasonal flows in the catchments, that could have fed the lakes, is diverted into channels for keeping impounded water “clean”, without considering where the sewage will end up.

Can we take any remedial measures at all? Are there any low-tech, low-cost answers?

5 The UNEP report

Not too long ago, there appeared a report in a document prepared by the UN Environment Programme (UNEP) on the global threat from untreated sewage discharges to coastal people and the environment. The gist of the report was that inhabitants of southern Asia face a greater threat than anywhere else in the world from the discharge of untreated sewage, apart from endangering marine wildlife and habitats, and fisheries. The document was published as a follow-up to the World Summit on Sustainable Development (WSSD, Johannesburg). Almost 40% of the world's population lives within 60 kilometers of the coast in southern Asia, putting it at high risk of sewage-related diseases and even death.

Since the report made no mention of a tentative finding that discharge of raw sewage into the Caribbean from the southern U.S. and eastern Mexican coasts (and, possibly also, into the Guanabara Bay from the flanking metropolises, São Paulo, Rio de Janeiro …) had endangered coral formations in the Middle and South Atlantic I thought, at first, that it was of the same ilk as a paper published by U. S. authors in a respectable scientific journal holding India and China responsible for the largest emission of the greenhouse gas, methane, because domestic ruminants are kept in large numbers in those yet-to-develop countries. But then I had to take it seriously because it added: "There has been impressive progress in providing sanitation in many of the worst-affected areas …… But

the population grew by 222 million, wiping out the gains that had been made." It continued: "One way of tackling this is to get key parties to set realistic but ambitious wastewater emission targets (WET-s), echoing those that have been developed in many parts of the world for emissions of toxic chemicals and noxious gases from power stations and factories. In some cases, wastewater treatment systems modeled on those in Europe and the US may be needed. *But there are many low-cost techniques that could make huge improvements* (italics mine)." The report did reflect the then current thinking but to this we must now add the increasingly large amounts of plastic waste.

6 Low-tech answers

In making its recommendations, UNEP report said the low-cost techniques could give the environment a double benefit. It added, in a rather obvious manner, that such techniques could include dry sanitation and natural sewage filtering systems like ponds, reed beds and mangrove swamps, and re-using and refilling groundwater reservoirs. It warned that many such natural systems, important habitats for wildlife such as waterfowl and fish, are being cleared and drained for agriculture and other activities. "If more people are aware of their potential as 'natural' wastewater treatment systems, then more will be conserved for their economic and health benefits, as well as for their importance for nature and wildlife." There are some expert cost estimates of providing safe drinking water and proper sanitation to everyone in the world by 2025: $180 bn a year, two to three times more than the present investments in the water sector. That may sound very high but the benefits in terms of disease reduction and dramatic environmental improvements are also high."

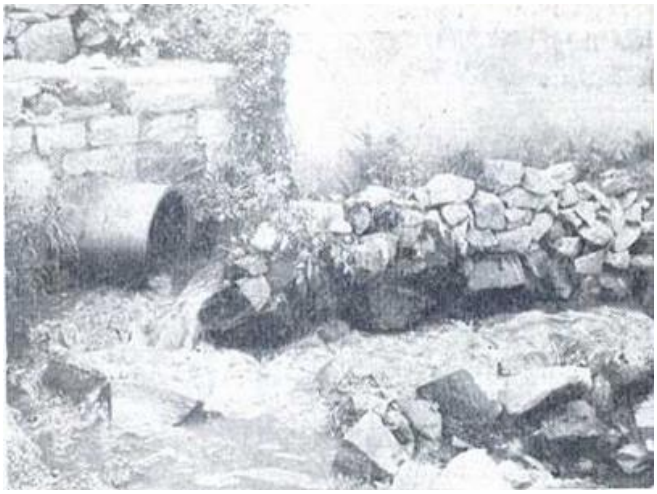
7 Courses of action

Thankfully, there is a realization on the part of responsible people, activists, organizations, etc. on the need to preserve and maintain clean water bodies in and near urban settings. But those, including even municipal bodies or government agencies who want to set things right, seem to entertain many misconceptions about how to go about such matters. Letting in untreated sewage is an unacceptable practice. But stopping sewage flow is not the remedy since that is near impossible - letting in properly treated, cleaned-up sewage is not. Indeed, that practice is necessary since, as already implied, the water bodies are virtual living systems - they need replenishment of water loss. Mere dredging and deepening, touted as "rejuvenation of lakes," for which large funding has been made available from time to time to governmental agencies, while necessary, is not a remedy that is going to pull the water bodies from the brink of death. Growth of water hyacinth [Eichhornia crassipes; Flor de aguapé in Spanish] which is common and quite extensive, is, by itself, thought of as 'pollution'. Actually, it is not only an indicator of the presence pollution but also an important cleaning-up agent. (Please see information on such use of Eichhornia available on the Internet through any search engine.) It shows there is a lot of nutrient available in the form of unclean discharges into a lake.

8 The microbiological clean-up process: A study of the natural process of cleaning sewage

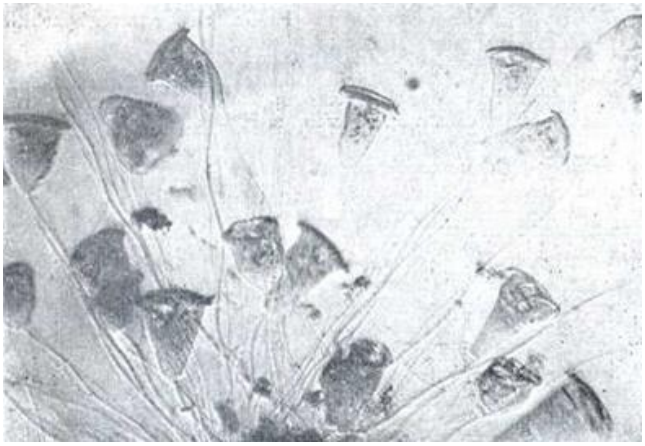
More than three quarters of a century ago, the late Dr. C. V. Natarajan (1899 – 1964), then Deputy Director in the Department of Public Health of the Karnataka state, Bangalore, India, noticed clothes being washed by washer men (‘dhobies’, ‘agasaru’, in Kannada) in the traditional manner, without any ill effects, in streams he knew carried sewage from Bangalore. A preliminary analysis at the Public Health Institute (Seshadri Road, Bangalore) showed that the water was free from pathogenic organisms some distance upstream, before the places where the washer men were active. He persuaded the late Professor S. C. Pillai of the Sanitation Biochemistry section of the Department of Biochemistry, Indian institute of Science, Bangalore, to study and pinpoint the factor or factors that seem to lead to the upgradation of flowing sewage to apparent natural river-quality water. The collaborative work of Natarajan and Pillai lead to the publication of a series of scientific papers. The one that appeared in India’s biweekly national magazine Current Science ["Natural Purification of Flowing Sewage" by S. C. Pillai, G. J. Mohanrao, A. V. S. Prabhakara Rao, C. A. Sastry, P. V. R. Subrahmanyam and C. V. Natarajan, Current Science, XXIX (12), 461 (1960)] can be regarded as a summarization of results then in hand. This paper, gathering the results of their investigation showing microbial activity that leads to the natural elevation of flowing sewage to river-quality water, disclosed that turbulence in a channel with adequate gradient facilitates the dissolution of oxygen. When once oxygen concentration reaches about 3.5 ppm fluffy masses of ciliate protozoa (Carchesiunm, Epistylis) develop and flocculate suspended matter and microbial entities, including pathogenic organisms. Since amino acids in the clarified sewage are also rapidly destroyed eventually, what underlies the development of high biological oxygen demand is removed.

The authors found that flowing sewage can be divided broadly into four zones (please see the figures below). The lengths of each of these zones appeared, understandably, depended (rather critically) on the gradient of the channel through which the sewage was directed to flow. I now quote in extenso from the Natarajan-Pillai paper:

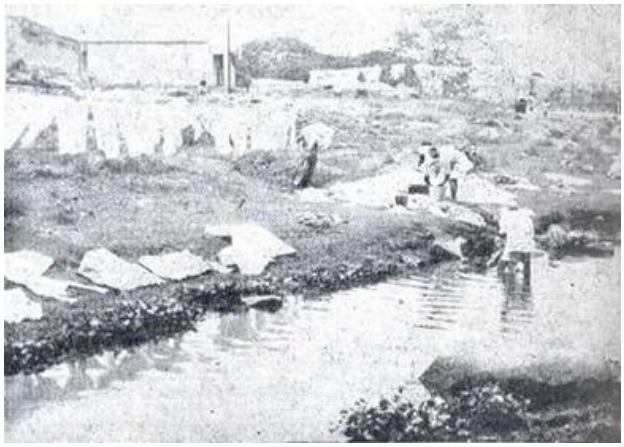


First zone: Discharge of raw sewage over rocks. Preliminary changes leading to clarification and oxygenation.

Second zone: Growth of protozoa on rock surfaces leading to further clarification and oxygenation.



Third zone: Clumped growth of Epistylis and Carchesium assist denitrification. Nitrogen-containing entities (amino acids) percolate into the soil and nitrification.



Fourth zone: The relatively cleaned-up, river-quality effluent used for clothes washing purposes with no client ill-effects.

[Illustrations reproduced from the paper in *Current Science* referenced in the text.]

"…. Bacteria, as generally found in domestic sewage, and occasionally, epidemic-causing Salmonella typhi, Vibrio cholerae, etc. were found in the first zone. Fungi of the Sphærotilus sp. were often present in samples. While algae were generally not seen, protozoa (Rhizopoda -. Amoeba and Arcella sp.; Mastigophora - Bicosoeca and Euglena sp.; Ciliophora - Colpoda, Colpidium, Coleps, Stylonychia, Paramecium, Vorticella and occasionally species of Opercularia, Epistylis and Carchesium) were beginning to be detected. Besides, insect larvae (Aulophorus sp.; Mosquito (Culex sp.); Bloodworm - Chironomus sp.) were seen often…….

"[Our] most interesting finding was that protozoa of species Epistylis and Carchesium developed in strikingly large numbers in the second zone. They formed large masses adhering to the rock or masonry surfaces of the channels. Insect larvae, now present in greater numbers, included Anopheles and Rotifera. Snails, fish Gambusia affinis that eat mosquito larvae) and frogs also made their appearance. Algae (Oscillatoria, Ulothrix, Urospora Stigeoclonium, Pinnularia) began to predominate in the third zone. Larger fish, frogs and water hyacinth began to proliferate. The water became much less odoriferous."

The authors successfully reproduced the clarification/purification process under laboratory conditions using the protozoan species taken from the sewage channels where the second stage conditions prevailed: "……. the more important factors influencing purification of the flowing sewage include: (1) adequate agitation or turbulence of the sewage and other conditions in the channel, which facilitate the dissolution of oxygen to the extent of about 3.5 p.p.m., with the (2) consequent development, in large numbers, of ciliate protozoa, notably of the species of Carchesiunm and Epistylis, which are always found in activated sludge. When these protozoan colonies were taken out, washed and introduced into the sewage (at 10-25% level, by volume) and the mixture gently shaken or

into which air was bubbled for 1½ - 6 hours (depending on the number of the organisms), it was observed that the sewage was clarified and oxygenated almost to the same extent as under the natural conditions in the channels. The flocculating activity of the protozoa and the clarification of the sewage also seemed to explain the relatively high nitrogen content of the soils under the flowing sewage in the zone of clarification and to bring about nitrification and other changes, e.g., rapid; removal of amino acids from the sewage in the succeeding stages of purification in the channels. The quality of the final effluents from these channels was similar to that from the activated sludge process.

The authors concluded their paper saying: "Natural purification of flowing sewage is thus essentially an aerobic process and, under the most favorable conditions, it would proceed rapidly, as observed in the channel having l-in-50 gradient, and gives results attainable only by the activated sludge process. [Our] observations are of scientific interest as well as of practical importance as they not only relate to a sanitary principle in Nature and its bearing, particularly, on the modern methods of sewage disposal but indicate the possibility of increasing the efficiency of the activated sludge process and other methods of aerobic treatment of sewage."

These quotations clearly illustrate how the proliferation of different species in the successive stages of flowing sewage dramatically upgrades the quality of water. The work did not, evidently, look for the presence and concentration of heavy metals (e.g. chromium from tanneries, both chromium and cadmium from electroplating industries, lead from battery works, metals from manufacture of electric lamps, industrial scale washing, etc.) etc.) that might prove lethal to the organisms (protozoa) whose presence leads to the natural water quality upgradation phenomenon.

I think it is evident from these results that the natural process can lend itself to acceleration to a good degree. There already exist in the Bangalore region many channels that lead the sewage out of town. (I must add here that the channels have been engineered to make the flow straight. Expert opinion now holds that a meandering flow, being more natural, would have given a chance to the natural processes to work better.) Treatment plants have been erected but they treat only some of the discharge. The natural processes continue, of course, but they may not be able to handle, within practicable flow distances, the heavy load that should, by now, be many times more than what it was three quarters of a century ago.

9 What can be done

It appears clear that the natural process can lend itself to acceleration to a good degree. Much of the systems of the old, serially connected artificial lakes and ponds is still intact, distributed over many districts of the state of Karnataka. Of particular interest are, however, those near heavy settlements - cities and townships. There already exist in the Bangalore region many channels that lead the sewage out of town. But these channels have been engineered to make the flow fast coursing through straight, not meandering, channels. Treatment plants have been

erected at great expense, and under the guidance of foreign expertise, but they treat only some, and not all, of the grey water discharge. The natural processes continue, of course, but they may not be able to handle, within practicable flow distances, the heavy load that should, by now, be many times more than what it was three quarters of a century ago.

Firstly, a survey should be conducted to map and identify a given system of serially connected lakes, a task that may not be easy now due to illegal construction. It can be assumed that at the present time all the lakes, from the one at the highest elevation to the lowest receive sewage water at various points. It is possible that some inlet points may not be identifiable or the inlet has been diverted to "protect" the lake.

The primary action to take in the second step is to restore the outflow channels and repair the weirs that carry off the excess water flowing into the lakes. Wherever possible, meanders should be introduced into the channels that connect the lakes. It will be highly advantageous to establish mechanical gatherers that operate in the meanders to remove plastic materials and floating debris. Well-designed debris gatherers (booms, nets etc.) are readily available in the market.

In order to accelerate the process of oxygenation artificial aeration has to be carried out by means of aerators of sufficient power. Aerators of standard design employing the air-entrainment principle are commercially available. An alternate method of aeration could be to erect a fountain or a series of fountains that throw water straight up to a height of about 10 meters near the centers of the lakes. No doubt, taking such actions will be energy intensive but they can be avoided by constructing waterfalls of short height and providing for flow through emplacement of large rough rocks to stir the flow of water greatly.

The third step is to create holding systems where water hyacinth is allowed to grow, where it can survive, mitigating the presence of heavy metal contamination.

10 Heavy metal contamination

Over time there may be an accumulation of sedimented heavy metal contamination in the lakes, especially within the ones at the lowest reaches. Natarajan and Pillai and their team did not specifically investigate this aspect though one may be certain they would have been fully aware that heavy metals would have deleterious effects on the proliferation of the biological organisms that are the clean-up agents, the protozoa. Presence of heavy metal contamination was, perhaps, not a serious problem at the time the investigation was carried out 60+ years ago. If anything, heavy metal content could only have increased since the 1960's due to the proliferation of diverse modern industries which may discharge their effluents directly into the channels. The investigation did show, however, that when once clean up has proceeded to an extent water hyacinth and certain water plants begin to grow.

There is widespread misconception that the presence of water hyacinth is, by itself, "pollution". Rather, its growth is a declarative symbol of pollution. It shows there is a lot of nutrient available in the form of unclean discharges in the water body. Numerous investigations have shown that water hyacinth can not only lead to the destruction of many degradable toxic materials and absorb heavy metals but can also reduce biological oxygen demand significantly. Harvesting the growth from time to time, burning it for useful heat or subjecting it to the bio-methanation process and disposing off the residues/ashes in a safe way, (treating it as if it were radioactive waste!) at designated sites wherefrom the toxic materials cannot be leached out into the groundwater are the sensible actions to do. Removing water hyacinth ('eradicating it' as it is often described) is like cutting the head off to cure one's headache!

A practical way to remove much of the metal contamination would be to create strategically located shallow (not more than one meter deep) ponds provided with controlled inlet and outlet channels. Needless to say, the inlet channel will be somewhat lower than the water level of the water impoundment with which it connects and the outlet will be made to discharge water into the lake at the next lower-elevation. Water hyacinth is cultivated in these ponds and the growth is mechanically collected from an end of the pond where it is blown by the prevailing wind. The pond can be so shaped as to facilitate such collection. Mechanical devices that collect and bring out on shore hyacinth growths have been demonstrated in Bangalore.

11 Presence of industrial and heavy greases and mineral oils

Though mineral oils and heavy greases are biodegradable in the long run there may be no clear-cut low-cost way for their removal. It is known that micro bubbles of air flock such material and bring them to the surface from where the flocculated material can be skimmed off for eventual incineration. The procedure can be expensive. It appears best to combine a chosen method of flocculating greasy materials with the aeration at the second stage, before the water enters the water hyacinth growth stage.

12 The final stage

The final stage in bringing the sewage to river quality water is to erect a pumping system of large enough capacity to convey water from the lake at the lowest elevation to the one at the highest elevation to effect the desired recycling of water. This could be the most expensive and most energy-consuming part of the proposal.

I expect that the quality of water will take time to improve but the time to become shorter gradually after the start of the process. The water needs to be tested for quality (reduction in suspended matter, in the pathological bacterial count, in biological oxygen demand, etc.) at several points of the system to enable any corrective measures to be taken. If it meets standards set for agricultural uses the water can be diverted for such use since the water in the system will be replenished constantly. Alternately, whenever the water quality permits, the excess water can be let out into nearest river system.

The way the system is designed there need not be any restriction on where additional sewage is added. It can even easily handle the extra inflows during the rainy season. Each lake, at every level, needs to get filled up after natural loss of water for different types of use during the dry season before it begins to overflow and the processes of natural improvement in the quality of water (dilution among them) will continue in an uninterrupted way.

Strict vigilance must be exercised that no non-biodegradable matter (plastics, metal structures or pieces, building debris, etc.) is thrown in. Open or clandestine discharge of non-biodegradable solid waste either into the channels or directly into the lakes should be declared a cognizable offence.

13 Concluding remarks

The lake systems of India's Deccan are a priceless heritage bequeathed to us by the forefathers of the present inhabitants. The water bodies they created are virtual living systems in that they now form part of an important ecosystem that includes traditional methods of cultivation, animal husbandry, and, indeed, the mode of daily living.

The lake systems were adequate to handle man-made pollution when the population was small and methods less exploitative. Overexploitation of ground and riverine water resources will lead to water scarcity and public unrest in the not too far future (It may be beginning to happen right now!). Lack of care, dumping of solid wastes by persons who lack civic sense and pride, absence of setting of enforced emission standards for industrial effluents, letting in raw sewage either directly into the lakes or into the connecting channels without remediation, etc. contribute to the active destruction of really valuable extant public assets in the form of ancient unnatural water bodies that replenished ground water resources.

The living lake systems need replenishment to make up for loss of water. Mere dredging and deepening under the so-called, much touted, program for the "rejuvenation of lakes", for which large funding has been made available, while necessary, is not adequate to pull the water bodies from the brink of death by eradication. Projects for building of jogging and walking paths, raising rose gardens, etc. do not look into how the lakes will get filled to the optimum level. Rainfall within the spread of the lake or even within its catchment area will never be enough and the flow of sewage through former seasonal flows, now filling some lakes, is diverted into channels for keeping impounded water "clean", without considering where the sewage will end up.

If natural methods as outlined above are adopted and the infrastructure necessary for them to work is in place, the existing sewage collection and lake network can be rejuvenated. What has been proposed will sound utopian and impracticable. But then, if achieved, it is needless to say, the benefit from clean recharging of groundwater would be incalculable. Since the sight of bodies of water and babbling streams has a stress-relieving effect, construction/rejuvenation of lakes may even help to contain human extremism and fundamentalism of various forms.

There is bound to be loss of water from the system over a period of time. The total storage in the lakes can be replenished from sources from which current supplies are drawn (in the case of Bangalore it is the Cauvery River).

If the initial operation proves successful in clarifying the sewage, in reducing its bacterial content, and biological oxygen demand, reduction of stench, no reason should stand in the way of going ahead with a fully planned project. It is thought that the proposed system, which can cater to an extended Deccan region, will be economically feasible compared with a high-technology, high-cost system that needs to be individually established for each municipality. It is unnecessary to add that the method will have beneficial effects on the water table level.

It has been said Bangalore and its environs (and, indeed all of the state of Karnataka) is fortunate in having beautiful 'lakes'. It is necessary to remember that these 'lakes' are not natural but man-made reservoirs. I hope enough wisdom will come to those who talk of something called ‘water harvesting’, as if it was something new, and then go about destroying the very facilities created for that very purpose during a more creative past.

Modular AirCubes: Attenuated-air Devices for Lifting, Transporting, Building, Energy Capture, and Agriculture

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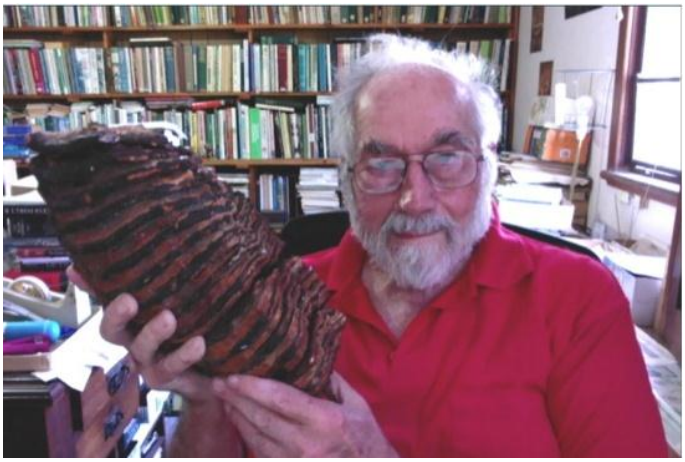
Abstract: Attenuated-air devices have a 2000-year history, starting with the Chinese Sky Lantern, a small hot-air balloon. Other such devices perfected or imagined over the years include hydrogen balloons and vacuum balloons, all individual devices, mostly for lifting purposes. The present article describes the construction of all manner of structures and devices, using Modular AirCubes to produce objects of much lower cost and wider application than the conventional one-item approach.

Key words: Attenuated air devices, hot air balloons, hydrogen balloons, modular construction, AirCubes.

Resumo: Dispositivos de ar atenuado têm uma história de 2.000 anos, começando com o *Chinese Sky Lantern*, um pequeno balão de ar quente. Outros dispositivos aperfeiçoados ou imaginados ao longo dos anos incluem balões de hidrogênio e balões de vácuo, todos dispositivos individuais, principalmente para fins de elevação. O presente artigo descreve a construção de todos os tipos de estruturas e dispositivos, usando AirCubes Modulares para produzir objetos de custo muito menor e aplicação mais ampla do que a abordagem convencional conhecida como *one-item approach*.

Palavras-chave: Dispositivos de ar atenuado, balões de ar quente, balões de hidrogênio, construção modular, *AirCubes*.



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1 Attenuated-air devices in history

Attenuated-air devices have a history of more than 2000 years, starting with the Chinese Sky Lantern. This is believed to date back to the Third Century BC, but perhaps the oldest well-documented sources are the references to the Chinese sage and military strategist Zhuge Liang (181–234 AD), popularly called Kongming.

Figure 1 — The Chinese military strategist Kongming.

Kongming is said to have used a message written on a sky lantern to summon help on an occasion when he was surrounded by enemy troops. For this reason, they are still known in China as Kongming lanterns.

In modern times, sky lanterns are readily available from the Internet, costing less than $2 each. These miniature hot-air balloons get their lift from a contained lit candle or similar fuel source.

Figure 2 — Sky Lanterns as sold over the Internet. From reference [1].

2 Passenger-carrying balloons

The first hot-air balloons capable of carrying passengers were developed in France by the Montgolfier Brothers, in 1783 [5]. The first free flight carrying human passengers took place on November 21 in Paris, and among the spectators was Benjamin Franklin, who was the US Ambassador to France at the time.

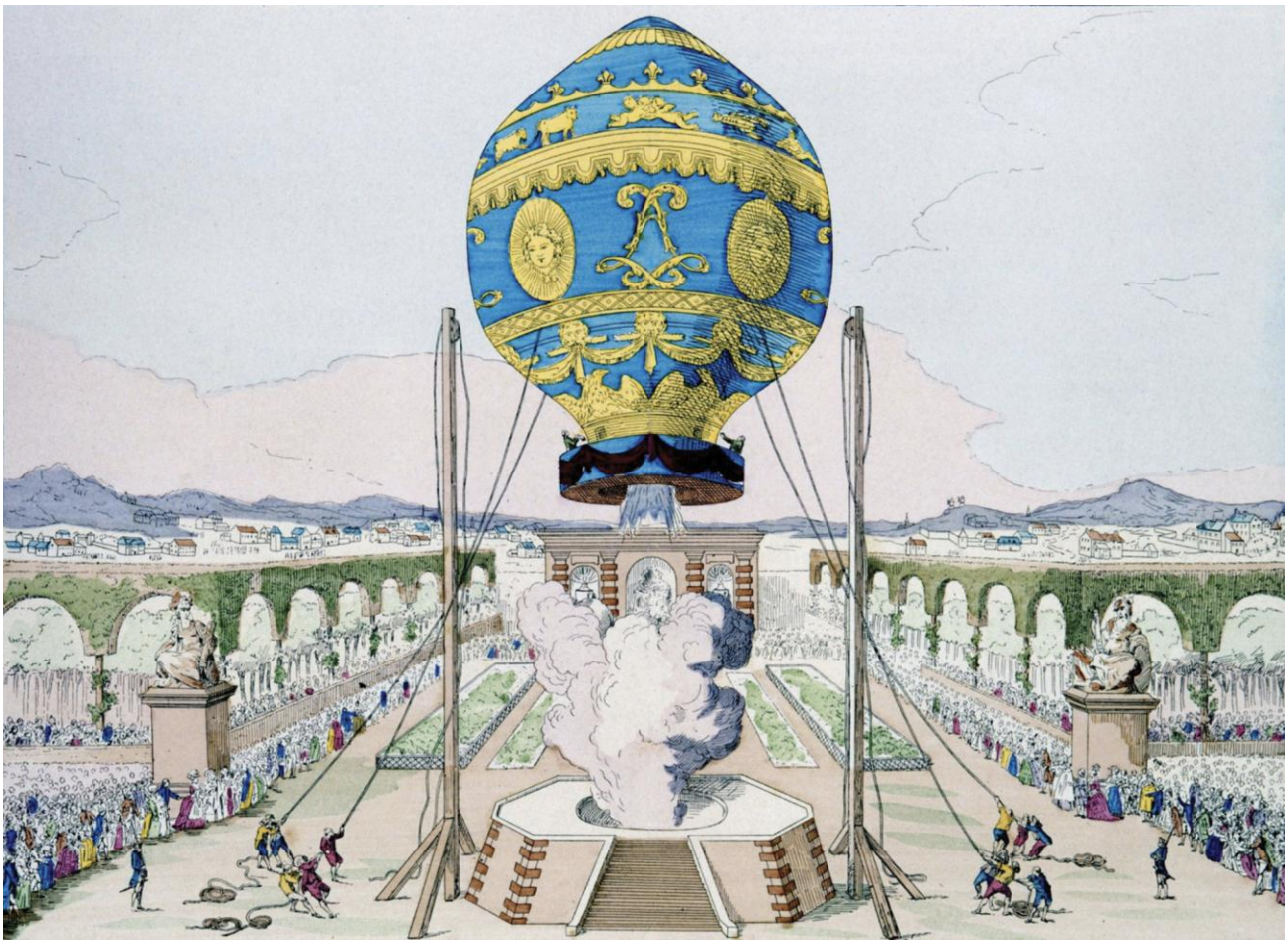


Figure 3 — Launch of a Montgolfier hot-air balloon. From reference [6].

In modern times, hot-air balloons are mostly used for recreational flights, though some are used in research. These balloons can reach extreme altitudes — in 2005 one attained a height of over 21 kilometers [5].

Hydrogen-filled passenger balloons were developed at the same time as hot-air balloons. The first manned flight of a hydrogen balloon took place in Paris on December 1, 1783, only a few days after the hot-air balloon launch. The flight reached a height of 550 meters, and went for 36 kilometers [7].

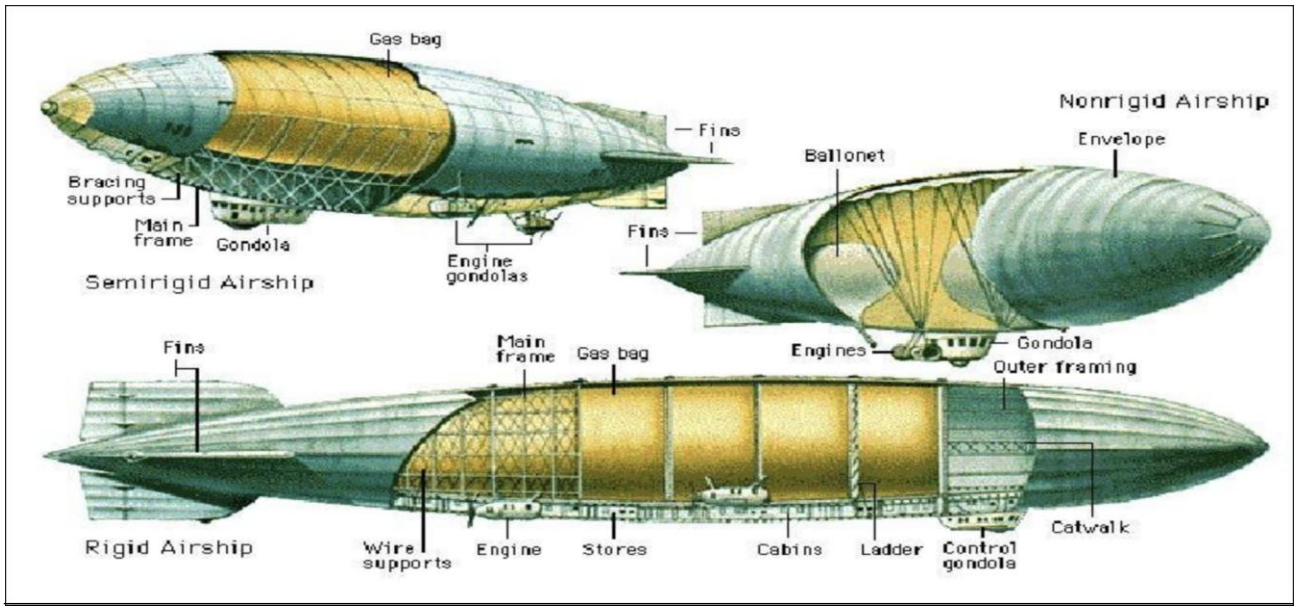


Figure 4 — Construction variations in airships. From reference [9].

During the early 1900s, rapid development took place of gas-filled airships, particularly the German craft known as Zeppelins [8]. These airships had a number of gas-bags contained within a rigid light metal frame. Between 1910 and 1937, commercial airship services were run using hydrogen-filled Zeppelins. Zeppelins were also used by the German military to bomb Britain during the first World War.

3 **Vacuum balloons**

In 1982 I realized that lighter-than-air craft could be made using cells from which all air had been evacuated — vacuum balloons — and had a relevant article published in *Speculations in Science and Technology* [9].

Obviously the evacuated cells had to have walls which were rigid enough so that they would not collapse under the pressure of the surrounding atmosphere. This could be done with a rigid metal sphere, or with a spherical wall supported by a geodesic dome framework. It could also be done with an inflated double sphere, like an inflated motor tyre, with the two surfaces connected by threads. I consulted with a local mathematician, Malcolm Hood, and his advice was that such a device would theoretically be stable in a 1-atmosphere pressure if the internal pressure of the air within the double skin was in excess of 2 atmospheres.

I had read a story by the science-fiction author and inventor Arthur C. Clarke, in which one of the characters claimed that the only lifting balloon possible, on a planet with a hydrogen atmosphere, would be one based on hot hydrogen. I sent a copy of the Speculations article [9] to Clarke, pointing out that a vacuum balloon should also work.

Clarke replied graciously and said the article was very interesting, but why hadn't I mentioned Lana's work? When I followed up Clarke's lead, I was very surprised to find that as long ago as 1670, a Jesuit Monk, Francis Lana, described an aircraft based on the vacuum balloon principle in his book Prodromo dell'Arte Maestra, published in Brescia, Italy.

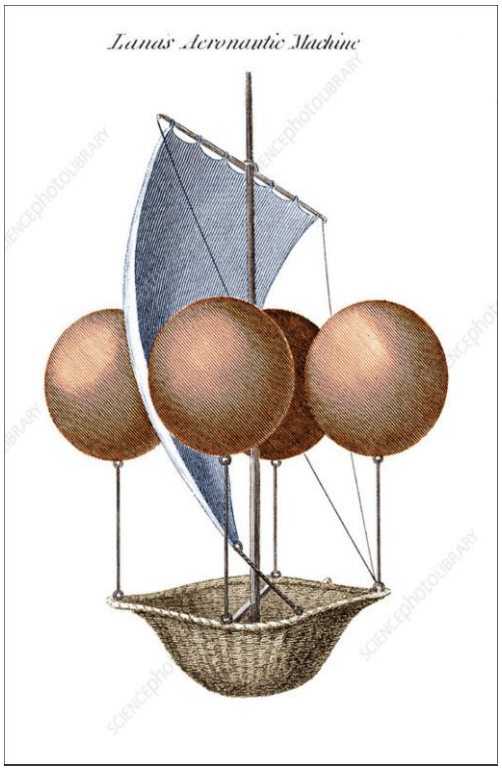


Figure 5 — Lana's Aeronautic Machine. From reference [12].

Lana's design suggested using perfectly spherical, evacuated thin-copper spheres. In practice, these would have been rapidly crushed by the atmosphere.

But the theory is sound, and evacuation, together with attenuation by heating, and part or full replacement by hydrogen, form the three main contenders for use in AirCubes.

In 2006, I collected today various discussions and suggestions about vacuum balloons in a web article, The Vacuum Balloon [11].

Building up devices and structures from standard modules is a basic requirement in the development of AirCubes as practical and commercial items. In this approach, the standard module is taken to be a cube with edge dimensions of 2 meters — and hence with an internal volume of 8 cubic meters. The importance of modularity can be seen by comparison with another type of project, that of building a house. In Western Australia, it is still common to build detached houses with double-brick walls (inside and outside walls both brick). A typical house might use 20,000 bricks.

If architects draw up a plan for a house using double-brick walls, they need only specify the dimensions of the walls. Bricks are a standard size, they can be obtained from any brick supplier to suit.

The production of a commercial airship like the Zeppelins is a major project and involves considerable planning and major costs, typically in the millions of dollars. It is estimated below that Modular AirCubes, produced in a large factory, would cost only $10 each, and perhaps less.

A competent bricklayer could conceivably himself build most of the structure of a brick house, working from a rough plan, and ordering new lots of bricks as needed. Similarly, a competent person could conceivably build many of the devices and structures described below, ordering in batches of AirCubes as needed.

5 Manufacturing AirCubes

In this article, "AirCube" refers to one module of a system of construction using empty cubes, each made up by joining 6 sides or Faces, usually made of plastic and fibers. Typically, each Face is a double skin with the two sides of the Face connected together by multiple threads, and each face can be made rigid by inflating the air between the two sides.

There is an existing heavier analog of AirCube faces which uses "Drop-Stitch Fabric", a special type of PVC-coated fabric material that has billions of polyester "spacer threads" holding the top and bottom PVC layers. The air chamber is held firmly in shape by these spacer threads, allowing the inflated structure to maintain its shape and stability under heavy outside pressure and impact. These fabrics are used to produce inflatable boats and docks, some of considerable size — as much as 18 meters long.

Figure 6 — Inflated boat and dock structures. From reference [13].

For AirCube faces, the structures must be much lighter than those using drop-stitch fabrics. Each square face has sides of length 2 meters, so when six Faces are combined into a cube, this cube will have a volume of 8 cubic meters.

Note that the corners of each Face in Figure 7 are shown as separate parts (with dotted lines). In the process of joining the six Faces to make a cube, these corners are folded back and not joined to adjacent Faces. The reasons for this will be seen below.

Typically each Face is a square made up of two PVC layers, enclosing a square of fiber fluff slightly smaller than the enclosing PVC layers.

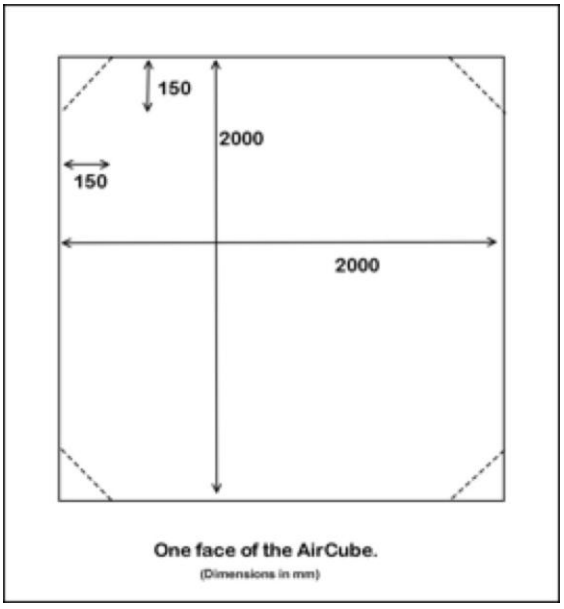


Figure 7 — An AirCube face.

5.1 Pilot Manufacture of AirCube Faces

Setting up a manufacturing facility for producing AirCube Faces will first require trials of suitable materials. The three components to be trialed are: the Sheeting, the Fiber, and the Adhesive. A suggested trial route is described in *Appendix 1: Pilot Manufacture of AirCube Faces*.

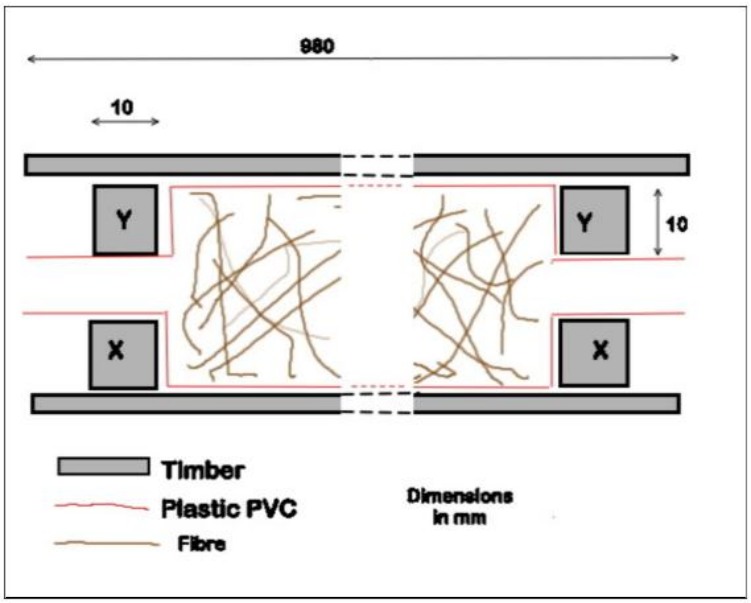


Figure 8 — Pilot production of AirCube faces.

A cube has 6 faces. To put together an AirCube, six faces are cut from the belt, in two sets of 3. Each triplet is bent at the joint into an open U-shape, as in Figure 10. The two triplets are put together to form the six faces of the cube. This arrangement means that half the face-edge joins are already made.

6 Manufacture and assembly of Simple AirCubes

AirCube faces would typically be manufactured in a continuous belt, as depicted in Figure 9. The brown parts are where fibers fill the space between the Sheeting, while the white parts are where both parts of the Sheeting are welded together,

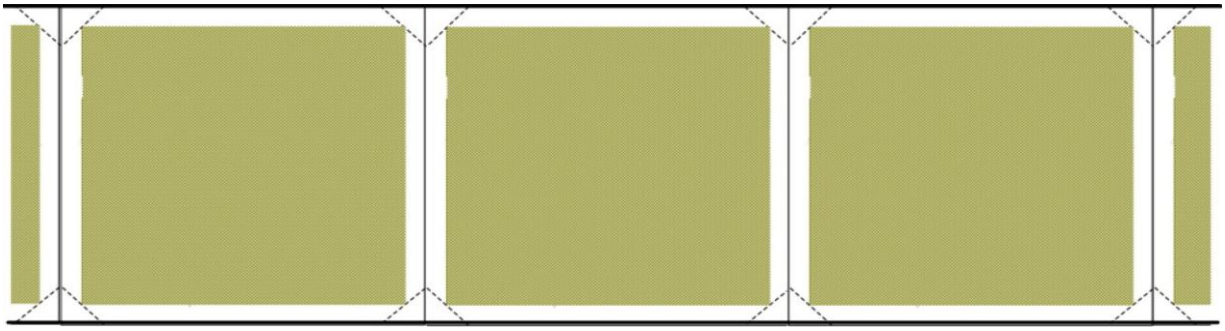


Figure 9 — Factory production of Simple AirCube Face belts.

A cube has 6 faces. To put together an AirCube, six faces are cut from the belt, in two sets of 3. Each triplet is bent at the joint into an open U-shape, as in Figure 10. The two triplets are put together to form the six faces of the cube. This arrangement means that half the face-edge joins are already made.

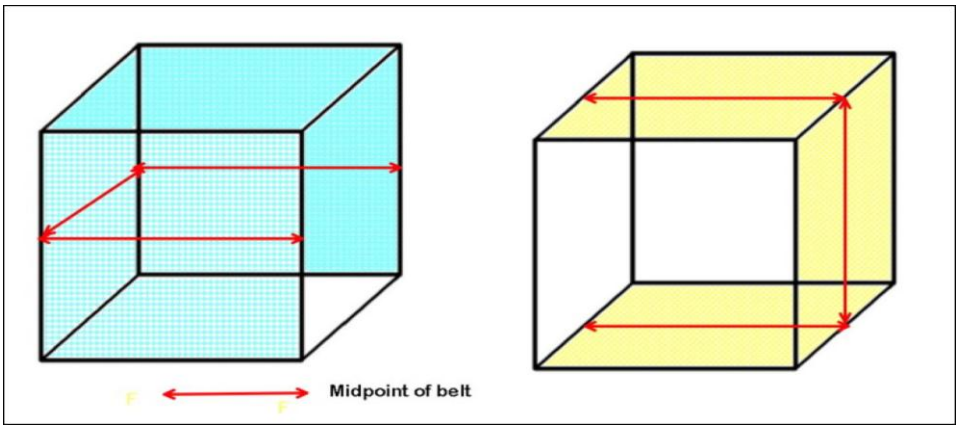


Figure 10 — Two face-triplets joined to form a complete cube.

The rest of the joins are then made by heat-pressing, gluing, or some other means (such as with ultraviolet-set resin). Note that the cube corners are not square, as shown in Figure 10. Instead, the belt sections are cut down to where the dotted lines intersect in Figure 9, leaving triangular flaps. These flaps are then glued together so that all corners of the cube are beveled. If, in making the beveled corners, one or more tabs are formed, these provide the simplest means of combining a number of cubes, by roping them together.

In an alternative simple method of assembly, use is made of the sort of press seals used to open or close plastic bags. During manufacture of the Face belts, these press seals are incorporated along the belt sides and between each face. To assemble an AirCube, the edges of the six Faces are simply pressed together.

For transport, Faces can be folded back on each other to form a vertical stack, as in Figure 11. This pattern is technically known as a boustrophedon pattern.

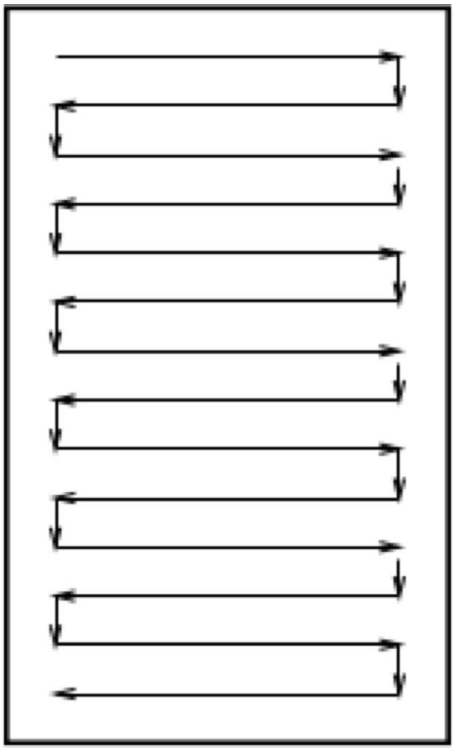


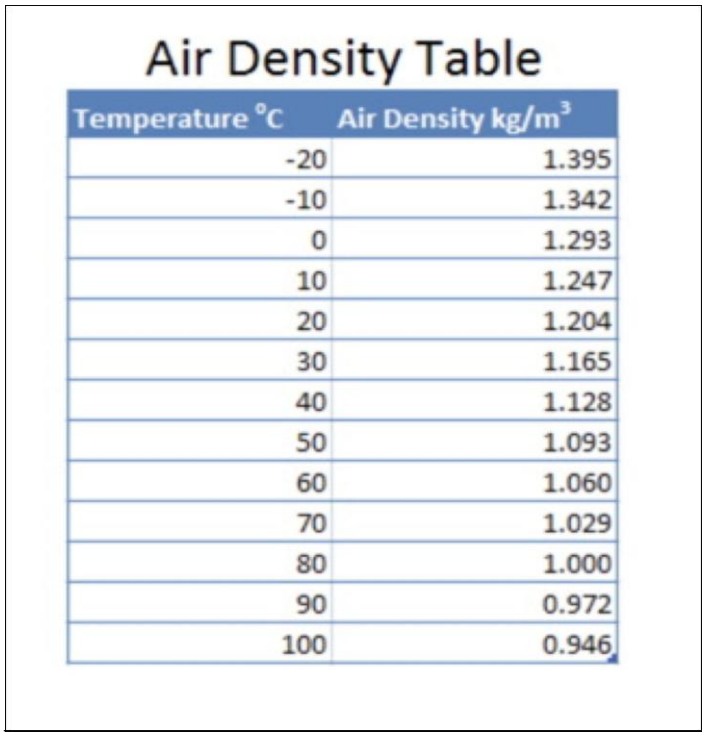
Figure 11 — Stacking Face belts for transport in boustrophedon pattern.

7 AirCube contents and lifting ability

Once formed, a cube has one internal space (the Core) and six bounding faces, each of which has an internal (Skin) space. The contents of each of these spaces will be referred to as the Core Fluids and the Skin Fluids. Typically, the Core Fluid will be hydrogen or attenuated air, and the Skin Fluid will be compressed air.

The simplest approach is to use hot air as the Core Fluid, but use of hydrogen, and attenuation with a vacuum pump, don't present any special difficulties. The most lift will be obtained when the Core Fluid is completely attenuated,

that is, is a vacuum, but much lesser degrees of attenuation have been demonstrated successfully in the past, in particular, with hot-air balloons. Figure 12 shows a table of air density at different temperatures.



Air Density Table

Temperature °C	Air Density kg/m³
-20	1.395
-10	1.342
0	1.293
10	1.247
20	1.204
30	1.165
40	1.128
50	1.093
60	1.060
70	1.029
80	1.000
90	0.972
100	0.946

Figure 12 — Air density at different temperatures. From reference [14].

At a standard temperature of 20 deg C ("room temperature"), 1 cubic meter of air weighs about 1.2 Kg. Displacing this air with a complete vacuum would yield a theoretical lift of the same amount, 1.2 Kg. A standard AirCube would have a volume of 8 cubic meters, and a theoretical lift of 9.6 Kg. For convenience of calculation, assume that the structure of the AirCube weighs 1.6 Kg, then the "standard lift" of an evacuated AirCube would be 8 Kilograms.

We will use this "Standard Lift" of an AirCube of 8 kg in the various calculations below. It should certainly be attainable, possibly even bettered, but that depends on details of materials and such.

Now consider the AirCube as a hot-air balloon. Note from the table in Figure 12, that 1 cubic meter of air at a temperature of 80 deg C (a reasonable working temperature) has a density of about 1.0 Kg per cubic meter (about 83 % of standard atmospheric). Therefore, heating the air inside an AirCube to 80 deg C should provide a lift of 0.2 x 8 Kg = 1.6 Kg — just about enough for the AirCube to start to take off.

As a simple trial, an electric element could be inserted inside an AirCube to heat the air inside to 80 deg C, with an escape valve to allow excess air to escape. If this air increased in temperature above 80 deg C, the AirCube should start to rise — and there would be no pressure difference between the outside and the inside of the cube.

The same reasoning applies if a vacuum pump was applied to suck some of the air out of the AirCube. When the Core Fluid is attenuated to about 83 % of standard, the AirCube should start to rise, There is no need to evacuate the air completely to demonstrate the effect.

For comparison, if all the air in an AirCube was replaced by hydrogen, this would reduce the density of the Core contents to about 7% of standard, providing considerable lift. Heating the hydrogen would increase the lift.

For practical use, photocells on the surface of an AirCube could provide ample power to heat the air inside -- the candle in a Sky Lantern represents about 80 Watts of power. For night-time use, a rechargeable battery could be added, though this might not be needed (once heated, air inside an AirCube should be insulated by the still-air Sides, as are double-glazed windows).

6 Manufacture and assembly of Complex AirCubes

The properties and capabilities of simple AirCubes could be greatly enhanced by a number of improvements at both the manufacturing and assembly stages.

Corner Sockets. It was mentioned earlier that AirCubes would not have square corners, instead the corners would be beveled (in Figure 7, the Face corners are shown with dotted folds at 150 mm from the square corners). Figure 13 shows a schematic of AirCube corners.

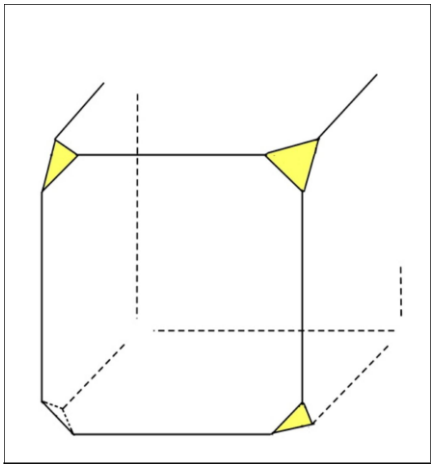


Figure 13 — Beveled corners of AirCube.

While in the Simple AirCube these beveled corners might have one or more tags or loops (through which cords could be used to tie groups of AirCubes together), in the next stage, Corner Sockets would be inserted in all corners. These would consist of short lengths of rigid tubing, with a plug or valve at the center to close off the Socket.

Internal Struts. In the next stage, Struts could be used to improve the rigidity of the Cube and strengthen it against collapse. In their simplest form, Struts would be hollow plastic tubes, but much variation is possible, as with carbon-fiber tubes, or tubes with many holes in their sides, or with internal pin supports (as in some bird bones). When an AirCube assembly includes Struts, they can be collectively classed as the assembly's Endo-Skeleton.

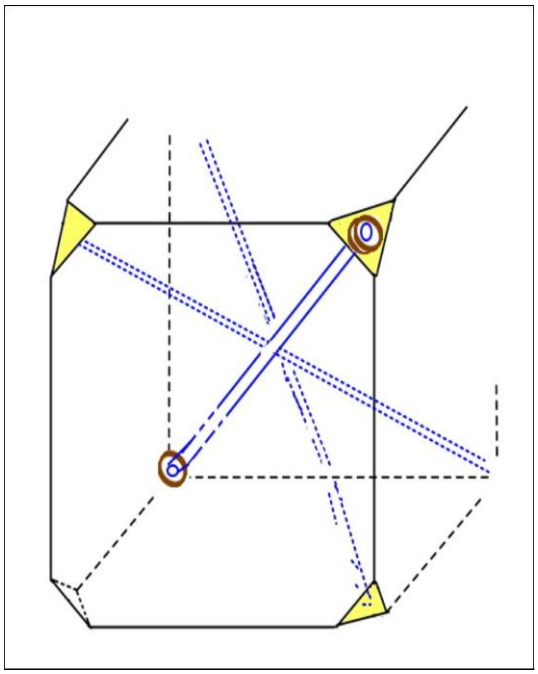


Figure 14 — Cube with Sockets and Struts.

If used, Struts would fit into the inside part of the Sockets. There would be 4 Struts in each Cube, crossing at the center of the Cube, where they would be tied together. They would greatly strengthen the Cube against collapse.

Nodes. An assembly of 8 Cubes (2 x 2 x 2) would have at its center a space in the shape of a regular octahedron (with 8 triangular faces, each matching the beveled corner of one of the enclosing Cubes). In another development, this space could contain an octahedral Node.

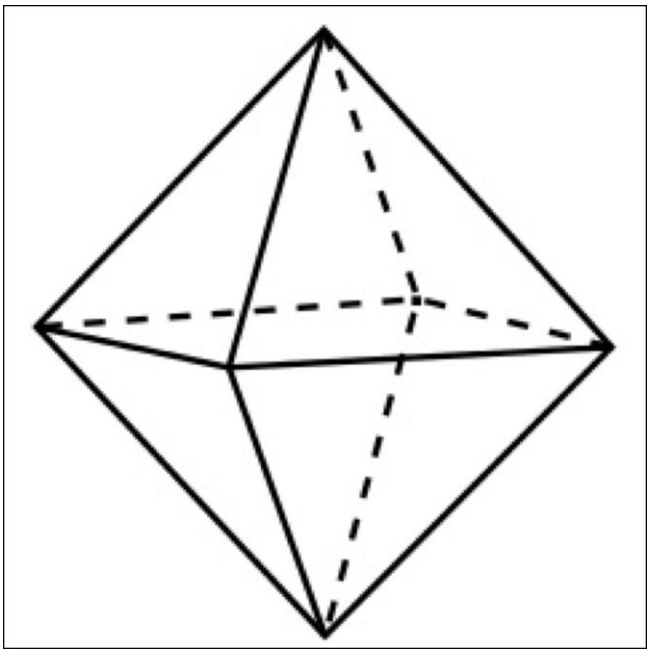


Figure 15 — The octahedral Node.

In multi-Cube assemblies, the Nodes would play a vital part in controlling the behavior of the assembly. In their simplest role, each face of the Node would contain a plug which would fit into the outside part of the Socket, so Cubes could be assembled together like Lego blocks. The plug/socket joins could be separable or permanently fused, according to need.

External Struts. For an assembly of Cubes which needed to be rigid, independently of their contents, external Struts could be added, connecting together the Nodes. For such assemblies, the external Struts would form their Exo-Skeleton. For very large assemblies, the Exo-Skeleton might be needed for attachment to the various loads.

The Selvedge. In the most developed form of manufacturing, for the Complex AirCube, extra line items would be inserted along the edges of the Face belts during the manufacturing process.

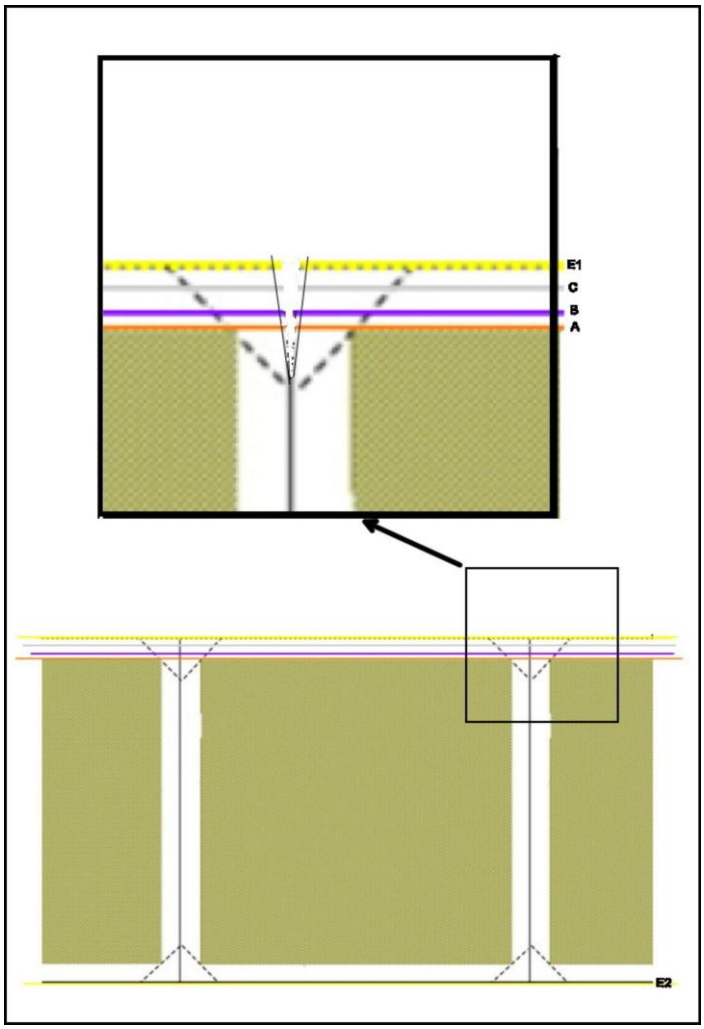


Figure 16 — Line services in the Selvedge.

Figure 16 shows a section of the Face belt as supplied by the Belt manufacturer. Along one edge of the belt (the Selvedge) three line services (A, B, C) are built in, and the outer edge (E1) is also formed in a special way.

Two of the line services are thin (maybe 2 mm) plastic tubes, the other is a wire as used in a computer USB connector. The concept is that the line services are available, if required, to increase the capability of an assembly of AirCubes. During the manufacturing process, the line services are cut across and sealed at the intersections of the Faces. The outer edge (E1) is formed as the male part of a seal as in a zip-seal plastic bag, while the edge on the other side of the belt (E2) is formed as the female part of the zip-seal.

The aim of all this is to make it possible to use a standard modular product from a manufacturer (the Face-belt) and customize it for a particular assembly to produce an "intelligent" assembly by connecting the line services, as

required, to the Node which is positioned between the Cubes. Any of the line services can be stripped back towards the dotted fold, joiners added (USB connectors for the wire), and these plugged into sockets in the (customized) Node.

The final outcome of the process should yield an AirCube assembly through which the Core Fluids and Skin Fluids can be pumped in or out through program circuitry present in the Complex Nodes.

The aim is that the manufacturer should supply a single product, produced on a continuous assembly line in an automated plant, in the form of a long, rolled-up or folded belt, and that this product should be customized as required. This might be at the manufacturer's supply centers, or advanced users' own premises.

It is estimated that material costs for a standard modular AirCube could be as little as $10, for a sufficiently large market.

7 Manufacture and assembly of Complex AirCubes

The range of items which might be produced from AirCubes or AirCube assemblies is very large. Some suggestions are outlined here.

The Cube-Drone. The Cube-Drone would use a single AirCube, or possibly a pair, to function like the helicopter-style drones which are coming into use for aerial photography, searches, and delivery of small articles. The Cube-Drones would have an advantage over the normal drones in that they would not need energy to stay afloat, although they would need motor energy to follow a prescribed path. They would not work well under very windy conditions.

Cube-Drones could also function in mineral prospecting. Because they would not use energy to stay aloft, they could be programmed to prospect quite a big area over several hours, using magnetometers, metal-detectors or similar, and radioing their readings back to a base point as they did so. They could also function at night, recording ground emissions at infrared or other wavelengths which would be drowned out during daylight.

The Cube-Tether. Devices similar to Cube-Drones, but tethered to the ground (or a ship) could be used where continuous actions needed to be taken, at height, over semi-permanent stretches of time. These actions could be weather reporting, transmitting or receiving cell-phone signals, and detecting distant ships or planes "over the horizon". Their heights in the sky are more likely to be limited by legislation, rather than by technical limitations.

In a simple application, an AirCube with an electric element inside, powered through the tether, could be used as a Cube-Tether — technology involving neither hydrogen nor vacuum for lift.

The Cube-Medusa. Large tethered structures kept afloat by hydrogen at a height of about 1 kilometer were described in a 2011 web article, with the title "The Hydro Medusa". The relevant web reference is at <http://aoi.com.au/devices/Hydro-Medusa/index.htm> [15]. This article had the subtitle *Free water, energy, fuel, and communications anywhere on Earth*. Such devices could be implemented using standard AirCubes.

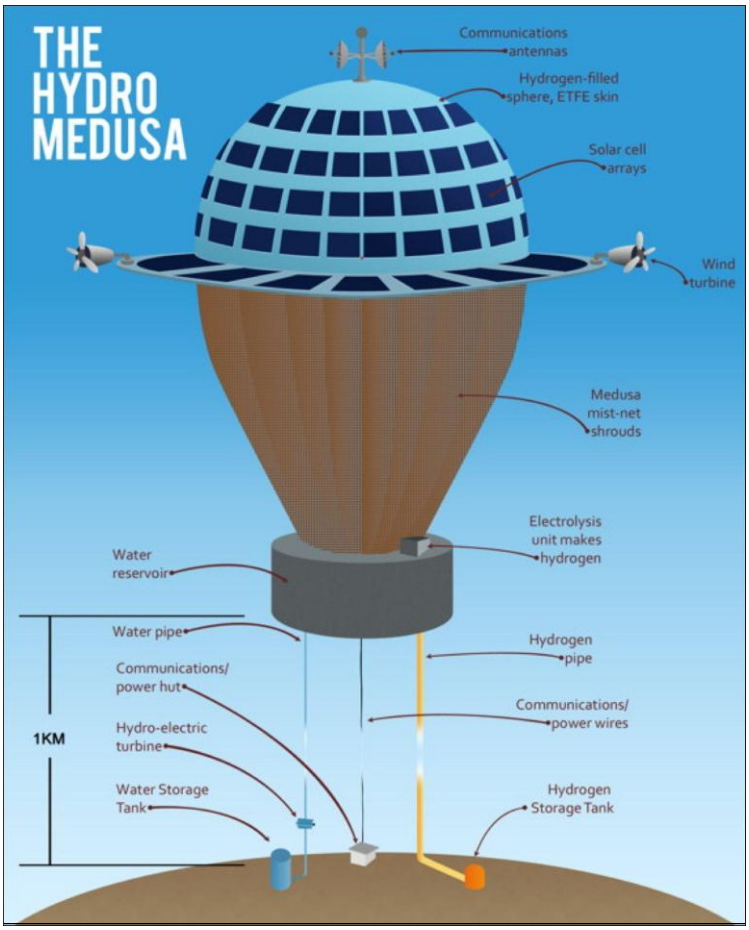


Figure 17 — The Hydro-Medusa. From reference [15].

According to this article [15], "Almost everywhere on the Earth's surface has an adequate supply of free water and energy within 10 kilometers! Unbelievable as this may seem, this article shows how this may be brought about". In this initial concept plan, the Medusa is maintained at a height of about 1 kilometer above the ground. At this height, it would be an excellent communications structure for television broadcasting transmitters and mobile phone repeater towers.

The Medusa could gather and condense water from mist nets or condensation panels, mimicking techniques used by plants (and even insects) in arid regions [16]. It could also gather power from photo-cell arrays, wind turbines, and

hydro-electric turbines (water falling through a head of 1000 meters). Some of the power could be used to electrolyze some of the water to produce hydrogen for lift, or as a fuel.

Cube-Rafts. Cube-Drones and Cube-Tethers would use small numbers of AirCubes. Because of their modular nature, and likely small unit cost, it would be quite feasible and economic to use larger assemblies of the Cubes for lifting and freighting purposes. For example, assuming a standard unit lifting power of 8 Kg, an AirCube assembly of 4 x 4 x 16 (256) units would have a lifting power of 256 x 8 Kg — about 2 tones. Such an assembly, within a suitable frame, cover, or superstructure, could be called a Cube-Raft.

A raft platform with a lifting power of 2 tones would be useful for a range of local and regional uses. These might include moving goods within a community, carrying parts of a building being constructed to a required height (Cube-Cranes), and freighting small containers to distant destinations, over land or sea. It might prove more usual not to provide propellers on the CubeRafts themselves, but instead to add in the required sets of Cube-Tugs — special Air-Cube assemblies fitted with motors (diesel, hydrogen-fuel-cell, etc.) for particular needs.

Cube-Rafts could also be crew-less, controlled by software like driverless cars, or could be remotely controlled like the giant ore trucks and ore trains in Western Australia. Small Cube-Rafts might be tethered to a truck, which might pick up a building component at the manufacturing site, attached to a Raft, drive to the building site with the Raft floating 20 meters overhead, and on arrival let out the tether to raise the component 100 meters to the current build position.

As a basis for calculation, assume an AirCube assembly of 256 units has a lifting capacity of 2 tones. With a unit cost of $10, the whole raft would cost $2560. Obviously control and superstructure costs would need to be added to this, but it is feasible that a complete, off-the-shelf 2-tonne Cube-Raft could be sold for $5000.

Cube-Freighters. Cube-Freighters are much larger AirCube rafts or raft sets, capable of carrying international air-freight cargo. An air-freight company such as DHL uses freighter versions of aircraft such as the Boeing 757 [17]. Such an aircraft could cost 30-50 million dollars, carry a cargo of 35 tones, and cost 3 million dollars a year to run.

Say you would like a Cube-Freighter capable of carrying 40 tones, comparable to a Boeing 757. Put together 20 Cube-Rafts, each costing $5000, total cost is 0.1 million dollars. Double this cost to include framing and propulsion, say $200,000. This for a craft not needing an airport or dock, capable of travel over land or sea.

The Cube-Stalk. Cube-Stalks or square towers could be put together from assembled AirCubes to form structures of any desired height. Because each level of the Stalk would be self-supporting, the Tower could be easily assembled at ground level. The procedure might be: tethering construction to date, letting that rise one level (2 meters), adding in a new level of AirCubes, and so on.

Cube-Stalks could have similar functions to the tethered Cube-Medusas described above. They could also act as the support points for giant nets or canopies, maybe 1 kilometer on a side, which in one application could carry photocells to produce electricity or hydrogen to be piped to the ground.

Cube-Solar-Towers. Solar Towers for electricity generation include two main components, the greenhouse and the tower. The greenhouse has a very large inverted-saucer transparent canopy for collection of sunlight and solar heat (infrared) during the day, with a bed of dark rocks or other material to store heat to use during the night (Figure 18).

Figure 18 — Working Solar Tower. From reference [18].

Heat collected under the greenhouse rises up and into a central tower, where the upflow drives one or more conventional turbines.

Solar Tower technology has been tested and proven with a successful small-scale pilot plant constructed in Manzanares, Spain [18]. The pilot project was the result of collaboration between the Spanish Government and the German designers, Schlaich Bergermann and Partner. The plant operated for seven years between 1982 and 1989, and consistently generated 50kW output of green energy.

The pilot plant conclusively proved that the concept works, and provided data for design modifications to achieve greater commercial and economic benefits associated with an increased economy of scale. The pilot plant was taken

out of use only because its steel support cables rusted, and the design principles had been successfully verified. In an interesting side note, it was found that fruiting trees grew very well in the warm rapid airflows under the solar tower canopy. Both the greenhouse and the tower could easily be constructed from AirCubes. which being self-supporting, would not need support cables. Cube-Solar-Towers could even be demountable, able to be shifted to a new area of demand.

Cube-Windcatchers. The Norwegian company WCS (Wind Catching Systems) has released its design for a colossal floating wind turbine array, which it says can generate five times the annual energy of the world's biggest single turbines. This while reducing costs enough to be immediately competitive with grid prices [20].

Standing more than 324 m high, these mammoth Windcatcher grids would deploy multiple smaller turbines in a staggered formation atop a floating platform, moored to the ocean floor using oil and gas industry techniques.

Figure 19 — Windcatcher Grid, with other comparable-size objects. From reference [20].

The multiple smaller rotors should perform much better in wind speeds over 40 to 43 km/h, when larger turbines tend to start pitching their blades to limit production and protect themselves from damage. The overall effect, says WCS, is a 500 % boost in annual energy output, with each array making enough power to run 80,000 European homes.

A Windcatcher system using AirCubes would be much simpler and cheaper than the Norwegian plan. Instead of a flat grid, Cube-Windcatchers could be set up in the form of windsocks, with hundreds of turbines lining the surfaces of the windsocks. Secured by cables above an industrial area, fields of windsock-shaped Cube-Windcatchers could supply all the power needed by the industrial precinct — as long as the wind blew.

Cube-Launchers for Space Freight. Because each level of a Cube-Stalk would be self-supporting, the Stalk could be extended upwards more or less indefinitely, certainly to the current record for a high-altitude balloon, 53 kilometers. Using special Air-Cubes for the upper levels, perhaps with hydrogen as the Skin Fluid and vacuum for the Core Fluid, this record might conceivably be beaten.

A hollow Cube-Stalk could be used to launch items into space, using thin metal tracks and linear-motor principles, possibly even using photocells on its outer surface to supply the necessary energy — free space-travel. A sophisticated Cube-Launcher could even change its shape in its upper reaches, to direct a payload into a particular orientation in space.

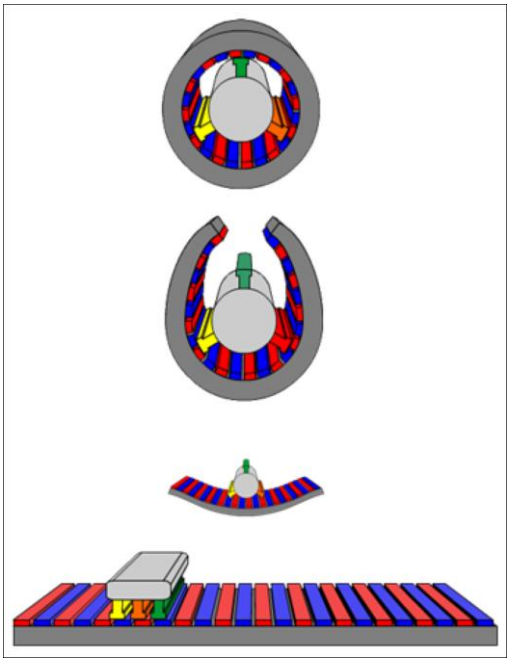


Figure 20 — Synchronous linear motor. From reference [19].

In linear-motor designs the rate of movement of the magnetic field is controlled, usually electronically, to track the motion of the rotor. Synchronous linear motors rarely use commutators, so the rotor often contains permanent magnets, or soft iron. Examples of linear motors include in rail-guns and the motors used on maglev systems [19].

The Cube-House. Habitable structures could be erected very quickly and easily using AirCubes for the outer walls and roof. Such structures could also be used as temporary tents, enclosing a building under construction to exclude detrimental weather effects. In such structures, the lower-level AirCubes could contain water as part of their Core Fluid, giving them a solid anchorage.

In more permanent structures, the ground-level AirCubes could be pumped with concrete or another solidifying material.

Because such structures would have self-supporting roofs, they could easily be made very large, maybe for use as aircraft or spacecraft hangars. They could also be used as warehouses or to store grain, or enclose communities — the "domed-cities" of science fiction.

Cube-Strata and Cube-Fields. The possibility was mentioned above of Cube-Stalks supporting nets or canopies -- large flat surfaces to carry photocells or other services. It would be possible to "super-size" these nets into enormous rafts, of kilometer dimensions, with beds several Cube thicknesses, capable of carrying heavier loads.

These Cube-Strata might carry such industries as automated hydroponic plant production — floating at heights where light and water vapor were abundant, these Strata Greenhouses could be very productive.

Agriculture and horticulture could be well suited to Cube-Strata. Conventional farmers always need to consider the costs and bad effects of insect pests. These could be easily avoided by moving the growing strata a few hundred meters into the air, away from the conditions hosting the pests. Strata could be moved temporarily to adjacent spots with more favorable conditions, harvested in the air, or lowered to the ground for major overhauls.

Cube-Strata need not necessarily shade inhabited areas, they could float above areas of sea or desert. They could possibly even support human habitation — "Check the news center, they're moving our Stratum next week into a more temperate weather band for the Summer".

8 Cube-Viaducts and Cube-Interways

There are considerable developments possible using long, continuous, Air-Cube structures which link population or activity centers and carry materials, communication services, and perhaps eventually, people.

Cube-Viaducts. A concept sketch for Cube-Viaducts is shown in Figure 21. The intention is to build floating "roadways" or viaducts, connecting together locations and carrying services or materials.

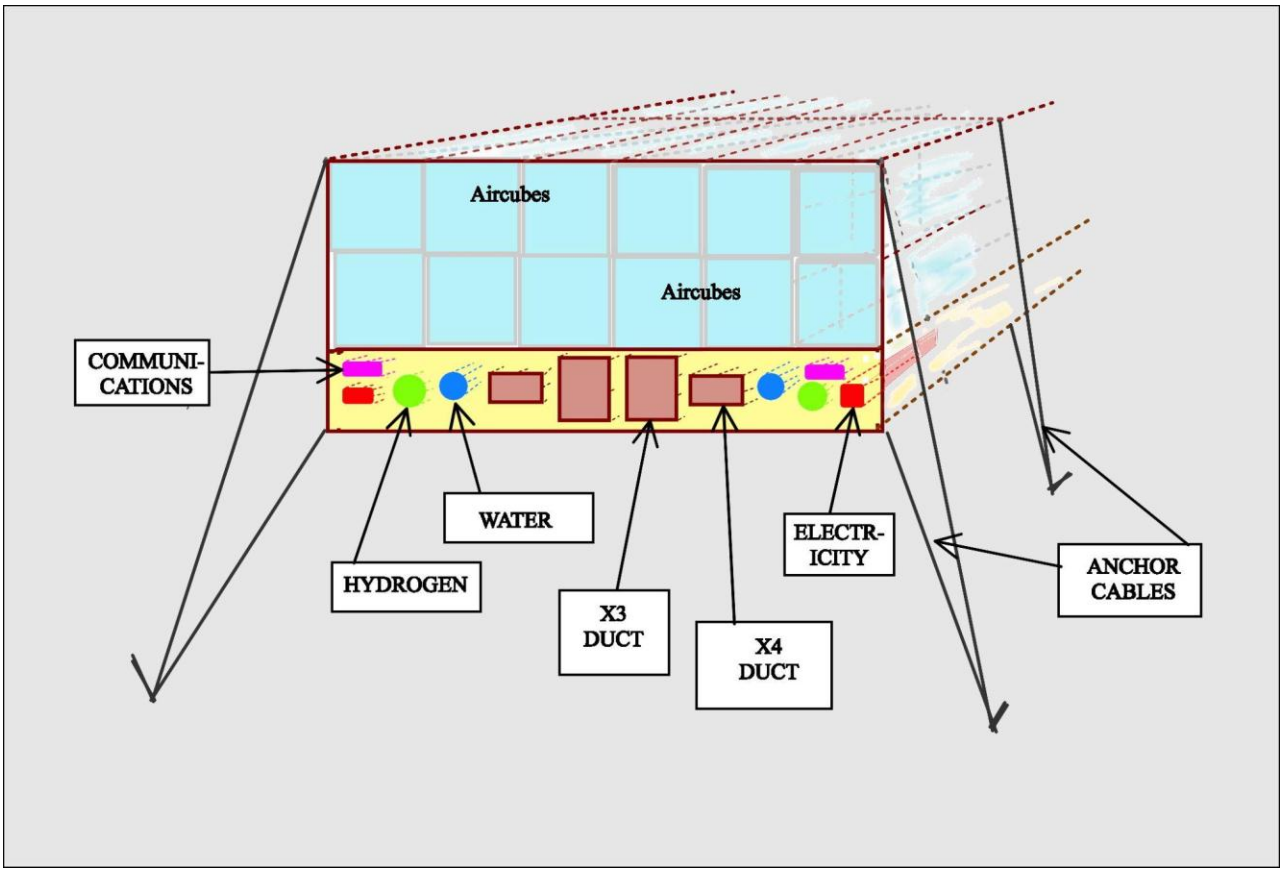


Figure 21 — Concept sketch for AirCube Viaducts and Glideways.

Cube-Viaducts could extend over land or water. They could carry pipelines containing water, hydrogen or other gases, and communications cables, also electrical cables. They could be linked internationally. They might well gather much of their energy from photovoltaics.

Obviously any implementations would need protection from weather events. Net covers would be standard. Strong winds could be catered for, although cyclones and tornados would be risk factors, as in normal constructions.

Cube-Interways. An important use of Cube-Viaducts would be as Cube-Interways, networks for carrying goods and packages.

In the modern world, transmission of information and information-based media has been revolutionized by the use of computers and the Internet. Nowadays, users in their own home can get a movie delivered to their TV or computer

with a simple command. The transaction may be in real time, and involve no human action apart from that of the user themselves.

Cube-Interways could be planned to provide transmission of goods or packages with the same human-free facility as for information. In Figure 21, the suggested Cube-Interways are shown as ducts, X3 and X4 Ducts.

The nature of these ducts is only notional at this stage. Rather than being of solid material as in air-conditioning ducts, they might be open frameworks of netting material, meant to catch accidental falls.

Goods would be moved along the duct Interways using "Baskets", frames equipped with linear motors, moving on tracks either above or below the "Baskets" — rectangular containers, again of notional design.

It could be useful to design the Baskets to be in Golden Cuboid shapes — cuboids where the longest edges are the square root of 2 longer than the medium edges, which are the square root of 2 longer than the shorter edges [21].

In Figure 21, it is suggested that the Interway section depicted holds X3 and X4 Ducts. These would be of a size to carry Baskets in the X0 range of golden cuboid sizes (Figure 22).

Name	X0	X1	X2	X3	X4
c (cm)	84.1	55.4	42.0	29.7	21.0
b (cm)	118.9	84.1	55.4	42.0	29.7
Face	A0	A1	A2	A3	A4
a (cm)	168.1	119.0	84.1	55.4	42.0
Volume (m^3)	1.681	0.554	0.196	0.069	0.026

Figure 22 — The X-Series range of Golden Cuboids, From reference [21].

In this range of cuboids, the Endpoint is set by making the smaller face of each cuboid equal to the corresponding paper size in the A0 series of metric paper sizes [21]. So the X3 and X4 ducts in Figure 21 would carry Baskets with sides equal to A3 and A4 paper sizes.

Using the Golden Cuboid system means that Baskets can be switched between adjacent-size ducts, so that an X3 duct could carry an X4 basket turned through 90 degrees. Also, Baskets could sometimes be nestable, with a set of smaller baskets clamped together forming a cluster the same size as one higher in the range,

Baskets would all carry computer chips in their frames, capable of storing the intended address of a particular journey, plus other information which might be needed, such as for Customs checks. They would also have automatically-contacting data connections on all sides, so that the carrier ducts would have real-time availability of all relevant information concerning the baskets and basket-clusters they were conveying.

Ultimately, the system could be developed to the stage where it was effectively an Internet of Goods. A manufacturer of, say, spare parts for vehicles could conceivably use their order-fulfilment system to automatically write the electronic address of a customer package on a basket-chip, and automatically place the basket in an Interway Gate on their own premises.

The Interway system envisaged could evolve to cover the planet, with Interway streams passing through Way-stations where baskets and basket clusters were separated and combined and directed along relevant routes, without human intervention. Where inter-continental or long-distance sections were involved, baskets could be moved into Interway Holds fitted into ships or airplanes, to be discharged into local nodes of the Interway in their destination countries -- again without human intervention.

9 Air-Cube Materials

While it has been suggested that standard Air-Cubes might be of uniform construction and materials, specialist lines could be manufactured for particular purposes. Traditional drop-stitch fabrics use PVC as the skin-forming plastic. There are plenty of other possibilities for particular purposes, such as the tough and impermeable plastic ETFE (ethylene tetrafluoroethylene), used in building the Water Cube swimming center for the Beijing Olympic Games [22]. Silicone materials, known for their resistance to heat, are also possibilities. Plastics with reflective surfaces could be useful for heat retention.

Skins containing carbon fibers, graphenes, or the recently discovered HBNs (hexagonal boron nitrides) [23] offer possibilities for extreme toughness combined with light weight.

10 The AirCube as the analog of living creature cells

The largest living creature on Earth is said to be the Great Barrier Reef off the east coast of Australia. It is essentially made up of cells — animal, vegetable, and fungal, living and dead. The Reef, and almost everything we think of as life, is a conglomeration of cells.

Some of Nature's most intriguing creatures go under the unattractive name of Slime Moulds. For most of their lives, these are single-celled creatures like amoebas, living in isolation.

Yet when under stress, these slime moulds can do amazing things — they can combine together to form slug-like bodies or "grexes" which can move relatively quickly across a landscape. They can also come together to form fruiting bodies, which release spores into the air.

Figure 23 — Slime Mould fruiting bodies, From [25].

In [24] it says "When food is abundant, these slime molds exist as single-celled organisms. When food is in short supply, many of these single-celled organisms will congregate and start moving as a single body. In this state they are sensitive to airborne chemicals and can detect food sources. They can readily change the shape and function of parts, and may form stalks that produce fruiting bodies, releasing countless spores, light enough to be carried on the wind or hitch a ride on passing animals".

In their combined form, Slime Moulds have been claimed to be capable of many of the functions usually ascribed to complex animals, such as solving maze puzzles!

In a similar way, there is the possibility for some of the complex things we use in civilization being developed through combining AirCube Modules. In this, the Module is the industrial equivalent of the Cell. The Endo-Skeleton and Exo-Skeleton are analogs of mammalian skeletons and turtle shells, Nodes are the analogs of neurons and nerve cell junctions, the Selvedge services are the analogs of lymphatic, endocrine, and nerve systems. With increasing development of the Nodes, an AirCube assembly begins to take on some aspects of intelligence.

In this analogy, the standard Air-Cube is the equivalent of a stem-cell, convertible by choice and design into a specialist bone, skin, blood, liver, or other cell. Air-Cubes could be a useful step in the progress of civilization.

Summary

This article is intended to alert the World to a vast range of possible uses for devices and structures based on attenuated-air modules. It is offered in a spirit of humility, for others to develop possible devices and ideas in the future.

References and links

[1] Wish Chinese Paper Lanterns Sky Fire Fly. https://www.wish.com/product/ 5d01eb4e8093636dd3ec64fc.

[2] Sky Lantern. https://en.wikipedia.org/wiki/Sky_lantern.

[3] Zhuge Liang. https://en.wikipedia.org/wiki/File:Zhuge_Liang_scth.jpg.

[4] Common Questions About Sky Lanterns. https://weddingdaysparklers.com/common- questions-about-sky-lanterns/.

[5] Hot-air balloon. https://en.wikipedia.org/wiki/Hot-air_balloon.

[6] Joseph-Michel and Jacques-Étienne Montgolfier. https://www.britannica.com/ biography/Montgolfier-brothers.

[7] History of ballooning. https://en.wikipedia.org/wiki/History_of_ballooning.

[8] Zeppelin. https://en.wikipedia.org/wiki/Zeppelin.

[9] A Brief Study on Airship Using Aerospace, Electronic and Communication Applications. Md Abdul Sami et al. Int. Journal of Engineering Research and Applications, Vol. 5, April 2015, pp.34-46. Online: http://ijera.com/papers/Vol5_issue4/ Part%20-%205/G504053446.pdf.

[10] David Noel. Speculations in Science and Technology, Vol. 6, No. 3, 1983, p. 262-267. Online: http://aoi.com.au/Originals/VacuumBalloon.pdf.

[11] David Noel. The Vacuum Balloon. http://aoi.com.au/bcw/VacuumBalloon.htm. 2006.

[12] Lana's Aeronautic Machine. https://www.sciencephoto.com/media/1004316/view/ lana-s-aeronautic-machine-illustration.

[13] Zephyr-Yachting.https://www.zephyr-yachting.com/luxury-watertoys/zephyr-inflatables/funair-inflatables/funair-personal-watercraft-docks/.

[14] How Hot Air Balloons Fly. https://www.brisbanehotairballooning.com.au/how-hot- air-balloons-fly/.

[15] David Noel. The Hydro Medusa: Free water, energy, fuel, and communications anywhere on Earth. http://aoi.com.au/devices/Hydro-Medusa/index.htm .

[16] David Noel. LB702: How plants water themselves from the air. http://aoi.com.au/LB/ LB702/.

[17] Boeing 757. https://en.wikipedia.org/wiki/Boeing_757.

[18] Solar Updraft Towers Generate Mega Power. http://www.solaripedia.com/ 13/371/5042/solar_updraft_tower_pilot_plant.html.

[19] Linear motor. https://en.wikipedia.org/wiki/Linear_motor.

[20] Loz Blain. 1,000-foot multi-rotor floating Windcatchers to power 80,000 homes each. https://newatlas.com/energy/wind-catching-systems-multirotor-turbine/.

[21] David Noel. BS808: The Golden Cuboid system for designating volumetric items. http://aoi.com.au/BaseScience/BS808/index.htm.

[22] ETFE makes Beijing Olympic stadium a reality. https://www.icis.com/explore/ resources/news/2007/08/06/9049807/etfe-makes-beijing-olympic-stadium-a-reality/.

[23] This 2D Material Is Way Tougher Than Graphene, And Scientists Are Excited. https://www.sciencealert.com/this-two-dimensional-material-is-even-tougher-than-graphene.

[24] Slime mold. https://en.wikipedia.org/wiki/Slime_mold.

[25] Slime mould fruiting bodies, SEM. https://www.sciencephoto.com/media/13914/ view.

Appendix 1: Pilot Manufacture of AirCube Faces

To make AirCube Faces, you need the following items:

1. Roll of heat-sealable plastic.

2. Two square timber frames, made of 10 x 10 mm timber.

3. Two chipboard squares.

4. Stock of Fiber Fluff as described.

5. Jar or spray of Adhesive.

6. Some 2 mm plastic tubing.

7. Air Pump (eg bicycle pump).

8. Heat Sealer.

Standard AirCube Faces are 2 meters x 2 meters. Before routine manufacture, it will be necessary to trial the various components to get suitable results. The trialing might be done with 1 meter x 1 meter Faces, assumed in the description herewith.

The aim is to produce, in each Face, a lightweight sandwich, say 20 mm thick, of stiff fibers sealed within plastic, usually containing air under slight pressure above atmospheric. The outer plastic can be light household PVC, only strong enough to contain the compressed air. The strength in the sandwich is obtained by suitable choice of the Fiber Fluff and Adhesive -- the aim is to wet the fiber and plastic surfaces with an adhesive which will dry to produce interlocking stiff fibers, secured to each other and to the plastic surfaces.

The procedure for making one 1 m x 1 m Face

Cut two 1-metre squares of plastic, place one so it overlaps the square "picture frame" XX on the lower board, as in Figure 8, overlapping about 1 cm over the frame. Spray or apply adhesive to the upper surface of the plastic, add enough of the Fabric Fluff to make a layer about 2 cm thick. Spray the Fabric Fluff layer with the adhesive.

Similarly place the second plastic square on the upper frame YY lying on the upper board, spray the surface with adhesive, then invert the frame and board over the first one. Insert a length of 2 mm plastic tube along a grooved channel cut 1 mm deep along the corner-join of both frames. Heat-seal all the external edges of the plastic sandwich where they lie beyond the frames.

When the edges are sealed, pump air into the sandwich so it is under slight pressure. Ideally, when the adhesive sets (10 minutes?) the Fiber Fluff and plastic surfaces should form a very open but fairly stiff matrix, resistant to bending. Six faces can then be heat-welded or glued together to form an AirCube.

NOTES.

A. Use a roll of light plastic from a DIY store.

B. A picture-framing business has the jigs etc to make up the frames from 10 mm square timber.

C. The chipboard squares can be cut with any saw -- dimensions aren't critical.

D. You will need to research the Fiber Fluff. Generally, you will need fibers of ramie, flax, or hemp, well-separated and cut to an average length of about 25 mm, so as to expose the maximum fiber surfaces to the adhesive. See reference [1] for fiber properties.

E. You will need to research the Adhesive with an adhesive supplier. You want something which will set to give a stiff layer over all surfaces, but not stick clumps of fiber together, and which will set in a convenient time. Turn over the whole square/frame sandwich.

F. For an air pump, get a 12v tire inflator from an auto store (about $20), the sort which plugs into a cigarette lighter socket. These usually come with a valve adaptor for blowing up footballs, this should fit in the 2 mm tubing (which be crimped over for a temporary seal).

G. Heat sealers for plastic bags are available from hardware stores.

Reference

[1]. K L Pickering et al. A review of recent developments in natural fiber composites and their mechanical performance. https://www.sciencedirect.com/science/article/pii/S1359835X15003115.