

The R. Buckminster Fuller FAQ

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This is the **Frequently Asked Questions and Answers (FAQ) Resource on R. Buckminster Fuller**. It is based primarily on the history of the discussions, interests, and needs of the readers of the BITNET mailing list Geodesic and its USENET gateway `bit.listserv.geodesic` (I will use the word "GEODESIC" or sometimes simply "the list" to refer to these two gatewayed discussion areas). Some of the information could be in error (especially addresses and phone numbers). Please send all errors and suggestions to the FAQ maintainer, Chris Fearnley (*cjf@CJFearnley.com*).

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1 Introduction

Buckminster Fuller (1895-1983) is the renowned inventor of the geodesic dome, the world game, and a new system of mathematics called *synergetics*. He was a polymath whose writings and lectures touched upon every aspect of the human condition. He was a “new-former” pointing out, exploring and prototyping designs in numerous, previously uncharted areas of science and humanity. His greatest writings were *Critical Path*, *Synergetics* (2 volumes), and posthumously *Cosmography*. Since his physical death a class of recently discovered allotropes of carbon, the fullerenes, have been named in his honor.

A note on the compilation of this material. I tried to preserve as much about the original authors as possible. Some citations are in brackets before the text, others follow it. Most material is directly taken from the mailing lists and newsgroups (with minor editing to correct typos, a bit of streamlining, etc.).

BEWARE OF OUTDATED INFORMATION.

Please follow-up with discussion and questions to

bit.listserv.geodesic news:bit.listserv.geodesic

or to one of the mailing lists such the one described in section 7.2.1 (List Geodesic) or in the section on 7.2 (Related Mailing Lists).

2 Synergetics

In its broadest sense *synergetics* is Fuller’s hypothesized coordinate system of Universe — both in its physical and metaphysical aspects. Fuller’s system of epistemography and mathematical-physics attempts to disclose how Nature actually operates — her “operational mathematics.” Fuller claimed that synergetics could be understood by children (though they probably couldn’t comprehend his books on the subject). He published this material in his essay “Omni-directional Halo” (in *No More Secondhand God*), *Synergetics: Explorations in the Geometry of Thinking*, *Synergetics 2: Further Explorations in the Geometry of Thinking*, and *Cosmography*. *Cosmography* is probably the easiest to read for people unfamiliar with Fuller’s prose style. An “interleaved” version of *Synergetics* and *Synergetics 2* is available on the Web at <http://www.rugrayprojects.com/synergetics/synergetics.html> .

From my own study of synergetics, I’m convinced that Bucky did in fact identify the coordinate system used by Nature. But I would add the caveat that he didn’t get too far along in developing it. Fuller points to what the coordinate system is in broad strokes. He gives many penetrating insights and new discoveries, but the synergetics coordinate system needs a lot more development (and integration) before it will be possible to use it as the operative model in all of Science.

Tip to students of synergetics: Build models.

The essay *Reading Synergetics: Some Tips*

offers useful help for anyone struggling to read *Synergetics*.

[From Kirby Urner]

Synergetics: A metaphoric language for communicating experiences using geometric concepts.

Thinking is the tuning in/out of systems. Systems are spherical networks of interrelated points of interest. The density of points is a measure of a system's "frequency" – super high frequency systems approach sphericity.

The minimal system with the fewest possible points is a tetrahedron – four points make a primitive volume with an inside and an outside. The canonical tetrahedron has a volume of one.

The tetrahedron may be sliced into 24 irregular tetrahedra (12 left handed, 12 right handed) called "A modules." The octahedron is comprised of 48 A and 48 B modules of equal volume = 4 x the volume of the tetrahedron. A and B modules may be used to assemble the cube (3 tetravolumes), rhombic dodecahedron (6 tetravolumes), and the Coupler (1 tetravolume). The Coupler, with the same volume as the tetrahedron (1), is an irregular octahedron that packs together to fill space without gaps.

Radiation is explosive outwardly while Gravitation is an implosive squeezing at 90 degrees to Radiation, i.e. is circumferential. Metaphysically, Gravity networks points of interest into systems of interrelated thoughts while Radiation drains away the sense of our systems and turns them into meaningless noise. Radiation is compression, Gravity is tension. Radiation is Entropy. Gravity is Love. Clearly this is not Physics but a more metaphorical language for communicating experiences using geometric concepts. This is Synergetics.

[Ed: I think Fuller's synergetics describes real physics. Though it is true as Kirby points out that Bucky's presentation is more "descriptive" than "hard" physics. I contend that because Fuller is "right on" in his description, it is up to us to find the "hard" physics interpretation behind his "metaphors."]

[Typed in by Kurt Przybilla]

[From *Synergetics* [900.20-900.33] <http://www.rwgrayprojects.com/synergetics/s09/p0000.html#900.20>]

900.20 Synergetics

900.21 Synergetics is a book about models: humanly conceptual models; lucidly conceptual models; primitively simple models; rationally intertransforming models; and the primitively simple numbers uniquely and holistically identifying those models and their intertransformative, generalized and special case, number-value accountings.

900.30 Model vs. Form

900.31 Model is generalization; form is special case.

900.32 The brain in its coordination of the sensing of each special case experience apprehends forms. Forms are special case. Models are generalizations of interrelationships. Models are inherently systemic. Forms are special case systems. Mind can conceptualize models. Brains can apprehend forms.

900.33 Forms have size. Models are sizeless, representing conceptuality independent of size.

- Bucky, *Synergetics 2*

Bucky went far in describing experience in terms of the experientially derived model, discovering along the way the synergetically surprising benefits to build structures based upon the special case structures designed using the generalized principles understood using this evermore useful mentality.

[From *Synergetics* [200.001-201.03] <http://www.rwgrayprojects.com/synergetics/s02/p0000.html>]

200.001 Definition: Synergetics

200.01 Synergetics promulgates a system of mensuration employing 60-degree vectorial coordination com-

prehensive to both physics and chemistry, and to both arithmetic and geometry, in rational whole numbers.

200.02 Synergetics originates in the assumption that dimension must be physical; that conceptuality is metaphysical and independent of size; and that a triangle is a triangle independent of size.

200.03 Since physical Universe is entirely energetic, all dimension must be energetic. Synergetics is energetic geometry since it identifies energy with number. Energetic geometry employs 60-degree coordination because that is nature's way to closest-pack spheres.

200.04 Synergetics provides geometrical conceptuality in respect to energy quanta. In synergetics, the energy as mass is constant, and nonlimit frequency is variable.

200.05 Vectors and tensors constitute all elementary definition.

201.00 Experientially Founded Mathematics

201.01 The mathematics involved in synergetics consists of topology combined with vectorial geometry. Synergetics derives from experientially invoked mathematics. Experientially invoked mathematics shows how we may measure and coordinate omnirationally, energetically, arithmetically, geometrically, chemically, volumetrically, crystallographically, vectorially, topologically, and energy-quantum-wise in terms of the tetrahedron.

201.02 Since the measurement of light's relative swiftness, which is far from instantaneous, the classical concepts of instant Universe and the mathematicians' instant lines have become both inadequate and invalid for inclusion in synergetics.

201.03 Synergetics makes possible rational, whole-number, low-integer quantation of all the important geometries of experience because the tetrahedron, the octahedron, the rhombic dodecahedron, the cube, and the vector equilibrium embrace and comprise all the lattices of all the atoms.

-Bucky, *Synergetics*

The isotropic vector matrix provides a model for thinking - for thought - a model more flexible than the squarebox X-Y-Z cubist mindframe, a clearly defined mathematical and physical model, an organic matrix based on the closest packing of spheres, bubbles, atoms. A model which attempts to explain everything, much more than any linguistically linear metaphor can ever manage.

It provides a structure in which to think about any structure or system. Whether you want to discuss why people first built dome shaped huts, why St. Peter's cathedral was the largest space man had domed until Bucky came along, why planets and stars are spherical, the structure of the atom, the structure of complex carbon molecules scientists worldwide are building, or dome homes we wish to build.

I dream of building many. The nicest is portable, made of the highest quality, light weight alloys, easily affordable and assembles almost anywhere on the planet by the average human and friends in about a day. It will utilize the best solar technology, all technology comprehensively integrated to improve living.

2.1 What is a tetrahedron (tetra), octahedron (octa), and an icosahedron (icosa)?

These are the three omni-triangulated, omni-symmetrical, stable, space structures in Universe. The tetra has 4 vertices (crossings), 6 edges (vectors) and 4 faces (openings). The octa has 6 crossings, 12 vectors, and 8 openings. The icosahedron has 12 crossings, 30 vectors, and 20 openings. The Greeks called these three figures "platonic solids." They are very important in synergetics.

[From Vincent J. Matsko]

For those interested in group theory, from a group theoretical perspective, we can view the symmetry groups of the tetrahedron and the octahedron as subgroups of the symmetry group of the icosahedron (with reflections included) - so that, in a sense, the tetrahedron and octahedron are “children” of the icosahedron.

2.2 What is “synergy?”

[From *Synergetics* [101.01-102.00] <http://www.rwgrayprojects.com/synergetics/s01/p0100.html>]

“*Synergy* means behavior of whole systems unpredicted by the behavior of their parts taken separately.

“*Synergy* means behavior of integral, aggregate, whole systems unpredicted by behaviors of any of their components or subassemblies of their components taken separately from the whole.”

[From Blaine A. D’Amico.]

Fuller’s clearest example of “behavior of whole systems unpredicted by the behavior of the parts” is mass attraction. The Earth and the Moon maintain their relationship through an interattraction of their respective masses. This mass attraction (gravity being a special case of mass attraction) is a function of the mass of the two bodies AND THEIR DISTANCE FROM ONE ANOTHER. The scientific law governing this attraction states that if you halve the distance between the two bodies you quadruple the attraction and vice-versa (i.e. double the distance and the attraction is 1/4 the original). This generalized principle (the law of mass attraction) is a synergy because if either body is considered separately there is no attractive force to examine. The law of mass attraction is mathematically exact and exists only as a function of the whole system. It is therefore a Synergy.

2.3 What is Fuller’s definition of “Universe?”

[From *Synergetics* [301.00-302.00] <http://www.rwgrayprojects.com/synergetics/s03/p0000.html>]

“*Universe* is the aggregate of all humanity’s consciously apprehended and communicated nonsimultaneous and only partially overlapping experiences.

“ ‘Aggregate’ means sum-totally but nonunitarily conceptual as of any one moment. ‘Consciousness’ means an awareness of the otherness. ‘Apprehension’ means information furnished by those wave frequencies tunable within man’s limited sensorial spectrum. ‘Communicated’ means informing self or others. ‘Nonsimultaneous’ means not occurring at the same time. ‘Overlapping’ is used because every event has a duration, and their initiating and terminating are most often of different duration. Neither the set of all ‘experiences’ nor the set of all the words used to describe them are instantly reviewable nor are they of the same length. Experiences are either involuntary (subjective) or voluntary (objective), and all experiences, both physical and metaphysical, are finite because each begins and ends.”

2.4 What is the “Isotropic Vector Matrix” (IVM)?

[From *Synergetics* [410.06] <http://www.rwgrayprojects.com/synergetics/s04/p1000.html#410.06>]

“So I then went on to say if all the energy conditions were everywhere the same, then all the vectors would be the same length and all of them would interact at the same angle. I then explored experimentally to

discover whether this ‘isotropic vector matrix’ as so employed in matrix calculus, played with empty sets of symbols on flat sheets of paper, could be realized in actual modeling. ...” He than describes his kindergarten discovery of the octet-truss (octahedrons + tetrahedrons in an all-space filling array).

[From *Synergetics* [420.01] <http://www.rwgrayprojects.com/synergetics/s04/p2000.html#420.01>]

“When the centers of equiradius spheres in closest packing are joined by most economical lines, i.e., by geodesic vectorial lines, an isotropic vector matrix is disclosed – ‘isotropic’ meaning ‘everywhere the same,’ ‘isotropic vector’ meaning ‘everywhere the same energy conditions.’ This matrix constitutes an array of equilateral triangles that corresponds with the comprehensive coordination of nature’s most economical, most comfortable, structural interrelationships employing 60-degree association and disassociation. Remove the spheres and leave the vectors, and you have the octahedron-tetrahedron complex, the octet truss, the isotropic vector matrix.”

2.5 What is an octet truss?

[Mitch Amiano]

An Octetruss, to use the trademarked moniker, is an OCTahedral and TETrahedral complementary grid implemented in such a way as to form a structural truss. A truss is an engineering mechanism for dispersing loads across a relatively long span, to enable coverage of large, primarily horizontal areas with a minimum of underpinning supports (posts). Most trusses appear to be arranged to act independently of one another, whereas the members of an Octetruss are all part of the whole unit. Octetruss is not the only such truss system. Other geometries have been used to create omnidirectional truss systems; the more general name for any one of these systems is a ‘space frame’.

It should be very well known that Alexander Graham Bell built Octahedral/Tetrahedral trusses and used them for enormous kites and flying machines. I saw some *very* old films of Bell and one of his octet configuration kites; it seemed to be one of his hobbies.

[Hal Adams]

Most trade publications periodically have articles on space frames. You might try “Architecture” a monthly publication of the American Institute of Architects, “Engineering News Record” an engineering weekly. You can check the “Art Index” which has an index of all articles from design publications. A good general structural book is *Why Buildings Stand Up* by Mario Salvadori, published by McGraw Hill paperbacks.

[Bruce T. Lael] The following quote comes from Hugh Kenner’s book *Bucky: A Guided tour of Buckminster Fuller*, c.1973

“...What are we to make, for instance, of Alexander Graham Bell’s infatuation about the tetrahedron?”

“About two years after little Bucky’s adventure with the toothpicks and the peas, the veteran inventor of telephony perceived in the tetrahedron a figure of singular virtue. It is the three-dimensional equivalent of the triangle, holding its form with invincible tenacity. It is the minimum space enclosure, with four identical sides nothing simpler can be envisaged. Having of all space enclosures the maximum structure in proportion to its content, it has therefore the maximum attainable strength. Bell’s mind moved to performance per pound and to aeronautics, and in the very summer before the Wrights flew he wrote in his son-in-law’s National Geographic of the virtues of a tetrahedral configuration in kites. Such a kite will not easily lose lift, and Bell’s idea that the future of aeronautics lay in a design which wouldn’t tend to kill the pilot in case of a stall led him to hundreds of experiments with kites composed of many tetrahedral cells, as many

as 1300.

“In 1905, such a kite powered by a feeble breeze, lifted a man some thirty feet into the air

“...He did erect, on his Nova Scotia island, a tetrahedral tower, its seventy-two foot legs meeting tripod fashion five stories above the ground. Each leg was subdivided into four-foot tetrahedral cells of half-inch pipe, and each cell could support two tons without signs of distress. Bell had effected about 1907 one of the periodical rediscoveries of the oc-tet configuration Bucky stumbled onto in kindergarten, and moreover has used it in a practical structure. He seems not to have applied for a patent and the tetrahedral tower was dismantled after a decade. Bucky had very possibly never heard of it when he came upon the principle yet again during his geometrical work of the 1940's and wrote to his patent lawyer.”

2.5.1 I wondered if hexagonal closest packing forms an IVM? Also, is a diamond cubic structure the same as an IVM? [Steve Mather]

HCP allows infinite permutations as successive layers of spheres do not need to lie over top a specific hole in the layer 2 down. HCP is not a restrictive enough packing method to generate the IVM per se.

The IVM is equivalent to the face-centered cubic packing (FCC). I believe all diamond atoms occupy FCC positions, but leave others empty. Buckminsterfullerene will pack into an IVM (appropriately), and, with potassium wedged in some of the interstices, become a superconductor. (See section 6.1 (What are Fullerenes? and Buckyballs) for more on the fullerenes.) — Kirby

2.5.2 What are some good ways to build sphere packing models?

[From Blaine A. D'Amico.]

I use various sized Styrofoam (yes I know its not a green material) balls in my classes. They are very easy to work with.

[From Chris Fearnley]

Ping pong balls are wonderful. I use a tacky tape type stuff to bind them together (this helps me to dis-assemble and then re-assemble them into new shapes). I got about two gross to work with - very fun and educational. I prefer the sticky tape to glue, less messy, reversible and pliable to adjust for physical imperfections.

[Charlie Hendricksen]

Some years ago I took a delightful course in “Patterns in Nature.” We made models of the various crystal structures and geometric models using Duco cement and the plastic beads from bead chains from the import shop (Pier One). Cheap, the right size (about 5mm), and best of all many colors.

2.6 What is the “vector equilibrium” (VE)?

[From *Synergetics* [205.01] <http://www.rwgrayprojects.com/synergetics/s02/p0000.html#205.01>]

“The geometrical model of energy configurations in synergetics is developed from a symmetrical cluster of spheres, in which each sphere is a model of a field of energy all of whose forces tend to coordinate themselves, shuntingly or pulsatively, and only momentarily in positive or negative asymmetrical patterns relative to,

but never congruent with, the eternality of the vector equilibrium. The vectors connecting the centers of the adjacent spheres are identical in length and angular relationship. The forces of the field of energy represented by each sphere interoscillate through the symmetry of equilibrium to various asymmetries, never pausing at equilibrium. The vector equilibrium itself is only a referential pattern of conceptual relationships at which nature never pauses.”

2.7 What is the “jitterbug”?

[Making this model will greatly ease understanding of the jitterbug transformation described below. I use 6" dowels joined together with surgical tubing. Cut the surgical tubing into 2" pieces. Use a washer to form a four-valent, flexible vertex joining two pieces of the surgical tubing or insert one piece of 2" tubing into a hole (you must cut it yourself) in another 2" piece of tubing to create the vertex. The diameter of the surgical tubing should be very slightly (1/16") smaller in diameter than the dowels. You will need 24 such struts and 12 such vertices. Geometers call the shape of the VE a “cuboctahedron.”]

[From *Synergetics* [460.01-460.05] <http://www.rwgrayprojects.com/synergetics/s04/p6000.html#460.01>]

“The ‘jitterbug’ is the finitely closed, external vector structuring of a vector-equilibrium model constructed with 24 struts, each representing the push-pull, action-and-reaction, local compression vectors, all of them cohered tensionally to one another’s ends by flexible joints that carry only tension across themselves, so that the whole system of only-locally-effective compression vectors is comprehensively cohered by omniembracing continuous four sliced hexagonal cycles’ tension.

“When the vector-equilibrium ‘jitterbug’ assembly of eight triangles and six squares is opened, it may be hand-held in the omnisymmetry conformation of the vector equilibrium ‘idealized nothingness of absolute middlelessness.’ If one of the vector equilibrium’s triangles is held by both hands in the following manner - with that triangle horizontal and parallel to and above a tabletop; with one of its apexes pointed away from the holder and the balance of the jitterbug system dangling symmetrically; with the opposite and lowest triangle, opposite to the one held just parallel to and contacting the tabletop, with one of its apexes pointed toward the individual who is handholding the jitterbug - and then the top triangle is deliberately lowered toward the triangle resting on the table without allowing either the triangle on the table or the triangle in the operator’s hands to rotate (keeping hands clear of the rest of the system), the whole vector equilibrium array will be seen to be both rotating equatorially, parallel to the table but not rotations its polar-axis triangles, the top one of which the operating individual is hand-lowering, while carefully avoiding any horizontal rotation of, the top triangle in respect to which its opposite triangle, resting frictionally on the table, is also neither rotating horizontally nor moving in any direction at all.

“While the equatorial rotating results from the top triangle’s rotationless lowering, it will also be seen that the whole vector-equilibrium array is contracting symmetrically, that is, all of its 12 symmetrically radiated vertexes move synchronously and symmetrically toward the common volumetric center of the spherically chorded vector equilibrium. As it contracts comprehensively and always symmetrically, it goes through a series of geometrical-transformation stages. It becomes first an icosahedron and then an octahedron, with all of its vertexes approaching one another symmetrically and without twisting its axis.

“At the octahedron stage of omnisymmetrical contraction, all the vectors (strut edges) are doubled together in tight parallel, with the vector equilibrium’s 24 struts now producing two 12-strut-edged octahedra congruent with one another. If the top triangle of the composite octahedron (which is the triangle hand-held from the start, which had never been rotated, but only lowered with each of its three vertexes approaching exactly

perpendicularly toward the table) is now rotated 60 degrees and lowered further, the whole structural system will transform swiftly into a tetrahedron with its original 24 edges now quadrupled together in the six-edge pattern of the tetrahedron, with four tetrahedra now congruent with one another. Organic chemists would describe it as a quadrivalent tetrahedral structure.

“Finally, the model of the tetrahedron turns itself inside out and oscillates between inside and outside phases. It does this as three of its four triangular faces hinge open around its base triangle like a flower bud’s petals opening and hinging beyond the horizontal plane closing the tetrahedron bud below the base triangle.”

[From Blaine A. D’Amico.]

For a full (and quite mind boggling) discussion of these Jitterbug Transformers see “The Complete set of Jitterbug Transformers and the analysis of their motion” by H.F. Verheyen in COMPUTERS, MATH AND APPLICATIONS Vol 17, No. 1-3 pp. 203-250, 1989.

2.8 What is a sphere?

[From *Synergetics* - typed in by Kurt Przybilla]

224.07 <http://www.rwgrayprojects.com/synergetics/s02/p2400.html#224.07> Sphere: The Greeks defined the sphere as a surface outwardly equidistant in all directions from a point. As defined, the Greeks’ sphere’s surface was an absolute continuum, subdividing all the Universe outside it from all the Universe inside it; wherefore, the Universe outside could be dispensed with and the interior eternally conserved. We find local spherical systems of Universe are definite rather than infinite as presupposed by the calculus’s erroneous assumption of 360-degreeness of surface plane azimuth around every point on a sphere. All spheres consist of a high-frequency constellation of event points, all of which are approximately equidistant from one central event point. All the points in the surface of a sphere may be interconnected. Most economically interconnected, they will subdivide the surface of the sphere into an omnitriangulated spherical web matrix. As the frequency of triangular subdivisions of spherical constellation of omnitriangulated points approaches subvisibility, the *difference* between the sums of the angles around all the vertex points and the numbers of vertexes, multiplied by 360 degrees, remains constantly 720 degrees, which is the sum of the angles of two times unity (of 360 degrees), which equals one tetrahedron.

2.9 What is Fuller’s concept of “space?”

[From *Synergetics 2* [100.62-100.63] <http://www.rwgrayprojects.com/synergetics/s01/p0000.html#100.62>]

“[One reason for human incomprehensibility of the findings of science] is our preoccupation with the sense of static, fixed “space” as so much unoccupied geometry imposed by square, cubic, perpendicular, and parallel attempts at coordination, rather than regarding “space” as being merely systemic angle-and-frequency information that is presently non-tuned-in within the physical, sensorial range of tunability of the electromagnetic sensing equipment with which we personally have been organically endowed.

“The somethingness here and the nothingness there of statically interarrayed “space” conceptioning is vacated as we realize that the infratunable is subvisible high-frequency eventing, which we speak of as matter, while the ultratunable is radiation, which we speak of as space. The tunable is special case, sensorially apprehensible episodically.”

[From Chris Fearnley]

Space is “systemic angle-and-frequency information” because like all awareness it is patterned systemically and hence polyvertexially. It is information because the angle-and-frequency constituted system can be resolved into bits, 20-questions-wise.

Space is “presently non-tuned-in within the physical, sensorial range” because we are presently not receiving electromagnetic energy or information to our eyes, ears, nose, tongue or skin. But space is identifiable as a metaphysical system – it is “out there.”

[Kirby Urner’s contributions.] Space, the Final Untuned

Vis-a-vis whatever is in experience at the moment, is a vast otherness, which is by definition not tuned. That is space, the field of potential experience, I would say. Or maybe the field of “unmeant meanings” (no experience of that at this time). The trichotomy of “outside system, system, inside system” or “ultra-system-infra” is a generic description of that system (e.g. “belief system”). The “space of the untuned” or “final frontier” of a specific system is whatever that system cannot tune in. We all live in the space of our ignorance.

Space as “ultratunable radiation”

Before people knew about clusters of galaxies, or this galaxy for that matter, or “outer space” in general, they had yet to receive the energy through their instruments that would inform them of this “space” and its contents. The only way we have a concept of “space” is owing to our receiving energy. Relates to your dwelling on “experience” which Fuller equates with the “tuned” (vs untuned). What we tune is energetic. The far apartness of the galaxies, their infrequency, is what made them so ultratunable (unexperiential) for such a long time.

2.10 What is a “system?”

[From *Synergetics* [400.011-02] <http://www.rwgrayprojects.com/synergetics/s04/p0000.html#400.011>]

“A system is the first subdivision of Universe. It divides all the Universe into six parts: first, all the universal events occurring geometrically outside the system; second, all the universal events occurring geometrically inside the system; third, all the universal events occurring nonsimultaneously, remotely, and unrelatedly prior to the system events; fourth, the Universe events occurring nonsimultaneously, remotely, and unrelatedly subsequent to the system events; fifth, all the geometrically arrayed set of events constituting the system itself; and sixth, all the Universe events occurring synchronously and or coincidentally to and with the systematic set of events uniquely considered.

“A system is the first subdivision of Universe into a conceivable entity separating all that is nonsimultaneously and geometrically outside the system, ergo irrelevant, from all that is nonsimultaneously and geometrically inside and irrelevant to the system; it is the remainder of Universe that conceptually constitutes the system’s set of conceptually tunable and geometrical interrelatibility of events. ...

“All systems are polyhedra. Systems having insideness and outsideness must return upon themselves in a plurality of directions and are therefore interiorally concave and exteriorally convex. Because concaveness reflectively concentrates radiation impinging upon it and convexity diffuses radiation impinging upon it, concavity and convexity are fundamentally different, and therefore every system has an always and only coexisting inward and outward functionally differentiated complementarity. Any one system has only one insideness and only one outsideness. ...”

2.11 What is the “minimal system?”

The tetrahedron, of course.

[From Gary Lawrence Murphy]

The minimum system is an entity distinct from the rest of universe. The division is between the consideration set and the irrelevant; there will be leaks because no system is an island ;-), but for design purposes, the boundary defines the extent of energy interchange as represented by the concavity of the tetrahedral interior.

The four components [of our friend the tetrahedron] are four sub-tunable systems, only resolvable as a single point, but a system none the less. Between these, we have Euler’s rules for relative abundance of topological features, so if we can identify four stellar partners, we can postulate 6 interaction pairs and four interaction ‘facets;’ we can also look at the non-simultaneousness of the pair-interaction vertex stars as potential leak points (in reality, each is probably involved in a myriad of other tetrally-thinkable systems) or in Fuller’s terms, shunting-off points.

2.12 What are the A and B quanta modules?

[From Chris Fearnley]

Take a tetrahedron. Hold the opposite vertices in turn (two pairs). Spin the tetra. Use a “knife” to cut the tetra where the “great circle” from the spinning would cut it. You now have the 24 A quanta modules of the tetra (12 positive, 12 negative in orientation). Take 1/8th of an octahedron (it’s simple to see that the only way to do this is to extract the tetrahedron formed by the center of the octa and the three vertices that form one of its faces). Divide this into 6 equal parts (put the octa face on the table and use the edge bisectors). Note the line from the center of the octa to the center-face of the octa in the 1/8th octa. (It will be on the inside of the last division into 6 parts.) Find it’s midpoint and slice the 1/48th octas along this midpoint, dividing the original octa into 96 pieces. The piece of the 1/96th octa that is 1/6th of the face of the octa is our old friend the A module. The B module is the other part. They have the same volume though the shapes differ.

2.13 What is the “omnidirectional halo?”

[This relates to Fuller’s epistemography. From *Synergetics* [501.10-501.12] <http://www.rwgrayprojects.com/synergetics/s05/p0000.html#501.10>]

“Any conceptual thought is a system and is structured tetrahedrally. This is because all conceptuality is polyhedral. The sums of all the angles around all the vertexes - even crocodile, or a 10,000-frequency geodesic (which is what the Earth really is) - will always be 720 degrees less than the number of vertexes time 360 degrees.

“The difference between nonconceptual, nonsimultaneous Universe and thinkability is always two tetrahedra: one as macro, to complete the convex localness outside the system, and one as micro, to complete the concave localness inside the system, to add up to finite but nonconceptual Universe. Thus the thinkable system takeout from Universe has a ‘left-out’ outside irrelevancy tetrahedron and a ‘left-in’ inside irrelevancy tetrahedron.

“You have to have the starkly nonvisible to provide the complementary tetrahedron to account for the visibility, since concave and convex are not the same. That stark invisible reality of the nonconceptual macro-

and micro-tetrahedra also have to have this 720-degree elegance. But the invisible outside tetrahedron was equally stark. The finite but nonconceptual inness and outness: that is the Omnidirectional Halo.”

2.14 What does Fuller mean by 4D?

[From Kirby Urner]

Fuller used 4D to refer to the 4 rays from a central hub that omnisymmetrically define an expanding volume (e.g. the four lines from the center of a tetrahedron to its four vertices). The Cartesian system consists of 6 rays from the origin defining an expanding cube. The expanding tetrahedron uses/defines volume more economically, Bucky claimed.

[From Clifford J. Nelson]

The four dimensions refer to the movement of the four enclosing planes of a tetrahedron, not to rays to the vertexes.

2.15 Does synergetics provide an extension or modification of the “scientific method?”

I’ve been thinking lately: Does Bucky offer in SYNERGETICS an extension of the scientific method? The definition of Universe “The aggregate of all humanity’s consciously apprehended and communicated (to self or others) experiences.” Together with Fuller’s notion of thinking as the systemic process of sorting experiences into three broad sets: the macroscopic irrelevant, the microscopic irrelevant, the lucidly relevant set. This is his omnidirectional halo. I think it provides a means of organizing our thinking to make it more effective. Isn’t this what the scientific method is supposed to do? Moreover, the dynamic nature of synergetics implies that we need not get stuck permanently in paradigms as Thomas Kuhn suggests. Maybe synergetics is transparadigmatic. — C. Fearnley

Most definitely. Fuller did not choose the name Comprehensive Anticipatory Design SCIENCE lightly. Like all of Fuller’s language the name was carefully chosen. I feel that your characterization of Synergetics as an extension of the scientific method is absolutely true. In fact this is one of Fuller’s main criticisms of traditional geometry, that it is not science; meaning that it is not “... setting in order the facts of experience” but farther constructing an imaginary Universe out of non existent points, lines, and planes. — Blaine A. D’Amico

2.16 Are there connections between synergetics and fullerenes (besides the name, of course)?

The connections that I see between Synergetics and the Fullerenes are manifold. First, Carbon is a tetrahedral atom. It would seem logical that even if there were exceptions to Fuller’s tetrahedral concept of the shape of space, Carbon would surely obey these geometric principles (if the principles are true.) Fuller’s discussions of tetrahedral bonding are remarkably similar to Linus Pauling’s illustrations in “The Architecture of Molecules,” for example. — Blaine A. D’Amico

(See section 6.1 (What are Fullerenes? and Buckyballs) for more on the fullerenes.)

2.17 Why use synergetics' conversion factors and other irrationals?

[From *Synergetics* [410.02] <http://www.rwgrayprojects.com/synergetics/s04/p1000.html#410.02>]

“The omnirational associating and disassociating of chemistry - always joining in whole low-order numbers, as for instance $H(2)O$ and never $H(\pi)O$ - persuaded me that if I could discover nature's comprehensive coordination, it would prove to be omnirational despite academic geometry's fortuitous development and employment of transcendental irrational numbers and other 'pure,' nonexperimentally demonstrable, incommensurable integer relationships.”

[From Mitch Amiano]

Why does he so often make use of square root of 2, and to approximations of π ? It seems in fact that he actively uses them, but only as approximations, and with a synergetic conversion factor.

[From Kiyoshi Kuromiya]

I believe Fuller uses synergetic conversion factors simply as handy “fudge factors” and, if he had his way in the world, there would be no need for conversions, because everyone would use an entirely rational number system—or even more, a system consisting entirely of whole numbers. The use of the square root of two, I believe, is simply to illustrate principles of alloying, and like in the other case, could be dispensed with, if everyone were used to proofs that only relied on whole numbers.

[From Kirby Urner]

Relevant here is that giant Scheherazade number – abbrev. Sz – Fuller suggests would rationalize trigonometry. Adding lots of primes makes some sense, and a screen with that many pixels could certainly give us adequate resolution to submolecular levels, all with whole number coordinates. Second-root-of-two would be a shorthand symbol within a computational notation with a granular, integer underpinning. Given a grainy nature, with no absolute positions as represented by continuing irrational numbers to umpteen digits, I can see how Fuller felt no need to take the Number Theory idea of irrationality as a concept implemented in nature. But our symbols, our “root of 2” notations, continue to be useful, just as they always have.

I don't think Sz numbers make the number theory idea of irrationals go away. The problem was never “too few primes” in our base. The proof that the 2nd root of 2 is irrational has nothing to do with primes, more with an *reductio ad absurdum* showing it's neither true nor false that the root of 2 is even or odd ... anyway, I don't think Fuller is arguing that mathematicians have been wrong all these years in their own terms – just that nature doesn't need to continue π or other fractions according to some infinite rules. No time for that.

[From Mitch Amiano]

Given that Synergetics rejects irrationals, and given a modeling of nature based upon an integer representation with a specific sub-molecular resolution, could we not calculate the square root of 2 as a rational number?

This is what carpenters do every time they check the accuracy of a square layout by measuring from corner to corner. The resolution of their measurements is at a significantly higher level, in terms of fractional inches.

An example of measurement rationalization can be seen when moving from a relatively large base unit - the inch - to a relatively small one - the millimeter. More of the numbers are represented as whole integers.

Thus, the operational square root of 2 is 1.40625" when measured in thirty-seconds of an inch on a 1"x1" square, or 37mm when measured in millimeters.

[From Vincent J. Matsko]

Re: The irrationality of the height of an equilateral triangle: Again, I think it a matter of perspective. One may take an easy way out (I often do) and say that the square of the ratio of the height of an equilateral triangle to its edge is $3/4$. Voila, a rational number! Or alternatively, sometimes an expression involving square roots may be described as the solution of a quadratic equation with integer coefficients (i.e., the golden ratio is a root of $x^2 = x + 1$).

Now on another level, this is unsatisfactory, and I can't offer a good answer. Allow me a suggestion: change the comparison. For example, what is the ratio of the volume of a regular tetrahedron to the volume of a cube when both have the same edge length? Answer: irrational and irrelevant! Look through Fuller, and you never see (as least not to my recollection) two such figures. One only encounters a tetrahedron and the circumscribing cube. In this case, the ratio of the volumes is $1/3$.

Thus, not every "ratio" is rational; it depends upon what one takes the ratio of. And setting a standard is not simple. I believe, for example, that Williams in his book about structure gives data for the Archimedean solids relative to an edge length of one, which I find wholly unsatisfactory. Here is my choice for the "basic" Platonic solids: Begin with a tetrahedron, circumscribe a cube, and for the octahedron, take the dual to the cube (in the sense that the edge of duals perpendicularly bisect each other). Now the cube may in turn be inscribed in a dodecahedron, whose dual is an icosahedron. Now compute ratios of volumes of these figures, not those with edge length of one! For it is these figures which "naturally" occur in concert with each other.

For those ratios involving icosahedra/dodecahedra, one must be satisfied with rationals and the golden ratio as well. In fact, I am inclined to submit that the golden ratio be given honorary "rational" status!

[From Chris Fearnley]

This reminds me of the "canonical form" problem in mathematics. I realized in college that the notion of canonical form is ridiculous. Who cares if you have a $\sqrt{\quad}$ in the denominator of a fraction? Isn't a fraction of fractions still a fraction? If expressions not in canonical form are "bad" then doesn't that taint the whole derivation? Of course NOT! For synergetics calculations we are defining a new aesthetic for canonical form. One that is more geometrically intuitive and hence explainable to young children. From this perspective, it doesn't matter if we need to do "ugly" calculations to get some result - just put it in canonical (synergetic) form at the end. And by trying to do whole derivations entirely in synergetics (canonical) we accomplish the dual objectives of getting a clear geometrical representation and it's the one Nature is actually using in her transformings and intertransformings.

When reading synergetics it struck me that perhaps there are two basic phases in the Universe - tetra and ico. Your regular polyhedra hierarchy may be just another way of looking at the three fundamental geometrical forms in Universe - my so-called canonical (rational) forms.

2.18 What is "precession?"

[From Chris Fearnley]

I think the simplest first-order definition of precession is the side effects of a system in motion (generally occurring at 90 degrees to the direction of motion).

[Blaine D'Amico]

Bucky said that precessional effects are what most people label "side effects." i.e., I teach a person to fish so he can feed his family (Direct effect). One of his no longer hungry children now can focus in school and goes on to become an important scientist (precessional effect).

[From Gerry Segal]

My college physics books defines precession as:

“a complex motion executed by a rotating body subjected to torque, by a conical locus of the axis”

That’s quite a mouthful. Bucky gets even more complex. In

Synergetics [533.08] <http://www.rwgrayprojects.com/synergetics/s05/p3100.html#533.08>, he defines precession as:

“the intereffect of individually operating cosmic systems upon one another. Since Universe is an aggregate of individually operative systems, all of the intersystem effects of the Universe are precessional, and the 180-degree imposed forces usually result in redirectionals resultants of 90 degrees.”

A beautiful example is given in

Synergetics [417.00] <http://www.rwgrayprojects.com/synergetics/s04/p1600.html#417.00>. Here two exact sets of 60 Closest-packed spheres (wedges) are rotated 90-degrees and twisted (torque). An unexpected and marvelous result is a perfect 8 ball edged, 7-frequency tetrahedron that is formed.

I doubt that I have been successful in helping you understand precession. But I do know that if you take the time and build the models you’ll have an underlying sense of the meaning that provides the basis of understanding that the written word only hints at.

[From Leo Elliott]

The clearest example I recall Bucky giving of the notion of “precession” was that from the viewpoint of a waterbug or a jellyfish on the surface of the water, directly in the path of some big ship, which will send out precessional waves slightly ahead of the bow, thereby alerting the astute bug or jellyfish that something big is indeed on the way.

[From David Worrall]

Imagine a pebble dropped into a pond. The pebble goes to the bottom (closer to the centre of gravity of the earth!) The wave created moves outwards, at 90 degrees, precessionally, to the pebble.

[From Kirby Urner]

“Precession” in synergetics shows up as the relationship between two sides of the same generalized principle coin. Gravity begets radiation begets gravity. Tension begets compression begets tension. Pull on two ends of a rope, and its strands are squeezed even more tightly together. Where two very general aspects of nature always and only co-exist, and their relationship is generally precessional.

Synergetics is unlike traditional physics in its insistence on gravity as a circumferential pulling together (and thereby implosive), versus a radial explosiveness emanating from the center – a 90 degree relationship. The Sun is a giant squeeze ball. Strands of thought are likewise circumferentially implosive, nonlinear hypertext countervailing against vs the information explosion.

By extension, “precession” refers to nature’s way of getting the job done at 90 degrees to human selfishness and ignorance. We “do the right things for the wrong reasons.” The graduating from Class II to Class I evolution which Fuller anticipates involves our starting to do the right things for the right reasons, like you don’t need the Cold War to have the space program to have higher living standard spin-off technologies

(goodies yielding at 90-degrees to ignorance and fear). We don't have time for that kind of bumbling anymore.

2.19 What is the equation for finding the volume of a pyramid? [Steve Mather]

[From Chris Fearnley]

The issue of volume measure is dependent on the choice of the unit of volume. I recommend choosing the tetrahedron as the unit of volume. Then by subdividing the octahedron and tetrahedron into "building blocks" fascinating relationships will be discovered. Try building some models too!

[From Kirby Urner]

I agree with Chris F. – using Fuller's regular P-lengthed tetrahedron as a unit of volume is a good beginning. A regular P-edged octahedron will have 4 times the tetra's volume, while a cube with a P-lengthed diagonal will have 3 times the tetra's volume. That means a cube of diagonal P has 3/4 the volume of an octahedron of edge P. Say P=1. The corresponding cube of diagonal 1 has a volume of about 0.354 (conventional math), and so the octahedron has a volume of 4/3 that, or 0.471 (again, conventional math). If we multiply both results by the Synergetics Constant, we get a cube of volume 0.3750000 (precise) and an octahedron of volume 1/2. Those are the nice volumes we'd like, given a simple edge of 1. Note that the tetrahedron of edge 1 has a volume of 1/8. That's because of how the Synergetics Constant is derived. The so-called "prime vector" between any 2 adjacent spheres in the icomatrix is of Cartesian length 2 (these are unit-radius spheres after all). So the Synergetics Constant is the ratio between the volume of a prime vector diagonaled cube in Synergetics (=3) and the corresponding cube in XYZ geometry (2nd-root of 2 to the third power).

[From Martin Roller]

Kirby Urner writes:

>By the way, there *is* a formula that provides the volume of
>*any* tetrahedron given its 6 edges as inputs. It's a monster
>formula, derived by Leonhard Euler. I doubt I could write it
>understandably in ASCII.

Let ABCD be a tetrahedron with sides

$$\begin{aligned} a &= AD, \quad b = BD, \quad c = CD, \\ p &= BC, \quad q = CA, \quad r = AB. \end{aligned}$$

The volume V of the tetrahedron can be computed from the determinant of a 5-by-5 matrix as follows (here ^2 means taking squares).

$$288 V^2 = \begin{vmatrix} 0 & r^2 & q^2 & a^2 & 1 \\ r^2 & 0 & p^2 & b^2 & 1 \\ q^2 & p^2 & 0 & c^2 & 1 \\ a^2 & b^2 & c^2 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 \end{vmatrix}$$

[From Kirby Urner] Euler's equation for any Tetrahedron w/ edges p,q,r,s,t,u,v:

$$\begin{aligned} M = & (2qrt)^2 \\ & - [q^2(r^2+t^2-u^2)^2] \\ & - [r^2(q^2+t^2-v^2)^2] \\ & - t^2(q^2+r^2-s^2)^2 \end{aligned}$$

substitute above M in equation below (V=Volume)

$$V = 1/12 [M + (r^2+t^2-u^2)(q^2+t^2-v^2)(q^2+r^2-s^2)]^{.5}$$

This looks a lot more complicated than the determinant expression, but then a determinant is short-hand for a long messy expression. Anyway, both give the same answers. Then you can multiply by the Synergetics Constant to give the volume relative to a Tetrahedron defined by 4 adjacent unit-radius spheres of volume one.

2.20 How to communicate synergetically?

[From Kevin Sahr]

[Synergetics] seems to have the potential to be used as a mathematical basis for "communicating experiences" or for otherwise describing them in a precise way.

Though I agree with this in principle, I've never seen anyone actually use it for this purpose. For instance, can anyone out there right now communicate an experience to me using Synergetics? Even a "toy" example would be useful for discussion, but I'm thinking more along the lines of communicating some unique thought/constellation of thoughts to me; something that could not be well communicated using ordinary english sentences, but which would be unambiguously communicated to me by a set of geometrical relationships that, say, could be stored in a computer.

[From Chris Fearnley]

I think these synergetics explanations are not meant to replace ordinary english, but to supplement it. I think when you start (perhaps even at a metaphorical level) to examine the complex of interrelationships in an "english" story, you find deeper meaning. The synergetics patterns are there but our minds CAN (are capable of) dealing with these synergetics patters at an "unconscious" level. By trying to enumerate the precise geometry, you slow the normal geometric patterning - break the flow of thought. I suggest that by awareness of the inherent synergetic side of thinking, we can (as sort-of a side effect) find new relationships and understand more deeply the (initially obscured) relationships inherent in your "story." In other words synergetics probably does not supply a (logicians') decision procedure for unfolding a story, but rather a "mystics" science for appreciating relationships which before synergetics would have been left outside of cognition realization. In this synergetics science previously "impossible" ideas can become clear. Now you asked for an example of synergetics' application to understanding stories. Perhaps a new paragraph is in order?

Just some random thoughts. Antivirals may cure AIDS: AZT may be the answer! Well, synergetics suggests that we need to find ALL the relationships involved in our subject of concern. So we must look at the whole system. We now discover that the human body is chock full of viruses and bacteria. So it becomes clear that just by fighting the viral component of disease, we may be missing some vital components of disease. Perhaps AIDS is not a bad virus, but a "good" virus that through some co-factor some problem develops that is unrelated to the actual viral mechanisms. In sum, by looking at all the factors and keeping a clear

sight of inside-outside phenomena, we can begin to appreciate that the AZT craze of recent years, may be too simplistic a view of the situation. So with recent reports suggesting that AZT is mostly ineffective in improving the quality of life of AIDS patients. In conclusion, because synergetics asks us to consider the WHOLE complex of factors in inside-outside relationships, a disciplined thinker can be more skeptical of false eureka's and more sober when the false theories of yesterday are debunked. English's problem is that it doesn't provide the discipline of thinking that synergetics demands.

Hope that helps.

[From Kevin Sahr]

I agree that synergetics is important in the role you give it in your discussion and example, but I think reading Synergetics makes clear that Fuller was very much interested in "trying to enumerate the precise geometry." Synergetics consists of the types of principles you point out (i.e., look at the whole system, etc.), but it also consists of some very precise geometric statements (ie., the A-module break-down of the tetrahedron mentioned in the original post). So I guess I might re-phrase my original question: can anyone give me an example similar to Chris' AIDS example but applying, say, anything having to do with A and/or B (or, even T & E Quanta :-)) modules? Or maybe (a little bit less esoteric) the Jitterbug?

[From Kirby Urner]

Is Synergetics actually useful for communicating experience? Fuller's writings suggest how bare bones Synergetics supports fleshier metaphors in Critical Path and Grunch of Giants – Fuller considered them all one magnum opus, viewed from different angles.

The non-simultaneity of only partially overlapping events, some far apart in time and space, makes the tuning in of relations among these events a discipline. Fuller felt he was revealing some of these larger patterns in Critical Path. I find many of his visions tough to swallow, but that's another conversation. Like, where's the evidence for submarine aircraft carriers?

Since reading Fuller, I've done mental gymnastics to "feel" myself driving on the surface of a planet, stuck on by gravity, but not oriented in an up/down Universe. Once in New Mexico, a felt I was hanging upside down (my driving was unimpaired).

More, though, it's the word building associations, lying in the dark thinking of all the metaphysical communications going around the world (networking, diplomacy, broadcasting, satellites, telephone, exchange programs, advertising) as a circumferential countering of more physical explosions of violence (bomb blasts, big and small, gun fire). Not that some communications, such as inflaming of nationalist, racist sentiments and xenophobia, aren't also conducive to violence (wrong picture to think of communication as intrinsically beneficent – can be entropic in the extreme).

As for whether "precise" or "refined" synergetics, using A & B mods etc, is useful for communicating experience... well, to communicate precise geometric models and pictures certainly – my ability to visual the face centered cubic lattice of crystallography, and to understand the design of geodesic spheres and the dymaxion map certainly owes a lot to synergetics. But I think Kevin's question is more about whether electronics, molecular physics, quantum mechanics or the like may be illuminated by geometric descriptions – is a kind of "narrative mathematics" possible, in which your read "hard science" information more the way you read english syntax, than reading the usual mathematical symbolry? Fuller makes many attempts to talk about quanta, electron orbitals, energy transfer, stellar mechanics, using his language. I think we know what such narrative, or operational mathematics might look like. The question is whether these models have any experiential validity. Part of the problem, as Fuller saw it, is that geometric modeling of the physical world fell out of favor some decades ago, when the math left experiential visualization in the dust. So getting

back to geometric models is tough with or without the help of a geometric narrative-style language.

[From Chris Fearnley]

Synergetics is subtitled “Explorations in the geometry of thinking” - not explorations in the geometrical shape of an idea, argument, discussion. Fuller’s geometry is very dynamical. It shifts even more quickly than science’s theories about the origin of life on Earth (grin). So if I understand correctly, you’re asking for an example describing how an intertransforming isotropic vector matrix pulsating through it’s full periodicities (with A and B models as an integral part of the whole apparatus) can model the evolving process of “casting out irrelevancies” to focus thinking more-and-more on the system in question (the requested example). I think this would be impossible to do in a general fashion. Perhaps one could examine their own thought patterns carefully enough to see which thoughts correspond to which A-Module pulsations, but I think this would be difficult especially given the fact that by examining the process of our thinking we alter it in unpredictable ways. I think Fuller’s theories on the dynamics of thinking can only be “proven” with high-level, fundamental reasoning w.r.t. the nature of the geometry itself and its “uncovering” of the mysteries of thinking (the process, the verbs not the nouns). By exploring the fundamental logic of the basis of thinking in Synergetics, I convinced myself that in general Fuller is “right on the money,” but I have been unable to apply his work in the static way in which you would like to see it. (See Fuller’s essay “Omnidirectional Halo” in *No More Secondhand God* which is the essay which when “unfolded” turned into *Synergetics*.)

[From Kevin Sahr]

Again, I think this kind of thing is important, but “geometric modeling of the physical world” is not what I was getting at - what I’m after is geometric modeling of the *metaphysical* world, the world of mind. A lot of people are interested in Synergetics as throwing light on things which fall within the realm of the hard sciences (ie., molecular configuration (Buckyballs), civil engineering (octet trusses), etc.), and certainly I think Synergetics will repay any time spent with it by practitioners in those fields. But, to come out of the closet, my own interest is in mathematical models of how we think (and how we might think more effectively!), specifically those models which are computer programmable. I think that Bucky saw Synergetics as very relevant to that type of “science,” and I think he would have claimed that that relevance extends even to the more mathematically esoteric elements of his theories. I’m just trying to figure-out what that relevance might be!

By the way, I’m not claiming that Bucky himself always saw such a relevance in all of the “generalized principles” he discovered; often I think he was just cataloging such principles in hopes they might be useful to someone in the future. But I *am* claiming that I think Bucky would have argued that there *must* be some such relevance for all these principles. And I think it’s clear that he saw relevance in areas that I do not yet.

Again, to turn to the concrete. I apologize for not having the exact quote in front of me, but Bucky wrote in Synergetics something to the effect that the Jitterbug recapitulates the phenomenology of all experience. In what way is this true? If this is so, then shouldn’t it be the case that we could take any experience (including any thought or line of thought) and in some sense map it onto the Jitterbug?

[From Leo Elliott]

Interesting discussion on the nature of synergetics as science, as linguistics, and how Bucky may have conceived their pattern-integrity. Interesting enough to make me pull out some ancient transcriptions of a 1976 “Being With Bucky” gathering out in SF...

Like Kevin Sahr, I must confess that, as a non-scientific type, the appeal of Synergetics always seemed to come more from the notion, implied or explicit, that all Bucky’s perusings and perambulations pertained at least as much to the metaphysical as to the physical, that somehow ‘thought’ itself was structured in

the form of A and B quanta modules, or their equivalents... As a former devotee of *The Urantia Book* I used to get quite excited about all the triadic expressions of ‘universe reality’ presented therein, things like “thing/meaning/value” or “fact/idea/relation” or “origin/nature/destiny,” an attraction I now view as part of a basic rhetorical appeal that somehow reinforced, in a starry-eyed-seventies way, Fuller’s own novel rhetoric.

I suppose that if the ‘return to modelability’ that Bucky spoke of was part of his life enterprise, then perhaps a first step was a ‘return to speakability’ – and as any hereon who may have been fortunate enough to hear Bucky live (for me only once) may attest, it was an experience of sitting on the edge of my chair for three hours, straining to keep up with the thinking of a man three times my age, and at the end of which left wondering if perhaps Bucky weren’t receiving some kind of alien transmissions through his hearing aids. I still had that feeling when listening to these tapes again, almost twenty years down the road.

Is it fair to say that Bucky’s written grammar and syntax was at least as complex and intricate as his oral presentation? I know Bucky took a lot of flak from those whose eyes glazed over after the same sentence went longer than two minutes or twenty -or-so lines, but somehow whenever I tried to find any grammatical or syntactical error(s), none showed up, and while I never actually did so, I had the feeling that one could even diagram his sentences. There is a great photograph in E.J. Applewhite’s *Cosmic Fishing* which shows a page of galley proof, supposedly ready to go to press, which Bucky had filled the margins of with corrections and revisions, never being content with saying something, on paper or in person, just the way he had said it even the day before.

So in answer to queries for metaphysical specimens of synergetics, I can only think of Fuller’s written works, and his oral presentations as such have been preserved in various archives.

I also believe Bucky spoke of his ‘prayers’ being different every day, and how “it also seems illogical to remind God of anything.” If any are interested I have a version or two of at least one specimen of the Bucky-version of the Lord’s Prayer, which at least on the tape -started out- as an “our father” type soliloquy, but which in typical fashion mutated several paragraphs later into something else. I attach below my own specimen of fullerspeak, written in the best syner-linguistics I could muster.

Is it also fair to say that Bucky’s speaking and writing styles were as close to identical as any rhetoric in the collective recollection?

Our tetrahedron
who art in geometry
hollowed by thy concavity
thy convexity come
thy system be dome
on Urth
as it is in Universe.
Give us this eternity
our daily integrity
and fore-give us our dis-integrations
as we fore-give those
who dis-integrate around us.
And lead us only in -- to syntegration
and de-livery us from entropic monofocus
on material self-interest
universe within Universe
amen.

2.21 Modeling suggestions?

[From Clif White]

Try this the next time you have some time, newspaper, a dowel and some masking tape.

All that newspaper laying around your house can be made into large structures that are surprising strong as well.

Simply roll a sheet of newspaper around a 1/2" dowel secure the end of the roll with a bit of tape and slip out the dowel and then repeat procedure to make another strut.

Using your stock of newly created struts, secure the ends to form joints using more masking tape. (Don't use a lot of tape at the ends.) Form triangles and then tetrahedrons along with octahedrons and you will begin to make a large scale octet truss system that will quickly fill up your room.

You will be amazed at how strong this system is!

This is a great activity for a bunch of kids. You can make all sorts of polyhedra quickly and cheaply. A production line of strut makers, and joiners can really pump out the structures. My kids love this activity.

[From Christopher Rywalt]

The other day I was wandering through Star Magic – another one of those science toy-type stores – when I was about to complain that I never could find anything very interesting in such a store. Just as I began to speak, however, my friend said, “Sure, you play with the useless stuff and walk right past that thing you’ve been looking for for months.” And he pointed me at a little kit called a Vector Flexor. I don’t know how many of you have run into this, but its rather neat. It’s basically colored sticks and rubber tubes, and the rubber tubes can be assembled into an X shape and the sticks stuck into them to make a vector equilibrium. It’s pretty cool, because it can be made to jitterbug and it comes with a pretty detailed insert explaining what it is and even refers the buyer to several of Bucky’s books.

[From Mitch C. Amiano]

I note that, in Fuller’s Octetruss patent, there is an implementation disclosed in which the struts are formed by the overlapping edges of aluminum triangular plates with 3 flanges. I tinkered with an alternative (overlapping faces & flanges) form of the same thing in paper. I decided that with a few extensions and mating pieces it could be a real modeling kit; the major drawback being that the paper models were not self-aligning like plastic or metal formed plates would be, so large models tended to show signs of twisting.

I then took some empty 1-gallon polyethylene water containers, stripped the labels off, cut off and layered the flat sides, and melted them together carefully in a 375-450 degree oven, to get a ~1/8th inch thick laminated sheet. I cut and shaped a plastic prototype of an octet plate of my revised design. It’s about 3cm high, and looks pretty neat - but I think my wife would get X-(mad if I do it again soon: melted polyethylene smell even with the fans on and windows open.

2.22 What applications of synergetics are being discovered?

Here I want to include references to work that shows how useful Fuller’s synergetics ideas are and have been - To persuade the skeptical :)

[From Ed Applewhite]

Satellite sensing data displayed for first time on geodesic triangular-tetrahedral grid

“Scientific American.” (January 1991) reported that researchers at the Los Alamos National Laboratory turned a technique for modeling explosions into one that simulates climatic change.

“It relies on meshes made of half a million tetrahedrons. . . . Every tetrahedron covers an area no wider than 30 kilometers. . . . In the event of a disturbance such as a hurricane, these meshes would twist. Conventional models which use rigid meshes of rectangular bricks, typically lack the resolution to portray such comparatively local phenomena.” (The graphics accompanying this article demonstrate the kind of applied geodesics that Buckminster Fuller had in mind.)

2.22.1 What is Kirby Urner’s storyboarding concept?

[From Kirby Urner]

What’d be nice to have is a large inventory of artfully produced synergetics clips *in the public domain* which personal workspace enthusiasts (e.g. me) could inload, edit/recombine, and outload to the network. Over time, we’d build up quite a library. In the short term, I don’t think Internet is the place to communicate these high bandwidth scenarios so much as a place to verbally fantasize them or give info about how to get them through other channels (e.g. the mail). Most realistically, I think a CD-ROM of Synergetics Clip Art, stills, short animations, pictures of artifacts, inventions, Bucky’s prose and poetry, who’s who contact lists etc would be the ideal evolutionary tool to galvanize the incipient Design Scientists among us to get to work. As the dial-up and downloading of visual video clips becomes more available, then we can move our collection to a more public archives.

Again, I think these metaphysical assets should be public domain (even though the CD-ROMs themselves will cost) to encourage users to incorporate them freely into works of their own, and to upload these for downloading by others in turn, and so on. That’ll be the metaphysical/fantasy part: out in the real world, we’ll be sharing our storyboards with TV producers to get Hollywood-style storyboards enacted big time, on a bigger scale. Any mass infusion of domed domiciles would be televised for sure.

Best to work with the entertainment industry from the inside out, rather than expecting Design Science to take off on the side some place, and have TV news people come running to “the scene.” No. The Design Science revolution will start right in the studio, when the map behind Dan Rather’s head stops looking so stupidly distorted.

2.23 Is it possible to develop an operational pi?

[From Mitch C. Amiano]

I am trying to develop a procedure for giving the ratio of the circumference to the average radius of certain circle-like polyhedrals, as a function of the number of outer chords on the polynomial edge. The constraints I have (arbitrarily) placed require that the polyhedron be formed by a whole number of equivalent triangles placed about a center point. The triangles have (at least) two identical edge lengths (of unit length) which are the radii of a circle circumscribing the polyhedron, and one (outer) edge in common with the formed polyhedron.

As an example: for a hexavertexion (hexagon) with an outer radius of 1, there are six equivalent triangles which happen to be equilateral; the outer edge also has a length of 1. The frequency of subdivision is 6

(the number of outer edges). The average diameter is $1 + \sqrt{3}/2$. The approximation of pi for this case is $6/[1 + \sqrt{3}/2] = 3.2154\dots$ which itself is irrational, but at least it seems to have some relationship to the polyhedron.

[From Robert L. Read]

From the formula for regular polygons in *CRC Standard Mathematical Tables*, Edition #27, page 122, the inner radius of a regular polygon (the radius of the inscribed circle) is $(r = 1/2 * s * \cot(180/n))$, where \cot is cotangent, n is the number of sides, and s is the length of the chord on the outside edge. The radius of the circumscribed circle is $(R = 1/2 * s * \csc(180/n))$, where \csc is cosecant. Since the circumference of the n -gon is $(n * s)$, we can write the ratio of circumference to "average radius" (if you mean by that, as you apparently do, the average of the maximum and minimum, which is not obviously the same as what you would get by calculating the average over an infinite number of rays via calculus, but it might be) as:

$n * s / ((r + R) / 2)$, which by algebra is equal to

$2 * n * s / (r + R)$, which by substituting the above formulae is,

$2 * n * s / (1/2 * s * \cot(180/n) + 1/2 * s * \csc(180/n))$, and so the s 's can be crossed out of the top and bottom and we get:

$2 * n / (0.5 * \cot(180/n) + 0.5 * \csc(180/n))$, which is a function only of n , which is what we desire, and can be cleaned up to:

$4 * n / (\cot(180/n) + \csc(180/n))$

which, since \cot and \csc are kind of a pain we can replace with \sin and \cos via identities that we should all remember but happily can be found on page 135 ($\cot x = \cos(x) / \sin(x)$ and $\csc(x) = 1/\sin(x)$).

Then with a little more algebra we get the easy-to-use-if-you-have-a-calculator formula:

$\text{circumference} / \text{av. radius} (n) = (4 * n * \sin(180 / n)) / (1 + \cos(180/n))$

And, BTW, it works, I checked it at a few values.

[From Kirby Urner]

Nature is not using PI, nor are humans (part of nature). All computer-based and calculator-based representations of PI are truncated to the number of digits internal storage permits. Even those gazillion digit Cray monsters terminate (and besides, are not used in practice in any calculations). Bucky's argument that nature does not use irrational numbers is pretty straightforward: you have never used an irrational number in your life: all computations with root-of-two, pi, e and so forth are definite, terminated. We call them "approximations" just as we say all lines are "approximations" of perfectly straight ones. Bucky simply starts with what's right in front of us, in our everyday experience, and says "not approximations of anything, this

is what simply *is* – no perfectly straight lines and no ultimate value of PI actually exist or gets used for anything in nature.”

...

So are we agreed that what Bucky was advocating was a ‘grainy-pi’ using a super scheherezade number with tons of primes folded in? Like, the Babylonians chose 360 because of its easy divisibility. People came up with “Grads” (on most calculators) dividing the circle into 100 degrees – for the true die-hard decimal-heads. So Bucky, in true Babylonian fashion, but acknowledging the new level of computing power we’ve attained, suggested replacing 360 with a number with a great many more primes worked in. The idea would be to then generate a table of trig functions that always “came out” to some rational number. The whole set-up would be “grainy” but I think it was Bucky’s contention that we would find such a system to be sufficient to cover nature’s “scalables” – i.e. we would have a rational trigonometry of enough accuracy to do subatomics, architecture etc.

I have no clear understanding of what it would look like to carry this out in practice. Sounds like a job for a computer language. My question here though is: does anyone have a different understanding of what Bucky meant? And, yes, what about the phenomenal utility of such numbers as e, sqrt(2) etc? Although here, again, my earlier assertion is relevant: our computers only carry out our symbols to a finite number of numbers for crunching purposes in any case, so the question “can we get along without computing with nonterminating irrationals?” is moot in any case – we get along fine right now.

[From Mitch C. Amiano]

Given that there is no infinite precision in practice and in Universe, we must decide what precision to use. The most common approach is to just use however many digits our calculator gives us, which is usually too many, and get a bigger calculator if its not enough. Generally, the precision we need is determined by the size of our bolt-holes and the elasticity of the materials we’re working with.

For any working environment we could define a necessary precision (higher for steel than wood, higher for wood than plastic) and develop tables of fundamentals values, such as the ratio of circumference to diameter for an n-gon, expressed as fractions in simplest form that would be accurate enough for that application. (The decimal expansion could be used, but often we would find much simpler fractions that are accurate enough.) This would have a certain pleasing simplicity, but, on the other hand, it has no really obvious advantage over an over-precise description. However, it seems worth investigating, because if some pattern could be detected, then we would gain not only an engineering tool, but a tool for understanding, which is one of the wonderful things about many of Fuller’s inventions.

[From Vincent J. Matsko]

It is possible, beginning with a hexagon, to perform the “irrational” approximations [to pi] by doubling the number of sides each time (rather than increasing by one) so that the appropriate half-angle formulae may be used to calculate sines and cosines without any knowledge of pi.

Re: The practicality of pi: I have done quite a bit of solid geometry (Fuller was inspirational for me), and I have never had occasion to use pi. I think the natural choice of “unit” for angles to be “revolutions,” thus the range 0-360 degrees is just the range 0-1. Now these numbers are “dimensionless,” being interpreted as the fraction of the area of a circle that the sector cut out by the angle occupies.

Now let’s take the discussion to three dimensions. We wish to have a measure of solid angle so that we may discuss spacefilling ideas. So define the measure of a solid angle to be that fraction of a sphere (centered at the vertex of the angle) cut out be the solid angle. If A, B, and C are the measures of the dihedral angles of a solid angle, and the measure of the angle is $1/2(A + B + C - 1/2)$. Example: Take the corner of a cube.

Each dihedral angle has measure $1/4$ (i.e., 90 degrees). So the measure of the solid angle determined by a corner is $1/2(1/4 + 1/4 + 1/4 - 1/2) = 1/8$. Now in a cubic packing of space, 8 corners of the cube meet at a point, so it makes sense that each corner should occupy “one-eighth of the space” about the vertex of that corner. (This formula for a solid angle is derived from a standard result (in the CRC, e.g.) for the area of a spherical triangle by changing the units to revolutions and by dividing by the surface area of the sphere in question (so as to yield a ratio rather than an “absolute” area).)

As far as a generalization goes: (1) for an n -hedral angle with dihedral angles A_1, \dots, A_n , the formula for the measure of the solid angle is $1/2(A_1 + A_2 + \dots + A_n + 1 - n/2)$, which reduces to the above for $n = 3$. (2) However, in higher dimensions, there is no simple formula. Coxeter addresses the issue briefly in his *Regular Polytopes*, where he includes a formidable 4D formula derived by Schläfli. It’s really rather nasty looking, if I must say.

Thus, we may talk of solid angles in 3D without needing to bring in π , the results being, I believe, more geometrically intuitive. And, being that Fuller’s rather discrete geometry really never concerns itself with circles or spheres (I suppose excepting sphere packings), π is not really needed.

[From Kirby Urner]

I’ve come up with an algorithm for deriving π that uses no trig, just Pythagoras. Involves filling a unit circle with a fractal pattern of similar triangles, thereby approaching π as an *area* (vs circumference). The algorithm is easiest expressed as a short computer program:

```

pi=2
hypot=2^0.5
FOR n=1 TO 30
    height=1-(1-(hypot/2)^2)^0.5
    newhypot=(height^2+(hypot/2)^2)^0.5
    newarea=1/2*height*hypot
    pi=pi+2^(n+1)*newarea
    ? pi
    hypot=newhypot
ENDFOR

```

The output of which (from the line reading ‘? pi’) reads:

First 5 terms:

```

2.828427124746190000
3.061467458920718000
3.121445152258052000
3.136548490545939000
3.140331156954753000
<stuff deleted>

```

Last 7 terms:

```

3.141592653589789000
3.141592653589793000
3.141592653589793000
3.141592653589793000
3.141592653589793000
3.141592653589793000
3.141592653589793000

```

As you can see, I reach the limits of my computer's accuracy (using this particular programming language) at about 25 iterations.

There's some specific geometric reasoning that led to this algorithm of course, which involves starting with an inscribed square (2 triangles) and successively bisecting outer edges (hypotenuses) to create a series of smaller and smaller similar triangles pushing into the unfilled arc regions. As the triangles get smaller, their numbers multiply exponentially, hence the fractal-like (self-similar) nature of the algorithm.

Inscribe a square in a circle. Now imagine the mid-edges of the square moving out to touch the circle, making 4 triangles using each of the square's edges as a base. Now have the outer mid-edges of those new triangles move out to the circumference again, making more, smaller triangles. Repeat until the computer runs out of significant digits.

This is not a picture of a pie with narrower and narrower slices, all converging at the center. It's a pie with big sections at the center and smaller and smaller ones pressing out towards the edge of the circle.

This method may have already been published many times, but I derived it from scratch I'm proud to say.

I've further simplified, or at least re-expressed, an algorithm for generating pi without using trig functions.

Those interested should rewrite using conventional notation. $[]$ means subscript. $^$ means "raised to power" e.g. $2^{.5}$ means "2 to the one-half" or "2nd root of 2." SIGMA means one of those Greek summation symbols (just a fancy symbol for a programmer's DO-loop)...

- (1) $h[0]=2$
- (2) $h[i+1]=(2-(4-h[i]^2)^{.5})^{.5}$
- (3) $pi=SIGMA\{2^i*h[i]*(1-1/2*(4-h[i]^2)^{.5})\}$
where $(i=0,1,2,...)$

[Expansion]

```

h[0]=2
h[1]=SQRT(2)
h[2]=SQRT(2-SQRT(2))
h[3]=SQRT(2-SQRT(2+SQRT(2)))
h[4]=SQRT(2-SQRT(2+SQRT(2)))
h[5]=SQRT(2-SQRT(2+SQRT(2+SQRT(2))))
...
h[n]=SQRT(2-SQRT(2+SQRT(2+SQRT(2+...))))...
```

The above succession of terms derives from

```

h[0]=2
h[i+1]=SQRT(2-SQRT(4-h[i]^2))
```

Another way of expressing the continued radical:

```

i=0...n
k[0]=0
h[0]=2
```

```
k[i+1]=SQRT(2+k[i])
h[i+1]=SQRT(2-k[i])
```

In other words, you start with $h[0]=2$, then plug that in to the left side of expression (2) to get $h[1]$, plug $h[1]$ in to get $h[2]$ and so on. Expression (3) is a summation of terms indexed on i where $i=0,1,2,3,4\dots$ and so on, as long as you want to continue. Note the term 2^i – a successive doubling with each new term in the series, reflective of the doubling number of smaller and smaller triangles, the area of which is provided by the next two terms (a base*height expression).

I've also simplified the computer program a bit:

```
area = 0
hypot=2
FOR n=0 TO 25
    height=1-(1-(hypot/2)^2)^0.5
    area=area+2^n*height*hypot
    hypot=(height^2+(hypot/2)^2)^0.5
ENDFOR
? area
```

After 25 iterations, area should = pi to 15 decimals.

[From Kiyoshi Kuromiya]

I thought I would share part of an article (“Cosmic Noise”) by George Johnson in today’s New York Times (7/9/94):

“In trying to construct a science of science, people like Dr. Chaitin and Dr. Landauer are questioning some of the deepest assumptions of their craft. Since Newton, scientific laws have been expressed in the form of differential equations, which have exact solutions, and with the so-called real numbers, which can be expressed as infinitely long decimal expansions. Pi equals 3.14159

“In practice, science inevitably falls short of this ideal of infinite precision. In quantum physics, the simplest atom–hydrogen, with one proton and one electron–can be described precisely. But the equation for the helium atom, with its additional proton–is intractable. We must make do with good approximations. Estimates of the size of the shards of the Shoemaker-Levy comet vary so widely that some scientists predict there will be no measurable impact on Jupiter at all.

“Science has long operated on the assumption that space is continuous, with infinitely many points between two marks on a line. Mathematicians have calculated pi beyond a billion decimal places. But 61 decimal places are enough to describe a circle girding the visible universe with a deviation of less than a single Planck length—a unit 10-to the twentieth power (1 followed by 20 zeroes) times smaller than a proton. this seems as close to perfectly circular as a real circle can be. Do the rest of the decimal places have any meaning?

“The mathematician Herman Weyl once said that the belief in an infinite continuum of numbers ‘taxes the strength of our faith hardly less than the doctrines of the early Fathers of the Church or the Scholastic philosophers of the Middle Ages.’

“Few scientists are ready to abandon differential equations and real numbers for the more realistic mathematics Dr. Chaitin is proposing. but in seeking a foundation for science, everything is up for grabs, including the universality of mathematics.

“For centuries philosophers have debated whether mathematics is invented or discovered. Taking a middle ground, the 19th-century mathematician Leopold Kronecker declared, ‘God made the integers; all else is the work of man.’

“Einstein, it seems, went even further. Even the integers, he wrote, are obviously an invention of the human mind, a self-created tool which simplifies the ordering of certain sensory experiences.”

2.24 What are Koski’s and Kajikawa’s modules?

[From Kirby Urner]

David Koski is a master of the self-similar tetrahedron fractal. He uses the golden ratio (phi – not pi) to scale T modules. Phi-scaled T-mods of various sizes actually pack together to make cubes, icosahedra and other 5-fold symmetric solids. Even more shapes may be made if variant modules, each assembled from 6 of the 7 unique edges of the golden cuboid* are admitted to the phi-scaled building-block inventory.

Yasushi Kajikawa of the Synergetics Institute in Japan has a competing module set for assembling 5-fold symmetric shapes, and a hypercard stack for the Macintosh to show how it works. Kajikawa’s work was actually published in Scientific American (Japanese edition only) whereas David Koski’s work is as yet unpublished.

The literature of module sets, finding a minimum inventory of building blocks for assembling a wide variety of shapes (ala Fuller’s Mite, Kyte, Syte discussion) is fairly large. There’s that dome architect from Iceland who’s into it, and that book on particle physics which tries to model quantum mechanics using polyhedra (Fuller pushed in this direction of course).

2.25 What is Richard Hawkins’ curVE model?

[From Richard Hawkins]

I have made a model based on the Vector Equilibrium using quadrants (90 degree arcs) in place of straight lines. Visualize a cube with circular faces. All of the circumferentials (no radials in this model) are equidistant from the center of gravity; facilitating motion. View the model as 4 groups of 6 quadrants each forming “circuits” analogous to the 4 hexagonal components of the VE (cuboctahedron). Locate a rotating armature (straight-line structure) with its pivot point at the center of gravity and ends at opposing points on one of the 4 “circuits.” (I have used 4 different colors to help differentiate these in the model.) Animate the armature to make a complete revolution (keyframes at the beginning of each quadrant) around each “circuit,” alternating continuously through the 4 different axes of rotation (4-D). Grouping another armature at 90 degrees centered to the first produced a surprising (to me) result. For each revolution around a “circuit” by the first armature, the grouped armature tracks opposing spherical triangles twice. It bobs and weaves! Sorry if this verbal description is not easy to visualize.

One picture of this model is available by anonymous ftp

[switchboard.ftp.com:/bucky/curVE.jpg](ftp://switchboard.ftp.com/bucky/curVE.jpg) <ftp://switchboard.ftp.com/bucky/curVE.jpg> .

2.26 Fuller’s *Synergetics* and Sex Identity.

[From Chris Fearnley]

In the Humanities Citation Index I found an article by Prudence Allen, R.S.M (Concordia University) in International Philosophical Quarterly 32(1):3-16 entitled “Fuller’s *Synergetics* and Sex Complementarity.”

The article had several very interesting features. First, she provides a test-case example of Fuller’s principle that the minimum conceptual system is structured tetrahedrally.

Concept of Male Concept of Female Description =====
first vertex: male female Primarily Biological second vertex: masculinity femininity Primarily Psychic
(cultural) third vertex: femininity masculinity " fourth vertex: man woman As individuality

Allen argues that this tetrahedron of Male and Female is both historically and philosophically tantalizing (if not valid).

Second, Allen looks at Fuller's concepts of complementarity and parity (and implicitly the concepts of system, integrity, events, inter-relationships of events in a system - well, basically the whole of Fuller's epistemography) in application to sex identity. She also evaluates several of Fuller's references to male-female complementarity (*Synergetics*:

1210 <http://www.rwgrayprojects.com/synergetics/s12/p0000.html> ,

511.12 <http://www.rwgrayprojects.com/synergetics/s05/p1000.html#511.12> ,

1076.11-12 <http://www.rwgrayprojects.com/synergetics/s10/p7000.html#1076.11> ,

1024.15 <http://www.rwgrayprojects.com/synergetics/s10/p2000.html#1024.15> , and others). She quotes Fuller's article "Goddesses of the Twenty-First Century" in Saturday Review 14:(2 March 1986). (Has anyone seen this article?)

"Women are tensional and continuous. Each new female as well as male life comes from the womb of the women. We have, then, the new female life as a series of expanding waves, the new ever emerging from within the older wave. Women are continuous. ...

"Males are discontinuous. The new life is noncontiguous to the previous male life. Men are, then, islanded, individual discontinuities."

Finally, I noticed that Allen's article is a very interesting piece of scholarly applied synergetics and synergetics' philosophy. She really understands Fuller's philosophy of systems and its inherent complementarity, parity and synergy. Her only real criticism was that Fuller didn't take the next step to viewing man as a person in community and woman as a person in community. Although I don't recall any references to a philosophy of humans in community in *Synergetics* (besides the electronic voting), I think we need to review Fuller's essays in Ekistics before we can safely claim that Fuller didn't develop any specific thinking regarding communities. Overall, this is a good read for the Fuller scholar looking for philosophical applications to synergetics.

[BTW, there is another philosophical essay by Derek A. Kelly "The Philosophy of R. Buckminster Fuller" in International Philosophical Quarterly 22(1982): 295-314. This long essay disappointed me as the author does not seem to have integrated all the pieces of Fuller's philosophy. Well, in my opinion (based on a very cursory examination) Kelly didn't comprehend the full meaning of Fuller's concepts. I'll have to read this one more carefully before passing final judgment.]

2.27 Tips for reading *Synergetics*.

<http://www.cjfeanley.com/synergetics.essay.html> provides some tips for reading *Synergetics*.

3 Fuller's Ideas About Human Society: Critical Path

Fuller was interested and made contributions on a wide range of issues in the area academics call the "social sciences". Much of this work addressed economics. He published several studies of industrial trends. There

was the famous 1940 issue of Fortune magazine which he inspired. In the 1960s the *Design Science Decade Documents* were published. Fuller advocated the principle of “ephemeralization” or doing “more with less.” Fuller founded the world game which explores the task of making the world work for 100% of humanity. His major publications in this area are *Critical Path* and *Grunch of Giants* wherein he also gives a unique perspective of the history of humans on Earth.

3.1 What is the Design Science Revolution?

The “Design Science Revolution” references Fuller’s program of applying the principles of science to solving the problems of humanity in an aggressive, anticipatory and comprehensive manner. The principle of ephemeralization shows we can accomplish more and more functionality with less and less energy, material and time investment, “we are now able to do so much with so little that we can provide for the basic needs of 100% of humanity without disadvantaging anyone.” In contradistinction his “archenemy,” Obnoxico Inc., which tries to make money out of thin air (or rocks) with little or no appreciable benefit to humankind. Fuller suggests that by taking the design principles of Universe (as described in *Synergetics* and elsewhere) and our consciously developed values, we can emerge from the present-day “dark ages” and prosper like never before in history.

Pat Salsbury has an excellent web page describing *Comprehensive Anticipatory Design Science* <http://sculptors.com/~salsbury/Articles/Design-Science-proposal.txt> .

3.1.1 When will the Design Science Revolution begin?

[From Chris Fearnley] The Design Science Revolution has *already* begun

During the 1980s, under the smoke screen of republican conservatism conveniently provided by the mass media, large numbers of individuals and groups have begun to organize the resources available to them to understand the world and begin the process of working for 100% of humanity. Here are some events that suggest that Earth may be entering the design science revolution as predicted by Buckminster Fuller: World Game grew to be an Institute, World Resources Institute was formed (c. 1982), The World Watch Institute began publishing a yearly State of the World Report, home computing explodes in numbers and quality and became ubiquitous, BBSing becomes an institution for intercommunication,

[From Unknown]

Some of my colleagues have been doing realtime strategizing where NEWIDEA=“global design science revolution.” Fuller’s hypothesis was that lag times in social acceptance of new artifacts is a function of a natural gestation rate associated with different technological arenas e.g. novelty electronics proceed from drawing boards to end-users in a matter of years, whereas adoption of fundamental changes in household architecture is measured in decades. Obviously changes occur along different scales (geologic thru atomic). Some NEWIDEAs come with glacial-paced agendas that no amount of cleverness in strategy will accelerate beyond a top limit.

[From Kirby Urner]

Storyboarding for Design Science Drama: Some Pro-Net Propaganda by Kirby Urner June 12, 1994

In *Grunch of Giants*, Bucky Fuller cast the community of networkers in the role of David versus the supranational corporate Goliath. As in any good tale, the archetypal opposition (compression) provides a foreground plot against a contextual background of eternal principles (tension). Behind the scenes we ever rediscover

what teachers call “the unity of opposites.” David and Goliath are two aspects of the same psyche. We have met the enemy and the enemy is us.

The Internet is abuzz with rumors of huge conglomerates positioning for an all-out invasion. The funky, free and informal usefulness of a shared, non-hierarchical, decentralized, self-monitoring culture will be conquered by a culture of greed and aggressiveness. The world of commercial television, which has already invaded public schools, will storm into our peaceable kingdom to haul us as slaves in chains before our new corporate masters. We shall once again be cast as consumers of dumbed down infotainment carefully purged any content that might offend the sponsors. Everything will cost, nothing will be reusable or recopyable, and stories of these carefree days will be as legends in the ears of our children. The evil Grunch will have won.

In Bucky’s tale, the now omnipresent computer is on the side of Good. The global financial number cruncher keeps crunching away and crunching away and always comes up with the same surprising answer: we humans now, today, have the requisite physical and metaphysical assets in inventory to stage a great world play about the coming of age of our species. Late night religious broadcasting of the hopeless poverty in our world, ever in need of our guilt-derived dollars, might be supplanted by a new kind of program about actually ending death by starvation – forever. Props in our new world dramas: domes hanging from helicopters; graphical dymaxion map displays; computer monitors aglow with designs for livingry, ready for distribution on a massive scale, instead of killingry, (already massively distributed).

What Bucky hoped is that our youthful, globally networked generation, so full of promise, would stand up to the onrushing Goliath. He encouraged us to look at lawyer-capitalism’s (LAWCAP’s) shareholder enterprises as ghost ships on automatic pilot, the great pirates who once steered them having long ago passed from the scene. Crews of bewildered and superstitious bureaucrats still go through the motions, reciting their mindless mantras passed on as wisdom. But LAWCAP’s big picture accounts, steeped in Dark Ages obfuscation and contrived to sound paternal and profound, are becoming less and less a source of comfort in these uncharted waters. The crew members are beginning to awaken to the reality of their situation. They cling to our nets for survival.

Bucky knew the limited liability, legally irresponsible, soulless creatures of LAWCAP’s accounting hadn’t the humanity nor intelligence to navigate successfully in cyberspace. LAWCAP reflexes are all out of synch with what world game positions now need filling. The you-or-me never-enough-for-both great global tragedy is swiftly losing market share. Hollywood-style media extravaganzas, now in storyboard phase, need a new kind of star. Newscasters and media pundits with no knowledge of designer dwellings built for multimedia, no grasp of grand strategy maps minus their political overlays, no sense of what it means to surf freely through the Net, have a lot of homework ahead of them.

Our time is now. We, the global networkers, the world game players of today, have inherited the experimental prototype community of tomorrow. A giant BuckyBall stands at the center of Disney’s EPCOT, Grunch’s central shrine. The logo-language of corporate heraldry is destined to transform in the context of this world around web, a hypertext tapestry into which all of our metaphysical assets will be interwoven. Employing the know-how wealth amassed for us by our brilliant and courageous forbearers, we will make of this earth what the great pirates of old never dared wish for, except maybe in their most private prayers: a world in which our highest human values are consistent with the roles we are destined to play – a great tragedy no longer. Let the show begin!

3.1.2 What about increased unemployment from DSR and automation innovations?

[Ross Keatinge’s question and my reply]

> I recently read an article in an Australian Electronics
> magazine where the author is discussing unemployment,
> redundancies etc and the general topic of technology doing the
> work previously done by people.
>
> Like the author of this article, I am very much in favour of
> using technology to do more with less but am struggling to
> come up with an answer to the question of just what DOES
> happen to the factory worker replaced by a robot or the office
> clerk replaced by a computer?

I think it depends upon what you think the purpose of employment is. I think the goal of a job is to eliminate that job. Therefore, from my perspective unemployment is a virtue and the economy had better learn to appreciate and value it. We need to solve this problem quickly because in the current economy Fuller's profesy of "more with less" is being conducted with a vengeance: even highly skilled people are finding their jobs and departments eliminated at very high frequencies.

But what is the individual to do in an economy that obeys Fuller's laws of empheralization, but does not (at this point) support the "victims" of the modern economy. I think this is where another Fuller principle comes in: What is the purpose of humans in Universe? "To gather information and to solve problems." So it would behoove the individual to aggressively take up the task of becoming a general problem-solver (say during your next period of unemployment <grin>). Already it is clear the the economy does not really sport skills or experience; it seems that only can-do problem-solving is rewarded. OK, but what happens when our problem-solver finishes their job? Well, they go onto solve even more difficult problems. I think Fuller called this utopia. (Though the displaced factory worker or office clerk may disagree. It is sad but the Universe seems to work the way it works and it does not seem to support certain jobs or skills.)

[From Kirby Urner]

I think the missing puzzle piece vis-a-vis automation and unemployment in Fuller's thinking is in Education Automation.

The goal is not to render humans useless but to free them to perform metaphysical tasks with their minds. Setting up an economics to give people "tenure" in a more metaphysically driven economy does not seem all that far-fetched, given the information superhighway and all that rot.

Digital media are inherently copiable without limit, giving everyone access to tremendous cultural riches. But making it expensive by making it scarce is still the only way we can figure to "earn a living." So the FBI will continue warning us not to copy videos etc. But, in principle, we have what it takes, metaphysical resource wise, to raise living standards in a Global University context.

...

What Bucky may have been saying, to the chagrin of LAWCAP [LAWyer CAPitalism], is that a system which does *not* hold basic living necessities hostage pending proof of your usefulness to society, but rather supplies a workstation to all and lets each individual seek excellence (or not), will come out ahead in the innovation and creativity department. There are *lots* of ways to meter a digital product's usefulness to others, and even to reward its authors accordingly, but *without* forcing us into *earning a living* behaviors. So many digital properties are vitally useful, but simply do not fit into the "earning a living from revenues on sales" framework. In fact, its the infinite copiability of digital media that makes "earning a living from revenues on sales" a system that gets us actively militating to inhibit technology, with handicapped CD

copiers, dongles, other anti-copying schemes. We've made photo-duplicating an item (leaving it for others to also use and duplicate) a crime called "Piracy." Imagine a pirate ship coming alongside, snapping polaroids of your treasure chest, and dashing off, cackling. Such is piracy. (Again, I'm not personally into using a lot of pirated software, but I've seen whole countries sustaining their economies on same, without the foreign exchange to "make it all legal" and question a LAWCAP new world order (i.e. the GATT) that would permanently make metaphysical assets artificially, suffocatingly unacquirable in an economy desperate for such assets).

3.2 What is the "cosmic accounting system?" — Fuller's Economics.

[Typed in by Pat Salsbury.] The following is an excerpt from *Critical Path* by R. Buckminster ("Bucky") Fuller. (Copyright 1981, St. Martin's Press, NY – pp. 262-263)

"...We have pointed out that the geologist Francois de Chardenedes wrote for me a scenario of the technology of nature's producing petroleum which disclosed that the amount of energy employed by nature as heat and pressure for the amount of time required to produce each gallon of petroleum, if paid for at the rate at which the public utilities now charge retail customers for electricity, must cost over a million dollars a gallon. Combine that information with the discovery that approximately 60 percent of the employed in U.S. America are working at tasks that are not producing any life support. Jobs of inspectors-of-inspectors; jobs with insurance companies that induce people to bet that their house is going to be destroyed by fire while the insurance company bets that it isn't. All these are negative preoccupations...jobs with the underwriting of insurance underwriters by other insurance underwriters – people checking up on one another in all the different departments of the Treasury, the Internal Revenue, FBI, CIA, and in counterespionage. About 60 percent of all human activity in America is not producing any physical life protection, life support, or development accommodation, which physical life support alone constitutes real wealth.

"The majority of Americans reach their jobs by automobile, probably averaging four gallons a day – thereby, each is spending four million real cosmic-physical-Universe dollars a day without producing any physical Universe life-support wealth accredited in the energy-time – metabolic – accounting system eternally governing regenerative Universe. Humans are designed to learn how to survive only through trial-and-error-won knowledge. Long-known errors are, however, no longer cosmically tolerated. The 350 trillion cosmic dollars a day wasted by the 60 percent of no-wealth-producing human job-holders in the U.S.A., together with the \$19 quadrillion a day wasted by the no-wealth-producing human job-holders in all other automobiles-to-work countries, also can no longer be cosmically tolerated.

"Today we have computers that enable us to answer some very big questions if all the relevant data is fed into the computer and all the questions are properly asked. As for instance, "Which would cost society the least: to carry on as at present, trying politically to create more no-wealth-producing jobs, or paying everybody handsome fellowships to stay at home and save all those million-dollar-each gallons of petroleum?" Stated evermore succinctly, the big question will be: "Which costs more – paying all present job-holders a billionaire's lifelong \$400,000-a-day fellowship to stay at home, or having them each spend \$4 million a day to commute to work?" Every computer will declare it to be much less expensive to pay people not to go to work. The same computers will also quickly reveal that there is no way in which each and every human could each day spend \$400,000 staying at the most expensive hotels and doing equally expensive things; they could rarely spend 4000 of the 1980-deflated dollars a day, which is only 1 percent of a billionaire's daily income."

[From Ross Keatinge]

The most fundamental message I have got from his writings is about wealth. I cringe when I hear or read about a ‘worldwide recession’ and a ‘depressed economy’. I know it sounds like common sense but I find it difficult to get people to realize that it is all our own doing. I work for a company which among other things does foreign exchange dealing. I’m not directly involved in but I always find it amusing when they talk about ‘The Market’ as if it is some alien entity which we have no control over. There has been some currency crises in recent times and I hear phrases like “Everybody is watching the market very closely today,” or “I hope the dollar doesn’t drop any further today.”

I tend to see the population of the Earth as similar to a group of people living on an island with plenty of natural resources but some are starving because the people can’t get their act together even though they have the technology to transport resources around the island. The latest ‘Time’ has a bit about the huge stockpiles of food in Europe they don’t quite know what to do with (posted 1 Oct 1993).

[From Kirby Urner]

Bucky defined wealth as life support. Some feel wealth is what humans get credit for because it is produced through their work. This is also the Marxist view: that only labor creates value. Given Bucky’s definition, we see the sun and ecosystems as wealth-producing, but outside the cash system. Most of our life support (wealth) is not owing to human labor, but to automated, cybernetic, natural processes. Agriculture is hard work, but it wouldn’t happen at all without nature’s contribution. Given Fuller’s “cosmic accounting” (looking at wealth production with or without human components), it appears that no matter how hard we work, we individually get more life support than we produce. We do not “pay our own way” as a species.

There’s no way that you, born a helpless baby just decades ago, could possibly pay your debts to humanity for all the assets you use in life, including the words you use free of charge. Humans don’t pay the sun for powering the earth or take much credit for all the automatic wealth creation that goes on around us constantly, cashlessly. Humans get to work, yes, but they don’t get to take credit for everything they produce. Ultimately we’re distributing wealth to children (average global age: 15) and generations yet unborn – no way they can pay their own way.

I think the institution called The Library is fundamental to democracy and wonder what will happen to this institution in the digital age. What does it mean to “borrow” a digital asset when making a copy also leaves it on the shelf? Trying to make information assets fit the mold of real estate assets when talking about “intellectual property” is to seriously mix metaphors. Information assets are not English country estates.

Human language is more like an ecosystem asset than a capitalist one: we work with it without paying for the privilege. But language is not just a pile of words in the dictionary. Language is sense, knowledge, a way of ordering experience. The question is: how quickly will certain intellectual assets cross the line from cash-accounted assets to ecosystemic ones – how quickly will our metaphysical work be subsumed within Language? How will language masters be rewarded, if not with cash revenue from end users? Encryption and computerization offer the possibility of trafficking in zillions of currencies. You will gain access to assets you have demonstrated your ability to expertly use. Same as now.

Fuller’s point in *Critical Path* was that even many of those gainfully employed (not counting disemployed-through-automation) are doing nothing very vital to the creation of sustainable life support systems. Market pricing is just the tip of the iceberg of a system of pushes and pulls. At the far end of the cheap jeans is the barrel of a gun, pointed at people who cannot prove legal tenure to the land their ancestors farmed for generations. The prices we pay have a lot of brute force behind them, not just self-interested parties freely making choices. Making cash scarce to keep it valuable, by making those who have it fear the miserable state of those who do not, is a coercive system, not a freedom-loving one.

Cold cash is just one of many “currencies” – the most liquidly convertible (provided it is one of the globally

acceptable “hard” ones). I’m a big fan of wiring workstations to systems which dispense credits redeemable “in kind.” E.g. hours spent completing multimedia session on Insects of the World gets you tickets to the science museum and a \$40 credit at a book store. The museum and bookstore are also receiving lots of non-cash redeemables for their services. Not barter exactly, but not pure liquid either. Computers make it practical to electronify wealth distribution games that accomplish the movement of goods in services in more channeled, designed structures. Not big brother though, since no central planning authority – just lots of dial-in “games” with costs and rewards, likely to attract those with a self-interest in playing. Those are the details. From a distance, it looks like a planet full of professors on tenure, working hard, doing more metaphysical stuff than before.

[Karl Vogel replies]

No one has deliberately set out to “make” cash scarce. Earth does NOT give us everything we need without requiring any productive work on our part; if we want food, we have to grow it or get it from someone who has grown it. This can be done in one of two ways; peacefully through trade or otherwise.

[Kevin Sahr replies]

I think these two viewpoints define the crux of the debate. And I (and I think Bucky) would have to agree more with Kirby. Capitalism is based on scarcity, and those with a deeply vested interest in the status quo (or a simple fear of change, which I think we all share to some extent), will fight any efforts to, say, develop cheap renewable sources of energy which threaten the scarcity and thus the value of their sources of income. In the long run, we each individually and as a society suffer from this. I’ve heard the argument that the mechanics of a free-market economy will eventually overcome such inertia, but I find the idea that we live in anything even close to a free-market economy to be absurd.

I find Bucky’s vision of a society of scientist/artists who are self-fulfilled in the very act of creation/learning to be inspiring. The problem, of course, is how we get from here to there. I do not claim to have the answer. However, I think that the dawning of the information age is going to make it very difficult for people to, at the very least, delude themselves into thinking that we do not live in an economy of enforced scarcity. Because information, by it’s very nature, only has value in a capitalist economy to the extent that it is deliberately “made” scarce. If I have an HDTV with a digital recorder capable of perfect reproduction of “Jurassic Park,” and a fiber optic link direct to a digital copy of that movie, then someone is going to have to introduce a deliberate “mechanism of scarcity” to keep me from copying it. If I have a computer on my desktop capable of creating, from a hardware/software standpoint, the dinosaur sequences from “Jurassic Park,” then the only thing of real value in JP is Steven Spielberg’s creativity (and that of the other artists that participated in it’s making). Once Spielberg (or anyone else) no longer needs Hollywood’s money to make a movie like JP, and no longer needs their distribution channels (because everyone has equal access to the net – unless we CHOOSE to make access “scarce”) then what is to stop him from just making his movies out of the sheer pleasure of it and giving copies freely to anyone who wants them? As we move closer and closer to an “information standard” of value in our economy, I think the old economic models we’ve been using are in for a crisis. I, for one, hope it will be a fatal crisis.

If everyone gives freely of themselves without expecting anything in return, we will all have more than we could ever possibly dream. And because this makes so much sense, that must be where the universe is headed. To me that’s really what Bucky was all about. What a beautiful being!

[From Leo Elliott]

What has become *really* important (economically) is not the product (movie, book, code, net, etc.) of the artist (scientist, Spielberg, et al.), but rather the “enforced scarcity” youse have recently been battling around? What drives the GRUNCH economy is not the production of goods and services, as standard

economic theory might have it, but rather the perpetual maintenance of scarcities, such that once an item becomes abundant and low-cost, then production shifts to the new style, the movie sequel, the next year's model, etc.

What has come about is the denigration, to the point of debility, of what Bucky may have called the ability to maintain secrets, industrial, military, or otherwise (recall his tales of how civilization was advanced on the high seas with one nation getting the jump on another, as via the development of guns with longer ranges, by always keeping secret their more-with-lessing capabilities – now these more-with-lessing capabilities seem to be developing, mutating (dare I say evolving) faster than the old Giants' abilities to keep up with them, witness Aldrich Ames.)

Some may reference this to the Summer '93 issue of *Whole Earth Review*, wherein Stewart Brand prefaced Kevin Kelly's article on "Cyberspace, E-Money, and the Technologies of Disconnection" (pp. 40-59) as follows:

"This one is a world-changer. Personal encryption may be as revolutionary as personal computers in transforming the web of human communications..."

"Since I am allied with cypherpunks and their program, I feel cheerfully duty-bound to raise a question or two, such as: 'If the real world is awkward to work with and full of cops, and if electronic cyberspace is easy to work with and has no effective cops (thanks to universal encryption) AND is where all the money is, what does that suggest about the future of crime?' "

Thus in some odd extension of value-added marxian economics, the old-model consumer of mainline value-added products (folks who might pay the full ticket price to go see Jurassic Park in a bigscreen theater) becomes ever less significant in the economic factoring to those who would add value by passing lesser imitations around (videos or associated dino mdse)... which I *think* leads somewhere back towards Bucky's "ephemeralization" of economic processes. The "value added" manifest on the nets would simply be represented by the "passing on" of data, in the hope/probability that it will assume "added value" as info and/or entertainment on the receiving end.

[From Mark Stowe]

It is my strong personal recommendation that everyone unfamiliar with the game theory/evolutionary modeling of altruistic behavior, would do well to read up in this area (an adequate if less than inspired starting point would be the article on page 76 of the March 1994, *Scientific American*). Capitalism is currently a necessary evil in my view because of the presence of "defectors:" those whose power grows at the expense of those who volunteer their labor. Essentially my hope for the future lies with my belief that on-line communities provide unprecedented possibilities for getting around this problem, because 1) they provide enormous power to organize boycotts and otherwise isolate defectors and 2) they increase the power of the altruists by virtue of the fact that altruistic creations in an on-line community (helpful programs, enjoyable works of art) last much longer (the normal rules of entropy do not apply). I think that the problem of cheaters in an on-line community as discussed in the article on page 90 of the same *Sci-Am* issue can be overcome by a number of technological tricks.

3.3 What is the World Game?

[Keyed in by Patrick G. Salsbury.] This is an excerpt from *The Essential Whole Earth Catalog* (Doubleday & Company, Inc., Garden City, NY) p. 89

THE WORLD GAME

“To make the World work / for 100% of Humanity / In the shortest possible time / Through spontaneous cooperation / Without ecological offense / Or the disadvantage of anyone.”

Buckminster Fuller initiated the World Game in 1969 as one means of accomplishing this worthy goal. The idea is that with enough data on world resources and their distribution (including accumulated technology and problem-solving skills), the world’s citizens will do what’s best for all. Fuller assumed that once it was obvious that there was enough of everything to go around, people would stop fighting wars and get to work making the world work – if not as a utopia at least not continuing the current suicidal path. World Game is still developing. Recent sessions use an enormous basketball-court-size map in order to more easily visualize various strategies as they are suggested by participants. A formidable software database called Global Data Manager allows individuals to play with the numbers on their PCs.

3.3.1 What is the World Game Institute?

[Dane Winberg of the World Game Institute sent me this contribution.]

World Game Institute is a non-profit, non-partisan, global education and research organization dedicated to developing and disseminating problem solving and educational tools. World Game was conceived by world renowned architect, philosopher and visionary, R. Buckminster Fuller as a creative problem solving tool whose goal is to “make the world work for 100% of humanity in the shortest possible time, through spontaneous cooperation and without ecological offense or the disadvantage of anyone.”

Global Recall 2.0 -

A computer atlas featuring 300 world, regional and country maps and 600 data indicators for all countries; 18 essays on current global problems; a Solutions Lab section where you can describe your ideas for global solutions and compare them to real-world data. Comprised of several linked HyperCard stacks, available for Macintosh computers. Regular data updates.

Global Data Manager -

Available for DOS or Macintosh (currently only for system 6), GDM displays data on population, food, energy, education, natural resources, economics, etc. for the world, all continents and all countries. Separately sold disks of data from World Bank, World Resources Institute, UN.

World Game Workshops -

Interactive global simulations conducted for elementary and high schools, community groups, universities and corporations; adapted with an emphasis on world geography, history, current events, global issues, patterns of development, strategic options and sustainable solutions to local and global problems.

World View Map for the Playground -

A basketball court-sized world map is painted on elementary school playgrounds; includes an activities manual for several subject areas.

World View Map for the Classroom -

A smaller roll-out version of the playground map for indoor use.

World Game Institute
3215 Race Street

Philadelphia, PA 19104-2597
Phone: (215)387-0220 Fax: (215)387-3009
Web: <http://www.worldgame.org/>

>We're interested in knowing more about any World Game group in Seattle.
>-- Kirby & Nick in
>Portland, Oregon

Contact: Chuck Dingee
Pacific Northwest Regional Representative
PO Box 2681,
Bellingham, WA 98227-2681
Tel: (206) 647-5106 Fax: (206) 647-5106 (ext 77#)

Chuck was for many years in charge of putting on World Game workshops from the Philadelphia office.

[Posted by Ian Wells] INTRODUCTION TO THE WORLD GAME INSTITUTE

The World Game Institute is a non-profit research and education organization dedicated to developing technological and interactive tools for global problem solving. Among our many products and programs are:

- Computer software products for researchers, primary and secondary schools, policy makers and others who need global information at their fingertips to help them create problem solving strategies that work.
- Participatory workshops conducted for corporations, national governments, universities high schools and world organizations that demonstrate in real terms the distribution of resources around the world, and methods of using those resources to provide a quality standard of life for all humans without destroying the planet.
- Museum exhibits which display the status of resource distribution around the world, and which demonstrate the impact of environmental, military and agricultural policy.
- Publications which disseminate research methods and solutions for global problems, and demonstrating creative uses for the tools developed by the World Game Institute.
- Playground maps of the world, supplied with teacher's training manuals and activities to make global education fun.

The World Game was created by R. Buckminster Fuller, the eminent geometer, architect and thinker, as a creative alternative to war games. Participants in World Game workshops learn to see the world in terms of one population sharing the wealth of one planet, and "win" the Game when they meet the basic health, education, welfare and survival needs of the world's population. In its more sophisticated versions, the World Game also acts as a simulation and laboratory, used by policy makers, corporations and diplomats and world leaders to devise efficient problem solving strategies.

***The preceding was uploaded to CompuServe several months ago. The World Game Workshop, while conceived by Fuller, does not resemble the original Workshops closely at all. Neither is the World Game Institute actively involved in disseminating information about Fuller or pursuing his "synergetics" theory, per se. His theories are a jumping off point for the Institute, but we are not solely involved in propagating his teachings alone.

Susan Caskey

3.3.2 What are the World Game Institutes “games” like?

Did you know that some scientists have determined that the air could cleanse itself of all pollutants in TWO WEEKS if polluting stopped for that period of time?

Did you know that all nuclear warheads would be non-explosive in 18-22 years if no tritium was replaced in them?

Briefly, The World Game is a three hour experience including a 1 1/2 hour trading simulation game played on a dymaxion projection of the Earth. Lots of slides and music is used to make it entertaining as well as educational. Fuller’s intent was to design a game that would be an alternative to war games.

Although the game content deals with many issues besides the environment such as hunger, nuclear proliferation, and education, the ideas of cooperation and coordination are pervasive and based on up-to-the-moment data on all of the issues.

Costs are dependent on number of workshops to be held, distance traveled, etc. Figure around \$3500 and up. But it is worth it! Often our district will spend anywhere from \$5000- \$10,000 for a speaker for an evening seminar. So don’t flinch at the money yet.

Janet Whitaker Rio Salado Community College Phoenix, Arizona

3.3.3 What is Global Data Manager (GDM)?

To quote from the GDM manual: “If information is power, Global Data Manager is a powerful tool. Its intended purpose is to make accessible the vast amounts of statistical data upon which all fundamental resource allocation decisions in the world are made... Global Data Manager makes available for the first time, in an easy to use personal data computer format, the vital statistics of the world. Its purpose is to integrate into one system the world’s most complete inventory of global data into an easy to use, personal computer based, problem analysis and solving system that is accessible to the researcher, policy maker, social activist, student, teacher, media and general public”

Ian Wells Director, Social Impact Group Boston Computer Society

3.3.4 Does the World Game offer any solutions to the World Hunger Problem?

I just latched onto a copy of *Ho-Ping: Food for Everyone*, by Medard Gabel [ED: Medard Gabel is the executive director of the World Game Institute.] It is INCREDIBLE! It addresses the World’s Food supply/distribution problems from a holistic, comprehensive, design science approach. That is, by considering the ENTIRE planet, and 100% of humanity in all its study. — Patrick Salsbury

3.4 What were Fuller’s views on religion and God?

The following is a quote from pages 116 and 117 of *Ideas and Integrities* by R. Buckminster Fuller. (c) 1963. The actual passage is taken from something he wrote on Sunday, Nov. 7th, 1942. It is interesting to note how accurate the statements seem to be in our present time, despite their age. I got a kick out of them in light of the recent scandals in religious circles and all the other goings on. The statements come from Chapter Six of the Book. It is entitled “I Figure” and these two words are meant to proceed each of the ideas presented in the chapter. — Patrick Salsbury, 1-11-90

“...that the people are now more deeply conscious than ever before in history of the existence and functioning principles of universal, inexorable physical laws; of the pervading, quietly counseling truth within each and every one of us; of the power of love; and—each man by himself—of his own developing, dynamic relationship with his own conception of the Almightyness of the All-Knowing.

“...that our contemporaries just don’t wear their faith on their sleeves anymore.

“...that people have removed faith from their sleeves because they found out for themselves that faith is much too important for careless display. Now they are willing to wait out the days and years for the truthful events, encouraged individually from within; and the more frequently the dramatic phrases advertising love, patriotism, fervent belief, morals, and good fellowship are plagiarized, appropriated and exhibited in the show windows of the world by the propaganda whips for indirect and ulterior motives, no matter how meager the compromise—the more do people withdraw within themselves and shun taking issue with the nauseating perversions, though eternally exhibiting quiet indifference, nonchalance or even cultivating seemingly ignorant acceptance.”

3.4.1 How did Bucky’s “Ever Rethinking the Lord’s Prayer” go?

[Well, he came up with a new version each night! But here is one version posted by Leo Elliott.]

The following is a transcription from a 1976 “Being With Bucky,” New Dimensions Tapes, side 15 (parsing and punctuation by transcriptionist).

Our God, who art in we even,
even we who know most intimately
of our own weaknesses, failures, faults, and outright sins
our selfishness, fear and cupidity,
of our moments of jealousy, rage and hate
secret cover-ups, lies and self-deceits
God even of we
 Our God -- our intuitively-apprehended comprehensive-admonisher
Omni-experienced is your identity,
the everywhere and everywhen evolving omnireality
is your presence

and as the reality differs _uniquely_ from moment to moment
in respect to each individual
so do you speak to each
in exquisitely relevant, instructive terms
regarding that which the individual
can most effectively do
not in behalf of self
but in behalf of all humanity

and Thus in support of the intellectual functioning of humans
thereby in local universe support
of the eternal integrity of omniregenerative universe
which is God.

As omniexperience, you have given us

overwhelming manifest
of your complete knowledge
your complete comprehension
your complete concern
your complete wisdom
your complete responsibility
your complete co-ordination
your complete competence to cope
with any and all problems
and of your utter reliability
always so to do
Yours, dear God, is all the glory.

* * *

We oft-times think of ourselves
as independent individuals
able to get on by ourselves
by our own wits
forgetting altogether
that we did not invent those wits
nor the incredibly complex, 99.9% automated
biological organisms
nor the rest of the universe
with which they interfunction,
all of which is entirely
the prior competent conceptioning
only of God.
Yes dear God, yours _is_ all the Glory.

You are the totally mysterious
eternal integrity, both comprehensively
and incisively governing
the omni-intercomplementation and omni-interaccommodation
of all physical and metaphysical experiences
of ever and everywhere
separately and complexedly intertransforming
omni-regenerative universe.

You are the synergetic integral of all truths.
We have absolute trust and faith in you
and we wish of you
awe-inspiredly, thankfully, rejoicingly and lovingly --
for it's spontaneously feasible
for humans to be wishful of the truth
in awe of the truth
thankful for the truth
to rejoice in the truth
and to love the truth
and to love all the truths combined
for all truths are omni-interaccommodative

as are all the
only mathematically-statable generalized principles
discovered by human minds,
experimentally verified by science
to be externally governing
complex interrelationships of physical universe.

* * *

Truths and principles never contradict one another.
They are all concurrently omni-interaccommodative
and all the truths are metaphysical cognitions
by humans
of special-case realizations
of eternally-valid generalized principles.

It is only through many repeated experiences and recognitions
of the eternal principles
their non-contradicting interaccommodations
that each individual human
progressively and only intuitively discovers the existence of
eternal principles and their special-case manifests
and the truths of everyday events
and all the truths, as our lives discover them,
trend to integrate in synergetic perfection
beyond the special-case experiencing
of inherently terminal
ergo inherently limited
human conceptioning, comprehension and communication...

3.5 What is the Global Energy Grid idea?

[From *Critical Path* by RBF, 1981, p. 206.]

“It is engineeringly demonstrable that there is no known way to deliver energy safely from one part of the world to another in larger quantities and in swifter manner than by high-voltage-conducted ‘electricity.’ For the first half of the twentieth century the limit-distance of technically practical deliverability of electricity was 350 miles. As a consequence of the post-World War II space program’s employment and advancement of the invisible metallurgical, chemical, and electronics more-with-lessing technology, twenty-five years ago it became technically feasible and expedient to employ ultra-high-voltage and superconductivity, which can deliver electrical energy within a radial range of 1500 miles from the system’s dynamo generators.

“To the World Game seminar of 1969 I presented my integrated, world-around, high-voltage electrical energy network concept. Employing the new 1500-mile transmission reach, this network made it technically feasible to span the Bering Straits to integrate the Alaskan U.S.A. and Canadian networks with Russia’s grid, which had recently been extended eastward into northern Siberia and Kamchatka to harness with hydroelectric dams the several powerful northwardly flowing rivers of northeasternmost U.S.S.R. This proposed network would interlink the daylight half of the world with the nighttime half.

“Electrical-energy integration of the night and day regions of the Earth will bring all the capacity into use at all times, thus overnight doubling the generating capacity of humanity because it will integrate

all the most extreme night and day peaks and valleys. From the Bering Straits, Europe and Africa will be integrated westwardly through the U.S.S.R., and China, Southeast Asia; India will become network integrated southwardly through the U.S.S.R. Central and South America will be integrated southwardly through Canada, the U.S.A., and Mexico.”

[From The GENI website.]

GENI <http://www.geni.org/> , Global Energy Network International Global Energy Network Institute was founded in 1986 by Peter Meisen to investigate the idea of Dr. R. Buckminster Fuller, proposing a global electric energy grid as the number one priority to solve many of the world’s most pressing problems.

3.6 What is a “trimtab?”

[From Blaine A. D’Amico.]

A Trimtab is a tiny flap that controls the rudder on a ship or airplane. When the rudder needs to be moved, this tiny “trimtab” is adjusted which creates a low pressure area on one side and turns the rudder. Bucky used the word to illustrate what the little individual can do to “turn the great ship of state.” He also noted that the ship has [already] passed the point where the turn is occurring. This might be a comfort to those on the bow wondering if we have missed our chance to change course.

Bucky’s gravestone says simply “Call me TRIMTAB”

3.7 Was Bucky a socialist?

Not exactly. Though he did speak fondly of socialism (mainly the “take care of everyone” and the “plan ahead” ideas in socialism). The following exchange clarifies this a bit.

Blaine A. D’Amico: Fuller said nothing about redistribution. His Design Science revolution is based in raising the living standard of the ‘have-nots’ and ‘have-lesses’ without taking away from the haves. This is done through ephemeralization “more with less.”

Patrick G. Salsbury: He did, however, discuss DISTRIBUTION, and how the intelligent application of that could solve problems like global food shortages, etc.

3.8 What were Fuller’s views on Education?

Fuller’s book *Education Automation* http://www.bfi.org/education_automation.htm is a primary source.

[From Robert L Lamons]

I am enamored with his writings on education. For someone that had so much difficulty with standard education models he did quite well. I first read about his theory on “Education” in *Operating manual for Spaceship Earth*, chapters 3,4 and 5 I believe. I have read his other books on education too. All lead to the same conclusion, that education is active and must be sought, not something that you can sit down and drink up as someone pours it out to you. We have modeled our educational theories after this and are now “organically” homeschooling our 5 children. That is what we like most about Bucky.

3.9 What is the difference between “Class I” and “Class II” evolution?

[*Critical Path*, p. 229-30]

“Class-two evolutionary trendings are all those events that seem to be resultant upon human initiative-taking or political reforms that adjust to the changes wrought by the progressive introduction of environment-altering artifacts. All the class-two evolutionary events tend to flatter human ego and persuade humanity to deceive itself by taking credit for favorable changes in circumstances while blaming other humans or ‘acts of God’ for unfavorable changes. It therefore assumes that humanity is running the Universe wherefore, if its power-structure leaders decide that is is valid to cash in all of nature’s available riches to further enrich the present rich or to protect them militarily from attacks by their assumed enemies - all at the cost of terminating human presence on planet Earth - that is the power-structure leader’s divine privilege.

“All the class-one evolutionary trending is utterly transcendental to any human vision, planning, manipulation, and corruption. Class-one evolution accounts for humans’ presence on Earth. It accounts for their having always been born naked, helpless for months, and inexperienced - ergo, ignorant, hungry, thirsty, curious, and therefore fated to learn how to survive only through trial-and-error-won, progressive accumulation of experience. Class-one evolution accounted for humanity’s all-unexpected invention of verbal (aural, sound) communication, and thereby the integration of the experience-won information of the many, whereby the integrated information of the many increased the capability of humanity at large to cope with the exigencies of life. It is class-one evolution that led, after the progressive integration of the total experience-won information, to the unpredicted invention of writing or visual communication, by means of which the dead could speak to the living and within which total written information history human mind from time to time discovered repetitive patterns, which in turn sometimes led to the discovery of generalized scientific principles.”

3.10 How to house humanity? And other reflections on Making the World work.

Housing humanity was Fuller’s motivation for designing the Dymaxion House and the Geodesic Dome (See section 4 (Geodesic Domes) for more on the Dome). Fuller designed them because of the tremendous waste and inadequacy of cube-based dwellings. Also see sections 5.6 (What was Fuller’s “floating city?”) and 5.7 (Old Man’s River City Project (circular cities)?) on re-designing cities.

[From Kirby Urner]

And I’m one of the *lucky* ones! I’ve got indoor plumbing and heat! No way we can supply the world’s billions with these assets using the sadly obsolete construction methods of yesteryear, perpetuated with cosmetic improvements decade after decade. The USA living standard cannot be replicated globally, nor should it be, as inappropriate, wasteful and Dark Aged as it is! May the Chinese do it better!

A story on the radio the other day said metal is becoming more popular among construction workers in this age of dwindling forests and climbing lumber prices. For one thing, you can screw instead of nail. Imagine, pro-metal propaganda on the radio – in Oregon! The lumber industry is fighting back, saying mines are at least as damaging to the environment as logging. But Fuller’s point was that the majority of the metals we need are already mined, and can be recycled over and over (the dwellings will be designed with recycling in mind, kind of like the Germans have been doing with some models of BMW).

The old housing stock won’t disappear – decades of remodeling await the avid remodelers. But I wish those of us who are being pushed to the periphery by high housing costs had more to look forward to than mobile

home courts. I'm always passing these mobile homes on the backs of trucks on the freeway – Caution Wide Load. Why do helicopter deliveries from the local dealer to less paved over and bulldozed environs sound so far out and “futuristic?” Fuller’s little energy-harvesting, grid-autonomous units, constellated in remote little campus-communities, would make ideal living and learning environments – good places for children.

[From Leo Elliott]

“Why do helicopter deliveries... sound so far out and ‘futuristic’?”

I think the most telling answer is implied in a word contained in Kirby’s next sentence:

“Fuller’s little energy-harvesting, grid-autonomous units, constellated in remote little campus-communities...”

the key word being “grid-autonomous.” As per ‘*Grunch of Giants*, pushers do not like it when users decide they want to “grow their own,” be it homes, domes, education, or local support systems. Supposedly the dymaxion bathroom, mentioned here previously, received rave reviews until the plumbers unions of the time found out that it would be completely user-installable, thus depriving them of their “standard fees.”

I would suspect that it has been this whole notion of de-centralized energy systems (centrifugal energy flow/centripetal info flow) which has, over the years, aside from Fuller’s personal suasions and disuasions, been the most threatening (to the “giants”) aspect of his overall program – live anywhere you want, do what you want, all paid for by the dole, which itself will be more than paid for by the return on investment of those marvelous discoveries and inventions made by the less-than-1% who would produce the most wonderful synergy-revealing artifacts.

[From Kirby Urner]

Leo Elliott writes:

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> I would suspect that it has been this whole notion of de-centralized energy
> systems... which has... been the most threatening (to the ‘giants’) aspect
> of [Fuller’s] overall program
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Perhaps, perhaps. But think of the business interests in *favor* too: a huge aftermarket in user-installables (similar to computer component add-ons). Cellular phone and fax demands, satellite TV, the education and info-tainment dialup video needs of remotely deployed home-schoolers, a growing sector of under/unemployed defense workers with aerospace savvy... And the utility grids will *still* have LA, Paris and Tokyo to power. Its not like a sprinkling of grid-autonomous dust is going to spell ‘lights out’ in the sprawling megalopolis already covering the planet. Moreover, Fuller was hardly “anti-grid” what with his bi-hemispheric vision of same...

Recall that “the industry industry missed” (July 1932, Fortune magazine) was initially very appealing to industrialists in the pre-war 30s, including such as GE – was briefly subject of what we’d nowadays call “media hype.” The unions (along with the banks and county zoning boards) might have killed it, but the duck was lame to begin with – or at least this is what Fuller says in retrospect: “Fortune made the mistake of assuming ‘the industry industry missed’ had at last come of age... Evolution was clearly intent on postponing the inception of the livingry service industry until humanity had graduated from its pre-twentieth century condition as a planet of remote nations... all of which waited upon the completion of a world-around network of ... telephones ... and jumbo jet airplanes.” (*Grunch of Giants*, pp xvii-iii).

[From Kirby Urner]

Adequate shelter for all humans is possible. Not using forest products though. I think what tent life and

Fuller's homes have in common is energy-autonomy. With a Fuller unit, I can plunk down in the middle of nowhere. The tripod of my Fly's Eye is adjustable for bumpy, slopy terrain. I didn't have to rip a road through the wilderness to get it here. I didn't have to pour a foundation or bulldoze or whatever. Say I'm a student of ecology. A university consortium has these "remote campus deployment" units that programs rent for a few weeks or months. Whole little communities deploy, doing minimal damage to the environment, make their studies (staying in touch with cellular Internet etc.), and leave. The noisy helicopter part only comes at the beginning and the end, and maybe once a week during the middle.

I say we look at cities as huge campuses (the "city as campus" metaphor) and all humans as would-be students in a Global University. Work-study options, life-long "learning a living" scenarios give you access to all kinds of facilities, travel. Fuller computed that our global energy budget (solar derived) gave us enough to offer fellowships to all those impoverished and living in shanty towns, minus any really good education. I think many families in the Philippines would jump at the chance to enroll in the Global University. If you like the outdoors life, and growing food, or fishing, well, that can be arranged.

3.11 Was Bucky an "optimist" or a "pessimist"?

[Fuller quote from 1928 typed in by Leo Elliott]

"A pessimist is one who 'believes' the world to be rapidly diminishing to complete materialism, and looks only to the past with pleasure.

"An optimist is one who 'believes' in no fact of undelectable presence and looks only to the future for happiness.

"An individual is one, who, happy in the present time, perceives the relative progression of the spheres. Being unselfish, is he jealous of neither past nor future. Thus does he stay time."

3.12 What about Fuller's plan for a nationless world?

[From Kirby Urner.]

SOME THOUGHTS ON NATIONS FROM A FULLER FAN

Nationalism seems a bankrupt strategy for mapping ethnic/cultural distinctions to geography, which as too few dimensions to accommodate the interweavings of affinity. For all their drawbacks, notice how corporations support the trappings of nationhood, with logos, mottos, CEO-prezes, image/identity stuff, but without blocking off huge areas of the map. Corporate cultures hang together globally with dispersed campus settings wired by commlinks and frequent flyers. In this sense, I think Serbia, Inc. or Israel, Inc. or Palestine, Inc. – global networks with no huge territorial claims – would better accommodate the complex topology of "we" groupings.

Phasing in Fuller's nationless map doesn't mean declaring that nations don't exist, or waiting for some revolution. We're just de-emphasizing their importance. And I still think USA has a bright future, not so much as a territory as a democratic system for providing goods and services. Governments are systems, inherently global. You can log in to USA OS (USA operating system) from wherever. Much as it is today – I send email to mom & dad @usaid.gov in Africa.

To be a Fullerian, philosophically, is, I believe, to say "enough with the silly nation-state idea already!" That doesn't mean I don't pay taxes, or vote for this or that. But I'm not interested in deciding the boundaries between Israel and Syria or Serbia and Bosnia. That's a jigsaw puzzle that's hopeless to the core. Lets get

folks into domes and such, and online. With multimedia and a future to live for, life will again seem too precious to waste in war to defend the future of some obsolete institution called “nation.” That was the real purpose of the Spaceship Earth metaphor: not to make earth seem mechanistic (Jeremy Rifkin’s criticism) but to make it seem apolitical.

[From leo elliot]

No argument from me that nationalism presents some definitely grunchy, special case, anachronistic modes of ownership, which seems to be the prime directive in these various hideous nationalistic horror theaters (Rwanda, Bosnia, etc.). I might still have some reservations about there being a darker side to corporationalism that would lead me to suspect that, benign as it may sometimes seem, it would hardly make the world apolitical – maybe affect the political dialog, but I doubt it would erase the greed or fear or whatever it is that lies at the core of the mort-gaging system of accounting which, imo, is squeezing the forward-lookingness out of more and more arenas. (I am still debating whether to view Schindler-style commercialism as a testament that, even in the ultimate debasement of dialog that war represents, that there is at least some common dialect of commerce that will still be spoken (representing, presumably, some still-commonly-agreed-upon standards of value), or whether to view Schindler’s efforts as outrageous exploitation.)

4 Geodesic Domes

Fuller invented the Geodesic Dome in the late 1940s to demonstrate some ideas about housing and “energetic-synergetic geometry” which he had developed during WWII. This invention built on his two decade old quest to improve the housing of humanity. It represents a brilliant demonstration of his synergetics principles; and in the right circumstances it could solve some of the pressing housing problems of today (a housing crisis which Fuller predicted back in 1927).

4.1 What is a geodesic dome?

[From Robert T. Bowers’ paper on Domes last posted to GEODESIC in 1989.]

A geodesic dome is a type of structure shaped like a piece of a sphere or a ball. This structure is comprised of a complex network of triangles that form a roughly spherical surface. The more complex the network of triangles, the more closely the dome approximates the shape of a true sphere [sic].

By using triangles of various sizes, a sphere can be symmetrically divided by thirty-one great circles. A great circle is the largest circle that can be drawn around a sphere, like the lines of latitude [ED: he means longitude] around the earth, or the equator. Each of these lines divide the sphere into two halves, hence the term geodesic, which is from the Latin meaning “earth dividing.”

[From Mitch Amiano]

The dome is a structure with the highest ratio of enclosed area to external surface area, and in which all structural members are equal contributors to the whole. There are many sizes of triangles in a geodesic [ED: dome], depending on the frequency of subdivision of the underlying spherical polyhedron. The cross section of a geodesic [ED: dome] approximates a great-circle line.

4.1.1 Do domes really weigh less than their component materials?

[From Pat Salisbury]

Well, the structures weigh less when completed because of the air-mass inside the dome. When it's heated warmer than the outside air, it has a net lifting effect (like a hot-air balloon).

This is almost unnoticeable in smaller structures, like houses, but, as with other things about geodesics, being as they're based upon spheres, the effect increases geometrically with size. So you'd be able to notice it in a sports stadium, and a sphere more than a half mile in diameter would be able to float in the air with only a 1 degree F difference in temperature!

4.1.2 What about underground concrete domes?

[From Randy Burns.]

Underground concrete domes are rather interesting

- 1) They can use chemical sealing and landscaping to avoid leakage problems associated with wooden domes.
- 2) They are *extremely* strong. Britz [see 4.5 (Dome References) for more on Britz] has obtained extremely low insurance rates on his structures. The insurance company tested one building by driving a D8 Caterpillar tractor on top of the house!
- 3) There's little hassle involved in dealing with materials that were really standardized for use building boxes. The only specialized tools are the forms, everything else can easily be used off the shelf.
- 4) They can be quite aesthetic. Britz has shown that you can build developments where the houses can't really see each other.
- 5) They are *cheap* and easy to heat, cheap enough that you can build a much larger structure than you might using conventional housing and use standard room divider technology to split the thing up into room.

4.1.3 What are geotangent domes?

[Keyed in by Patrick G. Salsbury.]

The following is quoted from "Scientific American" in the September 1989 issue. (Pages 102-104)

Surpassing the Buck (Geometry decrees a new dome)

"I started with the universe—as an organization of energy systems of which all our experiences and possible experiences are only local instances. I could have ended up with a pair of flying slippers." -R. Buckminster Fuller

Buckminster Fuller never did design a pair of flying slippers. Yet he became famous for an invention that seemed almost magical: the geodesic dome, an assemblage of triangular trusses that grows stronger as it grows larger. Some dispute that Fuller originated the geodesic dome; in *Science a la Mode*, physicist and author Tony Rothman argues that the Carl Zeiss Optical Company built and patented the first geodesic dome in Germany during the 1920's. Nevertheless, in the wake of Fuller's 1954 patent, thousands of domes sprung up as homes and civic centers—even as caps on oil-storage tanks. Moreover, in a spirit that Fuller would have heartily applauded, hundreds of inventors have tinkered with dome designs, looking for improved versions. Now one has found a way to design a completely different sort of dome.

In May, J. Craig Yacoe, a retired engineer, won patent number 4,825,602 for a "geotangent dome," made up of pentagons and hexagons, that promises to be more versatile than its geodesic predecessor. Since Fuller's dome is based on a sphere, cutting it anywhere but precisely along its equator means that the triangles at the bottom will tilt inward or outward. In contrast, Yacoe's dome, which has a circular base, follows the

curve of an ellipsoid. Builders can consequently pick the dimensions they need, Yacoe Says. And his design ensures that the polygons at the base of his dome always meet the ground at right angles, making it easier to build than a geodesic dome. He hopes these features will prove a winning combination.

Although Fuller predicted that a million domes would be built by the mid-1980's, the number is closer to 50,000. Domes are nonetheless still going up in surprising places. A 265-foot-wide geodesic dome is part of a new pavilion at Walt Disney World's Epcot Center in Florida. A bright blue 360-foot-high dome houses a shopping center in downtown Ankara, Turkey. Stockholm, Sweden, boasts a 280-foot-high dome enclosing a new civic center.

Dome design is governed by some basic principles. A sphere can be covered with precisely 20 equilateral triangles; for a geodesic dome, those triangles are carved into smaller ones of different sizes. But to cover a sphere or ellipsoid with various sizes of pentagons and hexagons required another technique, Yacoe says.

Yacoe eventually realized that he could build a dome of polygonal panels guided by the principle that one point on each side of every panel had to be tangent to (or touch) an imaginary circumscribed dome. With the assistance of William E. Davis, a retired mathematician, he set out to describe the problem mathematically.

They began with a ring of at least six congruent pentagons wrapped around the equator of an imaginary ellipse. The task: find the lengths of the sides and the interior angles of the polygons that form the next ring.

To do so for an ellipsoidal dome, they imagined inscribing an ellipse inside each polygon. Each ellipse touched another at one point; at these points, the sides of the polygons would also be tangent to a circumscribed ellipsoid. But where, precisely, should the points be located? Yacoe and Davis guessed, then plugged the numbers into equations that describe ellipses and intersecting planes. Aided by a personal computer, they methodically tested many guesses until the equations balanced. Using the tangent points, Yacoe and Davis could then calculate the dimensions and interior angles of the corresponding polygons and so build the next ring of the dome.

After receiving the patent, Yacoe promptly set up a consulting firm to license his patents. He says dome-home builders have shown considerable interest, as has Spitz, Inc., a maker of planetariums located near Yacoe in Chadds Ford, Pa. Yacoe has also proposed that the National Aeronautics and Space Administration consider a geotangent structure as part of a space station. -E.C.

4.1.4 What are the advantages (and disadvantages) of Dome Life?

asemon@esu.edu (Alan Semon) writes:

>I was once interested in the idea of living in a geodesic dome home and,
>to the best of my recollection, these are some of the advantages:

>

>1. Heating and cooling the home become more efficient due to the fact
>that there are fewer (even no) corners where heat may be trapped. The
>overall air flow in a dome is substantially better than in a
>conventionally constructed home (straight walls and such).

>

...and there is less surface area per square foot of living space = less
heat loss.

>2. Many dome home designs allow the option of using larger lumber for

>the dome. 2x6's or 2x8's instead of the usual 2x4's, although this is
>an option in ANY home, it seems to be more commonly done in dome home
>construction.

>

Although for many areas of the US, there is no financial advantage to
using 2x6 construction. A dome with R-14 throughout can outperform a
well insulated conventional house of comparable S/F.

>3. For those solar minded people, the placement of the solar collectors
>on the "roof" is less critical due to the curved nature of the top of
>the structure.

>

>4. The inherent strength of the dome makes it suitable for either
>earth-bermed or even earth covered construction techniques. In the case
>of more common construction techniques, the structural members'
>dimensions usually need to be completely reworked in order to carry the
>extra weight.

>

>5. Hell, they LOOK pretty neat! This might be a problem in certain
>areas which one of those laws which say that all homes in an area MUST
>conform to certain guidelines concerning their architecture (bummer,
>huh? :-)).

-jg

[Based in part on a Brewer Eddy post]

The curved walls in a dome require either custom furnishings, 100% prefab design, or an "open spaces" approach. Each of these would be an advantage or disadvantage in one person's eyes or another's.

Mass producing domes is easy, greatly reduces the cost and could solve many of the housing shortage problems worldwide (especially emergency housing needs).

4.1.5 How to use solar panels in domes? [Kerri Brochard]

[From Tom Dosemagen]

I have a dome and tried to find solar panels to be installed on the dome. I had no luck finding such a beast so I installed 320 square feet of panels on the ground close to the dome and ran all connections under ground into the basement. I live in south central Wisconsin and my experience with solar is not the greatest. My system works fine, but in order for the system to work the sun has to shine. That doesn't happen a lot here until late February or early March. My advice to people in our part of country is to take the money you were going to spend on solar and invest it. Then take your interest money and pay for conventional heat. My dome is 44 feet in diameter and with a 90% efficient furnace and my total heating bill for one season is right around \$350.00. My exterior walls are framed with 2x6's. With thicker dome walls I'm sure that I could lower my heating costs by quite a bit.

4.2 Dome Math: What you've all been waiting for!!!

4.2.1 Dome Theory

[From Kirby Urner.]

The edges of a geodesic dome are *not* all the same length. The angstrom measurements between neighboring carbon atoms in a fullerene are likewise not equal.

Domes come in three Classes (I, II and III). The classification system has to do with laying an equilateral triangle down on a grid of smaller equilateral triangles, lining up corners with corners – either aligning the triangle with the grid (I), turning it 90 degrees to bisect grid triangles (II), or rotating it discretely to have it cut skewly across the grid (III).

20 of these triangles make an icosahedron which is then placed within a circumscribing sphere. The vertexes of the triangles' internal points, defined by the grid pattern, define radii with the circumscribing sphere's center. By pushing each vertex further out along the segments so defined, until each is made equidistant from the center, an omnitriangulated geodesic sphere is formed (orthonormal projection I think cartographers call this). Again, resulting surface edge lengths are not all the same length. The resulting mesh will always contain 12 sets of 5 triangles organized into pentagons, the rest into hexagons.

The Class I version of the algorithm above always creates $20F^2$ surface facets where $F=1$ gives the icosahedron itself. The external point population will be $10F^2+2$. Since points plus facets = edges plus 2 (Euler), you will get $30F^2$ edges. F is what Fuller called the Frequency of the geodesic sphere and, in the Class I case, corresponds to the number of grid intervals along any one of the 20 triangle edges.

Note: “buckyballs” in the sense of “fullerenes” are not omnitriangulated (the edges internal to the 12 pentagons and n hexagons have been removed) and come in infinitely more varieties than the above algorithm allows. The above algorithm is limited to generating point groups with icosahedral symmetry – a minority of the fullerenes are symmetrical in this way, although C60, the most prevalent, is a derivative of the Class I structure.

[From Ben Williams]

Andrew Norris writes:

```
>1/ Given a dodecahedron with the edges of length unity, what is
> the radius of the sphere that would enclose this body?
>
>2/ For the above case, construct each pentagon out of triangles.
> What are the angles required so that new center-node of the
> pentagon just touches the enclosing sphere?
```

This is just a 2 frequency (what-is-referred-to-in-Domebook II-as) triacon geodesic sphere. Funny you should mention that: Back in June when I first discovered this newsgroup, I got reinterested in my old hobby of building mathematical models (and R B Fuller as well). So I went through the laborious process of calculating the strut lengths to build a 2v triacon sphere (what you just described above) out of toothpicks. I have it hanging up over my monitor right now. I wish I could show how I used geometry and such to figure all the necessary lengths out. What I do is start out with a drawing of a dodecahedron projected onto a plane – if it is oriented correctly, you will get a 2-d figure that you can use to deduce the information you want from it. (To get this figure, think of a dodecahedron made out of struts (such as toothpicks) standing on one of its edges on a sheet of paper out in the sun with the sun directly overhead. The shadow on the paper will be this figure.) These are the lengths I derived

E = length of edge of dodecahedron Distance of edge of dodecahedron from center:

$$E_r = ((3 + \sqrt{5})/4) * E$$

1/2 distance between non-adjacent vertices of face of dodecahedron:

$$b = ((\sqrt{5}+1)/4) * E$$

given a face of dodecahedron, distance between vertex and opposite edge:

$$h = ((\sqrt{5} + 2*\sqrt{5}) / 2) * E$$

distance from center of dodecahedron to one of its vertices (your question 1):

$$R = \sqrt{(9 + 3*\sqrt{5})/8} * E$$

given a face of dodecahedron, distance from its center to an edge:

$$l = b/h * E_r$$

distance from center of face of dodecahedron to center of dodecahedron:

$$m = E_r/h * E_r$$

given face of dodecahedron, distance from center to vertex:

$$t = h-l$$

length of one of those struts going from a vertex of dodecahedron up to point above center of face but on the enclosing sphere:

$$S = \sqrt{t^2 + (R-m)^2}$$

Now, to derive the angles of one of those triangles whose side lengths I have just determined, you would need to do this:

$$A_1 = 2 * \arcsin ((E/2)/S)$$

This is the angle of the top corners of the 5 triangles which are arched above one of the faces of the dodecahedron. My calculator gives me this angle in degrees: 67.66866319 Notice it is slightly less than the 72 degrees it would be if they were flat on the face of the dodecahedron. Now the other two angles of each of the triangles are simply derived via:

$$A_2 \text{ and } A_3 = (180 - A_1) / 2$$

I get a value of 56.1656684 degrees for these two angles.

4.2.2 What are the basics of Spherical Trigonometry?

On Sat, 18 Dec 1993 03:11:53 GMT <scimatec5@UOFT02.UTOLEDO.EDU> said:

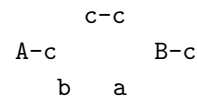
>Hey all,

> A while back I asked about calculating chord factors. I found the
>equation that without which I don't think I could have done it (by the way I
>was successful)-- it's a formula for calculating w/any spherical right
>triangle. The formula is $\sin a = \sin A * \sin c$.

> A
> / |
> c / |b
> / |
> / |
> B--a--C

>I'm sure you're all familiar w/it, but is there any other equation that would
>be just as helpful.

This is by Napier's rules. Here is Napier's circle:



where -c means the complement (or 90 degrees - (minus) the arclength measure). A, B are angles, C is the right angle and a, b, c are the sides opposite A, B, and C, respectively. There are two rules:

Rule 1:

The sine of any unknown part is equal to the product of the cosines of the two known opposite parts.
Or $\sin = \cos * \cos$ of the OPPOSITE parts.

Rule 2:

The sine of any unknown part is equal to the product of the tangents of its two known adjacent parts.
Or $\sin = \tan * \tan$ of the ADJACENT parts.

Your formula is the same because "c-c"=90-c and $\sin(90-c)=\cos(c)$. Examples: $\sin(b)=\tan(A-c)\tan(a)$ or $\sin(b)=\cos(c-c)\cos(B-c)$.

>

>

Steve Mather

Chris Fearnley

4.2.3 How to tessellate a sphere?

[From an old comp.graphics FAQ, posted by Christopher McRae 14 Apr 1993.] One simple way is to do recursive subdivision into triangles. The base of the recursion is an octahedron, and then each level divides each triangle into four smaller ones. Jon Leech leech@cs.unc.edu has posted a nice routine called sphere.c that generates the coordinates. It's available for FTP on <ftp://ftp.ee.lbl.gov> and [weedeater.math.yale.edu](ftp://weedeater.math.yale.edu).

4.2.4 Chord Factors - the nitty gritty.

First choose a tessellation of the sphere (icosa, octa, tetra, elliptical or really just about anything. Second use geometry and spherical trig to determine the surface arclengths for the specific tessellation. Third observe that in any circle a central angle cuts off an arc with the same exact measure. Next, calculate the chord factors: $cf = 2\sin(\theta/2)$, where θ is the central angle. Finally, multiply each chord factor by the radius of your dome.

Several dome books use the term “alternate” to refer to Class I domes (actually it seems Joe Clinton in his paper on domes has determined several methods for class I subdivisions - his method I is the “alternate” form). The other popular subdivision scheme is based on the rhombic triacontrahedron and is called “triacon.”

[From Steve Mather]

Hey all, I have some questions to ask about the trigonometry behind geodesic domes. Remarkably, I've understood what I've encountered so far, and am well on my way to calculating the the chord factors for a 5v icosa alternate (Why? when I can look it up in a book? Well, I figured I'd prove to myself I can.) I've been able to find those along the direct projection from the icosahedron (are 0.198147431 w/central angle of 11.3716678 degrees, 0.231597598 w/central angle of 13.29940137, and 0.245346417 w/central angle of 14.09281254 accurate beginnings for the outside?

[A big thanks to Steve for calculating and typing in all this for us!!! I'm not certain about the results, but he did such a careful job that I suspect they are correct. I'm sure someone will check this more carefully. Please let me know of any problems.]

The letters begin at the bottom of the horizontal edges to the triangle, from “a” to whatever letter (depending upon the frequency –“a” is the very bottom, as well as the sides.) The numbers are the chord factors.

The way I calculated my factors was like this:

I took the frequency (f) and divided the degree of the central angle of that frequency. I then multiplied this number times the number of rows down the row of lines are (check figure.) I took the sine of this number and multiplied it times the sine of the face angle (the angle between the great circles) to find the sine of half of the angle across the row (whew– is this making any sense? =) I then multiply this angle times two and divide by the number of rows down (check second sentence and figure.)

This gives me the angle of the geodesic I want. I then take these numbers and divide by two, take the sine and multiply by two, to find the chord factor. These chord factors are multiplied times the radius to get their lengths.

Here are the equations used:

```
f= frequency
n= number of rows
A= face angle
All numbers are in degrees
```

$$2 \sin^{-1}(\sin((63.43494885/f)*n)*\sin A)$$

(the extra ”)” shouldn't be there. sorry, my computer's acting up, and for some reason I can't delete it.) That was the equation for getting the geodesic. The chord factors are done from those by the following equation:

$$\text{Angle} = v \cdot 2 \sin (v/2)$$

2v icosahedron: b= 0.6257378602
 a= 0.5465330581

3v: c= 0.4240625600
 b= 0.4038282455
 a= 0.3669588162

4v: d= 0.3212440714
 c= 0.3128689301
 b= 0.2980880630
 a= 0.2759044843

5v: e= 0.2581842991
 d= 0.2539357295
 c= 0.2465769121
 b= 0.2357285878
 a= 0.2209776479

6v: f= 0.2156929803
 e= 0.2132468999
 d= 0.2090569265
 c= 0.2029619174
 b= 0.1947619676
 a= 0.1842631079

7v: g= 0.1851588097
 f= 0.1836232302
 e= 0.1810112024
 d= 0.1772461840
 c= 0.1722282186
 b= 0.1658460763
 a= 0.1579992952

8v: h= 0.1621725970
 g= 0.1611459677
 f= 0.1594077788
 e= 0.1569181915
 d= 0.1536238835
 c= 0.1494619675
 b= 0.1443671359
 a= 0.1382831736

9v: i= 0.1442501297
 h= 0.1435301153
 g= 0.1423149814
 f= 0.1405824320
 e= 0.1383022055
 d= 0.1354375402
 c= 0.1319478012

b= 0.1277927679
a= 0.1229389715

10v: j= 0.1298874025
i= 0.1293630412
h= 0.1284801673
g= 0.1272255402
f= 0.1255810391
e= 0.1235242767
d= 0.1210296754
c= 0.1180702193
b= 0.1146200925
a= 0.1106583339

11v: k= 0.1181213623
j= 0.1177276963
i= 0.1170660293
h= 0.1161281074
g= 0.1149025743
f= 0.1133752524
e= 0.1115296266
d= 0.1093476232
c= 0.1068107860
b= 0.1039019434
a= 0.1006074045

12v l= 0.1083071374
k= 0.1080040870
j= 0.1074954030
i= 0.1067757281
h= 0.1058376643
g= 0.1046719125
f= 0.1032675068
e= 0.1016121871
d= 0.09969296006
c= 0.09749689909
b= 0.09501222476
a= 0.09222967293

13v m= 0.09999681431
l= 0.09975856278
k= 0.09935906240
j= 0.09879471539
i= 0.09806054042
h= 0.09715024635
g= 0.09605635362
f= 0.09477038423
e= 0.09328314541
d= 0.09158513461
c= 0.08966709201
b= 0.08752071743

a= 0.08513955025

14v n= 0.09286965560
m= 0.09267896531
l= 0.09235948034
k= 0.09190871293
j= 0.09132321201
i= 0.09059860431
h= 0.08972966070
g= 0.08871039868
f= 0.08753423341
e= 0.08619419334
d= 0.08468321460
c= 0.08299452818
b= 0.08112214654
a= 0.07906144555

15v o= 0.08668999531
n= 0.08653500116
m= 0.08627549580
l= 0.08590971508
k= 0.08543520816
j= 0.08484886148
i= 0.08414693683
h= 0.08332512917
g= 0.08237865120
f= 0.08130235310
e= 0.07955142649
d= 0.07873891823
c= 0.07724141051
b= 0.07559395328
a= 0.07379316114

Octahedron geodesics:
alternate only

2v: b= 1.0000000000 (exact)
a= 0.7653668647

3v: c= 0.7071067812
b= 0.6471948470
a= 0.5176380902

4v: d= 0.5411961001
c= 0.5176380902
b= 0.4701651493
a= 0.3901806440

5v: e= 0.4370160244
d= 0.4253582426
c= 0.4032283118

b= 0.3667034258
a= 0.3128689301

6v: f= 0.3360254038
e= 0.3594040993
d= 0.3472963553
c= 0.3280400675
b= 0.2996195680
a= 0.2610523844

7v: g= 0.3146921227
f= 0.3105694162
e= 0.3032077023
d= 0.2918376001
c= 0.2754043542
b= 0.2528648441
a= 0.2239289522

I hope I typed those all in right.

4.3 How to build a geodesic dome?

[From Trevor Blake]

If there is any one Frequently Asked Question online in the 'Fuller School' (an unsupervised collection of mailing lists, Web pages and other online forums relating to R. Buckminster Fuller) it is "How do I build a geodesic dome?"

Trevor's web page, *How to Build a Geodesic Dome* www.box2321.com/synergetics/dome01.html , isn't comprehensive but might get you started.

4.4 Did Fuller invent the Dome?

[From Lloyd Kahn]

Fuller did not invent the geodesic dome. It was invented by Walter Bauersfeld of the Zeiss Optical Works in Jena, Germany in 1922, and the first use of it was as a planetarium on the roof of Zeiss that year.

Geodesic Domes and Charts of the Heavens <http://telacommunications.com/geodome.htm> gives further background.

[From Chris Fearnley]

However, Fuller was awarded several patents for the dome. Among them are US patent #2682235 (1954), US patent #288171 (1959), US patent #2905113 (1959), US patent #2914074 (1959), etc. Moreover, Fuller was the one who popularized the technology and pointed out the dome's advantages and the reasons for its great strength.

Since Bauersfeld conceived of his structure merely as a planetarium projector (a truly impressive feat) whereas Fuller had a more comprehensive vision of the geometrical and engineering significance of the dome. Which man should win history's designation as "The inventor of the dome"? I'll let the historians and the pundits debate that one.

4.5 Dome References

4.5.1 Geodesic Dome websites

The locations of Dome websites changes frequently. The FAQ editor maintains a listing at <http://www.CJFearnley.com/buckyrefs.html#geodesicdomes> . Kirby Urner maintains one at <http://www.grunch.net/synergetics/domes/domeman.html> , and the Buckminster Fuller Institute maintains a list at <http://www.bfi.org/domes/makers.htm> .

4.5.2 Dome Vendors

The list below has been enhanced by contributions from Joe Moore, Gary Lawrence Murphy, Garnet MacPhee, Robert Holder, and Matthew V. J. Whalen. This list is alphabetical. AT&T's *AnyWho service* <http://www.anywho.com/> provides a way to check for current information about any company including these vendors.

Affordable Dome Ceilings Inc Updated: Oct 2002
Melbourne, FL 32935 Tel: 321-259-759

Aluminum Geodesic Domes and Spheres Updated: Oct 2002
2111 Southwest 31st Avenue Edwin O'Toole
Hollywood, FL 33021 Tel: 954-963-2341 Fax:

American Geodesics, Inc. Updated: Oct 2002
1505 Webster St. Ben Rose
Richmond VA 23220-2319 Tel: 804-643-3184
a.k.a. Semispheres Building Systems

American Ingenuity, Inc. Updated: Oct 2002
8777 Holiday Springs Road
Rockledge, FL 32955-5805 Tel: 321-639-8777
Planning kit; Video; EPS Foam covered w/concrete Shells
<http://www.aidomes.com/>

Applied Geodesics, Inc. Updated: Nov 2002
P.O. Box 61741
Vancouver, WA. 98660 Tel: 877-518-1110
<http://www.agidomes.com/>

Asphalt Sealcoating Products Updated: Oct 2002
2111 Sw 31st Avenue
Hollywood, FL 33021 Tel: 305-625-9436

Astro-Tec Inc Updated: Oct 2002
550 Elm Ridge Avenue
Canal Fulton, OH 44614 Tel: 330 854 2209
<http://www.astro-tec.com/>

Charter Industries Inc Dome Strctrs Updated: Oct 2002
5325 Barclay Drive

Raleigh, NC 27606

Tel: 919-859-1872

Common Wealth Solar Svs.

Updated: Oct 2002

12433 Autumn Sun Lane

Ashland VA, 23005

Tel: 804-798-5371

<http://www.commonwealthsolar.com/>

Conservatek

Updated: Nov 2002

498 Loop 336 E.

Conroe, TX 77301

Tel: 800-880-3663 Fax: 936-539-5355

<http://www.conservatek.com/>

Deery Development Inc

Updated: Oct 2002

28101 South Yates Avenue

Beecher, IL 60401

Tel: 708-946-9292

Dome Inc

Updated: Oct 2002

2550 University Avenue West

Saint Paul, MN 55114

Tel: 612-333-3663

<http://www.domeincorporated.com/>

Domelite of Arizona

Updated: Oct 2002

Phoenix, AZ 85034

Tel: 602-264-6631

<http://www.domeliteaz.com/>

Domes America, Inc.

Updated: Oct 2002

126 S. Villa Ave.

Bob Casey

Villa Park, IL 60181

Tel: 630-993-1801

Fax: (630) 993 1809

800-323-5548

<http://www.arcat.com/arcatcos/cos32/arc32021.cfm>

Domes Northwest

Updated: Nov 2002

335 Vedelwood Drive

Sandpoint, Idaho 83864

Tel: 208-255-4840

<http://www.domesnorthwest.com/>

Domtec International

Updated: Oct 2002

4355 N Haroldsen Drive

Idaho Falls, ID 83401

Tel: 208-522-5520

<http://www.domtec.com/>

Econ-0-Dome

Updated: Oct 2002

RR 1, Box 295B

Sullivan, IL 61951

Tel: 1-888-DOME-LUV (1-888-366-3588)

<http://www.one-eleven.net/econodome/>

fazechange@one-eleven.net

Energy Structures, Inc.

Updated: Oct 2002

893 Wilson Avenue

Joe & Kevin Frawley

St. Paul, MN 55106

Tel: 651-772-3559

Fax: 612-772-1207

800-334-8144
<http://www.intlist.com/>

Fourth Dimension Housing Updated: Oct 2002
190 N. Livingston Bay Rd.
Camano Island, WA 98282 Tel: 360-387-1438
<http://www.archdome.com/> 1-888-301-7715

Geocon Manufacturing Inc Updated: Oct 2002
1502 Antelope Road
White City, OR 97503 Tel: 541 826 4545

Geodesic Domes and Homes Co. Updated: Oct 2002
P.O. Box 575 Larry Knackstedt Ray Howard
Whitehouse, TX 75791 Tel: 903-839-2000
<http://www.domehomes.com/> Fax: (903) 839 7228
(800) 825-2389
email: sales@domehomes.com
<http://www.domehomes.com>

GeoDomes Woodworks Updated: Oct 2002
6876 Indiana Avenue, Suite L Bob Davies & Glenn Van Doren
Riverside, CA 92501 Tel: 909-787-8800 Fax: 909-787-7089
Home Planning Guide; Wood kits

Geometrica, Inc. Updated: Nov 2002
908 Town & Country Blvd., Suite 330
Houston, TX 77024 Tel: 713-722-7555 Fax: 713-722-0331
<http://www.geometrica.com/>

Geo Tech Systems. Inc. Updated: Nov 2002
Corporate Office
775 Bunker Hill Rd.
South Tamworth, NH 03883 Tel: 603-323-8180
<http://www.domes.to/>

Hexadome Updated: Nov 2002
Glencor International
PO Box 519
Mount Compass
South Australia 5210 Tel: (08) 8556 8701
<http://members.ozemail.com.au/~hexadome/>

Good Karma Domes Updated: Nov 2002
James Lynch
3531 S.W. 42nd street
Oklahoma City, OK 73119 Tel: 405-685-4822
<http://www.goodkarmadomes.com/>

Growing Spaces Updated: Nov 2002
P.O. Box 5518

Pagosa Springs, CO 81147 Tel: 800-753-9333
<http://geodesic-greenhouse-kits.com>

Hexadome Updated: Oct 2002
Gene Hopster
El Cajon, CA 92020 Tel: 619 440 0434

Key Dome Inc. Updated: Oct 2002
10393 Southwest 186th Peter Vanderklaaw
Miami, FL 33157 Tel: 305-233-9000
[From Bruce Carroll]: If your looking just for plans/blueprints, try Key
Domes, in Miama, FL (305)-665-3541. They have 3 different types of plans
(foam/concrete, plywood on 2X4/6, and plywood panels).

KCS (KingDomes) Updated: Oct 2002
P.O. Box 980427 Einar Thorstein
Houston, TX 77098 Tel: Fax:
EDC Booklet (European design, 163 solutions, kits, math)
<http://www.mmedia.is/kingdome/>

Littlewood Geodesic Domes Updated: Nov 2002
3814a - 53a Street
Wetaskiwin, Alberta
Canada T9A 2T7 Tel: (780) 352-2569 or 497-0513
<http://www.freenet.edmonton.ab.ca/domes/>

Monolithic Constructors, Inc. Updated: Oct 2002
177 Dome Park Place Tel (972)483-7423 - Fax (972)483-6662
Italy, TX 76651 Tel: 800-608-0001 Fax:
Video; Free brochure; Concrete Domes
<http://www.monolithicdome.com/>

Natural Spaces Domes Updated: Nov 2002
37955 Bridge Road, Dennis Johnson
North Branch, MN 55056 Tel: 800-733-7107 Fax:
Local Phone: 651 674 4292
‘‘All About Domes’’; Video; Wood kits; Dome building classes
[Tom Dosemagen] Inquire about their ‘‘All About Domes’’ book. Dennis has
developed two different hub and strut systems for constructing domes.
The people at Natural Spaces, who have been in the dome business
for over 20 years, feel that the best way to insulate a dome is with
fiberglass insulation.
<http://www.naturalspacesdomes.com/>

Natural Habitat Domes Updated: Oct 2002
N4981 County Road "S"
Plymouth, WI 53073 Tel: 920 893 5308
<http://www.naturalhabitatdomes.com/>

New Age Construction Co. Updated: Nov 2002
13288-T Domes Ridge

Duncanville, AL 35456 Tel: 205-758-1996
<http://www.newagedomeconstruction.com/>

Northface Unverified
999 Harrison Court Bruce Hamilton
Berkeley, CA 94710 Tel: 415-527-9700 Fax:

Oregon Dome, Inc. Updated: May 1999
25331 Jeans Rd. Roger & Linda Boothe
Veneta, OR 97487 Tel: 541-935-5444
Phone: (800) 572-8943
<http://www.domes.com/>

Pacific Domes Updated: Nov 2002
247 Granite Street
Ashland, OR 97520 Tel: 1-541-488-7737
1-888-488-8127
<http://www.pacificdomes.com/>

P.D. Structures Updated: Nov 2002
180-4 Poplar St. Robert Gray
Rochester, NY 14620 Tel: 585-256-3918
rwgray@rwgrayprojects.com
<http://www.rwgrayprojects.com/company/company.html>
Pillow Domes

Pond-Brook Products Unverified
P.O. Box 301 Gladys Payne
Franklin Lakes, NJ 07412 Tel: Fax:
Hexa-Pent Dome Plans

Precision Structures LLC Updated: Oct 2002
2565 Potter St.
Eugene, OR 97405 Tel: Fax:
Book; 'Professional Dome Plans'; See Mother Earth News, 1-90
A book of detailed shop drawings and formulas for building wood framed,
3v icosahedron, panelized geodesic domes.
<http://www.domeplans.com/>

Shadow Wood Domes Inc Updated: Nov 2002
15250 South Paradise Lane
Mulino, OR 97042 Tel: 503 829 6370
AnyWho Categories: Dome Structures

Shelter Systems-OL Updated: Nov 2002
224 Walnut St. Bob Gillis
Menlo Park, CA 95060 Tel: 650-323-6202 Fax: 650-323-1220
Large dome tents, greenhouses, etc.
<http://www.shelter-systems.com/>

Solardome Industries Ltd. Updated: Nov 2002

P.O. Box 767
Southampton, S016 7UA
United Kingdom Tel: +44 (0) 23 80 767676
<http://www.solardome.co.uk/>

Starnet International Corp. Updated: Nov 2002
200 Hope St.
Longwood, FL 32750 Tel: 407-830-1199 Fax: 407-830-1817
<http://starnetint.com/>

Stromberg's Chicks & Gamebirds Updated: Nov 2002
100 York Street
Pine River, 4, MN 56474 Tel: 218-587-2222 Fax:
Starplate struts to build a dome shed/greenhouse up to 14' diam
http://www.strombergschickens.com/starplate_building_system/starplate_index.htm

Synapse Domes (name may be defunct) Updated: Nov 2002
Marshall Brasil and Scott Sims
Brasel & Sims Construction Co
1290 N 2 St
Lander, WY 82520
307-332-5773
This company may involve the principles from Synapse Domes. I have
not been able to verify. No websites could be found.

Temcor Updated: Nov 2002
PO Box 48008
150 West Walnut Street, Suite 150
Gardena, CA 90248 Don Richter Tel: 310-523-2322
800-421-2263 within US
Large aluminum commercial domes
<http://www.temcor.com/>

Timberline Geodesics Inc Updated: Nov 2002
2015 Blake Street Robert M. Singer
Berkeley, CA 94704 Tel: 510-849-4481 Fax: 510-849-3265
Catalog; Video Tape; Wood kits
Toll-Free: 800-366-3466 (1-800-DOME-HOME)
<http://www.domehome.com/>

Ultraflote Corp. Updated: Nov 2002
8558-T Katy Freeway, Suite 100
Houston, TX 77024 1809 Tel: 713-461-2100 Fax: 713-461-2213

Western Poly Dome Updated: Nov 2002
23430 High Bridge Road
Monroe, WA 98272 Tel: 360 794 4645

Worldflower Garden Domes Updated: Nov 2002
P.O. Box 2103 Tel: 512 863 2762
Georgetown, Tx. 78627

<http://www.gardendome.com/>

SouthEastDomes.com & TacoDome.co are Divisions of:

World Merchandising Company

Updated: Nov 2002

160 Bream Lane

Kingston, TN 37763

David Martin

Tel: 865-376-2161

<http://david.martiniiii.tripod.com/index-2.html>

4.5.3 Other Dome References

DOME is (was?) a magazine about the geodesic dome (ISSN 1041-1607). Published quarterly by:

Hoflin Publishing Ltd.

4401 Zephyr Street

Wheat Ridge, Colorado 80033-3299

Phone 303/420-2222 (7:30 am to 3:30 pm Denver time)

Thomas Register of American Manufacturers Updated: May 1999

One Penn Plaza

New York, NY 10001

Tel: 212-695-0500

Fax:

See Volumes 1-10: Products & Services (in most libraries)

Thomas' web page is at <http://www.thomasregister.com/>

National Dome Council

Updated: May 1999

1201 15th Street, N.W.

Washington, DC 20005

Tel: 800-368-5242, ext. 576

<http://www.buildingsystems.org/btgdg.html>

[From Alex Soojung-Kim Pang]

The two Domebooks – Domebook, and Domebook Two – were published in the early 1970s and are now out of print. They were written in much the same fashion as the Whole Earth Catalog, with readers sending in descriptions of their experiences and problems with domes, and the book's staff arranging the pieces, working in photographs and line drawings, etc. They are still often available in libraries, or through university interlibrary-loan. The full citation is:

Lloyd Kahn, et al. Domebook (One). Los Gatos: Pacific Domes, 1970. Lloyd Kahn, et al. Domebook Two. Bolinas, CA: Pacific, 1971. (Distributed by Random House)

[Editor: Warning: The math in these books is known to be inaccurate.]

There was also a book edited by John Prenis (or Prentis, maybe) called The Dome Builders Handbook (Philadelphia: Running Dog Press, ca. 1975). There were two editions of this, as well.

Lloyd Kahn has published three other books that contain information on dome-building: Shelter (which described a wide variety of self-built homes from all over the world), Shelter II (ISBN 0-394-50219), and a pamphlet called Refried Domes (Bolinas: Shelter Publications, 1990) (ISBN 0-936070-10-2). The latter contains the chord factors and angles for 8-frequency domes (critical information, and unavailable anywhere else as far as I can tell), suggestions about construction, and some second thoughts about domes as permanent shelter. If these books are not in your bookstore, you can order them directly from

Shelter Publications
Home Book Service
P.O. Box 279
Bolinás, CA 94924
<http://www.shelterpub.com/>

If you're interested in learning something about the history of domes in the counterculture, look up Charles Jencks and William Chaitkin, *Architecture Today* (New York: Harry Abrams, 1982). The magazine *Futurist* has also published a couple articles on domes in the last couple years.

Another book to look for Steve Baer, *Dome Cookbook* (Lama Publications, 1968); as I recall, it has tables for computing strut lengths and some useful information about dome construction.

[From Alex Soojung-Kim Pang, 25 Feb 1992]

Gene Hopster, *How to Design and Build Your Dome Home*
(Tucson: HP Books, 1981)
Edward M. Duke, *A Study of the Geodesic Dome Applied
to Housing* (Monticello: Council of Planning
Librarians, 1973)
John Fontanetta, *Building a Solar-Heated Geodesic Greenhouse*
(Charlotte, VT: Garden Way, 1979)

[From Garnet MacPhee in NOV 1989.]

There is a national association.

National Association of Dome Home Manufacturers
2506 Gross Point Road
Evanston, Illinois 60201

[From Gary Lawrence Murphy and Chris McRae]

Hugh Kenner's "Geodesic Math and How to Use It" Berkeley : University of California Press, c1976. xi, 172 p. : ill. ; 22 cm. (ISBN 0-520-02924-0) This is an excellent book for the hobbyist model builder, but also shows geometric derivations for a number of approaches to carving up the surface of a sphere into the smallest practical number of different shaped parts, which is the key matter in dome fabrication. The book also discusses tensegrity designs, although I believe Hugh has since release a volume devoted to tensegrity. For those without calculators :-), the appendix of the book lists the dome-vertex values for many practical frequencies in the basic polyhedral forms.

[From Alex Soojung-Kim Pang, 25 Feb 1992]

A technically useful book is Edward Popko, *Geodesics* (Detroit: U. Detroit press, 1968). It has lots of photographs, plans for domes made from a whole host of materials, different assembly methods, etc..

[From Matthew Clark, 28 Apr 1993.] Enchanted West, Inc. manufactures lightweight, precision-molded, fiberglass panels for building geodesic domes. Contact us at mclark@scf.nmsu.edu for more information.

[Posted Dec 1991 by Randy Burns]

Another alternative is concrete, earth sheltered domes. These aren't necessarily geodesic structures. Still, they may well be closer to nearing widespread commercial use than most geodesic structures.

Three Companies involved in this:

Utopia Designs, Eugene OR (founded by Norm Waterbury)

These are definitely oriented to the do-it-yourselfer. They specialize in selling forms and blueprints for domes build using inflatable forms.

EarthShips, Eugene, OR

This company was founded by Richard Britz, author of the Edible City Resource Manual. They specialize in turnkey structures and are more oriented towards larger developments. Britz does _wonderful_ architectural drawings.

Monolithic Structures, Idaho and Stockton CA

These folks are primarily involved in building _large_ structures, mainly industrial buildings and grain silo's.

[More concrete companies from Russell Miller. 1994]

The following three companies deal with concrete shell domes, some of which are geodesic, but none of which are specifically "Earth Sheltered."

American Ingenuity inc.	40' dia kit: \$13,058
8777 Holiday Springs Road	Video = \$8
Rockledge, Fl	Address current as of: 1994-05
32955-5805	
407-639-8777	
407-639-8778 (fax)	

Key Dome Engineering inc.	Plans only
P.O. Box 430253	Info pack = \$5
South Miami, FL	Address current as of: 1989
33143	

Monolithic Constructors inc.	40' dia dome kit: \$2300
1 Dome Park Place	Video available
P.O. Box 479	Address current as of: 1994-02
Italy, TX	
76651-0479	
214-483-7454	
214-483-6662 (fax)	

Build Your Own Geodesic Model:	A.G.S. Products
	2111 SW 31 Avenue
	Pembroke Park, FL 33009

[From Ross Keatinge, 2 Oct 1993]

I know of two dome manufacturers in Australia:

'The Dome Company' at 'Tapitallee' near Nowra NSW. They make house and garden domes 5, 7 and 10 metre diameter. I think they also produce them in kitsets so they may be able to help with hubs etc.

The contact is:	Rob Lusher	Phone (044) 460452
	The Dome Company	

P0 Box 3043
Nth Nowra
NSW 2541

Tapitallee is a rainforest retreat centre who run seminars on alternative technologies etc as well as personal growth type stuff. I gather some of their buildings are domes. I'm thinking of spending some time there.

The other is: Bretcod Geodesic Domes
27 Allawah Street
Blacktown NSW Phone (02) 621-7952

He makes all sorts of domes. Since his business is selling completely built domes I'm not sure how helpful he would be.

5 Other Inventions

Fuller was a tinkerer and made many small tools both to explain his principles and to perform useful tasks. All of his patented inventions can be found in his book *Inventions: The Patented Works of R. Buckminster Fuller*. His second most esteemed invention is "tensegrity" or tensional-integrity structures (See section 5.1.2 (Who was Kenneth Snelson and what was his role in the invention of tensegrities?) for Kenneth Snelson's role in this.).

5.1 What is a tensegrity model?

"The word 'tensegrity' is an invention: a contraction of 'tensional integrity.'

[From *Synergetics* [700.011] <http://www.rwgrayprojects.com/synergetics/s07/p0000.html#700.011>]

"Tensegrity describes a structural-relationship principle in which structural shape is guaranteed by the finitely closed, comprehensively continuous, tensional behaviors of the system and not by the discontinuous and exclusively local compressional member behaviors. Tensegrity provides the ability to yield increasingly without ultimately breaking or coming asunder."

[From Blaine A. D'Amico.]

Fuller stated as a general principle that "tension and compression always and only coexist." There is no way to have tension without corresponding compressional forces in the structure. A tensegrity is a continuous tension - discontinuous compression structure. This is as distinguished from traditional structuring which is continuous compression and discontinuous tension.

[From Kirby Urner]

Tensegrity structures employ tension primarily and compression secondarily. In pure tensegrity, compression members (i.e. metal rods) do not touch one another but provide rigidity within a network of tensed cables. Not only domes, but towers (and many sculptures) have successfully employed tensegrity principles. For Fuller, tensegrities manifested his philosophy: that nature uses tension primarily and compression secondarily (whereas humans often misguidedly do the reverse). Although he developed geodesic structures for the Marine Corps and Strategic Air Command, none of these were "tensegrities" exactly. Tensegritoy, available from most museum giftshops and teacher supply catalogs, admirably teaches about tensegrity.

5.1.1 How to Build Tensegrities?

[From Daryl Bunce]

To me, one of the best tools for help with building Tensegrity systems was/is *An Introduction to Tensegrity* by Anthony Pugh, LOC: TA658.2 P85x, copyright 1976, University of California Press, ISBN: 0-520-02996-8 (cloth/hard) or 0-520-03055-9 (paper), 121pp.

I suggest reading the first few pages of Appendix A then running out and purchasing some .75" dowel (see below) *then* start on page 1.

For struts: dowel (wooden rods) 3 feet long (standard US size), with a diameter = .75 inches. Cut with a fine-toothed saw into 9 inch lengths. Repeat until happy with amount (you'll need more, eventually). Take some 18-gauge wire brads (those nails with virtually no head), about an inch to 1.5 inches long and blunt the points. Warning: Use of steel nails, pins, etc. can be dangerous. Pound two nails into each strut end, with a wide gap between them and at least .5 inches protruding from the wood:

```
-----  
                                     //  
                                     /  -----o  
STRUT (yeah, right)  /  -----o   two brads, repeat for other end  
                                     //  
-----//
```

Repeat procedure for all ends of struts. Using rubber bands (#14, 2 inches, or #12, 1.5 inches) hung over one brad/strut, you should be able to model some Tensegrities. BTW: If there were only one brad at each end, the rubber bands have more of a tendency to slip off.

If your rubber bands are still slipping off, stretch one from one end to the other of the same strut before modeling. When you are ready to incorporate this strut, unhook this band, slide a band from the other strut onto a brad on this strut, and hook the original band back on over the new one. (Follow that?)

Most of the above was summarized from Mr. Pugh's book in one way or another.

[From chris@COGNET.UCLA.EDU]

There is a company called Plastruct which makes little plastic components for building various sorts of models. They are located in the City of Industry (I think (greater L.A. area)), California. Any good hobby or architectural supply shop in your area should have a catalog. I warn you, however, that their models are somewhat limited and the plastic tubes used for struts tend to split.

There is also a company in England somewhere which actually owns the design upon which the Plastruct models are based. The components they make are somewhat larger, I believe, and perhaps of higher quality.

If anyone is really interested in more details, I can dig up the names and numbers for you. In general, a good resource for this kind of information is the *Thomas Register of American Manufacturers*, which can be found in many large libraries.

[From Michael Justice, 23 Mar 1992]

Real Goods sells something called a "tensegritoy," which looks kinda cute. To quote from their latest micro-catalog:

Tension members:

Boating supply shops carry in bulk what might cost you \$\$\$ to get pre-cut: rope, cables, and that elastic cloth cordage (like the kind used in the Tensegritoy). The elastic cord cost about \$13 for a 50 foot roll.

Tough Tension members:

Nylon coated steel cable, 3/32 inch, with crimpable aluminum cable sleeves. Use the sleeves to make loops in the cable ends. Cable can be accurately measured by looping around two nails set in a block of wood and pulled tight. Sleeves can be crimped on one at a time. The nylon coating makes it less likely to have wire splinters, and makes for a neater finish.

Taking up slack:

Tiny turnbuckles. expensive at >50 cents a pop. Jim Flanagan's idea to increase the tension of the rubber bands by twisting them will work here, too. You just won't be able to twist up very much. Many forms of strain relief hardware can also be used to give springiness to inflexible cables.

Compression members:

Aluminum or brass tubing, 3/8 inch diameter. Aluminum costs about \$1 a foot, while brass is about twice as expensive. Neither is hard to cut, given a midget pipe cutter, about \$5.

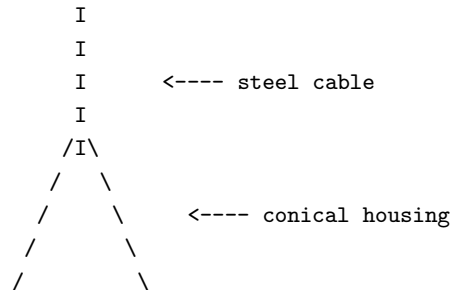
Fastening members together:

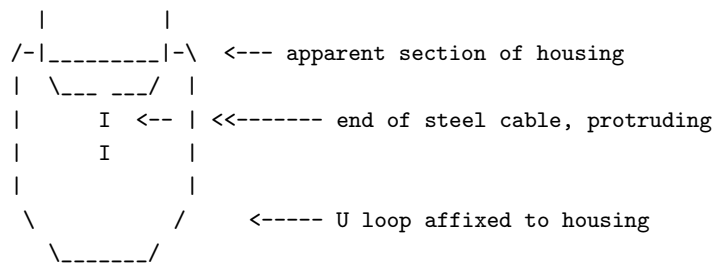
A hollow tube may be plugged with a variety of screw anchors, both metal and plastic. Then a small bolt or screw stock can be securely mounted. Some washers are all that's needed to complete the connection if you chose to use bolts. For screw stock, you also need nuts, and can use round-ended chromed nuts for a finer finishing. For both, cable or rope loops can simply be looped on. Make sure the loop is smaller than the washer, or it might slip.

[From Mitch Amiano]

Has anyone seen the in-line cable clamps used for utility-pole guy wires? The clamps do not have any perpendicular bolts, and have a U loop on the ground side (which is tied down). The steel cable goes right through the unit unbroken and untwisted, leaving a small stub of cable out the U loop end. The cable has no connection with the U loop itself - that is part of the connector housing. Finally, the unit is about 6 or 7 (~15cm) inches long, cone shaped, and about an inch and 3/4 thick (~8cm).

The reason I ask, is because it appears to be an ideal connector for a variety of tensegrities - one which I had conceptualized but for which I had not found a good implementation. Does anyone know if similar units exist for other size factors (esp. for desktop modeling), or know if the internal design relies on the use of pincers/teeth to grip? (The latter would make the design less attractive for monofilament lines.)





[From H. Jeffrey Rosen]

In-line cable fixtures are commonly stocked by manufacturers and distributors of wire rope. A quick scan of my yellow pages at that category identified a source of many sizes of the U-bolt style clamps used for antenna guy lines. Surely such providers exist in most areas, and can steer you to the particular gadget you seek.

If not, here's the number of the place I contacted:

AYERS WIRE ROPE SERVICE, INC., JACKSON SC (803) 827-1419

5.1.2 Who was Kenneth Snelson and what was his role in the invention of tensegrities?

Fuller began writing, speaking and thinking about coexistent tension and compression in the 1920's - see his first book *4D Time Lock*. He complained of having no good model to explain these principles. Then Snelson attended several of Fuller's lectures at Black Mountain College in the summer of 1948. In the winter of 1948 Snelson built the first tensegrity structure consisting of two "X"-shaped figures one suspended above the other in a sea of tension. He showed Fuller this model in the summer of 1949. After this initial contact both men developed the concept of tensegrity in unique and independent ways. Snelson designed large magnificent tensegrity sculptures while Fuller built large tensegrity spheres to demonstrate his synergetics (at that time he called it Energetic Geometry). Both Fuller and Snelson patented their structures.

I think the quote below shows that both Fuller and Snelson acknowledged each other's contribution. Given Fuller's disdain for footnotes and other forms of formal citations, he occasionally implied more credit than is his due. However, it seems to me that he documented Snelson's contribution sufficiently. Claims that Fuller stole Snelson's work are unsubstantiated. Also, claims by some of Fuller's admirers that Snelson stole from Fuller, ignore the breakthrough in design that Snelson contributed.

[From *Kenneth Snelson, an Exhibition* organized by Douglas G. Schultz; essay by H.N. Fox, p.23]

"In a letter from Fuller to Snelson dated December 22, 1949, Fuller states, 'In all my public lectures I tell of your original demonstration of discontinuous-pressure- (com-pressure) and continuous tension structural advantage; - in which right makes light [?] in a prototype structure, - the ready reproduction of which properly incorporated in fundamental structures, may advance the spontaneous good will and understanding of mankind by many centuries. The event was one of those 'it happens' events, but demonstrates how the important events happen where the atmosphere is most favorable. If you had demonstrated this structure to an art audience it would not have rung the bell it rang in me, who had been seeking this structure in Energetic Geometry. That you were excited by the later E.G. [**Energetic Geometry**], into spontaneous articulation of the solution, also demonstrates the importance of good faith of colleagues of this frontier. The name Kenneth Snelson will come to be known as a true pioneer of the realized good life and good will...' "

5.2 What are “cloud nines?”

[“‘Cloud nines’ are floating geodesic spheres. The following extract from a paper posted to GEODESIC by Robert T. Bowers explains the idea.] “When considering a geodesic sphere, the weight of the sphere is a function of the surface of the sphere. The amount the sphere is lifted by warm air is a function of the volume of the sphere. In mathematical terms, weight is a function of the radius squared, while volume is a function of the radius cubed. This is very significant. Even as the radius of a sphere increases, thus increasing the sphere’s weight, the lift of the sphere increases more. If you image a sphere that could grow larger, as the sphere gained a little weight, it would gain much lift.

“Buckminster Fuller proposed that as spheres of great size are considered, the amount of air enclosed grows huge compared to the weight of the sphere. Of a sphere with a radius of 1320 feet, the weight of the enclosed air is 1000 times greater than the weight of the sphere’s structure. If that volume of air was heated only one degree, the sphere would begin to float!

“Of course, domes of even greater sizes would be required if that sphere were to carry any additional weight. But it is not inconceivable that floating geodesic spheres could carry aloft entire communities. Perhaps the concept of a floating dome of one half a mile diameter is too much for most people to seriously consider. Regardless, it does demonstrate the scope of projects that are made possible with geodesic domes.” -Robert T. Bowers Fuller quote from *I Seem To Be A Verb*

Came across this small description which I thought might interest some people who haven’t seen it before ...

Geodesic spheres larger than half-a-mile in diameter can be floated in the air, like clouds. Draped with polyethylene curtains – to retard night-time air intake – the spheres would be light enough to remain aloft, at preferred altitudes.

“Cloud nines” one mile in diameter could house thousands of people, whose weight would be negligible. Passengers could pass from “cloud” to “cloud,” or from “cloud” to ground, as the “clouds” float around the Earth or are anchored to mountain tops. The “clouds” could become food factories by impounding sunlight.”

– David Paschall-Zimbel

5.3 What is “dymaxion?”

“Dymaxion” is a name coined by a friend [ED: an advertising man actually] of Bucky’s which is a contraction of the words “DYnamic” (or DYnamism, depending on your sources), “MAXimum,” and “ION;” three words that he noticed Bucky used often in his speech when describing things.

Dymaxion, and also 4-D (4th Dimension) became trademarks of Bucky’s and were frequently used on his products: -The Dymaxion 4-D House -The Dymaxion Car -The Dymaxion Deployment Unit (war-relief housing) -The Dymaxion Dwelling Machine (An improvement on the Dymaxion 4-D House) - Patrick G. Salsbury

5.4 What was the “Dymaxion Car?”

“The Dymaxion Car was a teardrop-shaped (least air resistance), 3-wheeled, rear-wheel (single) steering, 21 foot long, Aluminum bodied auto, designed by Bucky to achieve maximum output and service with minimum material input. It was about 6 feet tall (Kinda like a big van), seated the driver and 10 passengers, weighed

less than 1000 lbs., went 120 miles/hr on a 90 horsepower engine, and got between 30-50 miles to the gallon of gas! (Depending on your sources, again.)

“It was eventually supposed to be developed into a flying vehicle, held aloft on “jet-stilts” (downward facing thrusters of some sort) so as to make all of “Spaceship Earth” accessible to humans and make it so they could have a house ANYWHERE (on top of a mountain, in a desert, etc. [his Dymaxion Houses were self-sustaining, and didn’t need to be tied into powersewer/water lines]/) and still get around to go to work or whatnot. But only the car portion of the “Dymaxion Omnidirectional Human Transport” (Flying car) was developed, because at the time of development (1933-4), Jet technology was either non-existent, or not capable of the task.” - Patrick G. Salsbury

There is a Dymaxion car in the William F. Harrah Automobile Museum in Reno, NV. Very strange-looking vehicle indeed, and I was surprised to find out that it was from the 1930’s. -Dan Howell
dhowell.escp8@xerox.com

5.5 What is a “fog gun?”

The “fog gun” was an invention Bucky developed as a water saving alternative to the wastefulness of showers. While Bucky was in the navy, he noted that, while standing on the deck of a ship, in the spray and mist of the sea, nothing seems to stay on your skin for very long. Not even grease. He reasoned that it must have something to do with the abrasive action of the tiny water droplets, so he developed a device that atomized the water (like a perfume bottle with the little bulb that you squeeze to get perfume mist) and ejected it at high speed. He dubbed this the “fog gun” and found that it worked very well for cleaning a person off without soap (I’m not sure how he did hair, though) and without wasting a lot of water. (The “gun” could clean a family of four with 1 PINT of water!) -Pat Salsbury

5.6 What was Fuller’s “floating city?”

Around 1967, Bucky Fuller was put in charge of the Triton project for the Dept. of Housing and Urban Development (HUD) (You know, one of the current gov’t departments under investigation for all sorts of scandals! ;^)

Triton was a concept for an anchored floating city that would be located just offshore and connected with bridges and such to the mainland. It was a collection of tetrahedral structures with apartments and such. The model looked very interesting!

You can see some photos of the model in “The Artifacts of Buckminster Fuller,” along with technical drawings of just about everything else he ever designed! :) -Pat Salsbury

[Typed in by Charles Nicoll] Reprinted from *Critical Path*, (1981, St Martin’s Press) by Buckminster Fuller, p. 332.

“In the early 1960s I was commissioned by a Japanese patron to design one of my tetrahedral floating cities for Tokyo Bay.

“Three-quarters of our planet Earth is covered with water, most of which may float organic cities.

“Floating cities pay no rent to landlords. They are situated on the water, which they desalinate and recirculate in many useful and nonpolluting ways. They are ships with all an ocean ship’s technical autonomy, but they are also ships that will always be anchored. They don’t have to go anywhere. Their shape and its human-life accommodations are not compromised, as must be the shape of the living quarters of ships

whose hull shapes are constructed so that they may slip, fishlike, at high speed through the water and high seas with maximum economy.

“Floating cities are designed with the most buoyantly stable conformation of deep-sea bell-buoys. Their omni-surface-terraced, slop-faced, tetrahedral structuring is employed to avoid the lethal threat of precipitous falls by humans from vertically sheer high-rising buildings.

“The tetrahedron has the most surface with the least volume of all polyhedra. As such, it provides the most possible ‘outside’ living. Its sloping external surface is adequate for all its occupants to enjoy their own private, outside, tiered-terracing, garden homes. These are most economically serviced from the common, omni-nearest-possible center of volume of all polyhedra.

“All the mechanical organics of a floating city are situated low in its hull for maximum stability. All the shopping centers and other communal service facilities are inside the structure; tennis courts and other athletic facilities are on the top deck. When suitable, the floating cities are equipped with ‘alongside’ or interiorly lagooned marinas for the safe mooring of the sail- and powerboats of the floating-city occupants. When moored in protected waters, the floating cities may be connected to the land by bridgeways.

“In 1966 my Japanese patron died, and the United States Department of Housing and Urban Development commissioned me to carry out full design and economic analysis of the floating tetrahedral city for potential U.S.A use. With my associates I completed the design and study as well as a scaled-down model. The studies showed that the fabricating and operating costs were such that a floating city could sustain a high standard of living, yet be economically occupiable at a rental so low as to be just above that rated as the ‘poverty’ level by HUD authorities. The secretary of HUD sent the drawings, engineering studies, and economic analysis to the Secretary of the Navy, who ordered the Navy’s Bureau of Ships to analyze the project for its ‘water-worthiness,’ stability, and organic capability. The Bureau of Ships verified all our calculations and found the design to be practical and ‘water-worthy.’ The Secretary of the Navy then sent the project to the US Navy’s Bureau of Yards and Docks, where its fabrication and assembly procedures and cost were analyzed on a basis of the ‘floating city’ being built in a shipyard as are aircraft carriers and other vessels. The cost analysis of the Navy Department came out within 10 percent of our cost - which bore out its occupiability at rental just above the poverty class.

“At this point the city of Baltimore became interested in acquiring the first such floating city for anchorage just offshore in Chesapeake Bay, adjacent to Baltimore’s waterfront. At this time President Lyndon Johnson’s Democratic party went out of power. President Johnson took the model with him and installed it in his LBJ Texas library. The city of Baltimore’s politicians went out of favor with the Nixon administration, and the whole project languished. The city of Toronto, Ontario, Canada, and other cities of the U.S.A are interested in the possibility of acquiring such floating cities. Chances of one being inaugurated are now improving.

“In relation to such floating cities it is to be noted that they are completely designed under one authority, and when they become obsolete, they are scrapped and melted and the materials go into subsequent production of a greatly advanced model whose improvements are based on earlier experiences as well as the general interim advances of all technology.

“There are three types of floating cities: There is one for protected harbor waters, one for semiprotected waters, and one for unprotected deep-sea installations. The deep-sea type is supported by submarine pontoons positioned under the turbulence, with their centers of buoyancy 100 feet below the ocean’s surface. Structural columns rise from the submarine pontoons outwardly through the water to support the floating city high above the crests of the greatest waves, which thus pass innocuously below the city’s lowest flooring, as rivers flow under great bridges. The deep-sea, deeply pontooned floating cities will be as motionless in respect to our planet as are islanded or land-based cities.

“There are also deep-sea spherical and cylindrical geodesic floating cities whose hulls are positioned entirely below the ocean surface turbulence. Only their vertical entrance towers penetrate outwardly through the disturbed surface waters. The occupants of submarine cities with their vertical towers penetrating outwardly above water can be serviced by helicopters landing on the tower-top platforms. Such pontooned or hulled submarine cities also can provide safe mid-ocean docking for atomic-powered cargo- and passenger-carrying submarine transports. With their submarine hulls locked together below the turbulence, a safe passageway can be opened between them.

“Even in mild weather docking cannot be done on the open water surface of the ocean. Even the mildest ‘old-sea’ or ground swells would roll any two ocean ships’ great tonnages into disastrous hull-smashing clashes. Relative mass attraction is proportional to the product of the masses of the interchanges. When any two oceangoing steel vessels come within ‘critical proximity,’ their interattraction is fourfolded every time the distance between them is halved. This chain-attraction-increasing force pulls them sideways toward one another, ultimately to touch and chew up one another’s skins - that is, unless one is maneuvered in time backward or forward away from the other. Land harbors are essential for surface docking or inter-tie-up of ships of any size. There are relatively few big-ship harbors in the world. This fact, and the world-around scarcity of such good harbors as Athens’ Piraeus, France’s Cherbourg, Italy’s Venice, the U.S.A’s New York, or Tokyo’s Yokohama, have greatly affected the geographical patterning of world history. The new ability to transfer cargoes at sea could completely alter world economic balances and could bring ships once more into economic competition with airplanes. The recent decades’ development of seventy-knot submerged speed of the great atomic submarines, complemented by floating cities, could herald the beginning of a new era of subsurface oceanic traffic.

“In due time small cruising yachts also will be able to sail or power around the world in safe, one-day runs from one protected floating city’s harbor to the next.”

[From Jim Fiegenschue, 12 Oct 1993]

If you are interested in studying and solving some of the practical problems of floating habitations (such as anchoring, survival of storms, etc.) you might contact Sten Sjostrand, the architect who designed The Saigon Floating Hotel. The first and to my knowledge still the only floating resort hotel in the world, it was built in Singapore for about \$22 million in 1987-8 US dollars. Another \$5.5 million of furniture and accessories were added, plus a \$2.5 million special anchor system, so this is a serious professional project. The 7-story hotel has 200 guest rooms, a lavish lobby, a swimming pool(!), a tennis court, a night club, a sauna, a gymnasium, small shops, several restaurants, two cocktail bars, a library, fully equipped conference rooms, post office, sewage treatment plants, facilities for mooring sail boats and yachts, an underwater observatory, and a marine laboratory. Originally opened for business as the Four Seasons Barrier Reef Resort in 1988 over the Australian Great Barrier Reef, it was a big draw for scuba divers. All waste- disposal machinery is sealed off completely to protect the environment. It is currently owned by the Japanese company EIE, who operate it offshore Saigon.

You can possibly reach Sten Sjostrand through the Atlantis Project, which is currently raising funds to build a floating city/nation to be called Oceania. Their newsletter, called Chain Breaker, is located at 4132 S. Rainbow Blvd, Suite 387; Las Vegas, Nevada 89103. Phone: 702 897-8418.

[From Bill Kovarik]

There’s a book called “Engineers Dreams” which depicts a floating city as a mid-Atlantic airport plan from the 1940s. Sometime in the 1970s the University of Hawaii designed a floating city, and you can get the book on interlibrary loan. I know the Virginia Tech architecture school library has it, if you can’t find it anywhere else. Both the airport and the Hawaii ideas dealt with structural engineering problems primarily.

There are important reasons to consider floating cities as resources for the not too distant future, I believe.

A very important need is for factories for processing renewable energy resources which would be too expensive or too ecologically disruptive to collect on land. Of course, the most problematic aspect of renewable energy is its dispersed nature. It must be collected and concentrated, and the process of doing that can raise costs to a non-competitive level with fossil energy.

For many decades, biochemical engineers have looked to marine biomass resources as being possible to cultivate in enormous quantities without creating ecological disruptions. As early as 1918 the Pasteur Institute was engaged in the study of renewable liquid fuels like methyl and ethyl alcohol from kelp. They were able to produce about 10 gallons of fuel alcohol per ton using an acid hydrolysis method. This is very old technology; better methods are available today.

In the late 1970s and early 80s tremendous new attention focused on renewable resources, and marine biomass was the subject of a good deal of study. One of the most important was the Marine Biomass Energy Conversion Technology Research Committee of the Japan Ocean Industries Association. In one study they found that a 50 kg / m² per year was the average productivity of both Sargassum and Laminaria type kelp. I don't know if they investigated the various energy production scenarios or what their final figures are, but you could probably find out pretty quickly.

If we converted kelp to renewable liquid energy at the rate of 10 gallons per ton, what do we get? Lets assume one ton (1,000 kg) is grown on 20 square meters and produces 10 gallons. To make a million gallons we need an area of 200 square kilometers. To make a billion gallons would take a 2,000 square mile area, and to replace just the gasoline used in the U.S. (100 billion gallons a year) with alcohol from marine biomass would take a 40,000 square kilometer area – around the size of Ireland and Cuba. Of course, more efficient processes and enhanced production could decrease the necessary size, but there would be little problem finding space in the ocean for an extra 40,000 kilometers somewhere. You would hope that the final cost of this liquid fuel was within a tolerable range, lets say \$1.20 (US prices) to \$5.00 per gallon (European fuel prices).

OK, what about the waste products. When the kelp is hydrolized we get this goopy green leftover glop – some of it could go to other chemical processes and some could be returned to the sea, along with treated sewage from the city, to fertilize the kelp beds for future harvests.

How do you support the rest of the city? Ocean Thermal Energy Conversion (OTEC) for electricity and fish farming and hydroponics for food, other light manufacturing, some mining of deep sea minerals – those are possibilities.

What is impossible to make at sea? Probably heavy industrial processes, such as steel mills, aluminum refining, textiles, etc.

Who would live there? Given the need for dignified employment in many developing nations, I would think that you could find millions of people willing to become “kelpers.” If developing nations would divert financial resources out of the petroleum sector and into sustainable development, it could vastly raise the standard of living of some of the poorest people on earth and solve a large portion of the environmental crisis at the same time.

You can see (squint hard, now) some of the visions of Huxley or Fuller or even Dwayne Andreas in play here, and we can see the outline of a real solution to the world energy / environmental crisis in the development of floating cities that produce renewable energy and food.

[From Steve Mather]

One possibility in “floating cities” that I recently came across is the “Mining” Magnesium. Allegedly it can

be obtained from sea water. Volvo developed a car back in the eighties (unfortunately they only developed it, it never went into production) that was made of a significant amounts of magnesium for its weight and because it avoided damaging mining practices. It's called the Volvo LCP 2000. Allegedly it gets anywhere from 56 to 81 (tops, 100) mpg, and, being a diesel, will run on nearly anything. For more info write Bob Austin of Volvo of America Corporation, Rockleigh, New Jersey, 07647; or call (201) 768-7300.

5.7 What was the Old Man's River City Project (circular cities)?

This was Fuller's design science approach to solving the housing crisis in East St. Louis.

Here are some excerpts from BF's CRITICAL PATH:

"For eminently mobile man, cities have become obsolete in terms of yesterday's functions - warehousing both new and formerly manufactured goods and housing immigrant factory workers...

"Old Man's River City, undertaken for East St. Louis, Illinois takes its name from the song first sung by Paul Robeson fifty years ago, which dramatized the life of Afro-American blacks who lived along the south-of-St. Louis banks of the Mississippi River...

"I originally came to East St. Louis to discuss the design and possible realization of the Old Man River's City, having been asked to do so by East St. Louis community leaders themselves... It is moon-crater-shaped: the crater's truncated cone top opening is a half-mile in diameter, rim-to-rim, while the truncated mountain itself is a mile in diameter at its base ring. The city has a one-mile-diameter geodesic, quarter-sphere transparent umbrella mounted high above it to permit full, all-around viewing below the umbrella's bottom perimeter. The top of the dome roof is 1000 feet high. The bottom rim of the umbrella dome is 500 feet above the surrounding terrain, while the crater-top esplanade, looks 250 feet radially inward from the umbrella's bottom, is at the same 500-foot height. From the esplanade the truncated mountain cone slopes downwardly, inward and outward, to ground level 500 feet below.

"The moon crater's inward and outward, exterior-surface slopes each consist of fifty terraces - the terrace floors are tiered vertically ten feet above or below one another. All the inwardly, downwardly sloping sides of the moon crater's terraced cone are used for communal life; its outward-sloping, tree-planted terraces are entirely for private life dwelling."

If you want all the details see CRITICAL PATH pages 315-323. [C. Fearnley]

[From Alex Soojung-Kim Pang.]

The Old Man River project never got off the drawing boards. It was mainly the work of Washington University architecture prof James Fitzgibbon. He had a long relationship with Fuller, extending back to the early 1950s. Fitzgibbon had designed a domed city to be built on Frobisher Bay in Canada in 1956, and Old Man River was an extension and expansion of that earlier plan. It was also designed to address problems that architects, planners, and policy-makers considered central in the late 1960s and early 1970s, viz. racial segregation, urban decay, and economic growth in the inner cities.

Old Man River would have provided housing and services for several thousand families in the most depressed section of St. Louis. It would have been built and managed by a non-profit corporation, and taken something like 20 years to complete; in Fitzgibbon's evocative phrase, it would have been not only good housing, but a "job machine," a huge project creating new industries in the area by virtue of its immensity. Fuller claimed that it would be the incubator of a new classless, raceless society. However, it never got anything close to the \$1 billion required to build it, and the St. Louis municipal government never seemed to have taken it seriously.

[See section 6.8 (Fuller's 'failures.') for more commentary on this project.]

5.8 What was the Dymaxion Deployment Unit?

[From Jay Rozen.]

Alden Hatch, in his "At Home in the Universe," describes BF's "Dymaxion Deployment Unit" (DDU), a circular structure which BF intended as cheap civilian housing. From 1940 to Pearl Harbor, they were manufactured for Allied troops and sent all over the world.

[From Pat Salisbury]

For more pictures of the D.D.U., or the other stuff Bucky worked on, check "The Dymaxion World of Buckminster Fuller." For blueprints and such, (not necessarily in a size that is legible all the time! ;)) try "The Artifacts of Buckminster Fuller"

5.9 What is the Dymaxion Map?

The Dymaxion Map is Fuller's attempt to provide the best all-at-once view (therefore flat and not globe-shaped) of the Whole Earth. His solution is based on projecting the globe onto an icosahedron and then unfolding the icosahedron (making it flat). His design was awarded U.S. Patent 2,393,676 in 1946.

5.9.1 Details about the Dymaxion Map.

[From Kirby Urner]

It's an icosahedron with its 20 triangles subdivided to give new vertices, which are pushed out equi-radially to approximate a sphere. The icosahedron is an intermediate stage between this high frequency icosahedron sphere and the final unfolding into a flat projection.

[From Christopher L. Weeks]

Over my recent X-mas break from school, I had the opportunity to visit the semi-new St. Louis Science Center. Among many interesting and some not-so interesting displays there was a dymaxion globe with magnetic panels holding the map sections to its surface. It was a great puzzle to take them all off and assemble them flat on the surface provided. The display briefly noted that it was called a dymaxion map, and didn't mention Bucky at all. There is also an hourly(?) laser show on a huge (three-story tall) dymaxion map. Again no mention of Bucky. But it is exposure.

[From Sarah Lum]

[The] world map interface, which many of us feel is replete with desirable futuristic connotations, not to mention real advantages.

minimal distortion including in high latitudes no sinus cuts into land masses apolitically polar-centric

hardwired in the literature to civilian deployment strategies on a scale that would arm-chair military mas-terminds feel right @ home

World Game sells its Global Recall software which shows data on the map – the deflated, unfolded, orthonormal, omnitriangulated icosaspheric projection.

DISCLAIMER: I am not in any way connected or affiliated with the World Game Institute. This is not to be construed as a sales pitch by a party with a direct or even indirect financial interest in success of World Game, Inc.

5.10 What was the Dymaxion House?

[From Kirby Urner]

The Dymaxion House prototype, for instance, was more octagonal, suspended from a central “utility mast” – a house on a pole.

6 Miscellany

6.1 What are “fullerenes” and “buckyballs?”

SCIENCE magazine voted buckminsterfullerene “Molecule of the Year” in 1991.

[From Kenneth J. Fair.]

The exciting part of the discovery of C60 molecules is that they are only the third naturally occurring form of carbon to be found (graphite and diamond of course being the first two). C60 was first isolated from graphite (I think) in 1985.

As Paul Houle writes, C60 is formed in the shape of a geodesic sphere (like the panels of a soccer ball), hence the name “buckminsterfullerene” or “buckyballs” for short. Each carbon has three sp² hybrid orbitals and the fourth electron of each carbon resides in a delocalized pi orbital that ranges over the entire ball (like benzene).

The physical appearance of C60 is very much similar to graphite, as are some of its physical properties. C60, unlike graphite, can be dissolved in benzene to form a translucent amber solution.

Other developments of buckyballs:

- 1) Radicalization - Besides just the pure C60 form, researchers at Rice have added hydrogen molecules to the carbon junctures to form molecules such as C60H36. Also, work is progressing on making C60 radical groupings (similar to benzene -> phenol).
- 2) Property measurement - Although many of the properties of C60 are known, most of the properties of its compounds are still hazy.
- 3) Higher molecules - Other stable forms with greater numbers of carbons have been isolated as well, including C70, C72, and a couple of others I can't remember. All of these have geodesic shapes as classified by Buckminster Fuller and look like lopsided versions of the normal C60 molecule.
- 4) Ionization - One can trap metallic ions such as Fe⁺⁺ and Mg⁺⁺ in the cage of the C60 to make the molecule act as a very large ion.
- 5) Superconductivity - As far as I know, the 18K Tc for C60 is the correct figure. This of course is much lower than high-temperature superconductors, but this fact may be used in some way at a later date.

Kenneth J. Fair

[From Blaine A. D'Amico.]

I promised a citation for the best Fullerene book to date. It is titled *Fullerene C60; History, physics, Nanobiology, Nanotechnology*. North Holland Press by Djuro Koruga, Stuart Hameroff, James Withers, Raoulf Loutfy, and Malur Sundareshan. The first chapter explores Fuller and Synergetics and the entire book is consistent with Fuller's Cosmography. Take a look.

[From Kevin Sahr]

This thread began in sci.math. Gets to the heart of what mathematics algorithms underlie the Dymaxion Projection.

Kirby Urner writes:

>

> In article <2vs64v\$av@gaia.ucs.orst.edu> sahr@thuja.FSL.ORST.EDU (Kevin Sahr) writes:

> >From: sahr@thuja.FSL.ORST.EDU (Kevin Sahr)

> >Subject: Re: The Icosahedral Projection (& ancient cartography)

> >Date: 11 Jul 1994 19:22:07 GMT

>

> >In article <2vqmu9\$3to@omnifest.uwm.edu> mark@omnifest.uwm.edu (Mark Hopkins)> >writes:

> >>

> >...history/motivation deleted...

> >>

> >>(2) The Icosahedral Projection

> >> This is a projection I discovered (rediscovered?) about 8 years ago. It

> >>consists of 20 triangular plates that can be arranged in a variety of ways.

> >>To date (to the best of my knowledge) it is the only reconfigurable

> >>projection.

> >>

> >...description deleted...

> >>

>

> >This projection you've discovered is extremely similar to R. Buckminster

> >Fuller's Dymaxion Airocean World Map in both motivation and conception,

> >though subtly (to me, at least!) different in execution. Bucky's projection

> >(which also individually projects each triangle of the spherical icosahedron)

> >has the advantage that all great circle arcs parallel to any of the edges

> >of a given icosahedron triangle are straight lines on the planar triangle,

> >and distances along these arcs are preserved on the planar triangle. It

> >has the disadvantage (big, big :(here!) that it does not seem to be

> >mathematically well-defined.

> >Kevin

>

> I believe the Fuller projection is mathematically well defined. The faces

> of an ico are subdivided into similar equilateral triangles, which are

> pushed outward along radii from the sphere center to the surface (orthogonal

> projection). The mathematics for doing this, same as for the domes, is

> mathematically expressed and computer-implemented. And yes, more

> work needs to be done to popularize this map and its methods.

I don't believe your description of the projection method is correct; I don't think, for instance, that what you're saying (assuming I get your drift) would preserve distances along the great-circle arcs. I think what Fuller did was a bit more subtle than that; again I refer you to his "steel-straps and straws" illustration which appears in many of his books.

If you have any references or code for doing the Fuller projection I would be very interested in seeing it. The information I have is from an unpublished paper by Robert W. Gray of IBM, "Fuller's Dymaxion Map." In it he recounts how Fuller developed what he called a "three-way great circle grid" to use as a reference system for manually transcribing points off of a globe onto a Dymaxion Map, and this is the system which appears in Fuller's 1946 patent of the Dymaxion Map. However, before his death Fuller realized that when this grid was projected to the plane the intersections of the arcs did not form points, but little triangles (*Cosmography*, pg. 236). Gray's version of the projection suggests taking the average of the location of the vertexes of these little triangles to use as the projected point location. One of the things we are exploring is how this averaging affects the properties of the projection at various scales.

I do believe that the projection could be implemented "precisely" *to an arbitrary degree of precision* by recursively sub-dividing the spherical triangle until a point of interest lies within the specified precision of one of the sub-triangle vertices and then using the corresponding vertex on the sub-divided planar triangle as the position of the planar location of the point. But I need to spend more time looking for an analytic method of accelerating this procedure before it would be sufficiently efficient for our use.

But, I am more than open to being proved wrong about the mathematical nature of Fuller's projection! If you have more information I would appreciate hearing about it.

[From Kiyoshi Kuromiya]

Icosahedral projections (non-orthogonal) of the world have been proposed since the early years of the twentieth century. Fuller's projection is orthogonal and optimizes size and shape distortions of the land areas. But most importantly, places the vertices in such a way that when the icosahedral projection is unfolded into a planar map, none of the sinuses cut into any land areas. Therefore, it is the only world projection that minimizes size and shape distortions by distributing in equal proportion any existing pin-cushion distortion to the center of each of the twenty triangular faces.

In 1980, Chris Kitrick and Rob Grip, two engineers in Bucky's office developed the first computer generated projection of the Dymaxion Map (the three-way grid was computer generated and then data transferred). The Grip-Kitrick map is available from the Buckminster Fuller Institute in Santa Barbara, CA.

The triangular "weaving pattern" of the three-way triangular great circle grid that you mention (on page 236 of *Cosmography*), reconciles two basic ideas of synergetics: 1) that two lines cannot go through one point at the same time, 2) tensegrity models the reality that nothing in Universe touches anything else.

6.1.1 What are some of the properties of the fullerenes?

[From Kirby Urner.]

Buckminsterfullerene (C60) is becoming ever easier to get in quantity and shows many interesting optical properties. It stops light – the brighter the light the more effectively it stops it. Nano and pico-second laser pulses are effectively and instantly opaqued by small quantities of C60. A helmet visor treated with fullerene will instantly block an incoming laser beam – the stronger the ray, the faster the face glass turns dark (cooler than those "photosensitive" sunglasses) (Patterson AFB in Ohio is studying such applications). Many other optical properties of the fullerenes are under study.

However, C60 remains forty times more expensive than gold. As Smalley put it “it’s the yield, stupid” – i.e. the central issue facing fullerene researchers, in Smalley’s opinion, is how to get more of it. The Smalley team approach of using parabolic mirrors to sun-generate fullerenes (to produce “sunnyballs”) appears to be a potentially promising approach. Concentrated sunlight has less of the damaging frequencies in high-powered lasers that apparently to inhibit fullerene formation from vaporized carbon).

Fullerene is quite reactive and can be used as a building block in other structures. In some crystal formations, doped with potassium for example, it conducts electricity with no resistance (is a superconductor).

[From Mitch Amiano]

[One potentially useful property is] C-60’s peculiarly large capacity internal space - for instance, researching its use as a carrier for other molecules or as a molecular filter material. Something recently in the news was a test-tube finding that C-60 fits into a protein binding site on the HIV virus, thus preventing replication.

The buckyball attaches to a molecular binding site of an enzyme necessary for it’s reproduction. Perhaps ‘fits in’ is a better term, since I am not certain the buckyball attaches in the same way a protein molecule would. I think it is more or less the geometry of the thing that does the trick.

[From Kurt Przybilla. In reply to a question about boron and fullerenes]

From: Encyclopedia of Applied Physics, Vol. 6 1993 VCH Publishers

p.520 “A second method is the substitutional doping of an impurity atom with a different valence state for a carbon atom on the surface of a fullerene ball. Since a carbon atom is so small, and since the average nearest-neighbor C-C distance a_{c-c} on the C60 surface is only 1.44 Å (angstrom) (Johnson et al., 1992), the only species that can be substituted for a carbon atom on the C60 ball surface is boron, making the charged ball p type. Smalley and co-workers have demonstrated that it is possible to replace more than one carbon atom by boron on a given ball (Smalley, 1991). Also for graphite, the only substitutional dopant is boron, and for the same reasons as for C60. However, for diamond, which has larger C-C nearest neighbor distance of $a_{c-c}+1.544$ Å, both boron and nitrogen can enter the lattice substitutionally (Feild, 1979). It has also been reported that it is possible to place a potassium atom endohedrally inside the C60 ball while at the same time substituting a boron for a carbon atom on the surface of the ball (Smalley, 1991).”

The first method of doping deals with “endohedral” doping of rare earth, or alkali-metal ions. The third deals with similar dopants introduced between adjacent balls (intercalation)

There are over 20 pages of very good information in this source. I recommend it to all.

[From H. Jeffrey Rosen]

Those of us interested in Fullerenes will be thrilled by the publication of a letter to NATURE, the weekly international science journal, in that periodical’s May 5 issue.

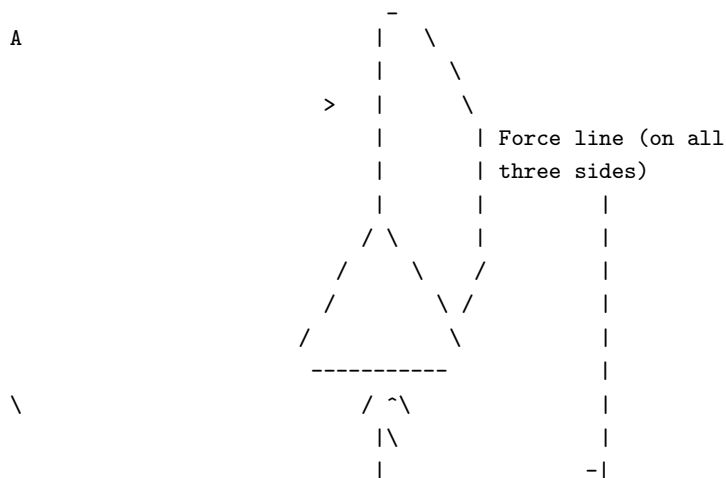
It seems that NASA’s Long Duration Exposure experiment, which orbited for nearly six years and was recovered for analysis four years ago, showed traces of carbonaceous matter in a cratered aluminum panel - matter which has been found to contain traces of Carbon 60 and other Fullerenes.

This news provides direct evidence that Fullerenes either exist spontaneously in Universe, or can be formed in space.

6.1.2 How can the non-triangulated buckyball be stable? <[Christopher Rywalt]

[From Steve Mather]

The Buckyball is triangulated by the electron's "want" to be as far away from each other as possible. The triangulation is along force lines between the three electron clouds (they are center bodied "planar" triangles) with the tensile parts as the force lines and the clouds as the compression members.



[From Christopher Rywalt]

According to Richard Smalley – this is one thing he told us at Science Kick – C60 has been found in the layer of earth that marks the boundary between the Cretaceous and the Triassic periods. This layer is very dark and is rich in carbon and is what leads current science to believe the last of the dinosaurs were wiped out in massive fires. This is not really a rare kind of rock formation; it's just not that easy to stumble on.

Also, Smalley told us that C60 – as well as other fullerenes – are formed from something as simple as a candle. The explanation was that what's glowing in a candle is actually soot – carbon – which, as it reaches the "edge" of the candle's "flame," cools so that it no longer glows. If you wave your hand at the air over a candle flame, you're waving away airborne carbon atoms, and among them, fullerenes.

[From Steve Mather]

C60 and C70 sublime considerably between 750 and 850C. They oxidize at 550 to 650C.

The larger fullerenes are more graphitic in that they have larger areas (20 of them) that are graphitic in properties (i.e. hexagon sheets.) They are harder (sometimes impossible) to dissolve in aromatic solvents and their CRYSTAL structure is more difficult to break apart. The individual molecules, however are less stable the larger they get.

As such, they sublime (whole molecules) at a higher temperature, but oxidize at lower temperatures than smaller fullerenes (such as C60 and C70).

By sublime, I don't mean that the molecules break apart into their component atoms, those atoms forming a gas, but rather the molecules break away from the crystal and form a gas.

In fact, one way to purify fullerenes, to get just the fullerenes one needs, is heating them up to 700 C, which breaks up the crystal, and collecting the cooled soot from particular spots where it cools. Different fullerenes travel different distances.

Further reading on fullerenes (although not the most recent) can be found in *Fullerenes*, ed. George S. Hammond and Valerie J. Kuck, pub. American Chemical Society, 1992 and *Buckminsterfullerenes*, ed. W. Edward Billups and Marco A. Cuifolini.

6.1.3 What are “buckytubes?”

Richard Smalley of Rice University believes these may hold promise in building an elevator to space as first proposed by Arthur C. Clarke in “Fountains of Paradise.” Bucky tubes may be tensionally stronger than diamond.

[From Kirby Urner.]

Buckytubes are super fine fillaments made of hexagonal “chickenwire” carbon mesh.

[From ‘‘Buckymania’’ in The Magazine of Fantasy and Science Fiction - typed in by Bruce Sterling.]

“Carbon-fiber is a high-tech construction material which has been seeing a lot of use lately in tennis rackets, bicycles, and high-performance aircraft. It’s already the strongest fiber known. This makes the discovery of “buckytubes” even more striking. A buckytube is carbon-fiber with a difference: it’s a buckyball extruded into a long continuous cylinder comprised of one single superstrong molecule.”

6.1.4 What are “endohedral fullerenes?”

[From Kirby Urner.]

Fullerenes with atoms or clusters of atoms inside, the so-called “endohedral fullerenes,” are presently extremely difficult to isolate in quantity and their properties are as yet poorly understood (no one yet knows, for example, if crystals of same will superconduct, as does K_3C_{60} – potassium atoms in all the interstices in a C_{60} crystal packing). The suggested notation for endohedrals, by the way, is $X@C_n$, e.g. $K@C_{60}$ (potassium atom inside C_{60}).

6.1.5 How can I make my own bucky balls?

The question of how to make your own “bucky balls” is completely answered in the Jan. ’94 issue of the American Journal of Physics p85-8. The title of the article is “Production and separation of C_{60} and C_{70} as and undergraduate experiment.” Though I haven’t attempted myself, the authors give a detailed account of the steps and apparatus necessary to produce your own “bucky balls.”

6.2 What is Biosphere II?

[Note this is not really Fuller related, but keeps coming up on the list. From Carl Dichter.]

“Biosphere I” is the earth. Basically, a whole ecology that is encapsulated by the atmosphere and needs nothing except solar power to continue living “forever.”

“Biosphere II” is an attempt by some scientists/entrepreneurs to model its behavior with (either 4 or 6, can’t remember) people, plants, and animals in a metal and glass enclosure.

The enclosure looks something like this from the side:





It's made out of a triangular latticework of aluminum, with glass panels, not in a dome configuration: more like four-sided pyramids. Supposedly, each of these panels costs \$20,000 to install, seal, and test.

Inside of the "sphere" are little climate/life zones. These each have mini geological features, like an "ocean," "mountain," "desert." These zone vary as much as possible considering they share the same air. They've planned the amount of each type of life form they can support.

6.3 What were Fuller's early years like?

[From Leo Elliot]

Bucky was raised in Maine, and according to his own story, squandered the money his family had staked him to for his Harvard education by going down to NYC to take out the entire chorus line of the Ziegfeld Follies (the original wild and crazy guy?). After getting kicked out, reinstated, and kicked out again, Bucky ended up at the Naval academy, where, so he says, he was amongst the last of the classes to be trained in such things as full command authority, meaning that he was given the type of education that trained him in all phases of naval operations, on the premise that should he be on a boat that was attacked, all the superior officers lost, etc., then he would have to take over the ship.

Among his accomplishments was the design of a type of crane for the retrieval of airplanes that overshot the runways of aircraft carriers.

Prior to his epiphany in Lake Michigan in 1927, he also worked in a family business designing some type of construction brick. He tried several other types of work, but basically felt as though he was a failure at all/most of them, and in addition lost an infant daughter to spinal meningitis which he blamed on himself, attributing the disease to the poor living conditions he afforded his young family in some gangster-infested

tenement in Chicago, all leading up to his being ready to throw himself into Lake Michigan in 1927.

6.4 Was Fuller formally educated?

Regarding his honorary doctorates the "Basic Biography" (available from the Buckminster Fuller Institute) lists 40 such degrees in a comprehensive list ranging from Doctor of Design, Laws, fine arts, Engineering, humane letters, literature, humanities, and science. He was granted Professional licenses as an architect in New York (1974) and Ohio (1979). - Blaine A. D'Amico

I remember reading in a biography (can't remember which) that Bucky made two false starts at college and didn't finish either time. - Bill Long

6.5 Bibliography: Culled from many postings

[Culled from postings by Blaine D'Amico, Gary Lawrence Murphy, Jim Lutz, and this editor's research]

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A pictorial and written retrospective of Fuller's work and thought.

Earth, inc. [by] R. Buckminster Fuller. Garden City, N.Y., Anchor Press, 1973. 180 p. illus. 21 cm.

Education Automation : Freeing the Scholar to return to his Studies, a discourse before the Southern Illinois University, Edwardsville Campus Planning Committee, April 22, 1961 / Foreword by Charles D. Tenney. Carbondale, Southern Illinois University Press, [c1962]. 88 p. 22 cm. (Southern Illinois University occasional publication.)
Fuller's diagnosis of and solution to the education crisis.

Energy, Earth, and everyone : a global energy strategy for spaceship Earth / by Medard Gabel, with the World Game Workshop ; with a foreword by R. Buckminster Fuller, and an afterword by Stewart Brand. -- San Francisco : Straight Arrow Books ; [New York] : distributed by Simon and Schuster, c1975. 160 p. : ill. ; 20 x 29 cm. Cover title. Bibliography: p. 153.

Expanded cinema. Youngblood, Gene / Introd. by R. Buckminster Fuller.

[1st ed.]. New York, Dutton, 1970. 432 p. illus. (part col.), ports. 21 cm. (Dutton paperback original, D263.)
Bibliography: p. 421-425.

Generation of Narcissus. With an introd. by R. Buckminster Fuller. [1st ed.] Boston, Little, Brown [1971] xii, 266 p. 22 cm.

Grunch of Giants. -- New York : St. Martin's Press, 1983. xxviii, 98 p. Includes index.
Fuller's analysis of the international banking system where he advises the world that the current economic systems have been robbed by multinational corporate giants. GRUNCH = Gross Universal Cash Heist. Fascinating reading.

Humans in Universe. Buckminster Fuller, Anwar Dil. -- 1st American ed. -- New York : Moutin, c1983. 235 p. : ill. ; 26 cm. Includes bibliographical references and index.
Conversations between Fuller and Indian Philosopher Anwar Dil.

Ideas and Integrities : a spontaneous autobiographical disclosure edited by Robert W. Marks. --1st Collier Books ed. -- New York : Collier Books, a division of Macmillan Pub. Co., 1969. 318 p., [32] p. of plates : ill., charts, ports. ; 20 cm. Includes index.

Intuition. foreword by Norman Cousins. -- 2nd ed. -- San Luis Obispo, Calif. : Impact Publishers, 1983. 223 p. ; 21 cm.
Blank verse describing humanity, mind, Universe and Synergy.

Inventions: The Patented Works of R. Buckminster Fuller. -- 1st ed. -- New York : St. Martin's Press, c1983. xxxii, 316 p. : ill., plans, ports. ; 32 cm.

Actual copies of Fuller's collected patents with historical and instructive notes by Fuller. Also contains Fuller's apologia mia vita in which Fuller describes his life strategy and discoveries.

Inventory of World Resources: Human Trends and Needs. [1963-1965]
Document 1: By R. Buckminster Fuller and John McHale [1963]
Document 2: The Design Initiative by R. Buckminster Fuller [1964]
Document 3: Comprehensive Thinking by R. Buckminster Fuller [1965]
Document 4: The Ten Year Program by John McHale [1965]

I Seem To Be A Verb, by Buckminster Fuller and Quentin Fiore.

Mindstyles, lifestyles : a comprehensive overview of today's

- life-changing philosophies / by Nathaniel Lande ; introd., Hans Selye ; conclusion, R. Buckminster Fuller ; col. ill., Corita Kent. -- Los Angeles : Price/Stern/Sloan, c1976. 495 p. : ill. ; 28 cm. Includes index. Bibliography: p. 492-494.
- Naga: cultural origins in Siam and the West Pacific / Sumet Jumsai ; with contributions by R. Buckminster Fuller. -- Singapore ; New York : Oxford University Press, 1988. xvi, 183 p., [16] p. of plates : ill. (some col.) ; 26 cm. Includes index. Bibliography: p. 179-181.
- Nine Chains to the Moon Philadelphia, J. B. Lippincott Company [c1938] xvi, 405 p. illus., 2 fold. diagr. 24 cm. Maps on lining-papers. Reissued Carbondale, Ill., Southern Illinois University Press, [1963]. 375 p. illus. 22 cm.
- No more secondhand God; and other writings. Carbondale, Southern Illinois University Press, [1963]. 163 p. illus. 22 cm. (Southern Illinois University occasional publication.)
- Operating Manual for Spaceship Earth. [New York] Simon and Schuster [1970, c1969] 143 p. 21 cm. (A Touchstone/Clarion book 20783) First paperback printing, 1970. Includes index. Fuller's seminal work regarding the relationship of humanity to the environment and planetary planning. World history takes on a new meaning and significance. A primer on Synergetics.
- A Question of Priorities, New Strategies for Our Urbanized World / [by] Edward Higbee. With an introd. by R. Buckminster Fuller. New York, Morrow, 1970. xxxiv, 214 p. 22 cm. Bibliography: p. [199]-203.
- R. Buckminster Fuller on Education. edited by Peter H. Wagschal and Robert D. Kahn. -- Amherst : University of Massachusetts Press, 1979. 192 p. : ill. ; 21 cm. [See Education Automation]
- A sculptor's world. [Noguchi, Isamu] / Foreword by R. Buckminster Fuller. [1st U.S. ed.]. New York, Harper and Row, [1968]. 259 p. 268 illus. (part col.). 27 cm.
- Synergetics: Explorations in the Geometry of Thinking. [by] R. Buckminster Fuller in collaboration with E. J. Applewhite. Pref. and contribution by Arthur L. Loeb. New York, Macmillan [1975] xxxii, 876 p. illus. 24 cm. Bibliography: p. 875-876.
- Synergetics II: Further Explorations in the Geometry of Thinking
These two books comprise the collected geometric modeling

system developed and used by Fuller in the development of his explanation of the 'coordinate system of nature.' Fuller claimed that Synergetics could be understood by a 5 year old.

Synergetics Dictionary : the Mind of Buckminster Fuller : with an introduction and appendices / compiled and edited by E.J. Applewhite. -- New York : Garland, 1986. 4 v. ; 32 cm. Includes bibliographies.

Synergetic Stew: Explorations in Dymaxion Dining. Philadelphia, Buckminster Fuller Institute, 1982. 118 p. Includes index.

Tetrascroll: A Cosmic Fairy Tale: Goldilocks and the Three Bears. New York, St. Martin's Press [1975,1982] xxvii, 129 p. illus. Introduction by Amei Wallach. Wonderful tale of Goldilocks and the three bears in which Goldi learns General Systems Theory and Synergetic geometry through real world examples.

This or else ... : a master plan for India's survival / by Dinshaw J. Dastur. -- Bombay : Jaico Pub. House, 1974. x [i.e. xvi], 184 p. ; 22 cm. Includes a foreword by R. Buckminster Fuller.

Uncommon sense : the life and thought of Ludwig von Bertalanffy (1901-1972), father of general systems theory / [by] Mark Davidson ; foreword by R. Buckminster Fuller ; introduction by Kenneth E. Boulding. -- 1st ed. -- Los Angeles : J.P. Tarcher ; Boston : Distributed by Houghton Mifflin Co., c1983. 247 p. ; 25 cm. Bibliography: p. 229-236. Includes index.

Untitled epic poem on the history of industrialization. Highlands [N.C], J. Williams, 1962. 227 p. 20 cm. (Jargon, 44.)

Utopia or Oblivion: the Prospects for Humanity. With an introduction by Stephen Mullin. [London] Allen Lane The Penguin Press [c1970] 416 p. illus. 23 cm. Includes bibliography.

BOOKS ABOUT R. BUCKMINSTER FULLER OR RELATING TO HIS WORK

Aaseng, Nathan. More with Less : the Future World of Buckminster Fuller (Minneapolis : Lerner Publications, c1986.) Ninth grade reading level. Excellent introduction into Synergetics and Fuller's significance in general

Applewhite, E. J. Cosmic fishing : an account of writing Synergetics with Buckminster Fuller. (New York : Macmillan, c1977.) xvi, 157 p. ; 25 cm.

- Applewhite, E. J. Paradise Mislaid : birth, death and the human predicament of being biological / E.J. Applewhite. -- 1st ed. -- New York : St. Martin's Press, 1991. xii, 480 p. ; 25 cm. Includes bibliographical references (p. 439-458) and index. 'A Thomas Dunne book.'
- Edmondson, Amy C. A Fuller explanation : the synergetic geometry of R. Buckminster Fuller / Amy C. Edmondson. -- Boston : Birkhauser, c1987. xx, 302 p. : ill. ; 25 cm. -- (Design science collection.) 'A Pro scientia viva title.' Includes index. Bibliography: p. [287]. Fuller Superb, plain english explanation of Synergetics from a mathematician who worked with Fuller for the last three years of his life. Part of the Design Science collection.
- Gabel, Medard. Energy, Earth, and everyone : a global energy strategy for spaceship Earth [See Energy, Earth, and Everyone]
- Gabel, Medard. Ho-Ping: Food for Everyone , strategies to eliminate hunger on spaceship Earth / by Medard Gabel, with the World Game laboratory. Anchor Books, c1979. 272 p. : ill. ; 20 x 29 cm. Includes bibliographic references.
- Grimaldi, Roberto. R. Buckminster Fuller : 1895-1983. Roma : Officina, 1990. 121 p. (Dizionario monografico degli architetti moderni e contemporanei ; 2)
- Hatch, Alden, (1898-), Buckminster Fuller: at home in the universe. New York, Crown [1974] vii, 279 p. illus. 24 cm.
- Kenner, Hugh. Bucky; a guided tour of Buckminster Fuller. New York, Morrow, 1973. 338 p. illus. 21 cm. Bibliography: p. 327-331.
- Hugh Kenner's 'Geodesic Math and How to Use It' Berkeley : University of California Press, c1976. xi, 172 p. : ill. ; 22 cm. (ISBN 0-520-02924-0) This is an excellent book for the hobbyist model builder, but also shows geometric derivations for a number of approaches to carving up the surface of a sphere into the smallest practical number of different shaped parts, which is the key matter in dome fabrication. The book also discusses tensegrity designs, although I believe Hugh has since release a volume devoted to tensegrity. For those without calculators :-), the appendix of the book lists the dome-vertex values for many practical frequencies in the basic polyhedral forms.
- McHale, John. R. Buckminster Fuller. New York, Braziller, 1962. 127

p. illus. (Makers of contemporary architecture) Includes bibliography.

Reese, K.M.

Certain activities of R. Buckminster Fuller. (Newsclips)
Chemical and Engineering News v71, n4 (Jan 25, 1993):60.

Abstract: R. Buckminster Fuller, for whom the fullerene was named, invented the geodesic dome in 1933. He also designed the Dymaxion car with a body made of duralumin. The car had three wheels, a teardrop shape and a maximum speed of 120 miles per hour with 40 miles to the gallon. It can be parked in a space only a foot longer than itself. The Dymaxion car can also be rotated 360 degrees within its own length.

Robertson, Donald W. Mind's eye of Richard Buckminster Fuller / by Donald W. Robertson. -- New York : St. Martin's Press, [1983?], c1974. 109 p. : ill. ; 22 cm. Reprint. Originally published: 1st ed. New York : Vantage Press, c1974. Includes bibliographical references.

Sieden, Lloyd Steven. Buckminster Fuller's universe : an appreciation / Lloyd Steven Sieden; foreword by Norman Cousins. -- New York : Plenum Press, c1989. xvii, 511 p. : ill. ; 22 cm. Includes index. Bibliography: p. 449-498.

Snyder, Robert. R. Buckminster Fuller: an autobiographical monologue/scenario / documented and edited by Robert Snyder. -- New York : St. Martin's Press, c1980. 218 p. : ill. ; 28 cm.

Fuller's earth : a day with Bucky and the kids / [edited] by Richard J. Brenneeman. -- 1st ed. -- New York : St. Martin's Press, c1984. x, 180 p. : ill. ; 22 cm. Includes index. Bibliography: p. 163-166.

Bucky for Beginners

Workbook style lesson plans for Synergetic activities. A must for teachers.

Shaping space : a polyhedral approach / Marjorie Senechal and George Fleck, editors. -- Boston : Birkhauser, 1988. xx, 284 p. : ill. ; 28 cm. -- (Design science collection.) "A Pro scientia viva title." Includes material from the Shaping Space Conference held at Smith College, Apr. 6-8, 1984. Includes index. Bibliography: p. 266-271. Also from the Design Science collection. The proceedings of a conference on polyhedral theory. A wealth of information

including a useful article entitled ‘‘Polyhedral in the curriculum.’’

[From Alex Soojung-Kim Pang.]

Wendell Barry in ‘‘Speaking for Words’’ has an excellent critique of Fuller’s writing style.

There are also a number of magazine articles, published mainly in the 1950s to 1970s, that profile Fuller and give ‘‘day in the life’’ views of him. These have been indexed in a bio-bibliography published by Vance (which does a lot of these for public figures) available at your university library.

6.6 Organizations and Corporations mentioned on GEODESIC (incomplete and dated)

BFI: The Buckminster Fuller Institute (latest address)

Buckminster Fuller Institute
111 N. Main Street
Sebastopol, CA 95472
Phone: 707-824-2242

1994: [From Kurt Przybilla.]

The best polyhedral modeling kit I’ve seen is available from *Edmund Scientific* <http://www.scientificsonline.com/>. It is called a ‘‘Star Structure Construction Set.’’ Although it is a little pricey at \$25, the vector joints are the best I’ve found. They resemble stars with 12 points. The struts are hollow tubes that fit on the stars. Though the book it comes with is a little lame, it explains how to make some of the more basic shapes. The main disadvantage is that the struts are all the same length which makes domes difficult. Edmund Scientific has a wonderful catalog that everyone should have their own copy of. The number listed in it to request a catalog is (609) 573-6858. To order directly (609) 573-6250. The set is catalog number G52,060. Probably the most widely available kit on the market are made by a company out of Oregon called Ikosa Kits. Though they are inexpensive and come in various sizes, they are really nothing more than shishkebab sticks with sections of plastic tubing which you must pierce yourself to make joints. They are available in new age toys stores like Star Magic.

[From Anton Bakker]

The *Zome-Tool* <http://www.zometool.com/> by Biocrystals in Bolder Colorado is a good tool. The large kit cost ~ \$600 A contact person is Marc Pellitier.

[From Carey W. Mason, Oct ’92]

I have recently completed owner-builder construction of 2 geodesic domes. After some research, I selected the dome-shell kits from Robert Kirkpatrick in Ft. McCoy, Fla. These kits are ‘‘Pease’’-type domes as opposed to ‘‘Hub-and- Strut’’ construction.

Kirkpatrick’s kits (I have a 39’ and a 45’) are each constructed of two sizes of triangles, pre-assembled, reinforced, braced, with plywood attached for the outer surface, and the outer surface coated with elastomeric polymer. We assembled the triangles into pentagons (small tri’s) and half hexagons (larger tri’s) and then lifted by crane to assemble the shells. The first taking two days, the second in one day (thanks to setting the angle of the section with a magnetic protractor before craning it into position). This \$10 Kirkpatrick trick saved several hundred dollars in crane time, etc.

Here's Bob Kirkpatrick's info:

Rt 2, Box 2862
Ft McCoy, Fl 32134
(904) 6853235

[From Kurt Przybilla]

The best polyhedral modeling kit I've seen is available from Edmund Scientific. It is called a "Star Structure Construction Set." Although it is a little pricey at \$25, the vector joints are the best I've found. They resemble stars with 12 points. The struts are hollow tubes that fit on the stars. Though the book it comes with is a little lame, it explains how to make some of the more basic shapes. The main disadvantage is that the struts are all the same length which makes domes difficult. Edmund Scientific has a wonderful catalog that everyone should have their own copy of. The number listed to request a catalog is (609) 573-6858. To order directly (609) 573-6250. Probably the most widely available kit on the market is made by a company out of Oregon called Ikosa Kits. Though they are inexpensive and come in various sizes, they are really nothing more than shishkab sticks with sections of plastic tubing which you must pierce yourself to make joints. They are available in new age toys stores like Star Magic.

[From David Roach]

ORB Factory Ltd., 5 Umlah's Road, Halifax, Nova Scotia, B3P 2G6 Phone: (902) 477-9570. This is a small company and the owner's name is Steven Kay. The company makes what Steve calls "Transformational geometry toys," which are primarily wire, tube and coil based products, based on geometric principles.

[From Pat Salisbury]

My Synergy Ball is being produced by Design Science Toys, of Tivoli, NY. They're the people who make the Tensegritoys, Octabug, Hoberman Sphere, and a slew of other geodesic and geometry based toys. They've got a nifty catalog which you can get by phoning 1-800-227-2316.

In case you weren't here 4-5 years ago when I first designed the Synergy Ball and discussed it here, it's a paper model of a 30-strut tensegrity, and makes a sphere ~9" across which exhibits quite amazing strength when fully assembled. It comes in either red or blue and is priced to retail at under \$5. I think you can get 'em from the factory for less.

Oh, and if you build one, be sure to hang it up with a bit of thread. It looks MUCH better when it can turn in the air currents and casts really nifty shadows on the walls. Especially when you have multiple candles burning! ;^)

6.7 Computer tools (may or may not be useful to dome design or synergetics' modeling).

There are several quality tools for doing mathematics and geometry. *Yacas* <http://yacas.sourceforge.net/>

is a general purpose computer algebra system. Graphs can be made with *gnuplot* <http://www.gnuplot.info/>. *Pari-GP* <http://www.math.u-psud.fr/~belabas/pari.html> is a very good high-precision calculator tool for Unix, DOS, MS-Windows, Macs, Atari, Amiga, and even VAXen. *POV-Ray* <http://www.povray.org/> is good for generating photo-realistic (or simply perspective) images. Rick Bono wrote a program *dome* <http://www.applied-synergetics.com/ashp/html/domes.html> for generating geodesic domes and spheres. *SpringDance* <http://shapeofspace.org/springdance/>

is popular for exploring geometry and tensegrity structures. Many people like *Mathematica* <http://www.wri.com/>

and its competitor *Maple* <http://www.maplesoft.com/>.

Geomview <http://www.geomview.org> is a program for looking at and interactively manipulating 3D objects. One of the reasons I use *Debian GNU/Linux* <http://www.debian.org>

for my computing environment is because of all the quality tools for *mathematical* <http://www.debian.org/Packages/stable/math>

work that work out of the “box” (including calc, gnuplot, POV-Ray, felt, dome, scilab, yacas, etc).

[From Ben Discoe]

Anyone interested in the geometry mentioned in *„Synergetics_* (and has access to a computer running 3D Studio R3) could check out a free program (on the net as HEDRA.ZIP) which purports to create a very wide variety of polyhedral forms. I don’t think 3D Studio will let you easily raise the forms to higher frequencies, though.

[From Kirby Urner]

I’ve seen some interesting Synergetics on the Mac: Yasushi Kajikawa did a new module system for assembling icosahedra and other shapes in that 5-fold symmetric family – 5-fold stuff is IN these days. He used HyperCard with XMD calls to MacroMind Director I think it was – the individual movie frames were developed in Mathematica. Lots of polyhedra exploding into parts – looked like car repair manuals for abstract geometric shapes. Music too. The text was all in Japanese. Robert Orenstein tried to get an English edition together – he also got a jitterbug transformation to run entirely from within Mathematica. Looked cool!

[From Robert L. Read]

‘FELt’ is a structural analysis program that is freely available under the GNU Public License (GPL). It is written and maintained by Jason Gobat (jgobat@ucsd.edu) and Darren Atkinson (atkinson@ucsd.edu).

It allows you to input a geometry of a structure, assign material types to various components, add on continuous forces like roof loads and specific forces like a 10,000 pound weight at a certain point, and then compute the forces in each member.

[Editor: The FELt website is located at <http://felt.sourceforge.net/> . Debian GNU/Linux users can check out <http://www.debian.org/Packages/stable/science/felt.html> .]

6.8 Fuller’s “failures.”

[From Alex Soojung-Kim Pang – See 5.7 (Old Man’s River City Project (circular cities)?) for background.]

It is also interesting to note that this [Old Man River City] was the most modest of a series of urban renewal projects that Fuller was involved in at the time: his proposals for floating cities, renovation of Harlem (which involved tearing down all the buildings and erecting a series of apartment blocks that looked like nuclear plant cooling towers), and floating spherical cities all date from this period. Ironically, they represent a kind of technocratic vision that many of Fuller’s followers in the counterculture rejected, though the tension between the “Whole Earth Catalog” and “Domebook” interpretation of Bucky and the Bucky that was proposing to build cooling towers on Harlem never became strong.

[From Leo Elliott]

Ross Keatinge raises some interesting speculations about Bucky's self-promotions and possible over-estimations of his projects' current or future feasibilities. The oldest one I can specifically recall, that seemed the most ordinary, was his "dymaxion bath" (part of the dymaxion house?), illustrated in Marks' "The Dymaxion World of Buckminster Fuller" – supposedly this two-piece, user-assemblable bath-utility would provide all the normal bath amenities (shower, tub, toilet, sink) with the additional economy of being able to take a very cleansing shower on only about a pint of water, an idea which Bucky says he got from watching how clean the engine-room sailors would get once they came up on deck and stood in the spray of a strong sea mist for a while – ? Not sure of any data/research ever done by the soap or the plumbing-fixture companies on this particular claim, but according to Bucky, the dymaxion bath (which would also be service-able in a recto-house, one presumes?) got nixed once the plumbers unions found out how little labor-time it would take to install, possibly even circumventing any requirements for their professional services at all.

So how much of Bucky's self-promotion was hot air, and how much has been demonstrated? As I recall, some of the materials prescribed for both the dymaxion house and bath were of the order of plastics, which hadn't come into existence yet. Bucky used to say he decided, after studying the various timelags that he saw existing in various industries between the inception of an idea and its practical application (the most egregious of which, 50 years, he saw existing in the housing/construction industries), that he wanted to live his lifeplan 50 years out from the rest of humanity, thereby avoiding the carping of the critics: "I do not care that I am not understood, but I do not like to be misunderstood." (rough paraphrase.)

It would seem, from the posthumous discovery of the Fullerenes, that at least some of Bucky's visions were spot on.

6.9 Where would you encourage your best friend to start in the Fuller literature? (For maximum ease of mastery) [Jeff Perth]

[See 6.5 (Bibliography) for full citations. *Cosmography* is a great introduction. *Critical Path* is also very good.

Synergetics <http://www.rwgrayprojects.com/synergetics/synergetics.html>

(both volumes) can be started immediately, but be prepared to build lots of models to clarify the text (and/or set it aside for awhile when the going gets tough :) Several fun but less complete works are *Operating Manual for Spaceship Earth*, *Tetrascroll: Goldilocks and the Three Bears: A Cosmic Fairy Tale*, *No More Secondhand God: And Other Writings*, and *Grunch of Giants*.]

[From Leo Elliott]

I would highly recommend, for those who may wish to see the genesis of some of Bucky's ideas, a review of his 1938 "Nine Chains to the Moon."

6.10 Quotes and Coinages.

"Dare to be Naive" -RBF in "Moral of the Work" in *Synergetics* <http://www.rwgrayprojects.com/synergetics/intro/moral.html>. "Ownership is onerous" -RBF [From Kirby Urner]

Greetings 'buckyophiles!' <-- term coined by Gene Fowler,
the armed-robber poet-founder
of the Regeniusing Project.

[From Chris Fearnley]

I have my favorite Fuller quotes on the web at <http://www.CJFearnley.com/cgi-bin/cjf-fortunes.pl?srchstr=Fuller&name=Submit>.

6.11 Bucky: humanitarian or cold-hearted technocrat — The value of a man?

[Admittedly to call the below thread distilled wisdom is pushing it. Maybe I will think up some way to edit it down into some pithy conclusion, but not today, sorry. Perhaps you like this lengthy discussion? E-mail me with commentary.]

[From Gerry Segal]

Some of R.B.Fuller's actions especially regarding the invention of tensegrity structures and his involvement with Werner Erhardt, EST and World Hunger project do not say much about the man.

It's his ideas, and through his ideas his hope for people that become important. I.B. Singer, the Nobel Laureate writer once asked if he would like to meet and talk with Leo Tolstoy said That while he read every word of Tolstoy he wouldn't cross the street to talk with him. His human failings might destroy the ideas he placed in his mind.

[From Alex Soojung-Kim Pang]

Gerry Segal points to what I think is an important question in evaluating Fuller's life and the value of his work. Having concentrated much of my attention on Fuller's inventive activity, I tend to evaluate him in terms of his work with and for the Marines, Strategic Air Command, Department of Commerce, etc.; and a study of this side of his life reveals a Fuller who was a vigorous Cold War technocrat, relatively unconcerned with the things for which he is now remembered— his philosophical work, his geometry, etc..

I think there is value in trying to evaluate him on the basis of his ideas, since in the last 20+ years of his life he was essentially a public philosopher, not so much an inventor. But this raises another thorny problem, that of trying to measure the impact of those ideas, particularly from about the mid-1960s on. The fact that Fuller could both have the *Whole Earth Catalog* dedicated to him, AND at the same time be condemned by Theodore Roszak (author of *Making of the Counterculture*) as the Ultimate Technocrat (and therefore an intellectual conspirator in a system that has produced the evils of materialism, ecological despoilation, exploitative labor systems, etc.) points to a fundamental problem of reading and interpretation: what do Fuller's ideas "really" mean? What should we make of, and how should we evaluate, interpretations of his ideas?

For example, in collecting accounts of Fuller's speeches in the late 1960s and 1970s (published in underground newspapers, mainstream magazines, and professional and trade journals), I've found that there developed a set of tropes describing Fuller's impact on his audience. It went something like this: "Fuller gave a four-hour marathon lecture that left his audience exhausted but exhilarated, dazzled by his vision and enthusiasm. Few members of the audience could follow exactly what he said, but it was the tone and Fuller's presentation that really mattered." Statements like these, it seems to me, make problematic claims about the value of his ideas, even as they stand as a testimony to his powers of self-presentation and ability to inspire audiences. Many people obviously came away from these talks feeling that they had seen something profound; but few, I am coming to believe, actually came away with any kind of grounding in Fuller's intellectual system. There was a huge difference between the read Fuller and the performed Fuller; that difference is the key to understanding how he could be honored by Stewart Brand and vilified by Theodore Roszak; and it raises deep questions about the value of his ideas and the importance of his life and work in the long run. These

are questions I'm puzzling through, and which I intend to address in my book on Fuller and the dome; I'm not yet sure if he ultimately deserves a larger place in history, a smaller one, or the place he has now.

[From Kirby Urner]

The charge that Fuller is a “cold warrior” stems from his work with/for the US government. Geodesic domes had a strategic value from the beginning. On the other hand, more than most academics, and certainly most architects and engineers, Fuller has done much to vilify capitalism, or LAWCAP as he called it (“lawyer capitalism”). The dust jacket of his book *Grunch of Giants* proclaims it as “more subversive of the property and profit values of the capitalist system than anything dreamed of since Karl Marx.” Yes, Ronald Reagan awarded him the Medal of Freedom. Yes, around the same time Fuller declared the “USA we have known is now bankrupt and extinct.” A curious mixture of pro-entrepreneurialism and individual initiative, and anti-corporatism. Too curious for some. I think Fuller’s critics are often in the business of gathering second hand sources and citing other critics (e.g. Roszak) vs. tackling the subject material directly. Second hand criticisms are often cursory and do not reflect serious scholarship. On the other hand, indictments of this or that aspect of Fuller’s work by people who really know their stuff are worth airing and I look forward to any such debates online. I have some criticisms of my own to share, if and when these seem relevant.

Gordon C. Muth III writes:

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> fuller was naive to believe that because he had come  
> up with a better way to live that the world at large  
> would one day accept it.
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Well, if he thought his vision was *exactly* what would bear out, yes. But I think his longing for a world without so much deprivation at the basic survival level was just the broad brush strokes. His little blurbs on the back of other futurists’ books (e.g. Gerard O’Neill’s – a maglev guy) show that he was open-minded enough to endorse other visions. Of course he thought his inventions would have a role to play. But many inventors have thought this, and were not naive to think it – was Edison naive to think the light bulb would catch on?

BTW, I think there *is* a basic shortage of adequate housing even now. I like Fuller’s idea of converting a lot of downtown office space to dorm/workspace units, while wiring the suburbs for “learning a living” in a tele-democracy. That would cut back on the mad ebb and flow of millions of tons of steel (i.e. cars) to and from “the office” (hi honey, I’m home). -Kirby Urner

6.12 What was the nature of Fuller’s involvement with Werner Erhardt, EST and the World Hunger Project? [Lance Fletcher]

[From Kirby Urner]

Around 1980, Werner Erhard rediscovered Fuller and found Fuller’s lifelong commitments (to serve “omnihumanity”) were illustrative of his own “making the world work for everyone” motto. Fuller appeared jointly with Erhard in Madison Square Gardens, where Erhard delivered emotional praise and Fuller spoke for several hours about the need to promote tetrahedra over cubes as a way of saving humanity (I was not present – as an est graduate, I was getting the newsletter and read about it, and this sparked my renewed interest in Fuller and sent me off to read *Critical Path*)... Fuller’s grandson, Jaime, did the est Training and for some time there was overlap in interest and volunteers. Asked what Fuller thought of Erhard on the Larry King show, Fuller said he thought he was “a good boy” or something to that effect (contrary to Erhard’s own assertions that he was “bad” – in the Michael Jackson sense perhaps).

EST was supposed to be in lower case, meaning “to be” in latin. But for legal reasons (you can’t name a corporation using italicized, lower case latin), it was also an acronym for Erhard Seminars Training. The Training took place over 2 weekends. 250 or so trainees would commit to sticking it through to the end after being briefed on what was to take place and after being given opportunities to leave. They were also not to chew gum, snack or leave for the bathroom except at scheduled breaks (“bathroom at will” people sat in the back row, for anyone with medical conditions requiring exceptions to the norm). The first weekend especially was a hard-hitting oral delivery that many labeled a “tearing down” and which earned est trainers the title of “verbal marines.” Trainings were not advertised but graduates were strongly encouraged to “share their experience” of the training. At its peak, EST was active in many cities both statewide and overseas. Many books came out on the subject, and a biography. Erhard later got into racing cars (Formula One) to discover “what works” in organizations. Although many were strongly critical of Erhard’s work, I think knee-jerk responses, either pro or con, are inappropriate vis-a-vis a complex and of course not unflawed enterprise. Walter Kaufmann, a well-known Princeton philosophy prof, was one of my teachers at the time, and he spoke highly of the est Training, which he had done the previous summer. He made it sound quite interesting so I enrolled.

The World Hunger Project was developed to promote the idea that World Hunger was a problem that could be solved, that only the political will to solve the problem was absent (i.e. food shortages were not the root problem). Erhard helped found the organization and Fuller was on the Board (of Advisors or Directors I’m not sure). The WHP was controversial because it was primarily a marketing and public relations enterprise aimed at changing attitudes i.e. awakening peoples desire to truly end death by starvation as a significant problem on the planet (“an idea whose time has come”). Because the money went to propogandize this cause, vs to actual relief workers or food shipments, it was branded by many as a sham and as further proof that Erhard was a con artist. Many have never forgiven Fuller for getting mixed up with Erhard’s work, but as a “do your own thinking” type, Fuller was never one to let others’ opinions be the determining factor.

[From Leo Elliott]

This business of self-promotion would certainly make him a fit with Werner Erhard, from what I have been able to make of the man and his movement. (btw, I am a more recent graduate of the kinder, gentler est, now the Forum, run by Landmark Ed. out of Alexandria, VA; last I heard Werner was off in Russia, drumming up new business, and letting his reputation get settled here in the states). I have an old Crawdaddy magazine account of the great encounter between the two magnates of consciousness, and the somewhat skeptical writer definitely presents Erhard as one who is trying to cop a hit off Fuller’s prestige; hard to imagine, but if the account is correct, Erhard backs down from Fuller when Fuller disagrees with the est-imation that brain=mind.

I find it also interesting that, even now, the Forum-est, like Scientology, is billed as a “technology” (vs. what?, a psychotherapy?, a pyramid-marketing scheme?).

6.13 What were relations like between Fuller and his Students?

[From Alex Soojung-Kim Pang]

Kirby writes:

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>Die-hard Fuller apologists may suspect the master was playing hard ball
>with his former student -- learn to self-promote, kid, like I did, cuz
>no one else will do it for you.
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This seems like a bit of a stretch, even for the best apologists– “I’m stealing from you for your own good, it will make you stronger.” I would like to propose an alternative, that Fuller’s relationship with Snelson [Ed: See section 5.1.2 (Who was Kenneth Snelson and what was his role in the invention of tensegrities) for some context] can be seen as an example of the problematic relations Fuller had with students in this period, problematic because of claims Fuller made as sponsor and inspiration of their work, and disputes over the ownership of ideas and artifacts.

It comes as no surprise to readers of this list that Fuller was always concerned to maintain control over his intellectual property rights. Aside from the financial strain losing control of inventions brings to inventors, there are deeper worries about losing other links between you and your creation– how it is used, who it is associated with, etc.. Fuller required students to sign statements in which they swore to “protect my proprietary rights,” as he told an architecture professor. “In return for their pledges,” he continued,

“I agree to provide them with unrestrained, unguarded disclosures of my evolving thoughts concerning unique experiences and emerging inventions.”

So far not a bad bargain. But Fuller made very large claims about the relative contributions he made to a student’s work, and who ultimately owned the fruits of a student’s labor. At Washington University in 1955, for example, after students complained that they had not been given sufficient credit for their work in developing a prototype dome, Fuller fired back to the Architecture School Dean:

“It must be remembered that the Dome was manufactured... ONLY because I had an experience-fertilized teleological design backlog.... It is true that every student was responsible for some phase of ORIGINAL design conceptioning, but none of them must make the mistake of thinking... that they have been responsible for teleologic processes as yet beyond the limits of their experience and capacity.... The thesis students only designed the sub-complex forwarding requirements of my preconceived comprehensive solution.”

Now, once this is decoded, it contains a truly remarkable claim. What I think Fuller is saying– and this is the interpretation drawn by several Architecture School professors– is that because he developed the mathematics by which domes were designed, and he IMAGINED the work that students would do under him, that *students had no claim whatsoever to authorship or anything they did under Fuller’s direction*. The message was not “learn to self-promote, kid,” but rather “because I imagined all this before I came here– and because you’re not old enough to have done any of this on your own– I own this work, and you don’t. The fact that YOU actually did the work is of not the slightest consequence.”

This is hardly the only example of arguments Fuller had with students and colleagues over the division of spoils and attribution of authorship in collaborative projects; throughout, Fuller maintained that HIS participation was necessary for work to be done, and that this was sufficient to establish exclusive ownership of prototypes and ideas. He ultimately broke with the NC State School of Design, which had been a generous provider of support and apparently gracious host to him, over precisely such issues.

In E.M. Forster’s *Maurice*, (Lord Risley) declares, “Words ARE deeds.” For Fuller, if my take on him is right, imagining was doing, and moreover, it was ownership.

[From Kirby Urner]

My feeling is that Fuller wanted to be the Father of Great Gifts to Humanity (and I personally acknowledge him for being precisely that) but in no way an anonymous benefactor. In Fuller’s vision, intellectual property conventions might well dissipate over the long haul (a lot of what he meant by “creating artificial scarcity” in the chapter “Legally Piggily” of *Critical Path* I read as an implicit indictment of modern-day intellectual property conventions), but he wanted his “ownership” of his contribution to be writ large in the pages of history.

Most of us came to know Fuller when he was already famous (“best known American genius” or however the cliché goes), but for years he struggled in relative obscurity, developing that Ralph Nader mentality that says “how can I sleep when the Corporations are working 24 hours a day, seven days a week, all around the globe?” Given the way Disney, Inc. effaces Fuller’s contribution to Epcot, the way that Philadelphia museum [above postings] uses his map without attribution, the way Synergetics is ignored, the way individuals in general are removed from the picture to make them feel appropriately helpless in the face of Corporate all-powerfulness, I can understand where Fuller’s conditioned reflexes come from. He is downright *furious* in some dimension. Students, guiltless and innocent, felt the onslaught of this guy’s life’s mission to buck the tide of history, which is about (felt Fuller) making ownership of critical assets the sole privilege of literally soulless legal fictions called Corporations.

That Fuller’s jealous guarding and hoarding of credit-to-himself for what he felt was proof of the glory of God makes him even more the caricature – at bottom was not a selfish drivenness to make money, but an ethical principle. To my way of thinking, none of this makes him more pathetic or ugly, but only shows how starved we as individuals are for acknowledgment, how imprisoned we feel as cogs in the machine. Without getting too maudlin, I think Werner Erhard felt precisely this in Fuller, his deep hunger for acknowledgment, and I am grateful to Erhard for offering wholehearted gratitude to Fuller at Madison Square Gardens.

[From Gerry Segal]

Bob Stubenrauch of Canton Ohio wrote a letter in today’s (18 Oct 1993) “New York Times:”

“The awesome earthquake in India with its tremendous loss of life brought back memories of two weeks with Buckminster Fuller, the engineer and inventor, 40 years ago.

“I was working for a custom photo lab in New York. Mr. Fuller brought in a notebook, every page filled with his crabbled notes and wonderful sketches of his ideas. For two weeks I printed photo reproductions of that notebook, while Mr. Fuller chatted at my side in the darkroom.

“One of his dazzling concepts was for housing the poor people of India. He had planned a huge factory and airport complex for that purpose. In the factory were assembly lines producing lightweight geodesic domes, the walls covered in a heavy transparent plastic.

“Each dome had a ring mount at the peak, and as it came off the line a waiting helicopter would hook up and fly off with the dome swinging below. The sketches showed a sky full of these choppers in formation, flying off to a prepared site to set down an instant town.

“Fuller’s estimated cost per unit (this was very low-wage India of the early 50s) was \$40.

“It is a sad irony that ancient traditions, like the dangerous use of unsupported clay or stone blocks, continue, when visionary concepts like Fuller’s could have saved thousands of lives if implemented for housing. It was accepted, and hundreds of domes built, for our early-warning radar outpost in Alaska, the DEW line of cold-war days.

“New technology is always first embraced by the military, a sad commentary on the priorities of governments.”

Mr. Stubenrauch was right. The structural tension-compression equilibrium of the domes would have saved massive amounts of life. We communicate in this electronic environment on an electronic highway that also grew from the loins of the Defense Department ARPANET. Maybe we can use this and other lists to help create the development of innovative ideas without using the “rearview mirror” approach of the military. We have to do it to get through what Bucky called Humankind’s “Final Exam.”

[From Alex Soojung-Kim Pang]

I read the “New York Times” letter with interest, since it was the first citation I’d seen of Fuller’s thinking

on using domes as emergency shelters. And certainly Mr. Stubenrauch is right to raise the question of whether military “first use” of high technology speaks well of the values of the society supporting that military. However, while Fuller may have had sketches in his notebook showing domes airlifted to the Third World, and in the early 1960s did a couple short courses in architecture schools on the use of indigenous materials (especially bamboo) in dome-building, it is important to remember that the dome’s use by the military happened not in spite of Fuller, but because of him.

In fact, in reviewing Fuller’s research in the 1950s, I find that he never presented students with the challenge of using the dome to solve Third World housing problems. He had a carefully-managed network of small consulting firms, architecture schools in which he held visiting lectureships, and a good-sized group of student volunteers (he was, in fact, an able if unusual manager who was deeply concerned with questions of securing patrons, exerting control over intellectual property rights, etc.) in this period, and they spent most of their time working on military and civilian defense applications of the dome. The initial studies for the DEW line domes, for example, were done by Fuller and students (mainly students) at MIT; studies for the Marine Corps were conducted at MIT, Tulane, NC State, and Virginia Tech. Other students designed automated cotton mills in geodesic domes, and worked under Fuller on designing private and public structures that could withstand atomic bomb blasts. Studies of how the dome could be put to more humanitarian uses, in contrast, seem to have received almost no formal attention from Fuller or his students.

This is not to say that Fuller was not interested in the dome being used in the Third World; but his vision, at least as described to his military patrons, was rather more complex and perhaps more sinister than Mr. Stubenrauch reports. Fuller articulated this vision in letters now held in the Marine Corps Historical Center archives; in them, he complimented the Corps for their interest in using domes in forward logistics plans (in which domes, filled with aircraft repair equipment, would be rushed to contested areas in the Third World at the first sign of Communist mischief, shortening logistics lines and allowing stronger support for air wings), and that they had discovered the key to winning to the Cold War. To quote:

“The Marine Corps [has created] an unexpectedly double-barrelled gun: one barrel for the hot war, one barrel for the cool war. The hot war barrel of the Geodesic structures weapon will function in the manner we have outlined above [e.g. in providing logistics and repair facilities for aircraft].... The cool barrel of the Geodesic structures weapon-inadvertently adopted by the Marine Corps – is the barrel which can now hit directly, instantly, and effectively at the heart of every peace-time economic pattern the world around....

“The logic governing the possibility of our winning the cool war runs as follows: controlled environment is the comprehensive package which contains and permits the uniquely high vantage functionings of industrialization. And it is towards industrialization that peoples of the world now direct the war-detouring hopes of swift emancipation from all the fundamental physical disadvantages and lethal deficiencies.... And, every function of further world-around industrialization is dependent upon the accelerated realization of comprehensively deployable environment controls....

“The swift delivery half-way around the world ... of all manner of controlled environment structures ... is a first requirement of all integrated agricultural and industrial economics - from farm buildings to factories, to governments, to homes.... If world man can witness the economically realized production of controlled environments capable of converting to man’s unprecedented advantage the most hostile environment events of converting to man’s unprecedented advantage the most hostile environmental events ... then world man’s intuitive response will be to focus his hopes of swiftest emancipation from ‘what ails him’ toward the heart of the American economy and the democratic processes which provide the synergetic strength of the U.S.A.”

Fuller’s other writings and speeches from this period deliver (broadly) the same message: that domes, filled

with power stations, hospitals, factories, etc., preassembled in the United States and airlifted to underdeveloped countries, would yield overnight industrialization and the reconstitution of these nations into American-style societies and economies. This vision is a far cry from the emergency shelters; it is also the one Fuller invested more in, and in which he was more interested. The domes weren't empty, either in a literal or political sense.

[From Kirby Urner]

Alex –

I cannot initially agree with your thesis, although I might see your points better with further elaboration.

True, Fuller was well-nigh incomprehensible to a large percentage of his listeners, partly because he threw out words like “tetrahedron” with high frequency (a glaze-over word), but mostly because he used what people called his “boardroom drawl” – he slurred his words together pretty seriously.

Nevertheless, what came out of his mouth, transcribed, does not appear so divergent from what he wrote (I have 40 hours of transcribed audiotape in my collection to compare with his books). I really don't think differences in the spoken vs. printed Fuller accounts for the Whole Earth vs. Roszak dichotomy.

Like any lifelong writer, Fuller recapitulates and recontextualizes his earlier writings in later texts, trying to give his readers a sense of what *he* thinks is relevant. His early work for the Dept of Commerce & Forbes Magazine, he later tells us, was important because it got people to measure wealth in terms of energy use per capita, vs tonnage of raw materials per capita. His emphasis back then, as later, was on “doing more with less” – the Dymaxion House being the paradigm example. Time to get away from the idea that higher living standards involves consuming more “stuff” per capita – or even more energy, ultimately.

My personal feeling is that Roszak is fundamentally suspicious of Fuller's assertion that “artifacts” make a bigger difference than political movements. To Roszak's ears, Fuller is promoting a “quick fix” through technology, offering as a solution what appears to have gotten us into such deep waters in the first place. The Whole Earth folks, on the other hand, are not technophobic but trend more towards the Cyberpunkish end of the spectrum, these days embracing VR and the Internet as part of their preferred future. Both are reading/hearing the same text and reacting according to their predilections. Both currents were part of the counter-culture, so it is not surprising that the counter-culture was schizophrenic about Fuller.

Fuller himself was a New England Transcendentalist, in the mold of Emerson and his great aunt, Margaret Fuller. He was a mystic. In Fuller's universe, technology is synonymous with the physical. Nature is the supreme architect and technophile, her creatures being far and away more sophisticated than anything humans have themselves consciously invented. For Fuller, the technology vs nature dichotomy did not exist and he was dismayed that the counter-culture might throw out the technology baby with the evil-uses-of-same bath water.

In sum, I think, as you do, that Fuller was controversial, but not because his listeners and his readers were getting (or not getting) seriously different pictures of the man.

[And more from Kirby]

The fact remains, that in presenting US Marine readers with visions of made-in-the-USA living standards, to be spread around the globe to “make the world safe for democracy,” Fuller is (1) replacing fantasies of ultimate killingry with visions of livingry as the primary means to the desired end (victory for the USA) and (2) casting the problem as one of “detouring war” – a goal shared by all sides in the 'cool war' (thus common ground with the enemy is established).

I think it is Fuller's ultimate faith in the power of *artifacts* and visions focusing on same, that allows him to

work in ways that, from a political point of view, are ideologically inconsistent. How can he sound like such a cold warrior and still be the “gentle genius” of 1960s pop culture? I think we need to take Fuller at his word here: he was radically *apolitical* and willing to propagandize livingry artifacts in whatever ways would speak to his primary audience, in the this case the defense establishment.

I don't have a problem with these ideological positions once I see the common thread throughout: only by raising living standards globally can we detour war. Obviously a Third World (both inside and outside USA national boundaries) in constant need of emergency shelters cannot be the end for which we are striving. The goal was to raise living standards – and since the USA is not living at the standard Fuller envisioned either, it is not the case that his futurism was merely a projection of contemporary USA living standards on the rest of the world. USA people are living in squalor, in pathetic housing, under onerous and fearful conditions compared to where Fuller hoped we would be by this time.

[From Leo Elliott]

To take Fuller at his word, that he wanted to live, by design, fifty years ahead of his time (that being the longest time-lag, existing in the housing industry, between the inception of an idea and its practical application), one might hypothesize that Fuller was simply good at self-promoting his novel technologies, which often appeared as self-promotion of his intellect, especially since some of his technologies were being designed for materials, or social systems, which had yet to come to pass....

However I would take issue with Alex's statement that “There was a huge difference between the read Fuller and the performed Fuller.” While I only saw Fuller live one time in my life, which conforms to Alex's trope of “exhausted but exhilarated, dazzled by his vision and enthusiasm,” I have several days of tapes, which, perhaps because they are more controllable than a stage presentation, permit a closer look at the visionary language and how he constructed these scenarios, and also permit of less exhaustion, coming as the tape cassette does, in controllable dosage.

However, my point is that serious concentration on some of Fuller's texts has at times led to exhaustion as well; I am reminded of a picture in Applewhite's *Cosmic Fishing* supposedly depicting a galley proof of a page from one of Fuller's books, supposedly ready for typesetting, in which Fuller practically rewrote the entire text in the margins. His seemingly off-the-wall (“precessional”) spinoffs in his oral deliveries are similar, imo, to the tangential approach Fuller used in many of his texts, to illustrate some common theme or idea. Whilst it may appear, to the casual observer, as stream-of-consciousness writing OR speaking (and mind you, I'm not saying it wasn't – in fact, I've often wondered, in my more mystical moments, if RBF wasn't channelling some Ancient of Days up there on stage! ;)) – despite the appearance of stream-of-consciousness, I've found a great sense of awe, at times, at being brought back, completely from left field, to the starting point of the argument. The great Ah-haaa ...

6.14 What is GENESIS II?

[From Kirby Urner]

Was chatting with Russ Chu the other night – he's a long time BFI affiliate and good with hands-on artifact-making. Worked with Terry Gwilliam on tensegrity furniture and stuff ...

Anyway, I was asking him about the GENESIS II in the LA area. A dozen domes (looks like 1 doz. eggs?) sits by the freeway, sheltering the homeless.

NPR (Natl Public Radio) did a spot the other evening. Russ says American Temporary Shelter, Inc. is behind those fiberglass domes, which appear to be about 5/8ths of an icosasphere – I don't know what

frequency.

The cost, as I hear from NPR (Natl Public Radio) is about \$6500 per unit.

[From Brady Thompson]

There was a short article on the project GENESIS II reprinted in the Toronto Star from a LA Times article. As I recall, the cost of the units was about \$8,000 U.S. and the interior lining was ferro-concrete.

[From Kirby Urner]

Just got my most recent TrimTab from the Buckminster Fuller Institute today. It has some of the information I was looking for about that community for the homeless in LA. Here are some excerpts:

“The domes are made of fiberglass and are similar in structure to plywood domes. They are 20’ in diameter and have many windows. Each dome takes only two to three hours to assemble allowing for speedy construction for the whole community ... The whole community can be put up in only five weeks ...

Craig Chamberlain, who worked with Buckminster Fuller in the 1970s, has helped Ted Hayes [head of Justiceville/Homeless USA] with the specifics of the dome construction ... A sample of each type of domes was on display in the Los Angeles location. These structures included a kitchen with two of everything, a laundry room with multiple washers and dryers, a dome with four individual bathrooms and showers, and the shelter dome split into two private bedrooms.

On November 5th Genesis 1, a one-acre community of 18 Omnisphere domes in downtown Los Angeles celebrated its grand opening as the first pilot dome village. Funded by ARCO, the domes were erected by homeless workers and the American Temporary Housing Corporation. If the first year is successful, Justiceville/Homeless USA hopes to erect such villages in other cities. Hopefully, Hayes and his volunteers have started a continuing trend of solving our shelter needs by doing more with less.”

Article by Melinda McDonald, BFI TrimTab Bulletin, Fall/Winter 1993 contact: JHUSA 1316 Wilshire Blvd, LA, CA 90017 (213) 483-8783 for more info.

6.15 Could Fuller’s proposed Very Large Structures work?

[From Martin Roller]

Buckminster Fuller claims in several of his books, that using dome constructions one could build arbitrarily large structures, the only constraint would be the available material (see e.g. the sketches of floating spheres of diameter one mile or a bubble enclosing Manhattan in *The Dymaxion World*). Frei Otto, a German architect, argues that this is still impossible, nobody could build a structure (arc, roof etc.) spanning one mile, say.

Does anybody know Fuller’s precise calculations for the structural stability of domes or more details of Otto’s case against it? Who is right?

[Chris Fearnley]

Since no one has ever built such Very Large Structures, we can’t know for certain. But in dome theory the key variable is radius and no restrictions are placed on its value. So there is no reason to suspect that they wouldn’t work. In fact geometrically the only way they could break were if a joint popped or strut broke. This is why Fuller suggests using very high frequency geodesics for large structures.

6.16 Why did Fuller apply for patents?

In *Critical Path* p. 149 Fuller writes:

“I did not take out the patents to make money but only to document and demonstrate what the inventive little individual can accomplish, and to prove documentably the socioeconomic existence of such unique industrialization lags. ...

“Now that I have proven that an individual can be world-effective while eschewing either money or political advantage-making, I do my best to discourage others from taking patents, which almost never ‘pay-off’ to the inventor. My patent taking was to effect a ‘bridgehead’ accreditation to more effective employment of humanity’s potentials.”

[From Kirby Urner.]

Highly recommended:

“The Economy of Ideas: A framework for rethinking patents and copyrights in the Digital Age (Everything you know about intellectual property is wrong).” By John Perry Barlow in the March 94 issue of WIRED. Barlow is co-founder of the Electronic Frontier Foundation and lyricist for the Grateful Dead.

“Perhaps those who are part of the problem will simply quarantine themselves in court, while those who are part of the solution will create a new society based, at first, on piracy and freebooting. It may well be that when the current system of intellectual property law has collapsed, as seems inevitable, that no new legal structure will arise in its place.”

6.17 Is there a Bucky CD-ROM available?

There is periodic talk of people working on this. Here are some relevant postings.

[From Blaine A. D’Amico.]

Ed Applewhite has succeeded in interesting the Voyager company in publishing an “Expanded Book” (multimedia) on Fuller and Synergetics. The challenge now is producing the product.

This would obviously be different from the clips that you are suggesting. However such a CD-ROM would certainly ease the development of this expanded book and other projects.

I’m slowly collecting the equipment to capture some of my video and sound footage into digital format.

[From Kirby Urner]

A thumbnail history of the scanning project: Russell Chu, Robert Orenstein, and Hal Hildebrand donated a lot of resources and time, to get a prototype IBM clone set up at the institute. Bonnie Goldstein (BFI staff) had earlier sketched out the scanning project in a document, with input from these folks.

Hal’s first donated motherboard wasn’t powerful enough, so Russ helped out and got a 386DX with 8MB RAM. Hal is/was a super high powered SmallTalk programmer then with a document scanning defense contractor and the idea was to scan “Everything I Know” as the basic text – that’s a transcribed version of spoken cassette tapes. This would form a core to which other materials could later be linked, hypertext fashion.

Hal’s SmallTalk program was to be the receptacle and retrieval system. Robert Orenstein was sort of lining up to apprentice under Hal to learn enough SmallTalk to help out (Hal lived in the Bay Area, far enough from BFI to make tech support tough).

But all these folks are/were busy busy earning livings. And SmallTalk is a pretty steep learning curve (I tried, got as far as the 4D turtle I described earlier – my hardware was inadequate too back then, although later Russ gave me his 386DX motherboard, and now I have a 486...never understood Hal's document handling system).

Hal drifted off to form his own small business to market a multi-user SmallTalk operating system called Tensegrity. Russ (in construction) moved to Seattle and got married. Robert is still in LA and continues doing trainings for Ingres. The Institute itself got caught up in needing to move away from LA.

So ... no progress on the scanning front. The idea of using "Everything I Know" as one backbone scenario through a hypertext archives seems valid, although the transcript itself has the drawback of being transcribed speech – not as polished syntax (but a good read nevertheless).

[From H. Jeffrey Rosen]

The recent thread RE the scanning project recalls a proposal I made to the BFI over a decade ago, while I was working as a videodisc specialist in the aerospace industry. My idea was/is to marry a videodisc based image archive to Bucky's scanned written/spoken works.

The last time I saw Bucky was in Pasadena, about eight months before he passed away. I mentioned my concept to him, proudly admitting that it was his vision in *Education Automation* which had inspired me.

He nodded gently, staring at me with those incredibly deep eyes, and said with a hint of regret, "Y'know, I've been meaning to do that."

I spent many afternoons at the house in Pacific Palisades with the Synergetics Discussion Group reviewing flowcharts, hypertext schemes and the index of videotapes compiled by Applewhite. We were all very excited about what the new interactive technology was offering us, and how the BFI could use it to make Synergetics more widely understood.

Even in my local discussion group in Long Beach, I explored ways to popularize the ideas of RBF in the media, designing what I called "Commercials for Sanity" which would have run on public access cable TV.

Sadly, Allegra had to postpone consideration of the proposal indefinitely, citing high equipment costs and shortages of human resources. After all, the BFI had only just moved to LA, and most of the volunteer help was busy figuring out where to store stuff.

So now that the text-scanning discussion is taking form, I'd once again like to offer this idea to the Bucky Fans on the Internet: a holistic (spherical) curriculum model, based on fundamental (synergetic) design concepts, as the human interface/front end of an all-inclusive, ever expanding hypermedia database.

Users will subscribe to the service through the BFI on a fee-for-use basis, allowing BFI to waive fees in particular cases at first, and perhaps altogether, after the value of the tool has grown, in favor of a royalty-based agreement with the users of the info.

The design curriculum allows tailoring of the interface to all ages and cultures. The hypermedia links the written, spoken, transcribed words of Bucky, his confederates, associates, critics, biographers etc. with the vast archive of images, models, pencil sketches, movies, videotapes etc. which are detailed in the Applewhite index, and which have been growing, I'm sure, over the past decade.

This tool is an achievable goal. It requires the support of the BFI, and the determined labor of people who believe both in the value of information and the future of humanity.

6.18 Why is overspecialization dangerous?

[From *Synergetics* - typed in by Kurt Przybilla]

We are in an age that assumes the narrowing trends of specialization to be logical, natural, and desirable. Consequently, society expects all earnestly responsible communication to be crisply brief. Advancing science has now discovered that all the known cases of biological extinction have been caused by overspecialization, whose concentration of only selected genes sacrifices general adaptability. Thus the specialist's brief for pin-pointing brevity is dubious. In the meantime, humanity has been deprived of comprehensive understanding.

6.19 Letters from Bucky to Mark A. Burginger.

[From Mark A. Burginger]

The following letters and more are available at Mark's website <http://www.burginger.com/STRUCTURE/Bucky%27s%20Letters>.

6.19.1 Letter #1

R. BUCKMINSTER FULLER · 3501 Market Street, Philadelphia, Pa. 19104 · USA · (215) 387-5400 ·
CABLE: "BUCKY"

· University Professor Emeritus Southern Illinois University University of Pennsylvania · World Fellow in
Residence University City Science Center

February 11, 1980

Dear Mark Burginger:

I think very well of your drawings of the prismatic polyhedral system and other systems. You are an excellent geometrical illustrator and you're clearly doing your own thinking regarding the nature of structure. I went a long time before anyone looked at my work. I'm particularly interested in your photon package drawing as inspired by SYNERGETICS. Your complete system should not be up-and-down but in-and-out. Your interlocking of shell groups, represents good thinking and good drawing.

I wish you well.

Faithfully, Signed: Buckminster Fuller

Buckminster Fuller

Mr. Mark Burginger 2288 Lucretia Ave. #3 San Jose, CA 95122

BF/kk

· Architectural Societies Royal Institute of British Architects, Honorary Fellow Royal Architectural Institute of Canada, Honorary Fellow American Architectural Institute of Architects, Fellow Mexican College and Institute of Architects, Member Society of Venezuelan Architects, Honorary Member Israel Institute of Engineers and Architects, Honorary Member Zentralvereinigung Der Architekten Asterreichs (Austria), Honorary Member Association of Siamese Architects Under Royal Patronage, Honorary Member

6.19.2 Letter #2

R. BUCKMINISTER FULLER · 3501 Market Street, Philadelphia, Pa. 19104 · USA · (215) 387-5400 ·
CABLE: "BUCKY"

· University Professor Emeritus Southern Illinois University University of Pennsylvania · World Fellow in
Residence University City Science Center

June 25, 1981

Dear Mark Burginger:

Far from taking offense at the beautiful drawing that you sent me in which you did incorporate ideas of my
own, it is so well done I'm having your framed copy mounted in my office.

Congratulations on your drawings for your stainless steel sculpture to be installed in the Lompoc City Hall.

Faithfully, Signed: Buckminster Fuller

Buckminster Fuller Mr. Mark Burginger 1341 Branham Lane San Jose, CA 95118

jb

· Architectural Societies Royal Institute of British Architects, Honorary Fellow Royal Architectural Insti-
tute of Canada, Honorary Fellow American Architectural Institute of Architects, Fellow Mexican College
and Institute of Architects, Member Society of Venezuelan Architects, Honorary Member Israel Institute
of Engineers and Architects, Honorary Member Zentralvereiningug Der Architekten Asterreichs (Austria),
Honorary Member Association of Siamese Architects Under Royal Patronage, Honorary Member

6.19.3 Letter #3

R. BUCKMINISTER FULLER · 3501 Market Street, Philadelphia, Pa. 19104 · USA · (215) 387-5400 ·
CABLE: "BUCKY"

· University Professor Emeritus Southern Illinois University University of Pennsylvania · World Fellow in
Residence University City Science Center

February 11, 1980

Dear Mark,

What a beautiful picture of lightning. Thank you so much.

Faithfully, Signed: Bucky

Buckminster Fuller

Mr. Mark Burginger 1341 Branham Lane San Jose, CA 95118

BF/aem

· Architectural Societies Royal Institute of British Architects, Honorary Fellow Royal Architectural Insti-
tute of Canada, Honorary Fellow American Architectural Institute of Architects, Fellow Mexican College
and Institute of Architects, Member Society of Venezuelan Architects, Honorary Member Israel Institute
of Engineers and Architects, Honorary Member Zentralvereiningug Der Architekten Asterreichs (Austria),
Honorary Member Association of Siamese Architects Under Royal Patronage, Honorary Member

6.19.4 Letter #4

R. BUCKMINSTER FULLER · 3501 Market Street, Philadelphia, Pa. 19104 · USA · (215) 387-5400 ·
CABLE: "BUCKY"

· University Professor Emeritus Southern Illinois University University of Pennsylvania · World Fellow in
Residence University City Science Center

November 14, 1981

Dear Mark Burginger,

Thank you for yours of October 27, and its photographs of the truncated icosahedron with modular form
attachments. It may be a good idea; it may accelerate development of the mass production units.

Warmly, Faithfully, Signed: Buckminster Fuller

Buckminster Fuller Mr. Mark Burginger 1341 Branham Lane San Jose, CA 95118

BF/aem

· Architectural Societies Royal Institute of British Architects, Honorary Fellow Royal Architectural Insti-
tute of Canada, Honorary Fellow American Architectural Institute of Architects, Fellow Mexican College
and Institute of Architects, Member Society of Venezuelan Architects, Honorary Member Israel Institute
of Engineers and Architects, Honorary Member Zentralvereiningug Der Architekten Asterreichs (Austria),
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7 Net Resources

7.1 The current version of the FAQ is on the Web

<http://www.CJFearnley.com/fuller-faq.html> .

7.2 On-line Discussion Forums

This section catalogs the on-line discussion forums related to Buckminster Fuller work.

7.2.1 List Geodesic: geodesic@listserv.buffalo.edu

[From MONTHLY POSTING* - GEODESIC 'how-to' info by Patrick Salisbury]

GEODESIC is a forum for the discussion of the ideas and creations relating to the work of R. Buckminster
(Bucky) Fuller. Topics range from geodesic math to world hunger; floating cities to autonomous housing,
and little bit of everything in between. Other lists that focuses more specifically on some of these topics can
be found on the *Reality Sculptors Website* <http://reality.sculptors.com/lists.html> .

To subscribe, send mail to LISTSERV@LISTSERV.ACSU.BUFFALO.EDU and in the body of your letter put the
line:

SUB GEODESIC <Your Real Name>

A web page to signon is available here:

<http://listserv.acsu.buffalo.edu/user/sub.html> <http://listserv.acsu.buffalo.edu/user/sub.html>

The list is gatewayed to USENET as *bit.listserv.geodesic* news:bit.listserv.geodesic .

LIST ARCHIVES:

Listserv itself is keeping archives of the list, dating back to June, 1992. Send a note to listserv@listserv.acsu.buffalo.edu with this message in the BODY of the note:

INDEX GEODESIC

You can get help on other Listserv commands by putting the line HELP into the body of the note. (Can be in the same message.)

Web-searchable archives for the lists are available at:

<http://listserv.acsu.buffalo.edu/archives/geodesic.html> <http://listserv.acsu.buffalo.edu/archives/geodesic.html> .

Most of the archives are mirrored at *List Geodesic Archive (mirror)* <http://www.CJFearnley.com/geodesic-logs/> .

7.2.2 Synergeo

Synergeo <http://groups.yahoo.com/group/synergeo/> is an unmoderated, public read access, only members can post, mailing list for all those forward thinkers interested in synergetics, geometry, geodesics, tensegrity, and other topics related to R. Buckminster Fuller's work. Set up by Ken Brown in March, 2000 to fill the void left by *Synergetics-L* <http://www.inetarena.com/%7Epdx4d/Synergetics-L/> .

[From Karl Erickson]

geomodel <http://www.onelist.com/subscribe/geomodel/>

mailing list for discussing primarily physical model-building.

The Struck community <http://www.critpath.org/idiaverse/struck>

has a mailing list, to subscribe to the list, send email to majordomo@xs4all.nl with the message body "subscribe struck."

The *Tetworld* <http://members.tripod.com/~Tetworld/world.html>

mailing list and web site are based on Fuller's World Game idea.

7.2.3 MSN Buckminster Fuller Community

Joe S Moore setup *this MSN resource* <http://groups.msn.com/BuckminsterFuller/home.htm> on Buckminster Fuller.

7.3 Web Resources

The Buckminster Fuller Institute's home page is at <http://www.bfi.org/> .

This editor maintains a list of Fuller related URLs at

<http://www.CJFearnley.com/buckyrefs.html> <http://www.CJFearnley.com/buckyrefs.html> .

The World Game Institute's (WGI) home page is

<http://www.worldgame.org/> <http://www.worldgame.org/> .

7.3.1 Books by R. Buckminster Fuller on the Internet

Synergetics and *Synergetics 2* can be found at

<http://www.rwgrayprojects.com/synergetics/synergetics.html> <http://www.rwgrayprojects.com/synergetics/synergetics.html> .

Operating Manual for Spaceship Earth can be found at

http://www.bfi.org/operating_manual.htm http://www.bfi.org/operating_manual.htm .

Education Automation can be found at

http://www.bfi.org/operating_manual.htm http://www.bfi.org/education_automation.htm .

Grunch of Giants can be found at

http://www.bfi.org/grunch_of_giants.htm http://www.bfi.org/grunch_of_giants.htm .

A Fuller Explanation: The Synergetic Geometry of R. Buckminster Fuller can be found at

<http://www.angelfire.com/mt/marksomers/40.html> <http://www.angelfire.com/mt/marksomers/40.html> .