Cwarel Isaf Institute

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Origins of Team Sentegrity

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Contents

Master and slave, squire and servant, boss and employee, ruling classes and proletariat… the notion of hierarchy is endemic to the human experience of social system. And yet it seems never to suffice as an organizing principle. Ways are always found to supplement, indeed to enrich, the simply autocratic "chain of command".

As a young staff officer at the end of WW2 I was quite startled to find the extent to which I carried the Area Commander's clout, although I soon discovered that the purview was limited in rather precise ways…
Then there are examples from long-lived institutions other than armies. The management of the Roman Catholic Church is actually known as "the hierarchy"; and yet so strong and inflexible an organization is interpenetrated by the influence of monastic order to major effect – as the history of the Second Vatican Council testifies. So much in this vein is known to social anthropology that it is sad to be given the typical organization chart put out by business or a government department. There stands the usual "family tree" in all its unsubtlety: A mere instrument for discovering who is to blame. the most sophisticated addendum that we are likely to find is a pattern of dotted lines in the horizontal plan indicating mysterious liaisons - committees of cousins maybe.

And yet serious work has been going on for many years in examining non-hierarchic solutions to the general problem of regulatory systems, which has resulted in practical spin-off: outcomes range from the creation of presidential offices to neighbourhood cooperatives. These are real, and effective, but perhaps fairly pragmatic in design. It might be advantageous to have a more rigorous theory. At any rate, there seems to be a steadily increasing need to offer a new focus for discussion and possible development.

The main reasons are the international trend away from centralization; a growing repugnance towards the very concept of hierarchy detectable in public debate; and the increasing elimination of what used to be called middle-management activity by automation. This has led to the phenomenon of "plateauing", or "flat management" structure, in which few positions are senior to any other. The social consequences outside the organization may well be dire; but the more immediate consequences have to do with creating new ways of working, that I shall call protocols, for operating the new kinds of organizational structure. And how indeed shall they themselves be described?

The purpose here is to recount and to record a process that began nearly forty years ago, flared into considerable activity twenty years ago, and occupied me throughout 1990 in a series of five major experiments. It is not a comparative study. I am well aware of many other approaches, and reference notably the Repertory Grid technique of George Kelly (Kelly, 1955), which seems to me most valuable, and the various forms of Matrix organization, which do not. The reasons that led me down the routes actually followed had to do with the place occupied by these matters in the context of all my other work, as both manager and consultant, rather than in academic appraisal.

The Start

At the time of my first civilian appointment in the steel industry in 1950 (heading operational research) we had no computers. but we also had little in the way of scientific process control. Pyrometry, for example, was no more than an experimental science in dealing with temperature control on the shop floor. With the help of expert workers, I had learned how to control a Bessemer converter by watching the colour and shape of the sparks blown off as the iron was purified into steel. In the rail mill, the experts judged the rolling temperature by throwing little bundles of twigs onto the steel and watching them ignite; in the billet mill they simply spat on the hot slabs instead. They were all very accurate and they had not a single qualification between them. They were the workforce. Their managers could not do these jobs…
Hierarchy?

Trying to model this kind of situation was not easy. The new science of cybernetics had recently been officially born: In the Proceedings of the Eighth Conference appeared an attempt to describe various kinds of social structure as networks in a Euclidean plan space – it was the work of Alex Bavelas (Bavelas, 1952). It looks mathematically simplistic in these days of graph-theoretic insight, but it was the first time that I had seen any proposal of a rigorous kind, and so made much use of it.

Bavelas devised three measures for quantifying the organizational pattern.

The first is Group Dispersion. Take each member of a network, and count the number of steps it takes (according to the protocol established to reach every other member. Some will be one step away. To reach others, one might need to ascend and descend various hierarchical ladders. Having made the count for every person, add up the results. This is now an unequivocal measure of the extent to which the group is dispersed.

Each member now has a personal Relative Centrality. To calculate this, divide the Group Dispersion by the minimal connectivity of the individual.
Thirdly, the measure of Peripherality for member Fred Bloggs is the Relative Centrality of the most central member, minus Bloggs' own.

Using these three measures made possible the theoretical investigation of paradoxes that seem to underlie attempt to adjust protocol, and as many empirical checks as could be made were made (recall that this was done in a real-life OR context and not under laboratory research conditions). In particular, the impact of protocol on morale is important. The central paradox resides in this: Morale is improved by diminishing peripheral isolation, but adjustments to relative centrality to achieve this lack efficiency and inhibit the emergence of leadership. And here we are, forty years on, observing exactly this phenomenon in cooperatives under observation in Britain – not to mention the inverse effect in the Baltic States.

The original considerations and conclusions were presented to the First International Conference on Cybernetics, held in Namur, Belgium, in 1956 (Beer, 1956). Four embryonic models of a non-hierarchic kind were then put forward.

One of these models was drawn from servomechanics. "Most progressive action in industry is driven forward by the organization using the positive feedbacks of form (supportive) sanctions and informal encouragement", I wrote. "Most catastrophes in the field of industrial development, as well as in the sphere of routine production, are averted by the organization using the negative feedbacks of criticism and inspection respectively." Ratios were developed that isolated technical factors in the productivity equation from the interplay of all the other personal and social considerations that generate shop-floor reality. Let us call the latter "systemic" factors, insofar as they are outputs of the system-we-have. A simple model distinguishing between technical and systemic unit step functions of displacement in a steady-state system enabled a study of transient behaviour to be made.

In particular, I had examined the impact of incentive schemes as a means of raising productivity, considered as triggering servosystems: There was a negative correlation between the technical residual systemic components. In this lay an explanation as to why "some incentive schemes "freeze", while others "run away".

The transient behaviour of the mixed technical/systemic stability was such that crude technically-based incentives either confirmed inefficiency in setting up a barrier to the change of state, or caused production to increase in an uncontrolled way by destabilizing the system itself.

Another model proposed on these "network" bases at the 1956 Namur Conference was drawn from entropy. After all, in a fully connected organizational network, Relative Centralities tend to equality. Entropy rises, and less energy is available to work the system. But if the organization be centralized, in order to liberate that energy, group dispersion increases, and a terrible loss of morale will be associated with the ensuing peripheral ignorance. Thirty-five years after Namur, the Soviet Union finally acknowledges that point. In the meantime, this work was the origin of the theory of autonomy eventually advanced in The Heart of Enterprise (Beer, 1975). But I had already been profoundly influenced by Wiener's demonstration (Wiener, 1948) that information is formally equivalent to negative entropy, as the Namur paper states. Western bloc countries and their financial institutions are taking even longer to acknowledge that point and to grapple with its consequences for the Third World.

Some space was devoted to Namur to yet a third model: It sought to quantify the networks under discussion by propagating stochastic processes (and in particular messages considered as Markovian self-avoiding random walks) through organizations depicted as transitional probability matrices. The main lessons learned at that time (which were recognized later as manifestations of Ashby's Law of Requisite Variety) had to do with the nature of organizational structure as a variety inhibitor. If N people are engaged in a network, and the passage of some form of message involves any unspecified number of them, then the number of ways in which the group could behave is approximately e^N!. If the network has only ten people, that number of possible arrangements reaches nearly ten million. Constraints were imposed on this preposterous proliferation of messages by inserting barriers representing organizational rules, depicted in the simulations (pre-computer, recall) as Boolean functions. Even so, we could not stop the messages from reverberating (rumour, gossip, folklore?) until a "dead man" was installed in the system. He did not pass any message to anyone, and came tro be recognized as a familiar bureaucratic persona. I mention with affection that this uncoffinned corpse was the invention of Michael Aczel. Some years later, and based on these experiments, an analysis was developed of the standard hierarchic protocol in which senior people may reach any junior person in one step, whereas a junior person must appeal to each more senior level in turn in order to reach an eventual boss. Trying to adjust the organizational design to optimise centrality for everyone resulted in a theorem proving that half the people (plus one) are in the bottom echelon. It has never been clear to me whether this result offered a powerful insight, or whether it is a trivial mathematical artifact of the protocol itself. It was for safety's sake never published.

All of these models greatly influenced the development of a cybernetic approach to management (Beer, 1959). But the fourth of the models, which was presented first, was based on neurophysiology, and the nature of synaptic transmission. It was this which developed into a set-theoretic model of the brain as an exemplar of management (Beer, 1962), and eventually became the first of the books (1972 dealing with the Viable System Model (Beer, 1981, 1975, 1985; Esperjo and Harnden, 1989). It is germane to the work here described as Team Tensegrity to note that these models are all based on interlocking homeostic subsystems, and are non-hierarchic in character for that reason – contrary to the critique of some rather casual readers. The essential idea was that the brain is engaged in balancing the reports it has in the sensory and motor cortices, so that action will be continuously appropriate to appearance. This approach belongs to the philosophies of subjective idealism, in that it contemplates internal rather than external "realities".

The 1956 paper, having proposed this normative theory of management, was led to a final set of reflections on its psychopathology in overwork, shock, trauma, and neurosis. All of these presenting symptoms have been apparent in these cybernetic enquiries ever since: not least in the five 1990 experiments in Team Tensegrity, one of which is described in the next chapter.

Categories and Priorities

Throughout the sixties and seventies of my experience, it became more and more clear that whatever one might do to undermine hierarchy and autocracy in structural terms, in political protocol, or in social rubric, powerful influences tended to maintain the status quo ante. It has to be accepted as a cynosure of the human condition that the pursuit of power is ubiquitous and prevailing. Well and good: Utopia is indeed, as says its name, the nowhere place. But it pays to reflect on the extent to which our very way of speaking never mind cupidity underwrites the system that needs reform.

If people gather to discuss the existing state of affairs, with a view to creating a new vision of the future, they begin by acknowledging the accepted categories by which those affairs are discussed. They speak of health, education and welfare – just as if it were not the same person who is well or ill, literate or not, nurtured or abandoned. In each profession, the same reductionism applies. It is possible to be attended by doctors, or lawyers, or accountants or teachers, to each of whom one is separately accountable – just as if it were not the same person who had gout and epilepsy, malfeasance and tort, cashflows and taxes, syntax and simultaneous equations….never mind the same person who suffers from all of these things at once. Each of us is stretched out on a Procrustean bed of society's devising. Small wonder that sages universally point out that spiritual freedom lies only in abnegating the whole structure, and wandering away. The sages are right. Meanwhile, business affairs and government must be conducted.

Then we should ask ourselves this question:

How shall we ever conceive

how ever express

a new idea

if we are bound by the categorization

that delivered our problem to us

in the first place

There is a supplementary issue to this denial of fixed agenda. Even if we were to agree that agenda actually exist – that there are topics to be named that ought to be discussed – in what order should they be taken? Pliny the Younger wrote a letter to a fellow Senator about the fact of a prisoner not yet judged. If he were guilty, he could be sentenced either to death or to exile. Pliny elucidated the fact that it made a difference if one first decided on guilt or innocence, and then on the sentence – or vice-versa. The argument is a treasure of subtle reason. Crude manipulators of agenda in politics, academia and business today are not nearly so clever, but may be twice as corrupting. “Let us get our priorities right” is a common cry. Yet in a holistic account of an interactive system, the cry makes no sense. Shall we build road to converge on a hospital, and then – having run out of money fail to build the hospital itself; or shall we first build a hospital in the desert, and run out of money to make it accessible? The dilemma merely illustrates the point, but actual incidents quite as bizarre are commonplace in the developing world.

Then a technique is needed that recognises that if a meeting sets out with agenda, it has structured the whole outcome in advance. Anything truly novel has two minutes as Any Other Business. Second, the meeting is merely a series of platform for those who determined the agenda on which to ride their familiar hobby horses. Third, the requirements to put the agenda in order says something (perhaps complicated) about the priorities of the organizers rather than the exigencies of the problem. These arrangements work well enough for purposes of routine management; but we have been talking about directional planning. In that case, they do not work at all. The technique proposed is called the Problem Jostle.

The Problem Jostle: Provenance

Meetings with no agenda must generate their own; and they must generate their own categories too – amid much exhortation not to fall back on established ways of talking. A recent protocol for doing this, emerging from the 1990 experiments, will be given in a forthcoming book. Here are its origins.

Problem Jostling was invented for “Marlow Seventy”, whereby the 1970 Council of the Operational Research Society redesigned its Constitution under my presidency. Note: small group; definite purpose; open-ended list of outcomes; highly successful (for an account see Beer, 1975, pp 490-498). After some more experimental plays, during which it became obvious that the size of the group was critical, the approach was used at the Silver Jubilee Meeting (1979) of the Society for General Systems Research (now the International Society for Systems Sciences) as a means of capturing the informal talk “Later in the Bar”. Note: group of several hundreds; no definite purpose; open-ended list of outcomes; successful enough to be copied in various conferences around the world.

We had overcome the problem of numbers by the use of facilitators, the continuous public posting of results with further signatories invited, and by a first attempt at statistical cluster analysis. Naturally (“nothing works”), the London University computer broke down and data had to be re-routed around the country, imposing damaging delays, but the experience fired the imagination of many as a liberating agent in the context of the orthodox formality of a prestigious international conference.

In 1984 during my Residency at the McLuhan Centre in the University of Toronto, a major new experiment was attempted, varying various parameters, and deliberately relaxing all constraints. Note: smallish group; hopelessly indefinite purpose such as “what shall we do?”; totally open ended; whole development of cluster analysis which was intended to pull these very loose threads together had to be abandoned because the computer team failed to deliver (or even appear); not at all successful.

In 1987 I designed a meeting for Premier David Peterson of Ontario, at which some 120 delegates of the Liberal Party, including the parliamentary caucus, met over a long weekend to discuss the failure of the Province. Of course, there were no agenda. There were ten facilitators, posting with signatories plus continuous voting; cluster analysis worked (and went on all night). Note: Large group in five sub-groups interacting; definite purpose; open-ended 47 outcomes were agreed.

Cybernetically, this was highly successful. It was marred in its effect. I discovered on my return from the trip that the Friday night launch had been cancelled in favour of political speechmaking, leaving the process to start from cold after breakfast. Despite all cajoling, the delegates from ridings brought their own agenda in their saddle-bags… Finally, the results were not vigorously injected into the government programme. It can never be known if the government would have gone beyond its second term had it acted on its own projected vision. It did not.

The question of critical size, which had haunted this work since the fifties, was evidenced in the Ontario meeting – and accounted for the division of the total group into interacting subgroups…

The Infoset: Provenance

What makes "a group" out of a random assortment of people? It surely has to do with motivation, and with what I had earlier been calling morale. I proposed that what brought people into cohesive groups was the shared information that had changed them into purposive individuals. Data themselves do not supply this cohesion. It is the interpretation of data that procures purpose, and it is shared interpretation between individuals that procures group cohesion. Thus groups of this kind were nominated as infosets.

The origin of the term INFOSET (Information Set) is found in an unpublished text called Status Quo which I wrote in Chile, June-August 1973, while working for President Salvador Allende. The President, working through his Minister Fernando Flores, had invited me to design a regulatory system for the social economy of the country. The story of what we accomplished, with Dr. Raúl Esperjo as the Chief of Staff, is recounted in the last five chapters of *Brain of the Firm* (Beer, 1981). The plot to "destabilize" Chile is well documented (US Congress, 1975) and led to the coup of 11 September, 1973, during which the President was murdered and many Chileans suffered torture and death.

Now President Allende was a Marxist-Leninist who did not accept the model in use in the USSR. In particular, we were (twenty years ago) busily engaged in a decentralizing system of regulation that would use peripheral knowledge (as here defined) through a whole series of interlocking "operations rooms", or management centres. It was indeed by that means that the notorious CIA-financed "gremio" strike of October 1972 was defeated.

Meanwhile, I had been asked to reconsider the tenets of the government's political philosophy in cybernetic terms. For example, Allende was well aware that the Hegelian concept of the dialectic, used by Marx, was parallel in the ubiquitous biological mechanism of homeostasis – and the cybernetician Ross Ashby had already evolved a mathematical theory to elucidate this. (It is interesting that both Allende and Ashby, who never met, were originally trained as physicians.) My idea was to replace the Marxist "classes" (where the ruling class exploits the proletariat) with a richer and less tendentious categorization based on shared information. "Exploitation" then becomes the deprivation of information; and the text points out that what are (laughably) called "the mass media" very often carry not zero, but negative information – insofar as they take away the opportunity to acquire positive information. (The concept is the same as "opportunity cost" in capitalist economics.)

"Now information, in cybernetic terms, is negative entropy; the infosets operate in terms of selection entropy, which absorbs information. If the information is not there, the selections are not possible – that is obvious. What is less obvious is that to feed them negative entropy, which is to say "pure" entropy.

"It follows that the exploited and alienated classes, with which we began, will lose any sense of revolutionary ferment – not because their entropy as a class is rising to the limit of unity. (…) The new sets, however, identified as they are by their informational characteristics, are negentropy pumps – which is to say, by cybernetic definition potentially revolutionary forces in society."

I worked sporadically on these ideas for the next ten years, undertaking a few experiments with people and many more with "paper machines". But it was not until I started working with Garry Davis and the notion of world government that the political drive to do something returned. World Government: we required "potentially revolutionary forces in society " indeed. Davis is the WW2 bomber pilot who renounced American citizenship very publicly in 1945, and has ever since worked tirelessly towards his ideal of One World.

No man is an island, maybe. But Garry Davis is not only his own man but also his own Infoset! The rest of us would need structure, but it had to be non-hierarchical; and we would need a procedural protocol, but it had to be non-hieratic. In short, we needed a perfect democracy.

In the Monadology of Leibniz, as also in much Eastern teaching, all parts are identical because all parts are the whole. The notion is wonderful, but difficult to make rigorous. I started with an attempted model through holography, in which the whole picture is reformulated in any broken piece of glass, but could not get a hold via Denis Gabor's mathematics – and he was by now dead. Then I stumbled on an old gift from Buckminster Fuller - an inscribed time map of his own life – and started to think more about his geodesics. And I heard again in my own head his dictum: all systems are polyhedra. It is an amazing insight.

Tensegrity: Provenance

Fuller formulated the idea that nature exists in an equilibrial balance between the forces of compression and tension. Obviously the existence of both forces was already known, but their collaborative coexistence in all physical systems had not been emphasized. For example, an architectural column is essentially a compressive structure – but vertical pressure creates unnoticed surface tension around the girth. A stressed rope is in tension: it twangs. but if it is not clear that the tension induces compression at right angles to the pull, stick a finger between the twisted strands of the rope – and then pull…

Overwhelmingly, architecture has recognized compressive force in obtaining structural stability: the triumph of the arch was to hold the span up by pressing the keystone down for example. But the result was that nature set a limit to the clear span of a compressive roofing dome – because of its ever-increasing weight. That limit is about 150 feet. Even then, the forces bearing down are so great that both St. Peter's in Rome and St. Paul's in London are reinforced by massive iron chains around their circumferences.

In 1948 Buckminster Fuller began by building domes – of which many thousands now exist, and may exceed the 150-foot compression barrier to arbitrary limits – that incorporated his own principal of structural relationship. According to this, the wholeness, the INTEGRITY, of the structure is guaranteed not by the local compressive stresses where structural members are joined together, but by the overall tensile stresses of the entire system. Hence came the portmanteau term for Tensile Integrity: TENSEGRITY.

Now in considering an Infoset and its behaviour, we might well contemplate its tensegrity. After all, Buckminster Fuller argues that it is an omnipresent aspect of nature, and makes a very good case for this indeed (Fuller, 1979a, 1979b). One matter in which (I argue) holistic thinkers ought to agree is that, when a good case for a natural invariant is presented, we are entitled to be excited by a possible advance in human understanding of the natural world and to seek out further examples. On the contrary, say the inherent reductionists (and of course these include many academic specialists) we have no reason whatsoever to compare architectural systems with social systems; and phrases such as "false analogy" abound.

To these I say, please suspend disbelief. After all, a new carbon molecule was recently discovered – a polyhedron named Buckminsterfullerene by gratified chemists. Consider what we know of group behaviour in the sense of an Infoset. Then such a group is consciously struggling to express its integrity, its wholeness; it looks for the compression of its shared idea into a cohesive statement, let us say. But it well knows that the popular term "consensus" is likely to represent merely a lowest common denominator that robs the group of its whole raison d'etre. It is also aware of tension. What else but tension generates discussion, never mind argument? Is this not indeed an exemplar of a Fullerian tensegrity balance?

These considerations led me straight to the notion of logical closure. Tensile integrity suggests that the Infoset already defined by its membership as a closed sytem (give or take the loss/gain of occasional members), probably behaves as a closed system – and gains its tensegrity from that fact. After all, a small group of friends who often discuss (say) politics among themselves, come to know positions – and watch them modify, to a greater or lesser extent! Of course the Infoset is not closed to information: new outside developments are pumped in as the lifeblood of the group's body-politic. But the views that we hear consolidate, gain or lose adherents, subtly change…these views are *reverberating* around the closed system. To put the point dramatically: Some node within the system propagates an idea, which then bounces round other nodes – and returns (somewhat modified) to hit its progenitors on the back of the neck.

This concept of Reverberation came to mean to me the instrumentality of tensegrity within the Infoset. Of course, it depends on structural closure. So how is an Infoset network to be structurally closed? The Bavelas nets were structually closed in a Euclidean plan space; but Fullerian domes are essentially three-dimensional. The answer may be found in any convex polyhedron. The structure that we seek must reflect the notion of a perfect democracy, as was argued before. It surely means that no individual, and initially no cause, should have ascendance over any other. Then in looking for polyhedra on which to construct democratic tensegrity models, we must consider only regular polyhedra. Figures which have no top, no bottom, no sides – indeed no feature by which they may be specially oriented at all. These regular polyhedra may be distinguished by the number of their faces: The tetrahedron (four), the cube (six), the octahedron (eight), the dodecahedron (twelve) and the icosahedron (twenty). The cube's faces are squares, and the dodecahedron's are pentagons; otherwise, the faces are all equilateral triangles.

The Convext Polyhedron and its Closure

According to Euler'w law, there is a fixed relationship between the numbers of faces, the number of vertices that the faces define (that is, points where they join), and the number of edges that define the faces. Euler says that the number of faces plus the number of vertices is equal to the number of edges plus two.

Then take a look at the models on offer:

Faces + vertices = Edges + 2 Totals: No of Directed Edges per Vertex

Tetrahedron	4 + 4 = 6 + 2 = 8 : 3
Cube	6 + 8 = 12 + 2 = 14 : 3
Octahedron	8 + 6 = 12 + 2 = 14 : 4
Dodecahedron	12 + 20 = 30 + 2 = 32 : 3
Icosahedron	20 + 12 = 30 + 2 = 32 : 5

Without pursuing all the relevant arguments here, I decided to base my major experiments on the icosahedron, and to consider the edges as representing Infoset members (namely thirty) and the vertices as representing topics or key issues (namely twelve), with the result that the edges conjoining at each vertex (namely five) would be protagonists for each topic. There is an indefinite number of ways of doing this modellingl but once these conventions were adopted, the attraction of the icosahedron above the other polyhedra becomes fairly evident. There are no proofs to offer, but there is accumulated knowledge about interpersonal systems.

In the first place, five discussants per topic is a "good" number whereas three is certainly low. In the tensegrity team, or Infoset, each person has a responsibility in the two teams (vertices) that define the ends of his/her edge, which means that one third of the Infoset has direct responsibility in topic formulation and development for any two topics. This is a high Centrality ratio, whilst no being stressful for the member concerned. Next, the fact of thirty members in an Infoset chimes well with experience: thirty guarantees a reasonably high variety of viewpoints, without reproducing too many clones or look-alikes. Moreover, and perhaps for just that reason, thirty people are often thought roughly speaking (a personal observation) the key number of influential members of a management group. A government may have 80 to 100 ministers, and a "kitchen cabinet" of 8 – 10. Perhaps thirty offers a balance of power that has to be seriously considered in order to maintain it.

We re left with the residual fact that in such a scheme there will be twelve, exactly twelve, topics… This sounds like imposing a strait-jacket. The more this was reviewed via the experiments the more obvious it became that the number is quite arbitrary. Any number of topics may be contracted or expanded to twelve by sensible drafting. What matters is whether twelve topics are sufficiently discriminatory – neither swamping us with "the world is a mess" on the one hand, or boring us for a lifetime with "the 793 rd item is the drainage system in the Priscelli Mountains". It was a clear judgement of experience by many, the participants in the 1990 experiments, that twelve topics made for rich discrimination but were not by their mere numbers overwhelming.

Thus it is that physical icosahedral models have been springing up in many contexts and sizes in many parts of the world just recently. And since every edge represents a person belonging to two teams, many of these models are coloured in twelve hues. There is a Ms. Red-Yellow, who belongs to both the red and the yellow topics, and a Mr. Silver-Gold whose "edge" lands in both the silver and gold vertices. Many people have newly begun to study the works of the great R. Buckminster Fuller; and this is the time to mention a wonderful synopsis for those daunted by the massive and difficult volumes of his already referenced. "The Synergetic Geometry of R. Buckminster Fuller" is the subtitle of this slim volume. Please consult the references (Edmondson, 1987) for the title itself, which I find it hard to write down…

The icosahedron already exhibits tensegrity: it is a remarkably strong structure. In his never-ending search for "more with less" improvements, however, Bucky elaborated its shell with sets of triangles implanted within the triangles of the icosahedral faces, and thereby created a kind of extra skin to reinforce his domes. He wanted to keep the internal space inviolate: because the idea was to live, exhibit or otherwise operate inside the geodesic dome. No such inhibition is exerted on the designer of a Team Tensegrity, for whom the internal icosahedral space is purely notional. This space is fascinating in itself.

Again, then, beyond its architectural embodiment. It fascinated Plato, Leonardo da Vinci and Kepler before Buckminster Fuller, and may fascinate the designer of social systems further yet.

Qualifications of the Icosahedron

There are, astonishingly enough, only three quantities that measure the physical extension of the icosahedron. The first is the length of an edge – the distance between a pair of vertices. The second is the distance between opposite poles, which is the longest length in evidence. There are six axes to the icosahedron, which can be made to spin serenely between each pair of poles. Buckminster Fuller referred to "spinnability" and considered that the need to neutralise (as it were) a pair of poles in order to effect the spin accounted for the invariant factor two in Euler's equation. It is a surprising idea. But never take a genius too lightly.

The third stable quantity is the distance, through the internal space, of next-but-one neighbours. Five vertices depend from each vertex that are neither neighbours nor polar opposites. That makes sixty internal tensile relationships, represented by thirty internal struts, that can be conceived as pulling all the vertices in toward each other. The strength of the whole edifice is now spectacular. What we need to know is what these tensegrity components could possibly represent in human terms.

And yet it is obvious. Insofar as an Infoset member (an edge, recall) "belongs" to the two teams that are the vertices of this edge, the teams represent the compressive strength of their members – although it is true, because of reverberation, that the icosahedral whole will exercise tension at each vertex. If however, each team of five at each vertex appoints one member each as a CRITIC to the next-but-one neighbour team, then the whole icosahdral space is interlaced with tensile componentry. The consequence for each individual is that not only is s/he a member of two teams, but a critic of two near-neighbour teams as well. There are now 120 roles being played out in the Infoset. Consider the strength, the cohesion… the tensegrity. And yet no-one is overwhelmed with variety, as so easily happens (for example in the Matrix organization mentioned before).

The fact is that in a group of n members, there are n(n-l) relationships – allowing for the undeniable fact that these relationships are directional. (That is to say that an uncle is not the same thing as a nephew.) So the total connectivity of a thirty-Infoset is 870. An Infoset meeting that tried to accommodate this number of direct personal interactions would take forever. But if each person has only four roles, we reduce proliferating variety to 120 – and this, it seems, can be handled. but (as the experiments laid bare) it still takes time.

It is interesting to apply the Bavelas measures with which we began to the three-dimensional closure of the icosahedron. Even though he did not envisage the extension from a plane space to a three-space, he had already – all those years ago – offered closure in the shape of the Ring Net. Well, if a Team Tensegrity player is directly a member of two teams, and also a direct critic of two other teams, he may contact twenty people (including his nodal self) in ONE step. This leaves the 10 people comprising the teams at his two polar opposites, each of whom may be reached in THREE STEPS around the polyhedron; making 30 steps. Thus each person has full connectivity in 50 steps, and Group Dispersion enumerates to 1500. Each person's Relative Centrality is 1500 divided by 50, which is 30. But since the Centrality of the most central player is 30, and all players are alike, Peripherality is 30 – 30 = zero. This is exactly what our presuppositions about democracy and symmetry led us to expect from adopting such a model as this.

These calculations can be satisfactorily repeated for other polyhedra, of course. But it is worth reverting to the choice of icosahedron in terms of the tensile role of critic. In a tetrahedron, all vertices are already connected by edges, so there is no internal tensility to play with unless the protocol is changed. Dr. Robert Pisani of Pacific Bell has reported success by doing so. A pyramid on a square base has eight people discussing five topics, and only two tensile components. A double pyramid on a square base (octahedron) has eight uniform triangular sides; three tensile components could be inserted across the apices. In the model as conceived (edges = people) this would involve twelve people in discussing six topics. The cube is an interesting case: we have twelve people discussing eight topics: but in the tensiles, if we want to maintain perfect symmetry, we have no less than sixteen critical functions – four body centred and twelve face-centred, to use crystallographic nomenclature. Playing with all these alternatives is a fascinating pursuit, and perhaps it is clearer now why the chosen polyhedron was selected.

The forthcoming book, in course of preparation for John Wiley & Sons, will describe the experiments and examine the consequences in full detail: there is much more to say. In the meantime, this chapter tells a story about origins, and the chapter by David Schecter recounts a practical experiment - made in the corporate context. The first published statement about these ideas (Beer, 1990) appeared five years after it was in fact written.

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