laetus in praesens

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# Polyhedral Pattern Language

## Software facilitation of emergence, representation and transformation of psycho-social organization

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Also available in a PDF version for printing convenience. Sequel to *Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors* (2008). Associated with: *Polyhedral Empowerment of Networks through Symmetry: psycho-social implications for organization and global governance* (2008) and *Configuring Global Governance Groups: experimental visualization of possible integrative relationships* (2008).

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*The significant problems we face can not be solved at the same level of thinking*
*we were at when we created them* (Einstein)
Learning: Governance needs a new language?

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## Context

Part A is effectively a commentary on the polyhedral exploration software *Stella Navigator*, produced by Robert Webb (*Stella: Polyhedron Navigator*. *Symmetry: Culture and Science*, 2000); a helpful overview of the application is provided in *Wikipedia*. Its most recent version provides unique access to polyhedra in both three and four dimensions. Demo versions (3D or 4D) may be downloaded free of charge; an explanatory manual is available.

The commentary follows from a recent study of the relevance of polyhedra to global governance (*Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors*, 2008). Here "polyhedral" is specifically used to convey the need to explore "many-sided" forms of psycho-social organization. These constitute an integrative challenge of governance from the world to the local level -- if not to personal self-governance and identity. In that respect "global" is also to be understood in its integrative sense of a "whole" and not only in its geo-political sense of world-wide (cf *Future Generation through Global Conversation: in quest of collective well-being through conversation in the present moment*, 1997) .

The concern here with polyhedra dates from work within the context of the Union of International Associations in the period 1997-2000 on the online, multi-media, interactive representation of complex networks of international organizations, world problems, global strategies and human values, notably developed from 1972 within the *Encyclopedia of World Problems and Human Potential*. The later work formed part of a project funded by the European Commission (*Ecolynx: an information context for biodiversity conservation*, 1997-2000) and subsequently evaluated positively by the World Bank for a development focus (*INTERCEPT: Interactive Contextual Environmental Planning Tool for developing countries*, 1998). In that period various experiments were undertaken to enable online users to associate particular portions of such networks with polyhedra in virtual reality (VRML) in order to facilitate their comprehension and as a point of entry to text profiles of the entities in the networks. Those in Figures 1 and 2 below were generated online directly from the databases, for example. Although the databases are still online -- some being freely accessible -- the transfer to a new platform has meant that these experiments are no longer accessible.

A range of these facilities is described elsewhere (*Information Visualization and Sonification: displaying complexes of problems, strategies, values and organizations*, 2001). The concern here however is to identify concrete possibilities and applications for the future.

Part B considers the possible future extension of *Stella* to tensegrity representation. Part C evokes a range of meta-patterning considerations, notably from other cultural perspectives.

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## PART A: Polyhedral mapping experiments and use of Stella Navigator

### Focus and psycho-social relevance

It should be stressed that the *Stella* software has been primarily, if not uniquely, developed for exploration of the geometry of polyhedra. Any associated possible uses in the above context are therefore incidental. The purpose of this commentary is to determine how it may already be used for the exploration of psycho-social organization and how it might possibly be extended to facilitate further explorations of that kind.

The argument for the use of polyhedra has been developed in the earlier paper (*Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors*, 2008). Basically the argument is that governance of any kind is cognitively challenged by the complexity of the psycho-social oranization that needs to be ordered and comprehended. Use of hierarchical organization charts, bullet points and simple mind maps is not adequate to the complexity and need for coherence.

Polyhedra, especially those of higher complexity, offer representational devices onto which complexity can be projected in such a manner as to enhance mnemonic possibilities and a sense of transformational potential -- especially when these are reinforced by properties of regularity, symmetry and appropriately variegated colouring. The concern in what follows is therefore with the **use of polyhedra as "conceptual coat-hangers" (integrative memory aids or "cognitive prosthetics")** and how the features of the *Stella* applications might be used for such purposes -- now or in the future..

The focus here is therefore both on how the application can be currently used for that purpose and how it might be extended in support of other uses. Additionally there is the question of whether such an application suggests unforeseen approaches to facilitating the emergence, representation and transformation of psycho-social organization (whether groups, organizations, networks, problems, strategies, concepts or values).

This focus on facilitating psycho-social organization, its emergence and representation (especially through symmetrical polyhedral forms of tensegity), depends on the confluence of several essentially independent lines of investigation -- some of which have been unfortunately inhibited by intellectual property rights. These are:

- the purely mathematical (geometrical) representation of polyhedra on which symmetrical tenesgrities are based,
- the analysis of non-linear dynamics typical of tensegrities
- the challenges of tensegrity for architects in the construction industry
- the implications for concept formation associated with the work on conversation theory and interaction of actors, based on the prismatic tensegrity
- the implications of spatial metaphors in physical space for the organization of cognitive and social space

The relevance is foreseen in relation to:

- emergence and support for "polyhedral" forms of "global" governance, as previously argued (*Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors*, 2008)
- emergence and support for new forms of organization, in which third order cybernetics is consider significant, as previously argued (*Consciously Self-reflexive Global Initiatives: Renaissance zones, complex adaptive systems, and third order organizations*, 2007)

- emergence and support for new forms of virtual organization within social network and gaming environments, because of the potential there for early uptake and dynamic development, for reasons noted elsewhere (*Engaging with popular games*, 2008), encouraging such uptake in virtual networks of excellence where issues of collective intelligence are significant (cf *Meta-challenges of the Future: for networking through think-tanks*, 2005)
- cognitive significance of the spherical metaphor in dialogue (*Spherical Configuration of Interlocking Roundtables: Internet enhancement of global self-organization through patterns of dialogue*, 1998), in ordering knowledge (*Spherical Configuration of Categories -- to reflect systemic patterns of environmental checks and balances*, 1994), in funding flows (*Spherical Accounting: using geometry to embody developmental integrity*, 2004), and in learning spaces (*Coherent Organization of a Navigable Problem-Solution-Learning Space*, 1996)

**Figure 1: Mapping of problems and organizations onto selected polyhedra in virtual reality**
**(**extract from *Exploring Intelligible Associations: integrative modes and metaphors*, 2006
as presented to the German Research Centre for Artificial Intelligence)

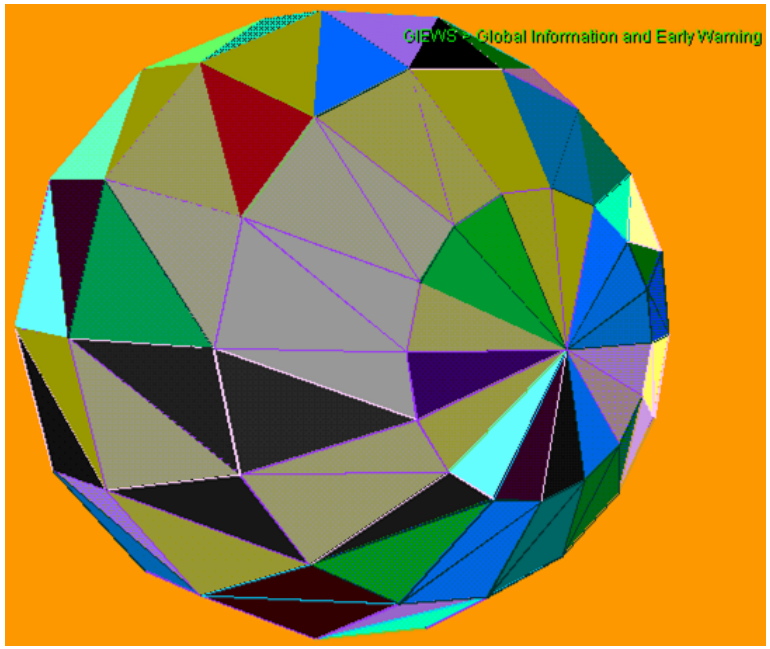
| Selected issues relating to "discrimation against women" | Selected components of the "EU system" |
|---|---|
|   |   |

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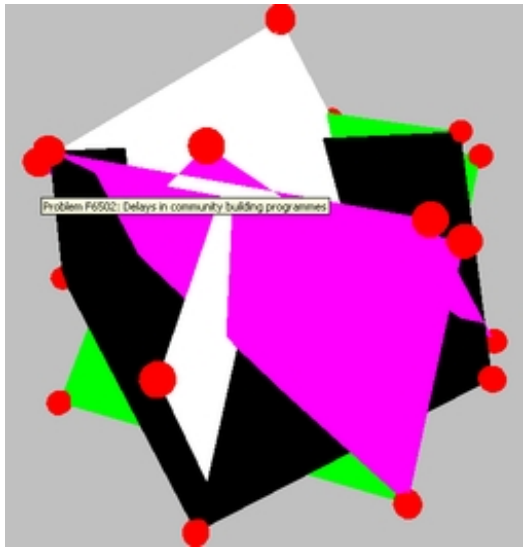
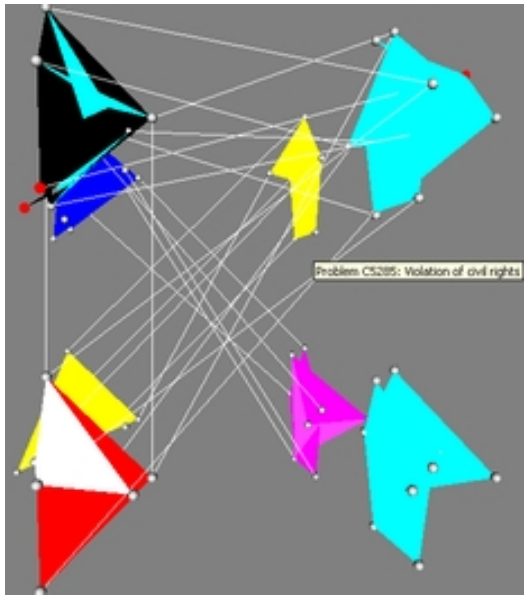
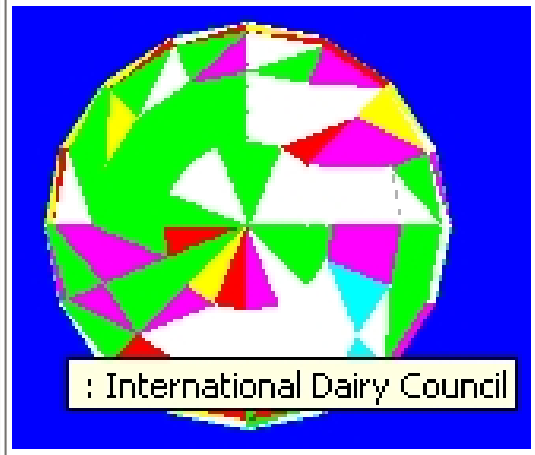
**Figure 2: Selected screen shots of previous experimental visualizations (1997-2001)**
(click on each for navigable version in **virtual reality**; possibly with the free browser Cortona plugin
-- available for PC, Mac OS X, and Pocket PC platforms --
**mouseover** nodes or faces for entity names; many **hotlinked to text profiles**)

| | | |
|---|---|---|
|   |   |   |
| Interlocking world problem loops displayed as a "polyhedron" of intersecting planes | Clusters of interlocking problem loops with links between them | International organizations mapped onto faces of an (incomplete) spherical polyhedron (larger file, slow to mani9pulate) |

## Currently relevant features of *Stella*

The general features are detailed in the original paper by Robert Webb (*Stella: Polyhedron Navigator*. *Symmetry: Culture and Science*, 2000). They are of course presented in detail in the current help manuals associated with the applications.

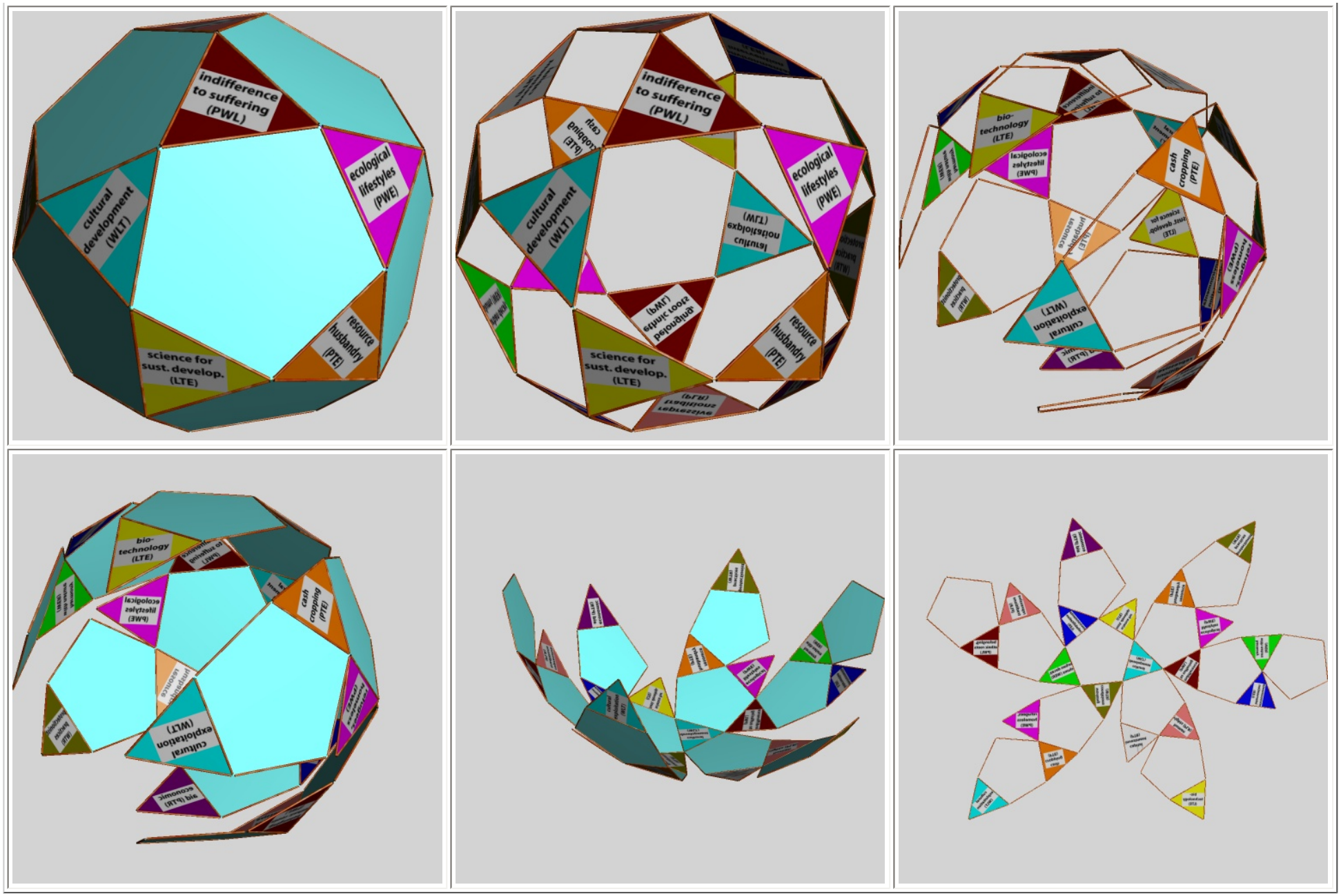
The following is a commentary on features of special interest that enhance the mnemonic function that might prove significant in various institutional and strategic design situations:

- **selection/deselection**: Faces or vertices of a polyhedron may be independently selected for subsequent operations.
- **2D/3D network mapping:** Polyhedra may notably be represented in
    - 3D form, which can be rotated, enlarged, etc
    - 2D form, as a map of the faces (net map)
  - The two forms may be positioned in facing screen windows with some changes made to one then reflected in the other.
- **colouring**: A complete sepectrum of colours may be used to distinguish faces according to various schemes. It is less evident to what degree the transparency can be increased to view through a polyhedron
- **images:** Application of images to faces is excellent. This could already be used to represent on an appropriate polyhedron::
    - logos of organizations collaborating in a coalition
    - faces of representatives, stakeholders, sponsors, collaborators in a collective endeavour
    - faces of organization members, contacts or friends in a network or coalition
    - faces of participants in a meeting
  - This is the basis for any relevant web page, allowing the global representation of such organization to be explored with a virtual reality browser.

- A list of images may be submitted for random allocation to faces of a selectged polyhedron.

- **labelling**: Having selected a face or vertex, text may be associated with it in two ways:
  - using "Edit->Text for Face/Vertex (or using Ctrl+T). Lengthy labels do not wrap within the face (and why should they). The labels stay upright when the structure is rotated.
  - applying text already converted into an image (as described above), presumably allowing more text in a wider range of formats. But the image would then not remain upright on rotation.
  - Typical labels might include names of:
    - people (contacts, collaborators, friends, etc)
    - organization units, collaborating organizations, sponsors
    - problems and elements of a problem
    - strategies and components of a strategy
    - values basic to an ethical charter
- **on-the-fly vs pre-set images/labels**: A distinction could be made in practice between:
  - a pre-selected polyhedron to whose faces and/or vertices images and/or labels were associated
  - a polyhedron selected in a meeting (say), to which labels and/or images were variously attached
  - a pre-selected polyhedron whose pattern of labels and/or images was then modified in the meeting (adding extra people, stakeholders, etc)
- **transformation:**
  - **between structures**: Morphing from one structure to another (notably duals) has been implemented in a variety of ways. It is not yet clear what happens to labels in the process. However with respect to transformation between two arbitrary forms, this cannot be done in *Stella*
  - **from 2D to 3D:** Flat net structures can already be folded (morphed) into the 3D variant -- and vice versa. One practical example of this challenge is illustrated by the use of the icosidodecahedron net structure as a mapping of strategic challenges from the Earth Summit (Rio de Janeiro, 1992) [image***]

**Figure 3: Transformation of representations of issue arenas on an icosidodecahedral net** (using *Stella*)
Derived from one original mapping of a set of global strategic dilemmas (as explained in
*Configuring Globally and Contending Locally: shaping the global network of local bargains by decoding and mapping Earth Summit inter-sectoral issues*, 1992)
The succession of images below shows stages in the unfolding of an icosidodecahedral mapping from 3D to 2D; a wide variety of other manipulations may be used in *Stella* to explore this pattern. Of particular interest is the relationship between the parts and the implications for any specific "roundtables" in relation to any global bargain (see commentary)
The 20 labelled triangles (paired) correspond to 3-fold issue complexes, whereas the 12 unlabelled pentagons correspond to 5-fold issue complexes, each necessitating more complex dialogue; the structure is integrated by 5 strategic themes. An unlabelled version of the structure, exported from *Stella*, can be viewed in virtual reality, possibly with the free browser Cortona plugin (for PC, Mac OS X, and Pocket PC platforms)
[click on each image below for enlarged version]




The above representation suggests a distinct between:

- "incommensurable" thematic concerns encoded by the 6 "great circles" used in the 1992 exercise: P = population, security; W = well-being, health; L = learning, education; T = trade, production; E = environmental, impacts; R = regulation, equity (*Inter-sectoral Strategic Dilemmas of Sustainable Development*)

- the various specific issue areas (encoded here as keyword-labeled triangles), which emerge from the interplay between any three of those themes (P, W, L, T, E or R); expanded descriptions of each triangle are provided separately (*Significance of 3-domain Dilemma Codes*)
- the distinct and relatively complex arenas (encoded here as unlabelled, or transparent, pentagons), possibly to be considered as the **dialogue environments** in which some reconciliation is sought between the 5 associated (triangular) issue arenas -- relatively unconstrained, in each case, by the **absence** of one of the 6 great circle themes

Framed in this way, it is how the configuration of elements offer a degree of integrity to the variety of otherwise fragmented elements in the global debates (cf *Spherical Configuration of Interlocking Roundtables: Internet enhancement of global self-organization through patterns of dialogue*, 1998).

## Possible additional features

There are clearly several options in this respect:

- **additional features** incorporated into subsequent releases of *Stella*
- **separate modules** (plug-ins) for optional use with *Stella*. In this case the approach is to get a module to work for a particular class of polyhedra, as with geodesics, and thereafter to build up plug-ins for various interesting classes of polyhedra.
- **development of a distinct variant** of *Stella* for the organization of data
- **export to third party packages**: *Stella* already provides for export in a variety of forms. The question is what might be the input constraints on other packages

It is important to recognize the prime function of *Stella* in considering such options. Such changes might simply complicate unnecessarily a well-honed application. One alternative is of course to allow users to select additional tool bars for facilities unrelated to the primary function -- such as some discussed below.

**Labelling and images**: As it currently functions, *Stella* ensures that colours, labels and images "stick" to surfaces to a very useful degree when rotated, etc. However, colours seem to stick over a wider variety of transformations -- including morphing -- than labels or images. Colours are also appropriately reflected in both 2D and 3D versions?

It would be convenient if labels and images applied to a face in 2D net representation could be preserved rather than lost when the image is folded into 3D. To what degree can labels and images be preserved through a greater variety of transformations

**External links:** These could be of various types:

- **links to external web pages:** Hotlinking from faces or vertices is not currently provided.
- **links to sound files:** An interesting possibility is to active a sound file associated with a particular face or vertex -- perhaps a key statement or commitment by a stakeholder
- **links to other applications:** These might include PPTs associated with progress reporting of an organization associated with a particular face or vertex.

All such links would currently require significant effort to export from *Stella* to VRML and might therefore be more appropriate in a separate application.

**Identification of usable representations**: With respect to on-the-fly input, one interesting feature would be to be able to call up (and/or select) a list of polyhedra with user-specified numeric properties, based on numbers of faces, edges, and/or vertices. Whilst polyhedra may be selected by type through a drop down menu, and many properties of any selected polyhedron are listed, there is no apparent means to search on such properties.

As an alternative, there is of course the *Wikipedia* *List of uniform polyhedra*, presented in tabular form, with images (in fact created using *Stella*) and with links to entries in *Wikipedia* on each. The table permits polyhedra to be identified by numbers or faces, edges or vertices. However the tabulation only includes a small subset of the polyhedra available through *Stella*. In *Wikipedia* the typology of uniform polyhedra is usefully described separately.

Thus if one had an organization with N major divisions, what polyhedra might one project (map) it on to -- in terms of faces, edges or vertices? Could the user run through a proposed list of possible "good fits" and make a selection?

How might one distinguish between primary features and secondary features, namely if each division had sections, how might these be attributed to smaller faces, etc? Or is the divisional level to be associated with groups of faces appropriately shaped and coloured?

**Importing sets of linked entities:** In the earlier online exploration, a set of linked entities was imported (effectively as output from a search process by keyword) and then fitted, according to a (crude) algorithm. The interface then allowed the user to intervene in the process (see image ***).

- The question is what kind of input format might be processed by such an algorithm -- clearly things could be made more or less sophisticated. That version put face or node labels into mouseover for VRML display and provided for hotlinking. Traces of this are still evident in the Java spring map version currently operational online.
- More interesting is the possibility to import an organizational nested hierarchy structure (line by line), or more generally a formatted network (links indicated to other nodes from each line), with a text label (for mouseover display) and possibly a URL (for hotlink). Input formats of this kind are common for network analysis and organization chart display programs
- Given the variety of entities that might be so input as a list (possibly of files), consideration could be given to distributing them across the available faces
    - randomly: as is currently done for colours in "rainbow mode" -- thereby extended to a list of images, sound files or labels, or possibly all three (CSV delimited) since they are not incompatible on a surface
    - ordered/clustered in some way (in the light of the following discussion on matching) -- raising the question of cognitively meaningful design metaphors for such distribution

  Already *Stella* provides for inputting a list of images to be randomly distributed to faces on a selected polyhedron.
- One of the possibilities, if the image has directionality and it is not feasible to turn it as the polyhedron is rotated (as is currently done with the label), is to provide for a means of turning the polyhedron so that the image on a face is upright
- Another possibility is to envisage a parallel split screen window (substituting for the net map, for example) in which items of information from such an imported list, and relating to each (numbered) face or vertex, could be listed in note form. The items so listed might include: name, geographical base, fund allocation, date, e-mail, etc. Whether this is open to editing in that mode, prior to subsequent export, could be considered. It might be easier to organize hotlinking such a parallel display.

With an easy input of a nested hierarchy of an organization structure, or array of nested strategies, this would enable a quick flip into a really integrative polyhedral overview of the initiative. Presumably outputs in a corresponding format might be made. One example of these approaches is the application *Decision Explorer*.

**Matching and "fitting":** Implicit in the previous point is the issue of how best to "fit" the structure to an appropriate polyhedron, or possibly a set of alternatives amongst which the user can choose or switch.

Clearly solutions vary greatly from simple to very difficult depending on how good a match is required. Issues include:

- Ability of the user to specify the goodness of fit, or accept a default
- Preference would clearly be for a polyhedron with as much symmetry as possible, but some numbers are easier to match to high-symmetry polyhedra than

others
- Acceptance of blank faces where fitting cannot be achieved. Indeed one variant originally developed in VRML had either blank faces, or possibly an incomplete polyhedron where fitting could not continue -- or where the user specified a more complex polyhedron than was necessary
- Complexes of faces: With respect to nesting, clearly several approaches might be taken:
  - the smaller (secondary) face approach (mentioned above)
  - ability to allocate standard sets of faces (eg a pentagon surrounded by squares on edges and triangles at vertices) to portions of a hierarchy or to a network with particular local connectivity
  - representing each nesting by a different polyhedron, whereby clicking on a face would display a nested polyhedron of a lower hierarchical level

Clearly links should not be assigned to faces that share an edge, which would make a solution impossible most of the time.

**Concentric polyhedra:** The possibility of having concentric polyhedra (that could be displayed in wire-frame mode or with relatively high transparency) differently rotated. Seemingly this is possible, although trickier to arrange with Stella as it is.

A related possibility is to play with a light source from that centre such that, according to rotation of the concentric polyhedra, the light only "got through" certain "aligned" facets and not otherwise -- as an indication of consistency between different kinds of psycho-social structure (values, strategies, institutions and problems, for example).

## Pattern language

The large set of polyhedra of distinct types together constitute a repertoire of patterns of order. As such they are a resource on which to call for subtler forms of psycho-social organization.

The key initiative with respect to pattern language has been that of Christopher Alexander and his team (*A Pattern Language*, 1977; *The Timeless Way of Building*, 1979). The idea of a pattern language appears to apply to any complex engineering task, and has been especially influential in software engineering where patterns have been used to document collective knowledge in the field. In a subsequent study (*The Nature of Order*, 2003-2004) the mostly static patterns from *A Pattern Language* have been amended by more dynamic sequences, which describe how to work towards patterns.

Alexander's earlier pattern language insights have been adapted experimentally to explore a more generic *5-fold Pattern Language* (1984) of relevance to psycho-social organization:

- Physical environment: an adaptation of Alexander's own pattern description
- Socio-organizational environment: the pattern as it applies to the organization of social groups, organizations and networks.
- Conceptual environment: the pattern as it applies to the organization of a conceptual framework or a body of knowledge.
- Intra-personal environment: the pattern as it applies to the organization of modes of awareness adopted by a person.

A question to be explored with a polyhedral software application is the extent to which such patterns can be suitably, and memorably, represented by families of polyhedra. This is the crucial question, determining the relevance of this approach.

Is the taxonomy of psycho-social organization now in what might be termed a pre-Linnaean stage, given the significance that came to be attached to Linnaean taxonomy? Of interest in this respect is the role first played in flowering plant classification of the number of stamens in the bloom. It might be asked whether conceptual models (including their strategic and organizational reflections) could not be usefully distinguished by the kinds of numbers used too distinguished

polyhedra (cf *Representation, Comprehension and Communication of Sets: the role of number*, 1978).

It would be very interesting if any periodic table of polyhedra -- each understood as a classification -- could be understood as providing insight into a classification of classification systems (cf Birger Hjørland, *Lifeboat for Knowledge Organization*; *Classification*, 2008). What indeed are the *Patterns of Conceptual Integration* (1984) in the light of the range of challenging examples (cf *Patterns of N-foldness: comparison of integrated multi-set concept schemes as forms of presentation*, 1980)? How such a periodic table might be "tuned" is fundamental to any response to the divisive psycho-social initiatives that are a preoccupation of governance (*Tuning a Periodic Table of Religions, Epistemologies and Spirituality -- including the sciences and other belief systems*, 2007).

Also of interest in this context s is the possibility of considering each polyhedron as modelling a learning system. This would then relate to the literature on the classification of learning systems, currently of relevance to artificial intelligence research (Douglas J. Pearson and John E. Laird, *Incremental Learning of Procedural Planning Knowledge in Challenging Environments*, 2005). Of relevance to understanding through polyhedra is the investigation of adaptive learning of geometry (Harri Ketamo, *An Adaptive Geometry Game for Handheld Devices*, *Educational Technology & Society*, 6 (1) 2003).

## Possible applications relevant to psycho-social organization

**Team building and associated strategy**:

- **syntegration**: One potential area of application is in building up teams. Relevant in that respect is the work of Stafford Beer (*Beyond Dispute: the invention of team syntegrity*, 1995) and the franchised process of syntegration. The focus in this case is in building psycho-social structures based on the icosahedron.
- **social networking**: Another variant of this is as an extension of social networking and the current interest in enabling visualization and mapping of such networks -- typically of friends and contacts. The question is whether more coherent structures can self-organize, effectively using suitable polyhedra as catalysts or templates. This might prove a desirable additional option for those already enabled to list out such networks by name or in some other order, or based on some criteria. One reason for such developments, beyond the simple naming of members of a network, is that there are complementary qualities and characteristics important to the construction of teams with coherence. There may be a case for having a diversity of such qualities. An early proposal to that end (*Group Questing or Twelving: Proposal for a large-scale small-group development process*, 1976) points to possibilities that have yet to emerge from social networking.
- **online gaming guild**s: As discussed in the earlier paper (*Engaging with popular games*), a more probable early use of polyhedral representation of teams is in the design and management of online interactive gaming teams ("guilds") -- especially where a given polyhedron holds the "secret" of the coherence of such a guild and therefore is fundamental to its strategy and competitive advantage. In that respect, given the increasing overlap between such gaming simulations and electronic warfare, it is probable that polyhedra of appropriate complexity may be the secret to strategic success in reality. However Peter Gould and Anthony Gatrell (*A Structural Analysis of a Game: The Liverpool v Manchester United Cup Final of 1977*, Social Networks, 2 1980, 3) used the q-analysis, or polyhedral dynamics, of Ron Atkin to define and operationalise intuitive notions of structure in a soccer match between Liverpool and Manchester United. They found that the injection of q-holes, or obtrusive objects, by the defence of one team appeared to contribute to the fragmentation and loss of the other.
- **research laboratories and "centres of excellence"**: Given the interdisciplinary challenges of such environments, mapping relationships onto a polyhedral form of adequate complexity (such as to highlight complementarities) might fruitfully clarify the integrative nature of the undertaking (cf *Meta-challenges of the Future: for Networking through Think-tanks*, 2005). The approach could also be applied to the "networks of excellence" promoted by the European Commission.
- **sporting teams**: Mapping the members and/or functions of such teams onto polyhedra could provide an appropriately visible sense of the integrity of the group and its vital complementarities -- in contrast with the simplistic schematics used for this purpose, notably in communicating through the media. Of interest is whether complexifying the polyhedra used would enable additional insights to be conveyed in team training. Clearly of greater interest is the possibility that a set of interrelated polyhedra might reflect the repertoire of strategies that the team might deploy against an opposing team. Of further interest

is the possibility that the two teams might be usefully mapped onto the same polyhedron. There is even the possibility that the set of teams in a competition might together be represented in this way -- raising questions about how, as with the planes of a crystal, cognitive fascination is activated and engaged by reflection and refraction amongst the set of teams as a whole. This consideration might open the way to development of multi-sided ("polyhedral") games -- beyond the ubiquitous, binary, polarizing pattern to which politics is typically reduced.

**Complementarity vs Imbalance:** Especially important to team building, and the formation of coherent coalitions of stakeholders, is to ensure a requisite variety of complementary elements (whether people, organizations, strategies, values or concepts). The symmetry properties of the polyhedra can be used to distinguish such elements, notably by colour. Use of polyhedra in this way also serves to highlight possible imbalance.

**Mapping and encoding psycho-social functions**: The value of a polyhedral pattern language is clearly associated with the degree to which cognitive significance can be usefully mapped onto its features such as to highlight and hold complementarities and contrasts. This may be primarily a matter of exploration within the contexts for which the mapping is to be used, whether a small group or a large community of interest. It may be a communication device, symbolizing an initiative, irrespective of whether the mapping is universally acceptable. The range of geographical projections of the world points to the kind of variety that is possible and variously considered desirable

In its simplest form, the question is if a set of specific psycho-social functions is distinguished -- whether as principles, action programmes, values, qualities, etc -- is it helpful to map these onto a polyhedral form rather than present them solely as a checklist? Many such sets have been elaborated with different numbers of elements. Clearly a match can be attempted purely on the basis of the number (*Representation, Comprehension and Communication of Sets: the role of number*, 1978).

An unfortunate feature of many such extant checklists is that, because of their simple structure, no attempt is made to consider the relationships between elements of the set -- relationships which may be of considerable importance to the integrity and viability of the set when applied. *Agenda 21*, as formulated by the UN Earth Summit (Rio de Janeiro, 1992) is an example of an asystemic set of articles in that the relationships between the disparate parts are not considered. A mapping onto a polyhedron may highlight useful questions about relationships implied by the polyhedral pattern. These can lead to useful reconfiguration of the set.

Of particular interest is the case of sets of functions that are considered well-defined and complete. The Myers-Briggs Type Indicator is one example, with its 16 types. These could be mapped onto the vertices of an octagonal prism or the edges of a square antiprism. Clearly the 12 astrological types, as with any other 12-fold set, may be mapped onto a wider variety of convex polyhedra of greater symmetry (vertices: truncated tetrahedron, cuboctahedron, icosahedron; edges: cube, octahedron; faces: dodecahedron, ) as well as non-convex forms (edges: tetrahemihexahedron; vertices: cubohemioctahedron, octahemioctahedron, great dodecahedron; faces: octahemioctahedron, great dodecahedron) and less symmetrical forms. Even those with more complicated names are readily comprehensible visually.

Given the importance of duals in relation to the geometry of many polyhedra, the significance of any corresponding mapping is of great potential interest. A dual of a polyhedron is one in which the vertices of the first correspond to the faces of the second. This implies an interesting relationship in alternating, through the dual, between:

- **vertices** used to map the nodes in a network of people, institutions, problems, concepts, -- with the edges of the polyhedron then indicating the links between them,
- **faces** used individually to map people, institutions, etc -- namely one per face -- with the edges linking the interface to other people, institutions, concepts, etc (across the edge)

Potentially more intriguing is the manner in which the form of a polyhedron may be usefully "decoded", recognizing the specialized interests that have explored this

-- such as anthroposophy with respect to "projective geometry" and others with various approaches to "sacred geometry".

**Mapping systems to highlight viability**: Governance of any kind is called upon to deal with systems of increasing complexity. Such systems may be represented on hierarchical charts or systems diagrams of many kinds -- in two dimensions. Recognizing the arguments of Buckminster Fuller that polyhedra are to be understood as systems, the possible corollary that systems may be represented by polyhedra merits exploration. In that sense complex systems could be, in principle, fruitfully mapped onto complex polyhedra such as to highlight vital complementarity and necessary communication patterns (notably feedback loops).

**Seeding organization emergence**: crystal / saturation / catalysis ***

**Transformation of organization:** Identification of pathways, and transitional forms, through which an organization might evolve from one polyhedral form to another such form, possibly more complex. *Stella* already offers a number of possibilities for such transformation.

**Significant issues of cognitive perspective**: The cognitive mapping onto a surface that can be formed into a sphere raises interesting issues:

- as a **spherically symmetrical polyhedron**, it can only be viewed from one "side" and therefore has to be rotated manually -- or set to rotate -- in order to expose the other "side", and see "over the horizon". This raises the question of how the whole is to be understood and integrated
- as an **unfolded flat net**, only one side can be seen, since it lies flat. This raises the question of the other "side" which is potentially trivial since the whole net map is visible -- unless any image can only be attached to one side. This is especially significant when the flat net is folded under user control into spherical form because then the image is typically on the outer surface of the polyhedron, namely on the side currently hidden when the net lies flat -- unless the image is somehow allowed to be visible through each face of the polyhedron
- from **within the polyhedron**, which is often an option for a user who may navigate in virtual reality though the side of the polyhedron to view it from within. Here the question again is whether any images are apparent and the cognitive significance of having to rotate the polyhedron to understand the whole from within.

**Encompassing disagreement:**

- **reconfiguring factional "sides", notably in a dispute:** This possibility was the basic theme of the earlier paper (*Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors*, 2008)
- **reconfiguring "territory":** This possibility has been partially explored in an earlier paper (*And When the Bombing Stops? Territorial conflict as a challenge to mathematicians*, 2000), notably in relation to the Middle East crisis.
- **configuring global "bargains":** A different approach was taken with respect to the strategic dilemmas articulated at the 1992 Earth Summit (*Configuring Globally and Contending Locally: shaping the global network of local bargains by decoding and mapping Earth Summit inter-sectoral issues*, 1992). This followed earlier related consideration of incommensurability (*Containing the incommensurable*, 1995; *Using disagreements for superordinate frame configuration*, 1995; *Insights evoked by intractable international differences*, 1993; *Reordering Networks of Incommensurable Concepts in Phased Cycles*, 1988)

**Communicating meeting outcomes**: The process whereby an integrative synthesis is derived from the insights expressed at a meeting -- the global "sense of the meeting" in Quaker terms -- could be understood in terms of the ability to produce a mapping of them onto a suitable polyhedron. This could then be a visual complement to a press release -- even an index to its elements (on a web page).

Curiously this echoes the intuition associated with the use of gold "nuggets" as a significant meeting product, or even the discovery of "diamonds" in the meeting process. To the extent that the pattern of such insight is reflected in a concluding declaration, its elements could also be usefully mapped onto a polyhedron

(*Patterning Archetypal Templates of Emergent Order: implications of diamond faceting for enlightening dialogue*, 2002; *Structure of Declarations: challenging traditional patterns*, 1993) possibly even to be associated with song (*A Singable Earth Charter, EU Constitution or Global Ethic?* 2006). In this context, in relation to discussion of tensegrity structures below, Ronald J. Barnett and Gregory W. Cherry have applied for a patent on *Tensegrity Musical Structures*.

**Communication of more complex forms of organization:** Just as a spiral staircase does not lend itself to comprehensible verbal description without any illustration (if only gestures), so there may be many forms of coherent organization that could well depend on the kind of cognitive prosthetic provided by a polyhedron of whatever degree of complexity. As with the spiral staircase, this may enable transition from one level to another. The polyhedron then functions as a mnemonic of a superior degree of order to bullet pointed charts, other checklists and complex organizations charts that do not enhance memorability. Without such support, higher degrees of ordered complexity become essentially unsustainable.

Configuration of the parts, with which people may variously and separately identify, helps to determine whether, as a confguration, a larger and deeper sense of identity and significance emerges. The question is then whether the emergent organization corresponds to a mode of organization with which people are already familiar (experientially) but for whose patterns no adequate description has as yet been found -- as with an "unformed" sense of community or team.

Insightful discussion of the associated communication and comprehension challenges is provided by mathematician Ron Atkin (*Multidimensional Man; can man live in 3-dimensional space?* 1981; *Combinatorial Connectivities in Social Systems; an application of simplicial complex structures to the study of large organizations*, 1977) as summarized elsewhere (*Social organization determined by incommunicability of insights*, 1995).

Such considerations point to the possibility of using interrelated polyhedra, of different degrees of complexity, to map psycho-social issues (over) simply, comprehensibly, and more challengingly -- such as to elicit a greater degree of imaginative engagement. Exploration of the transformations between these degrees of complexity enable learning pathways to be highlighted. They also point to patterns of insight and order that are more likely to be forgotten -- and which are effectively meta-stable and unsustainable, namely which lack adequate mnemonic reinforcement.

## Test applications

It is appropriate to consider a wide variety of test cases, which may help to render the use of *Stella* credible as a pattern language tool in domains in which this might not otherwise be the case:

- **Governance focus:**
  - **UN Specialized Agencies**: The most prominent of these could be mapped onto a polyhedron (using their logos, for example, as illustrated below). Of interest would be to complexify the polyhedron to varying degrees to enable addition of secondary UN agencies. The challenge would be to find an instructive mapping of all such agencies onto a polyhedron of suitable complexity. One use would be to be able to increase or decrease the complexity for different purposes and audiences.
  - **European Union agencies**: A similar approach could be taken to the UN case (as was done in an earlier experiment, illustrated above)
  - **UN Declaration of Human Rights**: A mapping of each of the 30 Articles onto a polyhedron, if only as keywords could be very instructive (whether or not hotlinking to complete texts was feasible).
  - **Groupings of countries**: Significant groups proposed for purposes of governance (for example, the Group of 20 -- industrial or the G20 Group of 20 -- developing) could be fruitfully explored by mapping each country onto a face of an icosahedron. But the lines and challenges of communication and coordination could be better highlighted by using an icosidodecahedron that interrelates negotiating arenas between clusters of 5 countries -- although a key challenge would be how the countries are then positioned in relation to such arenas (a complexification into 3D of the conventional challenge of configuring placement at a negotiating table). (Note: this was done, using *Stella*, as an exploratory exercise in a separate paper).

- **Symbolic and mythical focus**:
  - **Pantheons**: A mapping of the Olympian Dodekatheon, as suggested earlier (*Re-membering the Dodekatheon*), could prove of great interest if appropriate relationships could be highlighted
  - **Zodiac**: A representation on a dodecahedral form, as suggested earlier (*Engaging with popular astrology*), could establish relevance in a wide variety of contexts, especially if colouring and symmetry could be used to exemplify integrative relationships through complementarities; more complex dodecahedral forms might also be used. Collapsing the form down to its 3-fold and 4-fold elements might also be instructive in valued ways. The mapping could be done through astrological signs. It is appropriate to note the extensive interest in non-cubic (including dodecahedral) dice in parts of the widespread (online) role playing community with mythical interests, as discussed earlier (*Engaging with popular games*). Many might be intrigued by the potentials of the polyhedral manipulation of such a mapping.
  - **Sephiroth**: The challenge of mapping the central symbolism of the Kabbalah of Judaism onto polyhedra has been variously explored by many including Anders Sandberg (*Some Random Thoughts about the Occult Correspondences of the Platonic Solids and Their Symmetries*). Such possibilities are a focus for a variety of studies, using polyhedra, which the capacities of *Stella* could further enable (for example: *Sacred Geometry of One and the 13 Sephiroth Tree of Life*, 2003; Stephen M. Phillips, *The '120 Polyhedron' and the '144 Polyhedron' as the Exterior and Interior of the Inner Tree of Life*).
  - **Apostles**: Mapping the 12 apostles of Christianity onto a dodecahedral form could be considered very significant to many, especially if their characteristics, and relationships between them, could be aesthetically highlighted by colour and symmetry.

Self-reflexivity might even be further enhanced by mapping Christopher Alexander's set of patterns onto a suitably complex polyhedron.

Of related interest, in practice, is the possibility of using *Stella* to enable people to construct and share polyhedral mappings in support of their worldview, much as photographs and video clips are now exchanged worldwide:

- **celebrities and idols**: Clearly it would be a relatively simple matter to apply images to the surfaces of an appropriately selected and coloured polyhedron, whether to be printed as an image, attached to an e-mail, applied to a website -- accessible as a manipulable virtual reality representation or not.
- **bar coding access to sound files**: The capacity of some portable phones to scan bar codes, suggests the possibility of variously bar coding the surfaces of a polyhedron to evoke distinct voice messages or songs from each surface.
- **meeting conclusions**: Associating the key conclusions of a meeting (strategic elements, principles, or values, etc) with the faces of a polyhedron (whether as keywords or phrases, or additionally capable of triggering display of other information), would allow them to be widely disseminated as image or virtual reality files. The technology is even available to encase such a polyhedron in a transparent ball of plastic (of tennis ball size) as a significant form of "executive gimmick" -- for which there is indeed a significant market. Such "balls" might even be of interest for the public relations of complex intergovernmental organizations.

Success with a number of these test cases would offer powerful symbols, in polyhedral form, of the integrative identity of topics that are otherwise considered to be regrettably quite fragmented in the understanding of many. Such a possibility was notably seen as relevant on the occasion of the establishment of the Mediterranean Union (*Mediterranean Union: a symbolic challenge*).

**Figure 4: Application of 12 UN Specialized Agencies to faces of a dodecahedron in *Stella***
progressive unfolding from 3D to 2D

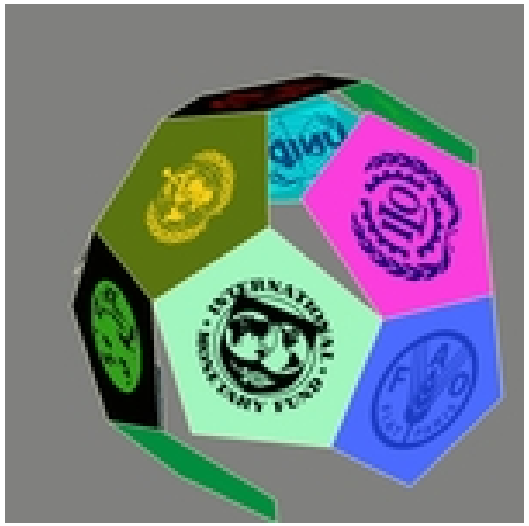




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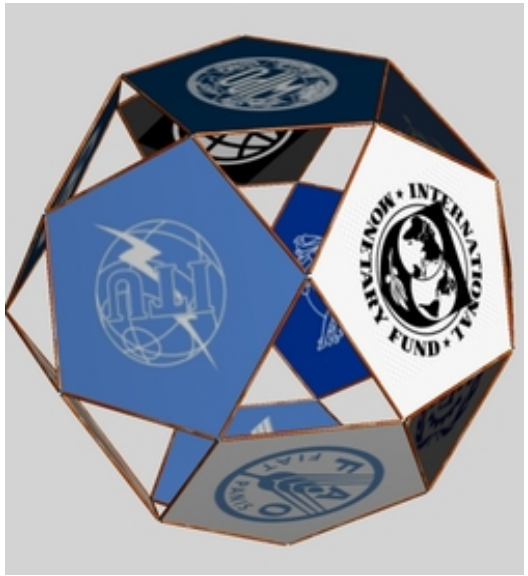
**Figure 5: Complexification of the above UN Agency example**
**(from dodecahedron to icosidodecahedron) using *Stella***
with subsequent morphing to yet more complex forms (by various methods),
suggesting increasing challenges (and possibilities) of communication and integration amongst the set of agencies so mapped;
a facetting diagram for the icosidodecahedron is also included (as an indication of possible communication pathways)



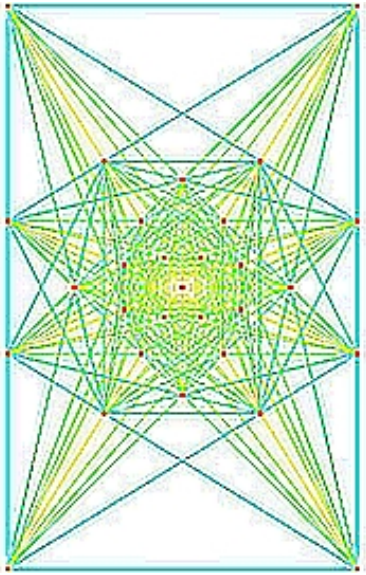


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**Figure 6: Mapping possibilities of Platonic and Archimedean polyhedra exemplified by G8 and G20 country groups (or other groups, including the nascent L20)**
(see examples of G20 mappings onto icosahedron, icosidodecahedron and rhombicosidodecahedron)

| Polyhedra. (images in illustrated list prepared using *Stella Polyhedra Navigator*; those in links below can be rotated) | Polyhedral characteristics (see comprehensive illustrated table or list) | | | | | | | | | Country Groups | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Faces | | | | | | Vertices | Edges | Total | G8 | G20 |
| | Triangle | Square | Penta. | Hexa. | Octa. | Deca. | | | | | |
| tetrahedron | 4 | - | - | - | - | - | 4 | 6 | 14 | - | - |
| octahedron | 8 | - | - | - | - | - | 6 | 12 | 26 | x | - |
| cube (hexahedron) | - | 6 | - | - | - | - | 8 | 12 | 26 | - | - |
| icosahedron | 20 | - | - | - | - | - | 12 | 30 | 62 | - | x |
| dodecahedron | - | - | 12 | - | - | -- | 20 | 30 | 62 | - | - |
| cuboctahedron | 8 | 6 | - | - | - | - | 12 | 24 | 50 | x | - |
| icosidodecahedron | 20 | - | 12 | - | - | - | 30 | 60 | 122 | - | x |
| truncated tetrahedron | 4 | - | - | 4 | - | - | 8 | 18 | 34 | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| truncated octahedron | - | 6 | - | 8 | - | - | 24 | 36 | 74 | x | - |
| truncated cube | 8 | - | - | - | 6 | - | 24 | 36 | 74 | x | - |
| truncated icosahedron | - | - | 12 | 20 | - | - | 60 | 90 | 182 | - | x |
| truncated dodecahedron | 20 | - | - | - | - | 12 | 60 | 90 | 182 | - | x |
| small rhombicuboctahedron | 8 | 18 | - | - | - | - | 24 | 48 | 98 | x | - |
| small rhombicosidodecahedron | 20 | 30 | 12 | - | - | - | 60 | 120 | 142 | - | x |
| great rhombicuboctahedron | - | 12 | - | 8 | 6 | - | 48 | 72 | 146 | x | - |
| great rhombicosidodecahedron | - | 30 | - | 20 | - | 12 | 120 | 180 | 162 | - | x |
| snub cube | 32 | 6 | - | - | - | - | 24 | 60 | 212 | - | - |
| snub dodecahedron | 80 | - | 12 | - | - | - | 60 | 150 | 202 | - | - |

Of particular interest is the manner in which use of mappings (whether for G8, G20 or L20) further down the table (namely more complex) ensures that the direct connectivity required of a given country is reduced. Thus in the G20 mapping onto an icosahedron, all triangular edges border other triangular edges and all verticies connect with other triangular vertices -- there is no "space", whatever flexibility that signifies. In the icosidodecahedron, however, only the vertices of the triangles are connected. In the rhombicosidodecahedron, the triangles do not connect with one another directly. Such complexification introduces "openness" and points to the challenge of "sparseness" rather than the need for "tight bonding" to ensure viability and integrity. Such opennes, as noted below, can only be achieved **in practice** through embodying tensegrity principles into both **communication pathways** (and dissociative **resistances**) between the countries, thereby constituting the emergent whole and its coherence.

**Figure 7: Mapping possibilities of duals of Platonic and Archimedean polyhedra**

| DUALS of Polyhedra (images in illustrated list; those in links below can be rotated) | Polyhedral characteristics of duals (for Archimedean duals, see list of Catalan solids) | | | | | | | | | Polyhedra (as in Figure 6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Faces (irregular)** | | | | | | **Vertices** | **Edges** | **Total** | |
| | **Triangle** | **Square** | **Penta.** | **Hexa.** | **Octa.** | **Deca.** | | | | |
| tetrahedron | 4 | - | - | - | - | - | 4 | 6 | 14 | tetrahedron |
| cube | - | 6 | - | - | - | - | 8 | 12 | 26 | octahedron |
| octahedron (hexahedron) | 8 | - | - | - | - | - | 6 | 12 | 26 | cube (hexahedron) |
| dodecahedron | - | - | 12 | - | - | -- | 20 | 30 | 62 | icosahedron |
| icosahedron | 20 | - | - | - | - | - | 12 | 30 | 62 | dodecahedron |
| rhombic dodecahedron | - | (12) | - | - | - | - | 14 | 24 | 50 | cuboctahedron |
| rhombic triacontahedron | - | (30) | - | - | - | - | 32 | 60 | 122 | icosidodecahedron |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| triakis tetrahedron | 12 | - | - | - | - | - | 8 | 18 | 38 | truncated tetrahedron |
| tetrakis hexahedron | 24 | - | - | - | - | - | 14 | 36 | 74 | truncated octahedron |
| triakis octahedron | 24 | - | - | - | - | - | 14 | 36 | 74 | truncated cube |
| pentakis dodecahedron | 60 | - | - | - | - | - | 32 | 90 | 182 | truncated icosahedron |
| triakis icosahedron | 60 | - | - | - | - | - | 32 | 90 | 182 | truncated dodecahedron |
| deltoidal (trapezoidal) icositetrahedron | - | (24) | - | - | - | - | 26 | 48 | 98 | small rhombicuboctahedron |
| deltoidal hexecontahedron | - | (60) | - | - | - | - | 62 | 120 | 242 | small rhombicosidodecahedron |
| disdyakis dodecahedron | 48 | - | - | - | - | - | 26 | 72 | 146 | great rhombicuboctahedron |
| disdyakis triacontahedron | 120 | - | - | - | - | - | 62 | 180 | 362 | great rhombicosidodecahedron |
| pentagonal icositetrahedron | - | - | (24) | - | - | - | 38 | 60 | 122 | snub cube |
| pentagonal hexecontahedron | - | | (60) | - | - | - | 92 | 150 | 202 | snub dodecahedron |

## PART B: Future extension to tensegrity representation

### Psycho-social operationalization of polyhedra through tensegrity representation

A major difficulty with abstract forms such as polyehdra is how they engage with psycho-social organization -- irrespective of their inherent aesthetic properties and appreciation of them as "sacred geometry". And, irrespective of recognition of their role in the architecture of biological cells (and *radiolaria*), this difficulty is evident in efforts to use such forms in the architecture of buildings -- especially those polyhedra of greater complexity.

It is in this respect that learnings from their application through tensegrity -- tensional integrity -- to unusual constructions (such as geodesic domes) are of significance (see *Documents relating to Networking, Tensegrity, Virtual Organization*). Tensegrity is the means through which polyhedral forms are "operationalized" in building and therefore, with some probability, in psycho-social organization. This raises the question of whether an as yet undiscovered "geodesic" form of psycho-social organization might notably be of great relevance to global governance.

As an additional feature therefore, the capacity in *Stella* to generate tensegrity representations of polyhedra would be an advantage -- where this is possible and appropriate . A principal reason is that there is a range of arguments suggesting that the viable structure of the more complex polyhedra -- if constructed -- is dependent on the kinds of distribution of forces associated with the tensegrity variant. This is notably true at the level of the biological cell (Donald E. Ingber, *Tensegrity and Systems Biology*, *Journal of Cell Science*, 2003).

As defined by R Buckminster Fuller (*Synergetics*: *explorations in the geometry of thinking*. 1975):

> A tensegrity system is established when a set of discontinuous compressive components interacts with a set of continuous tensile components to define a stable volume in space.

As models, the tensile elements (tendons) can be cables or strings, functioning like a network. The compressive elements can be beams or rods (struts) and function as spacers to prevent the network from collapsing. Despite the generality attributed to tensegrity principles (and explicit in the subtitle of Fuller's study), it should be stressed that most of the literature recognizes only their application to material structures. Of interest to any exploration of tensegrity are the following:

- Within the architectural context, the application of studies of management cybernetician Stafford Beer on "syntegrity" (synergistic tensegrity) in team building are ignored -- perhaps necessarily so. This is equally true of those of cybernetician Gordon Pask on the Fuller-Snelson prismatic tensegrity as a Borromean link model of the interactions in a minimal stable concept; it has been extended to modelling entailment meshes of concepts as spin networks. He noted that "a tensegrity, or tensionally integral structure, is an organizationally closed system, informationally open, viable system and an organism" (*Interactions of Actors (IA), Theory and Some Applications*, 1993). This work, a generalization of Pask's conversation theory and his work on self-organization and coherence, has subsequently been variously developed, notably by Nick Green (*Axioms from Interactions of Actors Theory*, *Kybernetes*, 2004); he has considered the isotopy of the orthogonal Borromean link and the icosahedral tensegrity. Such work is presumably highly relevant to the challenges of psycho-social organization.

- Curiously, whilst the concept of "network" has proven valuable in both material, psycho-social and abstract contexts, the interplay of forces fundamental to tensegrity has not as yet -- even though "network" is inherently related to that dynamic in practice. The same might be said of "virtual organization" in cyberspace. A noted weakness of psycho-social networks in practice may however be their tendency to design out "tension" -- which features in the "hierarchical" forms to which they are a reaction -- thereby inhibiting their capacity (*Tensing Associative Networks to contain the Fragmentation and Erosion of Collective Memory*, 1980; *Tensed Networks: balancing and focusing network dynamics in response to networking diseases*, 1978)

- Both in the architectural context, and in the non-architectural application of tensegrity developed by Stafford Beer, issues of priority and intellectual copyright have proven to be extremely important -- even disagreeable -- possibly even to the point of inhibiting further development. It is therefore interesting to speculate, in the light of "syntegrity", on the possible intellectual copyright with respect to the application of tensegrity to psycho-social organization. Of related interest is any patent constraint on the application of tensegrity construction methods to dome-like "buildings" constructed virtually in cyberspace or to any tensegrity art in that context. Given the fundamental role that Pask's focus gave to tensegrity in relation to interaction between actors, the emergence of a concept, and self-organization, one might ask how the important sense of "territory" is held in that context, and -- provocatively -- whether this is itself implicated in such considerations in unsuspected ways (cf *Einstein's Implicit Theory of Relativity -- of Cognitive Property? Unexamined influence of patenting procedures*, 2007)

**Figure 8: Indications for Construction of Tensegrities from Polyhedra**
on the assumption that having polyhedral coordinates in great precision in *Stella*, possible tensegrity form-fitting could be readily tested by appropriate algorithms

**Tensegrity design:** The most practical, accessible and focused summary of the challenge (for architectural purposes) is provided by:

Robert Burkhardt:

- *Synergetics Gallery: a pictorial record of investigations*, 2008
- *A Technology for Designing Tensegrity Domes and Spheres*, 2007
- *A Practical Guide to Tensegrity Design*, 2004.

Valentín Gómez Jáuregui: *Tensegrity Structures and their Application to Architecture*, 2004

*VRML Tensegrity Models* (2008), as elaborated by Robert Burkhardt, offer imaginative indications of possible "operationalizations" of polyhedra in the creation of new kinds of psycho-social organization. The following examples (from an extensive list), based on polyhedra, raise the questions: how might organization like that be experienced, how might it be recognized, and how might its emergence be facilitated:

- Tensegrity Tetrahedron (della Sala)
- T-Cuboctahedron
- Dodecahedron with X-Column Edges
- 2ν Zig-Zag Icosahedron Sphere (first variation)
- Concentric Five-fold Prisms

Access to such virtual reality models requires a browser plugin (eg free browser Cortona plugin for PC, Mac OS X, and Pocket PC platforms)

**Software support for tensegrity construction**:

- Robert Burkhardt has developed his own software to fabricate his style of double-layer tensegrity dome and sphere from geodesic breakdowns. This a front end which produces input for his tensegrity computation software. The software requires some sort of back end to use the product to finish off the tensegrity computations before moving on to VRML. He believes that the existing software could be adapted to output in a form suitable to another package (such as ANSYS).
- Diego Budavari and Valentín Gómez Jáuregui are in process of developing a computer programme: Tensegrity Simulator (*Simulador de Tensegridad*)
- Jason Evelthon Charalambides (*Computer Method for the Generation of the Geometry of Tensegrity Structures*, University of Texas at Austin, 2004) provides a comprehensive survey of the literature and states the focus of the computer program developed as follows:
  - Tensegrity is a technology that can be applied to structures and its use can influence the construction time efficiency and construction project management in general. However, a significant drawback for a systematic application of tensegrity structures in the building construction industry is the particularly complex geometry that engineers and architects have to generate, in a two or three dimensional virtual or physical environment. The objective of this dissertation was the development of a computer based utility that will facilitate the design professional to devise and construct a specific morphological variation of tensegrity structure systems. The development of this utility was based on a methodology that identified and included parameters that can be associated to the schematic design and design development phases of a design project. The main contribution of the developed computer program is the efficiency with which virtual models of a tensegrity structure can be generated, facilitating the designer in decision making during the design process. Emphasis was given on the development of an interactive graphical simulation/visualization environment for the computer program. This feature assists in the generation and modification of the numerical input, with parameters defined by the user, and allows unobtrusive regenerations of alternate solutions within the computer virtual environment.
  - The author notes that David Georges Emmerich (*Structures Tendues et Autotendantes*, 1988) developed a systematic method of deriving tensegrity forms from a range of Platonic and Archimedian polyhedra (citing A. Hanaor, *Beyond the Cube: the architecture of space and polyhedra*, In: F. Gabriel (Ed.), *Tensegrity: Theory and Application*, 1997)

**Relevant tensegrity mathematics:** Hugh Kenner (*Geodesic Maths and How to Use it*, 1976), notably a chapter on choosing a polyhedron.

**Sets of Rules** (Anthony Pugh, *Introduction to Tensegrity*, 1976)

- **Circuit pattern** associated with polyhedra:
  1. The tendons define the edges of a polyhedron, which need be neither regular nor semi-regular. Four tendons and two struts meet at each junction to form a vertex of the figure, so at least four edges must meet at each vertex of a polyhedron used as a basis for a circuit-pattern figure..
  2. When the struts are joined, they form circuits of struts, hence the name *circuit pattern* for this strut-tendon relationship. The circuits of struts follow the lines of circuits of tendons, which can be traced on models of appropriate polyhedra.
  3. The circuits of struts interweave with each other, passing under one circuit, then over the next, under the next, and so on.
  4. A network of tendons surrounds a series of circuits of struts, the tendons pulling inwards like the skin of a balloon, the struts pushing outwards like the air in the balloon.
  5. There is a junction of struts and tendons outside the midpoint of each strut, so there will be the same number of junctions as there are struts.
- Circuit pattern, based on **geodesic polyhedra** (alternate method), derived from an existing polyhedron (called its principal polyhedron)
  1. Triangulate any faces that are not already triangles
  2. The edges of each triangles are divided into equal numbers of equal parts and then lines drawn between the points established to define a triangular grid on each face
  3. With a sphere drawn through the vertices of the principal polyhedron, lines from the centre through all line instersections to that sphere then constitute the vertices of the geodesic polyhedron -- these are then joined to reproduce the pattern of lines on the surface of principal polyhedron
  4. Circuit pattern tensegrity systems can be based on any such geodesic polyhedron, provided that the faces of the principal polyhedron were subdivided to a frequency which is a multiple of two.
- Patterns can be based on **other polyhedra** by following the symmetries of the figure to provide a network of tendons, then to add in the struts.

**Unambigious set of rules:** It may well be that such a set is "buried" in the many attempts to develop algorithms to derive tensegrities from polyhedra. However such a set does not appear to have been clearly articulated in a manner that lends itself to immediate use.

One of the advantages of such structures is as a representation of a configuration of polarizing factors in social organization -- forces which may be essential to its viability, as discussed elsewhere (*From Networking to Tensegrity Organization*, 1984; *Groupware Configurations of Challenge and Harmony: an alternative approach to alternative organization*, 1979; *Implementing Principles by Balancing Configurations of Functions: a tensegrity organization approach*, 1979).

Just as tensegrity principles are fundamental to the architecture of the biological cell, they may also be fundamental to the coherence of psycho-social organization and community -- to community "architecture". **Such tensegrity structures may be especially significant in determining the patterns of (electronic) communication essential within cyberspace to the viability of an organization, a community or some other collective initiative.**

One of the challenges in deriving tensegrity structures for architectural purposes is what is termed "form-finding" (cf Milenko Masic, et al, *Algebraic tensegrity form-finding*, 2005). There is a case for understanding the challenge of matching or fitting psycho-social organization to polyhedra (discussed above) as an analogous process of "form-finding". In both cases a polyhedron provides a template for the solution, but the challenge is to find it. Hugh Kenner (*Geodesic Maths and How to Use it*, 1976) offers guidance on "choosing a polyhedron" (ch. 11) which usefully frames the challenge.

The challenge is to "massage" chaotic network representations into a "global" configuration as primitively envisaged as a challenge to mathematics (*Preliminary Clarification of Some Problems of Processing Networks of Entities -- in order meaningfully to map psycho-social relationships*, 1973). This may now be more readily feasible with the aid of "polyhedral" network analysis (cf P. Doreian, *Polyhedral Dynamics and Conflict Mobilization in Social Networks*, 1981).

## Process of use

In its current form, *Stella* necessarily calls for a degree of familiarity. With respect to its relevance to psycho-social organization, one challenge is to make evident which features it is more fruitful to use for what purposes, in what sequence and by whom.

In reflecting on the potential relationship between polyhedral structures and the dynamics of governance, it is interesting to reflect on the success of the online design environment, *SodaConstructor* -- a Java-based simulator -- open to popular participation. It allows participants to design a wide variety of mechanical systems empowered by parameter-controlled muscle-like dynamics and constrained by "gravity". It is interesting that the *Stella* application is associated with a "3D minesweeper game", played on polyhedral surfaces -- recalling the popularity of *Tetris* and *Exotic Minesweeper* (which uses cells of different shapes: hexagonal, octagonal, square). As with *SodaConstructor*, users of *Stella* may post interesting models into a collective repertoire. Several mind mapping software packages make use of hexagonal modelling which therefore help to reinforce the argument for exploring 3D variants.

A proposal has been made to adapt the *SodaConstructor* approach to the representation or design of complex institutional structures variously empowered by sectoral budget lines (*Animating the Representation of Europe: visualizing the coherence of international institutions using dynamic animal-like structures*, 2004). Clearly the future evolution of psycho-social organization, based on tensegrity principles, could encourage similar online exploration.

## Multi-dimensional heuristic work space

A focus to the confluence envisaged here may be given in terms of the kind of "work space" envisaged in a classical paper by Douglas Engelbart (*Augmenting Human Intellect: a conceptual framework*, 1962), notably:

- explorations of (computer-enhanced) environments appropriate to emergence and support of collective intelligence
- spatial metaphors (cf Heiner Benking, et al. *Design Considerations for Spatial Metaphors: reflections on the evolution of viewpoint transportation systems*, 1994) and their implications for the design of information systems (cf Paul Charles Schroeder, *Spatial Aspects of Metaphors for Information Implications for Polycentric System Design*, 2003)
- relevant metaphors associated with the technology through which space is contained by architecture, notably that explored with tensegrity (Robert D. Romanyshyn. *Technology as Symptom and Dream*, 1989)
- potential of "work places of the mind" (cf Heiner Benking, *Global Workspaces of the Mind: sign and symbol grounding in the cognitive panorama -- 3Space/Time*)

Schroeder appears to offer the most significant synthesis, in relation to the above argument, especially given his extensive reference to tensegrity (as the "defining figure" in the workplace he proposes) and his association of it with the pattern language of Christopher Alexander. His study focused on:

> ... three innovations that suggest an alternative approach to structuring information systems: a multidimensional heuristic workspace, a resonance metaphor for information, and a question-centered approach to structuring information relations. Motivated by the need for space to establish a question-centered learning environment, a heuristic workspace has been designed. Both the question-centered approach to information system design

> and the workspace have been conceived with the resonance metaphor in mind....
>
> This revised view of the metaphors of space was accompanied by a critical evaluation of the prevailing metaphors for information processes, the conduit and pathway metaphors, which led to the emergence of an alternative, resonance metaphor. Whereas the dominant metaphors emphasized information as object and the movement of objects and people through networks and other limitless information spaces, the resonance metaphor suggests the existence of multiple centers in dynamic proximity relationships...
>
> The federation of multiple autonomous problem-solving spaces, toward goals such as establishing communities of questioners, has become an objective of this work. Future work will aim at accomplishing this federation, most likely by means of the IS0 Topic Maps standard or similar semantic networking strategies.

Schroeder made extensive use of the *Axon Idea Processor: a visualization tool for thinkers*, as developed by Chan Bok, in elaborating his proposed workspace and illustrating its operation. It allowed total network views and management of relations in the form of clusters as well as explicit links. It also allowed the workspace to be organized in terms of concentric polyhedra -- a feature suggested earlier. Uunlike Stella, *Axon* does not have a virtual reality mode. Despite that, Schroeder argues that the workspace so enabled is an autonomous, stand-alone environment that affords the possibility of being federated with similar spaces through use of emerging facilities such the IS0 Topic Maps standard.

In his primary focus on the tensegrity in a virtual environment (but not in the virtual reality characteristic of *Stella*), Schroeder appropriately notes:

> It should be noted here that the tensegrity figure in this workspace is only an image, and does not have the capacity to behave in the digital environment as a physical tensegrity would. The figure included here was created based on observation of an existing physical model. The great advantage of the physical tensegrity structures is that the relationships among the forces that determine the structure and the physical stability that results creates an immediate understanding of the whole system. Realizing these characteristics in the digital environment, rather than just representing them, is suggested as an objective of future work.

Schroeder also provides a very helpful detailed summary (pp 199-207) of the advantages of the tensegrity-based workspace, notably in terms of :

- "cognitive plausibility"
- a central point of cognitive reference: "as locus of accepted assumptions, or negatively, as the place of ultimate unknown, the nave about which the wheel of knowledge turns"
- provision for "undefined as well as definable spaces"
- highlighting the role of context in terms of a "context sphere"
- suggesting an arrangement for the structured display of certainty and uncertainty relationships
- consistent display of multiple frames of reference
- possibility of displaying objects "as single entities, or they can be formally linked as networks, arrayed in clusters suggesting fields, or arranged along vectors suggesting the directions of operation of forces within the space. The meanings of the symbolic objects that are managed in this space can be represented in several ways: explicitly, by embedding definitional text within the objects, or by assigning values to links across objects; or implicitly, through relational arrays, with significance of the array determined through analysis of the object clusters".
- representation of networks "by the chords that connect the vertices of the polyhedra. A graph representing 'small world' phenomena can be seen in the tensegrity, with the tendons representing local 'strong ties' and the cross structure compression elements representing the long-distance 'weak ties'."
- manipulability and multiple location of objects / tokens making it a workplace for cognitive learning and discovery.
- ready representation of containment and inside / outside relationships
- ability to infer structural dynamism

- placement or representation of concepts that involve dynamic change and periodic events in time
- representation of relationships implying opposition and bi-polarity
- possibility of groupings in several different numeric patterns
- potential for simultaneous display of cognitive and geographical maps
- capacity to represent relationships characterized by discontinuity
- metaphorical use of "gravity effects" understood as accounting for stable proximity relationships when physical connections are not in place -- as in the clustering of concepts around categorical prototypes
- user control of the workplace environment, notably enabling different cognitive learning styles

Clearly such explorations need to be related to the multi-actor situation of organization emergence and self-organization. Of particular interest is the author's approach to:

- representation of relationships implying opposition, bi-polarity, uncertainty and discontinuity, usefully to be understood as appropriate separation -- rather than a "unification", as tends to be the inappropriate conventional aspiration
- the "central point of cognitive reference", which in the case of a symmetrical tensegrity is quite empty and effectively "virtual". From a philosophical perspective, even a spiritual one, this is especially significant, in contrast to the conventional approach in which any such central position is necessarily occupied by some organizational or conceptual entity, or even a central value.
- polyhedral organization of the geographical globe which includes research into "geodesic discrete global grid systems" (K. Sahr, et al., 2003) and "planetary polyhedral tesselation" (G. H. Dutton, 1991; 1999), namely the use of global coordinate systems based on regular polyhedra, as a complement to those based on traditional latitude and longitude. Notable is the author's idea that global geographic polyhedral projections could easily be incorporated into the proposed heuristic workspace.
- the challenge of cognitive embodiment associated with any workspace, as extensively argued by George Lakoff and Mark Johnson (*Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, 1999).

Implicitly, combining the above points, is the sense in which the emptiness around which globality is centred brings a special and necessary form of integrative order to "global" networks that are otherwise unconstrained (cf *Varieties of nothingness and emptiness*, 2008). Arguably it is this centrally referenced emptiness that creates a space, that is potentially isomorphic with that of the proposed workplace of the mind. The approach creates a "context" within which "global" discourse takes place effectively (*Future Generation through Global Conversation: in quest of collective well-being through conversation in the present moment*, 1997).

## "Cognitive circuits"

In a polyhedral pattern language, each polyhedron may effectively be understood as a representation of a "cognitive circuit diagram". This might be considered implicit, even explicit, in Fuller's "geometry of thinking" and intentions, although his insights are undermined and "denatured" by the inability to take account of the cognitive issues of embodiment so ably explored by Lakoff -- and close to Pask's conversation/interaction theories.

Operationalized and enabled as a tensegrity, the featurs and resonant dynamics of the circuit start to become apparent in their relevance to psycho-social organization. There are indeed analogues to the characteristic features of electrical circuits (resistors, capacitors, etc) through which "energy" is engendered, stored and redistributed (cf *Electrical Systems as a Guiding Metaphor for Stages of Group Dialogue*, 2001). But, in the sense explored by Francisco Varela (*The Embodied Mind: cognitive science and human experience*, MIT Press 1991, with Evan Thompson and Eleanor Rosch) and enactivism, such a circuit diagram has to be embodied to be enabled.

It is such cognitive circuits that sustain the patterns of behaviour on which governance is dependent -- and which it endeavours so desperately to seek to change. They

constitute the sustaining tracery of communication pathways and feedback loops.

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## PART C: Meta-patterning considerations from other cultural perspectives

The challenge of any pattern language lies in what makes the pattern meaningful. For psycho-social organization, what is "goodness of fit" in a cognitive, organizational and strategic context where comprehension is critical to communication, credibility, coherence and viability?

A core issue is any limitation on the capacity of the human mind to "grasp" sets of elements of any degree of complexity and how any such constraints may be circumvented in the organization of principles, categories, organizations or strategies as discussed elsewhere (*Representation, Comprehension and Communication of Sets: the role of number*, 1978). Polyhedra represent an interesting way of bypassing the constraints of hierarchical and networking metaphors -- combining their advantages and compensating for their respective weaknesses.

### Patterns as enabling emergence of a "quality without a name"

With respect to the challenges of governance, much has necessarily been made of issues relating to the tangibles (food, health, etc) on which economists so readily focus, and to the intangibles manifest over time (freedom of information, freedom of religion, etc) which are also a focus of politics. And, in the attention given to the pattern language of Christopher Alexander (discussed above), the focus has been on the process of design that the methodology enables in whatever domain. Little attention is given to his declared, and extensively described, purpose of using such patterns to enable the emergence of what he describes as the "quality without a name" (*Timeless Way of Building*, 1979).

In *A Pattern Language* (1977), in that spirit, Alexander has done much to clarify what would here be termed the elven pathways fundamental to providing a subtle sense of a desirable "place to be" or a "sense of place" -- of feeling "at home".

> There is a central quality which is the root criterion of life and spirit in a man, a town, a building, or a wilderness. This quality is objective, but it cannot be named... every place is given its character by certain patterns of events that happen there. These patterns are always interlocked with certain geometric patterns in the space... To reach the quality without a name we must then build a living pattern language as a gate. (pp ix-xi)

Industrialized society has however come to recognize aspects of its importance under the term "quality time" or in the increasing difficulty for top corporations to retain valuable executives. But the point was made long ago by the realization that "man cannot live by bread alone". This perspective is further discussed elsewhere (*Walking Elven Pathways: enactivating the pattern that connects*, 2006).

The merit of Alexander's achievement has been to create a qualitative bridge between the technical considerations of architecture, so evident in discussion of tensegrity, and the qualitative purpose of the spaces so created. This might be said to go beyond the "heuristic" workspace of the mind which Schroeder's work seeks to enable. Put succinctly, what is the quality characteristic of the space associated with any particular pattern and the manner in which it is embodied and lived?

Curiously, at best, the architectual aesthetic is very sensitive to the qualities of space created. It is in this sense that the use of strategic confifgurations of pillars can be fruitfully revisited. Associated with those pillars, for example, are the spaces between those pillars and the tension associated with the relation of those spaces to the pillars that define them. It might be argued that it is the purpose of the strategic pillars to create desirable "places to be". Were the spaces to be filled, extending the bounding pillars into a wall, "sides" are then created in ways that were noted as problematic in the earlier study.

## Quality of space as a central challenge of governance

Seemingly quite dissociated from the explicit challenges of governance, there is an extensive literature on the spirit of place and psycho-social attachment to the land:

- Edward S. Casey. *Getting Back into Place: toward a renewed understanding of the place-world*. Indiana University Press, 1993.
- James A. Swan. *The Power of Place: sacred ground in natural and human environments*. Quest Books, 1991
- Y-Fu Tuan. *Space and Place: the perspective of experience*. University of Minnesota, 1977
- Darrell Addison Posey (Ed). *Cultural and Spiritual Values of Biodiversity*. London, UN Environmental Program (UNEP), Intermediate Technology, 1999.

It is quite clear that it is precisely such attachment which provides a prime focus for major conflicts, notably the unresolved cycles of violence in the Middle East focused on the symbolism of Jerusalem. Implicit, but unmentioned in that context is the epistemological significance of more poetic understandings of space, as exemplified by:

- Fernand Hallyn. *The Poetic Structure of the World: Copernicus and Kepler*. New York, Zone Books, 1990
- Gaston Bachelard. *The Poetics of Space*. New York, Orion Press, 1958/1964

The question to be asked, as an extension of Schroeder's concern with a workplace of the mind, is the nature of the quality associated with particular enabling polyhedral configurations. The disciplines of architecture and design claim sensitivity to the appropriateness of spaces for particular functions. This is reflected in the design of parliaments, meeting rooms, think tanks and retreat centres.

Beyond the concrete however, what are the patterns that enable configurations of thought of relevance to the challenges of governance? How does a pattern language provide appropriate cognitive scaffolding for the emergence of viable strategy? How is engagement with such patterns enabled?

## "Spirit of team": vibration and resonance

The sense of quality associated with space is also sensed to be associated with psycho-social organization. Typically this quality is named in jargon such as "vibrations". People refer to the degree of "resonance" they experience (or do not) with particular initiatives and groups of people. The most frequent recognition of such "spirit" is in the experience of "team spirit" in sports, and its analogue in the military.

Various efforts have been made to elaborate such understanding:

- Harrison Owen (*Spirit: transformation and developmenty in organizations*, Abbot Publishing, 1987) agues that "we might recognize that organizations in their essence are Spirit". He highlights expressions in organizations such as: "The spirit around this place is terrible", or "Got to keep the spirit up" or, "Our spirit is our most important asset. As he says, however, " we apparently possess very l;itte in the way of appropriate technology in order to do something for Spirit."
- Jon R. Katzenbach and Douglas K. Smith (*The Wisdom of Teams: creating the high performance organization*, Harvard Business School Press, 1993) stress that much of the wisdom of teams lies in the disciplined pursuit of performance
- from the perspective of the OECD Centre for Educational Research and Innovation (CERI), Simon Field (*Does team spirit make economic sense?*, *OECD Observer*, No 226/227, Summer 2001) notes that teamwork is as vital for successful companies as it is for successful football teams. He recognizes that little attempt has been made to measure its contribution to the economy, or the cost of its absence, and suggests the need to pay more attention to this invisible asset. For Field, attention to such social capital can suggest new policy solutions.

## Insights from Chinese culture

This exploration was inspired by the use of "pillar" as the overriding European strategic metaphor, as discussed in the earlier paper (*Towards Polyhedral Global Governance: complexifying oversimplistic strategic metaphors*, 2008). Polyhedra have been presented there as configurations of such pillars in any more coherent approach to governance. With respect to global governance, involving a variety of cultures, it is therefore useful to seek complementary insights from the quite distinct Chinese culture -- especially if there is any tendency to assume that Eurocentric strategic thinking is to be considered appropriate worldwide.

Geometric elaborations of polyhedra, developed by the **logic** of geometric transformation from Platonic polyhedra, can be understood as patterns implicit in the Platonic forms -- as implied by the potential for such transformation. Corresponding elaborations and implications may be found in the Chinese **logical** elaboration of two classic coding systems, each a pattern language *par excellence*:

- the set of 64 hexagrams associated with the binary coding of the *I Ching*. Their representation in relation to a hexhedron (a cube) has been extensively presented by Z. D. Sung (*The Symbols of the Yi King or Symbols of the Chinese Logic of Changes*, New York, Paragon, 1969)
- the 81 tetragrams associated with the ternary coding of the *Tai Xuan Jing*, *T'ai Hsüan Ching* or *Canon of Supreme Mystery* (translated by Michael Nylan, *The Elemental Changes: the ancient Chinese companion to the I Ching*, State University of New York, 1994). An earlier commentary by Derek Walters (*The T'ai Hsüan Ching; the hidden classic*, Aquarian Press, 1983) includes a section on *The T'ai Hsüan Ching and Scientific Thought* which highlights the set of numbers that represent the balance between two opposing forces. This is presented in relation to mappings of imaginary numbers.

There is a visual irony to the fact that the European "pillars", and the "unfilled spaces" between them, can be fruitfully compared to the complete (*yang*) and broken (*yin*) lines constituting any hexagram. It is of course a fact that the *I Ching* was long used as tool of governance in classical times -- and was required study for entry into the Chinese civil service.

These patterns are then **qualitatively** associated, through their respective metaphorical representations, in

- the commentaries on the hexagrams of the *I Ching*
- the commentaries on the tetragrams of the *T'ai Hsüan Ching*

The set of patterns calls for exploration as a pattern language (*Conditions of Objective, Subjective and Embodied Cognition: mnemonic systems for memetic coding of complexity*, 2007; *9-fold Higher Order Patterning of Tao Te Ching Insights: possibilities in the mathematics of magic squares, cubes and hypercubes*, 2007).

This of course raises the question of the **qualitative** implications that may potentially be associated with the patterns of the other Platonic forms, as developments of the less complex ones. Both the icosahedron and the dodecahedron suggest mappings of:

- 12: the many 12-fold archetypes (Dodekatheon, Zodiac, Apostles, Arthurian round table, etc) onto faces in the case of the dodecahedron and vertices in the case of the icosahedron
- 30: such as the 30 Articles of the *UN Declaration of Human Rights* onto edges in both cases

The integrative (global) nature of such sets is a real challenge to comprehension in terms of how the parts play off against each other. It is for this reason that the relationships are typically embodied in metaphor and stories, an approach explicitly favoured by the authors of *The Wisdom of Teams* (1993).

There have been many exercises in interpreting the relevance of the *I Ching* and the *Tao Te Ching* to issues relating to organizational strategy and management. Perhaps most relevant to this argument is the classical text of Cheng Yi (1033-1107) as translated by Thomas Cleary (*The Tao of Organization: the I Ching for group*

*dynamics*, Shambhala, 1995), who comments:

> The *Tao of Organizations* analyzes relationships and power configurations within groups. Taking into account both the subjective and objective dimensions of these structures, it is extraordinarily subtle and complex. The relationship between interpersonal and intrapersonal forces... is the central focus of the explanation.

Cleary adds an appendix on Cheng Yi's instigation of "inner design" (or noumenalism) intended to bring out hidden dimensions in classical Chinese works -- obscured because of the use of rigidly fixed interpretation schemes, inappropriate in any context of transformation. He comments at length on how such principles were consciously applied by the legendary Japanese industrialist Matsushita Konosuke (1894-1989).

More generally the challenge of comprehending the interrelationship between seeming disparate facets of a pattern may be seen as a challenge of "correlative thinking" of which the Chinese understanding of *yin* in relation to *yang* offers an example (A. C Graham, *Yin-Yang and the nature of Correlative Thinking*, Institute of East Asian Philosophies, 1986). The issue for governance is how credible is any degree of correspondence and to what degree of confidence does it give rise in strategy development and implementation (cf *Theories of Correspondences and potential equivalences between them in correlative thinking*, 2007).

## Pattern dynamics: change, alternation, resonance

As noted above, the further work of Christopher Alexander and his team has been on *The Nature of Order* (2003-2004) in which the the mostly static patterns from *A Pattern Language* have been amended by more dynamic sequences, which describe how to work towards patterns.

As a set of patterns in its own right, the *I Ching* is also known through its translation as the *Book of Changes* -- namely the transformation between conditions symbolized by particular patterns. This focus on change is also evident in its companion classic, the *T'ai Hsüan Ching*.

It is interesting that at the molecular level, the benzene molecule fundamental to the structure of organic matter, is explicitly recognized to be based on a pattern of resonance in the bonding arrangements between its six constituent carbon atoms. As such it is known as a resonance hybrid -- characterized by the fact that its enduring viability is based on the alternation between bodning configuration. Such molecular resonance is recognized when no single conventional model, using only even number of electrons shared exclusively by two atoms, can actually represent the observed molecule. It might be expected that some analogue would be operative at the psycho-social level (cf *Configuration of modes as a resonance hybrid*, 1986).

Curiously whilst healthy democracy and governance is understood to be based on alternation of power between political parties or coalitions, there is little attention to the need to explore this principle in relation to healthy governance and the formulation of strategy. In certain forms of farming, the value of crop rotation is recognized as essential to systatainable exploitation of fields. It might be inferred that this offers learnings for alternation between strategies (*Sustainable Cycles of Policies: crop rotation as a metaphor*, 1988). More generally it might be inferred that sustainable governance is dependent on alternation between patterns (*Development through Alternation*, 1983).

In the light of such arguments, using the pattern coding language of the *I Ching*, the systemic relationships between various sets of patterns have been explored as an experiment (*Transformation Metaphors -- derived experimentally from the Chinese Book of Changes (I Ching) for sustainable dialogue, vision, conferencing, policy, network, community and lifestyle*, 1997).

## Possibilities of "variable geometry" in psycho-social organization

Within the above context current use of the term "variable geometry" fails to distinguish between different configurations, understood simply as alternatives, and the dynamics of shifting between configurations in response to different conditions. The latter is the essence of structural nimbleness (cf *Wanted - A New Social Entity: role of the potential association*, 1971).

An excellent metaphor is the switch consciously made, according to circumstances, between different tactical configurations in rugby and other such team sports. These configurations may be named or numbered to be called out by the captain during a game. They are termed formations in association football, as distinct from the formations in American football. They refer to the position players line up in before engaging during the course of play. There are both offensive and defensive formations with many in both categories.They also feature in computer simulations (see *Team formations*).

For purposes of governance, "variable geometry" has been defined in a European context as follows:

> 'Variable-geometry' Europe is the term used to describe the idea of a method of differentiated integration which acknowledges that there are irreconcilable differences within the integration structure and therefore allows for a permanent separation between a group of Member States and a number of less developed integration units. (*Europa Glossary*) [more]

As noted by Warren Mason and Susan Penksa (*The Variable Geometry of Security Cooperation: a policy framework for European integration*. 2004), the development in Europe of a vast array of new structures of cooperation -- both public and private -- has left analysts reaching for conceptual tools with which to frame these phenomena. Charles Grant develops the argument further (*Can Variable Geometry Save European Enlargement*, 2005). Its relevance operational relevance has been highlighted by Patrick Joachim Dunphy (*Variable Geometry Europe -- patching together what works in the fight against hard-core cartels: carrots, sticks, custody and leniency*, 2007). Mike Goldsmith (*Variable Geometry, Multilevel Governance: European integration and subnational government in the new millennium*, 2003) reviews the extent to which concepts such as variable geometry and multilevel governance remain useful in aiding understanding of the processes of change through which EU territorial politics are passing.

Variable geometry has been notably recognized in relation to trade (Paolo Guerrieri and Stephen S. Cohen, *The Variable Geometry of Asian Trade*, 1994. The approach has also been envisaged for the UN system (*Alternation between Variable Geometries: a brokership style for the United Nations as a guarantee of its requisite variety*, 1985) and within the UN system. As reviewed by C. Patel (*Single Undertaking: a straitjacket or variable geometry?* 2003) and discussed by Andrew Cornford (*Variable Geometry for fhe WTO: concept and precedents*, 2004) who notes that the idea of was raised during the Uruguay Round when the constitution of the new multilateral organization (eventually leading to the WTO) was under consideration. Indeed, as noted by the Swiss National Science Foundation,

> World trade rules are not marked by a uniform ‘geometry’. Exceptions are made to general principles for defined groups of nations, for specific principles and specific issues. Regional trade arrangements (RTAs) and Special and Differential Treatment (SDT) are the two most important exceptions. [more]

The relevance has been explored in relation to the "multilateral" trading system, notably at a meeting of World Trade Institute (*The Single Undertaking After Cancun: diversity and variable geometry in the WTO System*, 2004).

On the occasion of a multi-stakeholder dialogue and networking event for addressing the challenge of making ambitious targets of the world community a reality, the Helsinki Process on Globalisation and Democracy (2005), Susan George (*Variable Geometry to Design Positive Outcomes*, 2005) stated:

> In my view, variable geometry is the most useful political concept to emerge from the Helsinki Process. It is the recognition that no one institution, or type of institution, can solve by itself the problems we confront today. We need a cooperative framework in which various actors abandon their turf-wars and work together.

The question is whether comprehension of the possibilities would be enhanced by the software facilities outlined above through which a large repertoire of configurations and relationships can be explored.

Curiously, with respect to the suggestion above regarding sports teams and previously (*Engaging with popular games*), the pattern of numbers defining the formations is reminiscent to that used to characterize polyhedra:

**Figure 9: Comparison of number patterns in football formations and polyhedra**
(possibly suggesting that one might be represented by the other)

| Examples of nomenclature in offensive or defensive formations in American football strategy | Examples of polyhedral symmetry groups (typically further extended in vertex arrangements) |
|---|---|
| • 4-3-4: Four-Three defense<br>• 3-4-4: Three-Four defense<br>• 5-2-4: Short Yardage defense<br>• 4-2-5: Nickel defense<br>• 4-1-6: Dime defense<br>• 3-1-7: Prevent defense | • 3-3-2: tetrahedral<br>• 4-3-2: octahedral<br>• 5-3-2: icosahedral<br>• 3-6-6: tetrahedral truncated<br>• 4-6-6: octahedral truncated<br>• 5-6-6: icosahedral truncated |

If there proves to be a useful mapping from football tactics to polyhedra, given the extensive repertoire of the latter, this would then raise the possibility of unforeseen tactics in football -- as envisaged with respect to the emergence of unforeseen governance strategies. It would also offer a means to render credible more complex strategies of governance in response to the problematique -- a form of Rosetta Stone for strategy.

Given the variety of ways in which polyhedra can be represented, notably to foresee possibilities of transformation between them, it may be useful to note the manner in which *Stella* allows for the display of the cell diagram of any polyhedron -- typically in the form of an inverted hierarchy:

> A cell diagram is a graph indicating how stellation cells relate to each other. The layers of cells are shown as layers of nodes, each node representing one cell type. Edges of the graph connect nodes from one layer to nodes of the next layer if the two cell types share a common face, so the cell type at the bottom of the edge supports the cell type at the top of the edge.

Understanding of polyhedra may thus be usefully framed as providing a conceptual interface between hierarchy and network -- typically problematic in psycho-social organization portrayed in 2D -- using forms in 3D with degrees of symmetry that render complexity comprehensible. Such understanding also connects with traditions of "sacred geometry", even through "faceting diagrams".

In this context it is appropriate to note the many comments in the literature on the polyhedral structure of a football, notably in relation to the fullerene molecules (see also *Understanding Sustainable Dialogue: the secret within Bucky's Ball?* 1996).

## Comprehension of strategically appropriate patterns through the fourth dimension

It is repeatedly noted that the strategic challenges of the times now call urgently for **extraordinary thinking** -- beyond the **conventional patterns** that continue to exacerbate those challenges. As a prime advocate, Edward de Bono is instigating a World Council for New Thinking. As noted earlier, mathematician Ron Atkin asks whether man can indeed live in three dimensions (*Multidimensional Man; can man live in 3-dimensional space?* 1981). Another mathematican, Marcus du Sautoy (*Finding Moonshine: a mathematician's journey through symmetry*, 2007) makes the point:

> For centuries composers, writers, artists, choreographers and architects have pludered the mathematical world in search of new structures to stimulate them creatively. (*Creative Calculations*, *The Guardian*, 29 April 2008)

In also enabling the exploration of fourth dimensional polyhedral patterns (regular polytopes), *Stella* might then be said to act as a kind of bridging psychopomp. It traces virtual pathways through the unknown and the uncertain to facilitate *Walking Elven Pathways -- enactivating the pattern that connects* (2006). The appropriateness and relevance of such exploration of the paradoxical order of the hyperreality of the emerging knowledge society has been highlighted through the subtle aesthetics of such as semiotician Umberto Eco (*Travels in Hyperreality*, 1973) -- effectively calling for hypercomprehension (*Hyperaction through Hypercomprehension and Hyperdrive: necessary complement to proliferation of hypermedia in hypersociety*, 2006).

As a mathematician, Marcus du Sautoy has worked with musicians and dancers to explore how new ideas of mathematics can be woven into a piece of theatre pushing all boundaries (*The 19th Step*, 2008) -- inspired by a work of Jorge Luis Borges, author of the *Library of Babel* (1941), a knowledge-edifice of hexagonal-shaped rooms in a four-dimensional context.

For governance the challenge might indeed be framed as the *Comprehension of Appropriateness* (1986) -- for which a polyhedral pattern language is a vital "revolutionary" cognitive support (*Metaphoric Revolution: in quest of a manifesto for governance through metaphor*, 1988). The essence of this challenge is making the subtlety of appropriate connectivity credible. The mathematician's response to "moonshine" usefully frames one approach to this challenge (*Potential Psychosocial Significance of Monstrous Moonshine: an exceptional form of symmetry as a Rosetta stone for cognitive frameworks*, 2007).

## Homeostatic equilibrium: necessary "human sacrifice" to the "gods"

The dynamic equilibrium characteristic of tensegrity structures makes evident the challenge of the sustainability of psycho-social systems through what can be mapped onto them. In the earlier paper, it was argued that the deities of any pantheon can be usefully associated with the implicit polyhedra for mnemonic purposes (*Re-membering the Dodekatheon*). The self-stabilizing processes of a tensegrity, through the manner of interaction of its parts under stress, could then be understood as the manner in which the particular "gods" of which it is composed require appropriate "sacrifice" -- to be appropriately "honoured" -- to ensure the continuing integrity of the system as a whole.

How should such "gods" then be understood?

- in terms of **natural systems**, these are the interrelated systems that ensure the viability of the human environment -- water, air, etc. -- each appropriately linked through a pantheon to a particular deity, that may have specific relationships with several other deities.. Such relationships are fruitfully held by stories, myths and legends about the gods -- in ways that engage many of the governed beyond the communication capacities of governance. These have been a concern of Joseph Campbell (*The Power of Myth*, 1988) and Karen Armstrong (*A Short History of Myth*, 2005). As discussed elsewhere (*Cognitive Fusion through Myth and Symbol Making*, 2006), Armstrong makes the point with respect to industrialized societies that:

    - Another peculiar characteristic of the human mind is its ability to have ideas and experiences that we cannot explain rationally.... imagination is the faculty that produces religion and mythology. Today mythical thinking has fallen into disrepute; we often dismiss it as irrational and self-indulgent. But the imagination is also the faculty that has enabled scientists to bring new knowledge to light and to invent technology that has made us immeasurably more effective.... Mythology and science both extend the scope of human beings. Like science and technology, mythology...is not about opting out of this world, but about enabling us to live more intensely within it.
- in terms of **psycho-social systems**, these are the objective systems with which governance is variously and more explicitly concerned. They are the systemic "issues" that appear as major points on international governance agendas.
- in terms of **personal subjective systems**, these might be understood as the archetypal "deities within" that frame behaviour under particular circumstances, as envisaged by Marsilio Ficino (*Composing the Present Moment: celebrating the insights of Marsilio Ficino interpreted by Thomas Moore*, 2001). They might also be associated with the interacting sub-personalities highlighted by disciplines such as psychosynthesis. For some this is mnemonically held by systems of psychological typing, such as astrology.

It is the interplay of any set of "deities" that is then fundamental to the integrity and identity of the system mapped by the tensegrity used. Any such sense of integrity is typically much challenged in the current context, whether with respect to natural, psycho-social or subjective systems. Of great potential interest is then the nature and "appropriateness" of the "sacrifice" that must be made within that framework to particular deities "ruling" any of its parts. In tensegrity terms, this is the manner in which particular parts must necessarily be constrained in response to the equilibrating functions of the local (partial) systems within the tensegrity as a global system.

Use of the metaphor "human sacrifice" in this context provides a useful systemic context for the "sacrifices" that humans, collectively or individually, are currently being challenged to make in the interests of sustainable governance. It is of course useful to note the association to the mortal sacrifices that individuals were called upon to make in the past -- and which government may continue to expect of them to protect "the motherland" (but not "the planet?). As with the ritual sacrifices of the past, whether of animals or humans, it is unfortunate that their systemic significance has been lost with the rejection of the abhorrent characteristics that presumably were then considered necessary to render such significance memorable. Ironically, however, few regulatory measures, including legislation, are now introduced through modern governance without some form of preliminary mortal sacrifice to justify them.

On a personal level, how sacrifices are variously made may continue to be an issue in response to the different challenges of living in a resource constrained society. It is perhaps from this perspective that the seeming rigidity of systems of values, such as the Confucian, should be revisited in terms of the systemic significance attached to calls to "honour". The same applies to the promotion of "family values" whether by government or religion. These could be fruitfully positioned in relation to the "freedoms" (from such values) that tensegrities may also be seen as encoding. The relevance of such an argument may be seen in the analogous role played by calls for "respect" -- and the dgree of importance attached to it -- within the seemingly most alienated sectors of society.

A tensegrity based on a Platonic or Archimedean polyhedron is especially valuable in highlighting the interlocking cycles underlying its structure -- the "great circles" around it in geometrical terms -- in contrast to those associated with the "cognitive circuits" (discussed above). Elsewhere it has been argued that these fruitfully point to a cyclic understanding of identity in dynamic rather than static terms (*Emergence of Cyclical Psycho-social Identity: sustainability as "psyclically" defined*, 2007 ). It is in this sense that traditional articulations of sets of values and prescriptions with which many identify through religions can be fruitfully seen as offering indications of systemic relevance (*Navigating Alternative Conceptual Realities: clues to the dynamics of enacting new paradigms through movement*, 2002). The work of Alexander on dynamics in relation to pattern emergence is clearly relevant.

| **Challenge of a new language for governance?** |
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> "Why do we put so much emphasis on audio-visual means of portraying goal, trend, condition, projection, and alternative? Partly because so many valuable participants in decision-making have dramatizing imaginations... They are not enamoured of numbers or of analytic abstractions. They are at their best in deliberations that encourage contextuality by a varied repertory of means, and where an immediate sense of time, space, and figure is retained".
> (Harold Lasswell, *The transition towards more sophisticated procedures*. In: D. B. Bobrow and J. L. Schwartz (Ed.). *Computers and the Policy-making Community*, 1968, pp 307-314)

## CONCLUSION: "Globality", viability and comprehensibility

The key question is whether the possibilities of representation on a form -- whose integrity only fully emerges **virtually in 3D** -- augments the range of possibilities of negotiating necessary **constraints in practice** in order to achieve such integration. A crude experiential metaphor is whether a game of bridge is more feasible, interesting and sustainable where there is a recognized need for 2 pairs of players such that, if only 3 are immediately available, ensuring the presence of a fourth is desirable. A related illustration is the (arbitrary) statutory restriction on numbers of members of some elite clubs.

The simplest regular polyhedra may be considered the **least** "global" -- as exemplified by "spherical" -- in that, compared to more complex Platonic or Archimedean polyhedra, the facets are **most** distant from the circumsphere through the vertices. "Globality" is therefore essentially implicit in these simpler and most readily comprehensible cases. It is however the simplest that are the most easiest to construct in practice and are the most stable.

The ease of representation of the more complex polyhedra in *Stella* lies in the many advantages of a **virtual environment**. Ironically it might be argued that articulation of any complex sets of values -- as virtues -- is also much easier in a "virtual environment", unconstrained by the challenge of implementation in practice.

The structural viability of the more complex polyhedra relies on tensional integrity **in practice** -- namely an artful balance between compression and tension elements ("checks and balances") that is the focus of tensegrity architecture. The "art" of achieving this lies in the requisite variety of the multiplicity of differently oriented facets of such polyhedra -- that together, in psycho-social terms, reflect the sustaining culture of the whole.

It should be stressed however that, in the case of psycho-social organization, "in practice" is concerned with the necessary patterns of communication between the parts of the whole -- the necessary feedback loops. In a society constructed on information flows through cyberspace, viable "virtual organization" is therefore dependent on how these communication pathways get designed into the structure and reflected in e-mail exchanges, for example.

This is the significance of the tensegrity "operationalization" of polyhedra. It provides a map of both the requisite communication patheways and the necessary separators (or insulators) in order for a new degree of order to emerge -- with sufficient robustness to redistribute stresses globally, thus dynamically resisting any tendency of its constitutive network to collapse. It may be fruitful to consider the "insulators" as regulators (as provided by governance through directives and regulatory authorities), with the flexible communication pathways as exemplifying the "freedom" essential to resilience and the aspirations of the governed.

The challenge indeed lies in "bridging the chasm" between the simple and the complex, the "virtual" and the "concrete". This is a generalization of the challenge of "speaking across the chasm of frame conflict" in human communication (fruitfully discussed by Schroeder) -- to which the different orientations of the faces of polyhedra draw attention. It is also recognized as the two-culture chasm between the "sciences" and the "arts" -- exemplified in the realm of governance by the cognitive challenge of heads of state inspired by poetry (*Poetry-making and Policy-making: arranging a marriage between Beauty and the Beast*, 1993).

More provocatively and self-reflexively, this is also the challenge of interrelating the various threads (architectural, cognitive, and otherwise) of the above argument -- whose proponents might be variously seen as living on different faces or planes of a polyhedron as yet to be identified.

It is these principles that need to be embodied in tensegrity psycho-social organization and strategy -- if viable coherent "global" governance of any "integrity" is to be achieved, whether at the global, regional or personal scale. In this context, the set of polyhedra offer a range of explicit articulations of "global" -- especially through the dynamics of their tensegrity variants.

It is important to recognize that the above focus is on **enabling exploration** of possibilities and interpretations. The concern is **not with closure** on any particular set of definitive interpretations or understandings. In the application of such a "pattern language" to governance in uncertain times, it is the capacity to be cognitively sustained in the exploration of possibility and potential that is most to be valued in the quest for "sustainable development" and "quality of life". The art of global governance may turn out to be well illustrated by the capacity to explore and promote more integrative metaphors -- possibly mapped onto the transformational potentials of the set of spherically symmetrical polyhedra.

The possibilities of a polyhedral pattern language therefore lie in its capacity to trigger alternative and complementary ways of thinking about intractable governance issues -- eliciti9ng creativity appropriate to the much sought "paradigm shift".

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