IMPLEMENTING PRINCIPLES BY BALANCING CONFIGURATIONS OF FUNCTIONS

a tensegrity organization approach   by Anthony J N Judge

Introduction

When a decision is made to pursue a group of concerns, there is a basic problem of ensuring that they are appropriately interrelated and do not simply constitute a fragmented collection of initiatives. This paper examines a new approach to the systematic récognition of the interrelationships necessary to the emergence of a viable configuration of concerns at a new level of significance. The « concerns » could take many forms. They could emerge from individual resolutions or recommendations. They could be elements of a declaration of principles. Or they could be research priorities, projects, or the functions required in an organization. That they are interrelated, or at least should be, follows from the initial intention whereby they were treated as a set of in some way complementary elements(1). How they are interrelated is seldom clarified initially and often only emerges, if at all. in the operational considerations in any organization(s) through which they are implemented. The number of concerns accepted in a given case depends both on the distinguishing power and on the ability to comprehend and communicate their necessary nature as a consequence of that act of distinction. The level of ability may not be adequate for a viable structure to emerge (1).

Structural options

Leaving aside situations in which no conscious attempt is made to structure such relationships, one of two structural extremes may be used to reflect them :

- hierarchy for tree) structure, as in conventional organizations e.g. for 6 functions (see Fig. 1).

- associative network structure, as in « network » organizations e.g. for 6 functions (see Fig. 2)

The first of these merely indicates formal reporting channels and not the necessary operational communications. It is also in many ways symptomatic of the problems to be overcome. The second is seldom used explicitly, even though operational links could be represented, but it also fails to clarify what are necessary relationships. A more recent innovation also fails in this respect :

- matrix structure, as in « matrix » organizations (see Fig. 3)

Fig. 3	Dept A	Dept B	Dept C	Dept D
prog development			x	x
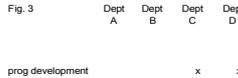
In previous papers the advantages of investigating « tensegrity » organization have been put forward(2, 3) The problem of deciding on functions and relating them to a given tensegrity pattern was raised but not addressed. This is the purpose of the next section.

Recognizing relationships

The question is how to represent explicitly the relationships perceived in a set of functions which are to be the basis of a viable organization, policy, programme or conceptual scheme(1). One interesting possibility is to adapt the conventions of the Venn diagram used in symbolic logic and « new mathematics ». e.g. for 3 functions (see Fig. 4)
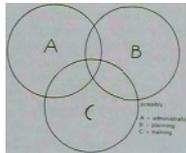

Fig. 4

It is the fact that functions A and B are represented as intersecting or overlapping in the diagram which makes explicit their relationship as a basis for any organization. As such, the diagram is somewhat trivial. However, the Venn diagram convention can be adapted in a useful way by introducing the concept of dominance or priority (*).

e.g. for 2 functions (see Fig 5)
By drawing thick lines at the cross-over points of the functional boundaries, it is possible to represent relationships of two distinct forms :

- function B has priority over function A
- function A has priority over function B

Fig. 5
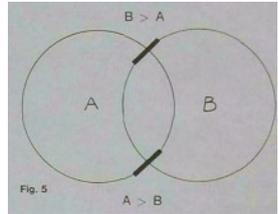
This may be interpreted from the diagram in terms of how the thicker line reflects either :
- the « penetration » of one boundary by the other, (e.g. A over B) or
- the « blockage » of any such penetration by an « impenetrable » boundary.-

This approach has the advantage of rendering explicit two functional situations of operational for policy) significance. It thus goes beyond the relatively simplistic recognition of « A and B are interrelated ». In contrast to the Venn diagram convention, it is not the bounded area which denotes the function, but rather the boundary line or track (which most economically takes a circular form).

The set of functions as initially conceived may give rise to misunderstanding if :
- each function is not of equal value (e.g. such that one is in all cases of lower priority than another)
- one does not in fact relate to the others in a group, or only relates to some of them.

These possibilities are considered in a later section. If the set has been well-conceived, it would appear that its constituent functions should obey the following rule, provisionally formulated as : Each function basic to the operation of a well-balanced group gives rise to two operational situations in relation to each other basic function :
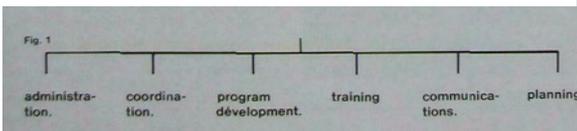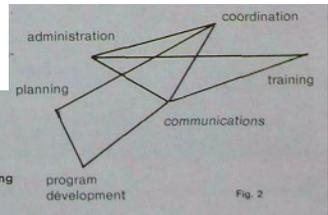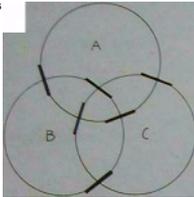

Fig. 1

administration. coordination. program dévelopment. training communications. planning

Fig. 2

Within the above convention, this is re-
presented by patterns of thickened lines
at the boundary cross-over points

e.g. for 3 functions (see Fig. 6)

Fig.6

Maintaining equilibrium

While such functional « weaving » is inter-
esting, it does not yet clarify what relation-
ships are necessary to prevent operation-
al shocks from de-stabilizing the configu-
ration as a whole. What ensures the main-
tenance of dynamic equilibrium ? (Growth
and evolution need to be considered la-
ter).

At this point it is helpful to conceive of the
« functional boundary lines » as being at a
higher level of abstraction than the
thickened portions at the cross-over
points. In effect the boundary lines are
made manifest or defined by the
thickened portions(*). It is also helpful to
conceive of the thickened portions as be-
ing straight, such that the curvature of the
boundary must be defined by a series of
thickened lines angled in relation to each
other.

The necessary relationships may now be
understood as the connectors required to
protect the geometry defined by the
thickened portions (separators) of the
lines.

e.g. for 3 functions (see Fig. 7)
Inserting the first 1 2 connector lines dem-
onstrates the approach to maintaining the
configuration. But is also raises the very
interesting questions of the unconnected
ends of the separators and the limitations
of the two-dimensional representation. An
« outer » set of 9 connector lines way be

(*) The boundary lines may perhaps be considered

added with some form of distortion, but
this still leaves the « outermost » 3 separ-
ators incompletely bound compared to the
others.

The operational significance of such con-
nector lines in an organization will be dis-
cussed below. At this point it is sufficient
to suggest that the incomplete bonding is
characteristic of many (non-self-reliant)
organizations which depend upon their
external environments to maintain their
functional stability. Typically this may in-
volve either of the following :
- an external resource pool
- an external waste product « sink » (i.e.
no recycling)

This dependence limits the organization's
ability to recognize the process cycles
through which it is embedded in, and
« feeds » off, its environments. David
Bohm's concept of « holocyclation » re-
lates to this(4).

3-Dimensional equivalent

Because of the topological nature of the
representation above, it can be trans-
formed into a three-dimensional structure
by simply « folding up the petals » in order
to insert the 3 final connectors. Were the
connectors made of elastic material, they
would then become of equal length in
such a final dynamic equilibrium configu-
ration. Fig. 9 is thus the equivalent of Fig.
7. Fig. 9 is one of the simplest tensegrity
structures : a tensegrity icosahedron.
(Fig. 8 is an indication of how Fig. 9 ap-
proximates to the circles of Fig. 7). It
would be a mistake to treat such repres-
entational transformations as trivial, for in
operational terms they reflect a funda-
mental change in attitude in which « in-
ner » and « outer » environments are re-
cognized as inverted mirror reflections of
each other(*). It would also be a mistake
to fail to reflect on the operational signifi-
cance of the minimum opposing (comple-
mentary extreme) properties that need to
be attributed to the « separators » (e.g. ri-
gidity) and the « connectors » (e.g. flexib-
ility) for the structure to exist. This has
been touched on in earlier papers, but re-
mains a fruitful area of exploration in
which premature closure, even if possible,
should be avoided (**).

More than 3 functions

Clearly the same approach may be used
where 4 or more functions are considered

basic. In Annex 1, the case of 6 functions
is explored. This results in a tensegrity
icosidodecahedron. Six functions have
been selected for the recently launched
Hexiad Project, although the instigators
choose to work with a different tensegrity
structure in the light of an interesting alt-
ernative interpretation (5).
Now although this approach could be
used in the case of any number of basic
functions, there is an indication of an early
limit. Most tensegrity structures have tri-
angular, square, pentagonal or hexagonal
«faces». Above this number there are
problems of stability (which remain to be
explored). Aside from which, in an organ-
izational setting there are problems of
handling more than about 7 varieties of in-
formation(1).

This limit may be bypassed by a logical
extension of the method described above.
This is explored in Annex 2 for the case of
the 26 sub-projects of the United Nations
University's Goals, Processes and Indica-
tors of Development project. By coinci-
dence, a recently produced diagrammatic
representation of the structure of that pro-
ject reflects the first step in the extension
of the method (see Fig. 12). Note that
where the number of equivalent basic
functions is so high, the circuits do not all
interact with each other (***). Although
there are always the two forms of interac-
tion. The rule mentioned above must
therefore be modified to ensure adequate
functional « basket weaving » for the
« basket » to be a viable structure. Further
investigation is required.
Functional articulation may be continued.
The tensegrity structural consequence is
reflected in the generation of geodesic
polyhedra developed by R Buckminster
Fuller(6). Needless to say, there are many
interesting aspects, variants and excep-
tions (e.g. for less than 3 functions) which
remain to be explored.
An important alternative to note emerges
as the number of crossover points for se-
parators (on any circuit increases. Whilst
the straight separators may always be re-

(*) in psychoanalytical terms it is equivalent
to an indi-

vidual's confrontation with his own « shadow » and an
understanding of the death/rebirth cycle - a counterpart
to recognition of both the ultimate feedback conse-
quences of waste-product dumping and the need for re-
cycling.
(**) It raises the same difficulties as comprehending
the nature of - yin - and - yang . in Chinese philosophy.

than **great** circles around the sphere; under certain

Fig. 7   Fig. 8   Fig. 9
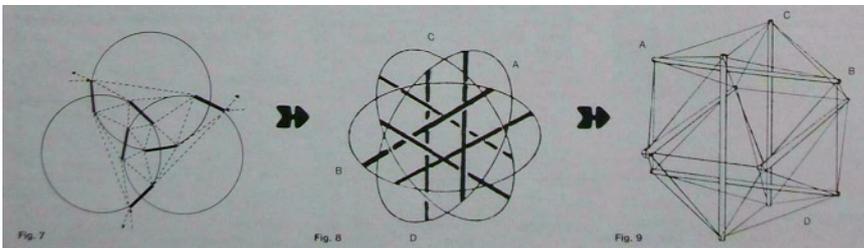
Using the same approach as for Fig. 7.
circles A, B. C. D, E and f can be inter-
linked to form Fig. 10. This is a two-di-
mensional representation of the tenseg-
rity icosidodecahedron shown in Fig. 11
in three dimensions. The shaded **pen-
tagons** in Fig. 10 are distorted progres-
sively away from the centre but are ATI
the same size in Fig, 11, as are the
shaded triangles. The edges of these ar-
eas are the connectors The separators
are shown in thickened black lines,
again distorted in length away from the
centre. The five outermost shaded por-
tions fold up together (like petals) to
form the twelfth pentagon. (Note that
right and left-handed versions of such
tensegrities may be constructed.)
Comments on the lettering are given in
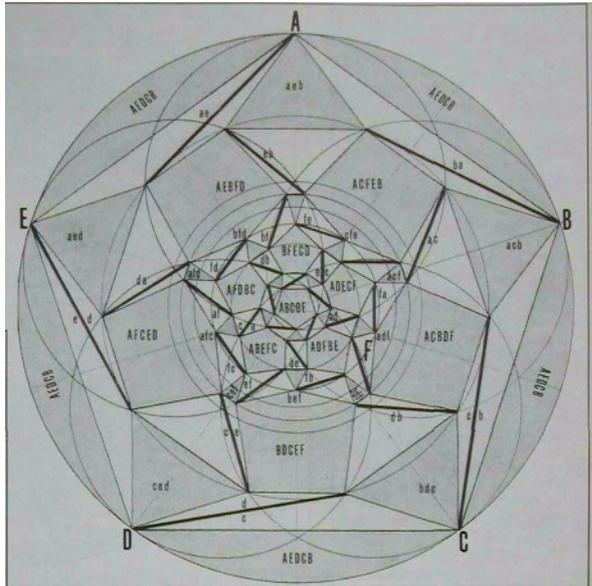
duced in length to maintain a separation
between them (resulting in a «diamond
pattern »), they may also be increased in
length and allowed to touch (resulting in a
«circuit pattern»). This eliminates the
need for some connectors which then fol-
low the circuit pattern of the linked separ-
ators(2). This can result in viable struc-
tures even when there are only three ele-
ments in the circuit. It is however the most
common pattern with higher numbers of
cross-over points per circuit.

Operational significance

For any of this to be of operational signi-
ficance, the « decodification » of the basic
features of such structures must be clar-
ified :

1. Separators: It was suggested above
   that the abstract «functions» should
   be defined at the level of the separa-
   tors which themselves only occur at in-
   teraction points between functions. As
   such they may be interpreted as some
   form of action in terms of one function
   but in relation to another. In earlier pa-
   pers the notion of a « struggle » be-
   tween opposing conceptions was sug-
   gested, and it is interesting that Calla-
   way treats them as « projects »(5). It is
   a question of what one function has to
   do to define itself in relation to another.
   Thus, for example, in the interaction in
   an enterprise of the functions « human
   relations » and « production » :
   - human relations must dominate pro-
     duction under certain conditions (to
     which trade unions and personnel
     managers are particularly sensitive!
   - production must dominate human re-
     lations if « the job is going to get
     done in time ».
2. Circuits : The significance of circuits as
   functions has been discussed above. It
   needs to be stressed that functions
   cannot be described in the abstract or

terms of action and that action only oc-
curs in relation to other functions(").

boats (separators; travelling around the circuit and
meeting successive waves corresponding to other
functional circuits The separator denotes the special
action required in each case for the direction (and func-

tional integrity) to be maintained.
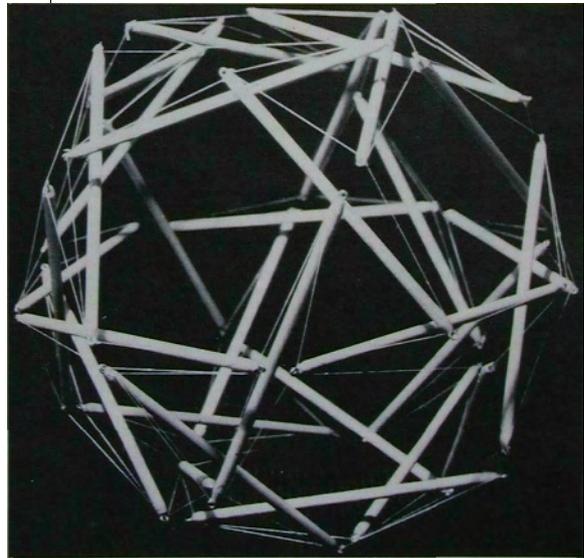
3 **Connectors :** As suggested above, these may be taken to signify the **lines** of communication whereby the relationship between different activities (separators) is maintained in order to preserve the interrelationship between functions necessary for the functional integrity of the whole.

4. **Facial areas** : These are the triangular, square, pentagonal or hexagonal areas defined by the connectors (and also by the separators in the circuit pattern). They may be usefully thought of as « decision arenas », or possibly « roundtables ». in which a balance has to be struck between the different forces (functional issues) entering the «mandate » of the particular arena. Clearly each such arena has quite distinct responsibilities. Note that the limitation on the number of sides to **an** area usefully reflects the practical limitations on the size of a viable committee or task force - or the varieties of information which can be handled together in such a setting.

5. **Structural « pimples » and « dimples » :** There is no need to focus solely on spherically symmetrical structures, despite their advantages. Portions of a structure may be missing, resulting in a « dimple » (an expression used by Buckminster Fuller). This would correspond to unactivated functions and activities. On the other hand « extra »
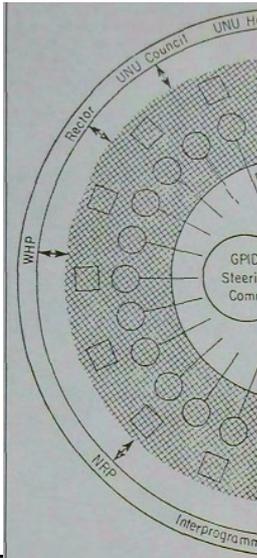

Fig. 12 : Diagrammatic representation of UNU/GPID structure.

Annex 2 :
Case of « 26 functions »

The Goals, Processes and Indicators of Development (GPID) project of the UN University started in 1977 with 24 subprojects (gradually increased by some 5 additional «study groups», of sub-project status). This complex project has recently been represented by Fig. 12 in which the small circles indicate 26 subprojects. There is internal concern regarding (a) proposals to increase the number of sub-projects, and (b) problems of ensuring appropriate interlinkage between them to constitute a coherent whole consistent with the GPID mandate.

Assuming that each sub-project represents a distinctive « function ». it is possible to construct, by geodesic subdivision of an icosahedron, a tensegrity with 30 functional circuits (some of them lesser circles). The (10-frequency) tensegrity icosahedron has 750 separators (activities ?) and 1500 connectors (communication paths ?). This seems to be unnecessarily complex given the level of activity of GPID. It is already difficult enough to understand. Assuming that the sub-projects are in fact « groupable » into sels of more basic «functions», a simpler approach may be adopted. And in fact the original 24 were grouped into 4 : goals, processes, indicators and tools. These however excluded the steering/coordinative function evident from Fig. 12. They also exclude the self-reflexive function characterized by some recent papers. For the **sake** of illustration only, let it be assumed that there are currently 6 basic functions grouping some 30 sub projects In which case Fig. 10 may be

used to explore the necessary interrelationships for the coherence of GPID as a whole. The separator circuits A, B, C. D, E and F represent the 6 functions with 5 sub-projects per circuit. For the GPID to maintain functional integrity, communications must then be maintained according to the pattern of connectors outlining the shaded areas of pentagons and triangles. The roundtable decision arenas represented by the latter are an indication of the inter-paradigmatic considerations to be maintained in balance. Some may appear obvious (possibly due to their ease or appeal), others much less so. The areas have been labelled according to the functions defining them. Thus area ABCDE (in the centre) indicates a priority or causal relationship of A)B) C)D),E)A... It may be considered as labelling the circularity of the priorities governed by a particular feedback loop necessary to the functional integrity of the GPID preoccupations. Note each labelled area is matched by one in which the reverse ordering holds. So ABCDE is matched by one formed when the outer areas are folded up to form the twelfth pentagon AEDCB. In the 3-dimensional form the apparent centrality of ABCDE in the 2-dimenstonal form is shown to be arbitrary for at most the temporary consequence of a particular viewpoint.

On the practical question of how to decode the functions and their 30 sub-projects. Fig. 10 raises an important issue. Because each element is defined in relation to the whole, the conventional practice of only articulating any such definition within a sub-project is shown

to be inadequate for even dysfunctional). The significance of verbal descriptors is challenged by the context. It is in this light that matching of Fig. 10 to GPID elements should be explored. Are sub-projects associated with a particular function equally distinct ? Is the set complete ? Into what « gaps » do additional sub-projects get slotted ? Are some sub-projects effectively sub-projects ? Is there a functionally significant sequence to sub-projects associated with a particular function ?(*) As stressed earlier, there are many tensegrities and perhaps many ways of making use of their power as « interrelators »..In the future, sets of viable patterns for consideration could be generated by cornputer(**). This is specially relevant to the continuing evolution of GPID through any more appropriate patterns of functional interlinkage (***)

(in their cultural contexts) to Navaho sand-painting or the associated discipline of mandata construction. Here

ticular pattern must be used. The act of

pattern is analogous to the cathedral builder's choice of a set of - sacred

symmetry of the building. Here the basic

(***) The dynamics of the relationships basic

11 will be considered in a later paper.

misleading as crude portrayals of models of the Bohr atom or the DNA molecule

functions may be associated with the basic pattern as represented by elements added onto the spherical structure. This is a rich area for exploration.

Organizational significance

It is important to note that the organizational pattern has been defined above in terms of the realism of activities, functions, communications and decision « arenas ». This contrasts with the formalism of conventional preoccupation with organizational units, reporting lines, and programmes.

In the light of the preceding sections, it is now possible to map out the complete functional organization. This done, there is then the interesting question of the « organization structure » to be associated with each component. Some types of organization structure are :
- independent organization
- department/section
- programme/project
- person/role
- job activity
- attention time
- procedure/rule
- automated decision procedure.

Now the notion of function may, for example, be associated with a department, a programme, or a person, which would thus be represented by a circuit of separators. The attribution would depend on the complexity of the organization. Alternatively, an individual activity might be associated with a department, a project, or someone's attention time, which would thus be represented by a separator. A decision arena might be the responsibility of a committee or task force, a person, someone's attention time, or an automated decision procedure - again depending on the complexity of the organization. The functional requirements make clear the activities or decision arenas to which attention should be given by whatever appropriate structural element - in order for the functional integrity of the organization to be maintained. In particular it draws attention systematically to features which have not been considered explicitly and which certainly do not emerge from conventional organization charts(**). In the latter it is assumed that functional integrity is maintained by top-down decision making. The weakness of this is evident from the increasing number of constraints (e.g. in personnel relations! to which top-down management is subject. In the tensegrity organization, the management/leadership function is merely one amongst several functional circuits. It dominates each other function under certain conditions, but is dominated by each of them under others (***). Where there are many functions, it may not even interact with some of them.

Implications

This paper indicates how, from the initial logical conception of an interrelated complex of functions, a non-hierarchical organizational structure can be elaborated. It has the ment of indicating specifically and systematically the interrelated opera-

tional concerns which must be borne in mind for reflected in functional responsibilities) in order for functional integrity to be maintained. This is a significant structural and operational step beyond any checklist of « management do's and don'ts » or of a mathematically generated set of possible functional combinations. The approach provides a functional coding scheme which emphasizes functional integrity in a non-parasitical relationship to the environment. As such it has built in « organic » and holistic qualities which contrast with the somewhat mechanical and fragmented thinking reinforced by conventional hierarchical coding schemes. It is almost as though the latter stressed a functional « flat earth » quality in contrast to functional « roundness » as a desirable alternative.

Whilst the approach lends itself to simple « cook-book » organizational design, any structures or structural features are a standing challenge inviting deeper comprehension. This is because the nature and significance of each element is necessarily determined by its relation to the functional whole. Thus if a verbally defined project is associated with a particular separator, the position of the separator is an invitation to understand a deeper significance of the words describing the project, or alternatively to recognize the functional characteristics the words have failed to capture.

The approach has much to recommend it in showing part/whole relationships such as of small groups (commissions) to a plenary body (e.g. in a meeting). It also offers a valuable means of seeing the relationship of independent organizations in a functionally integrated network. In seeking to use tensegrities, it may prove that it is more appropriate to treat them as extremely powerful conceptual « interrelators » for whatever projection onto them can be adequately sustained and comprehended within the collectivity concerned. This may be incomprehensible to « outsiders ». thus unable to work within that pattern. It is useful, for example, to reflect on the elegance with which tensegrities can interrelate complex patterns of differences (separators) and similarities (connectors) at a time when society is torn between the simplistic extremes of personal or collective violence on the one hand, and sexual/ecstatic merger or planetary integration/union on the other. Could it be that tensegrities indicate a way of articulating and interrelating differences such that the latters separative properties (normally destructive) provide the necessary basis for the construction of a new collective space ? (Is any attempt to base new structures solely on similarities doomed to failure as a contradiction in terms ?) The tensegrity, as a configuration of differences, then provides a way of releasing and channelling energy from differences (in orientation, including opposition, for example). What then are the energy containing patterns of differences and similarity (cf. social differences and the similarities of « equality •); paradigmatic and

ideological differences, etc), and how can they evolve? Is the energy derived through « oscillation » in relation to a more fundamental field than that embodied in the tensegrity as collectively comprehended ?

Finally, there is a certain practicality and elegance in moving beyond the divide-and-rule exploitation of the rivalries, which tend to undermine every initiative, to their transformation into a non-hierarchical structuring device - rather than trying vainly to eliminate them and thus forfeiting the energy they generate. The same might be said of the many illusions by which individuals and groups are plagued according to their learning experience-the containment and boundedness they provide, and the energy they generate, could well determine their place as information processing stages in a larger pattern which they collectively make manifest. Given the knowledge and population explosions, the amount of ignorance « generated » and « accumulated » is progressively increasing. If it cannot be eliminated, efforts should be made to benefit collectively from its characteristics before these make it impossible to do so. This perspective has the merit of indicating how this might be done without exploitation.

Although much remains to be investigated, numerous possibilities for practical experiment are now open. The Hexiad Project is to be congratulated on being the first to use tensegrity organization principles(5, 7). That they should be first used to link the alternative communities of Findhorn (Scotland), Auroville (India), and Arcosanti (USA), with the aid of computer conferencing techniques, is perhaps a lesson to more conventional international bodies.

(**) The non-Marly structured interrelationship of decision arenas here contrasts with the linear listings and checklists to be found in standart management textbooks.

(***) It is interesting that sophisticated hierarchical organizations achieve balance by having a functional safety-valve in which the « chief » is ridiculed and the « underdog » may even takeover temporarily. This is celebrations in which custard pies may be thrown at the president, possibly at a price for a charitable cause; or the special freedoms of New Year parties).

References

1. A J N Judge. Representation, comprehension and communication of sets: the role of number. International Classification. 5. 1978. 3. pp 126-133 (Pt. II; 6. 1979. 1. p 15-25 (Pt.II; 6. 1979, 2, pp 92-103 (pt III)
2. A J N Judge. Transcending duality through tensional integrity; from systems -versus-networks to tensegrity organization. Transnational Associations. 30. 1973, 5, pp 258-265.
3. A J N Judge. Group ware configurations of challenge 10. pp 467-475.
4. David Bohm. Fragmentation in science and society. Impact of Science on Society (Unesco). 22.2,197O.
5. Peter Callaway. Introduction to tensegrity organization principles. Transnational Associations. 31, 1979. 13. pp. 592-599
6. R Buckminister Fuller. Synergetics; explorations in the geometry of thinking. Mew York. Macmillan. 1975.

Auroville. Arcosanti. Cambridge, Mass . Hexiad Project (P O Box 38-206. Cambridge MA 02138), 1979