Appendix 6.3 - Proposal for Finite Project Structure

Ap6.3.1 Introduction

The particularly low results obtained from the quantitative and qualitative research method on the structuring of project teams, as well as the low ranking given by the respondents to the sub-process, despite extensive literature available, prompted the author to dwell on and propose an alternative approach.

Considering the project structure in three dimensions – time, project organisational depth and width, allows for improved visualisation as well as early consideration of the approach to be taken when structuring the project and for the duration of the project. It enables thus the translation of the current, inaccurate, cost spreadsheets into real project structure and cost.

Further on by considering individuals as nodal points in a 3D structure it facilitates:

- the introduction of complex adaptive systems;
- the establishment of the project functions of the structure;
- the formation of clusters and fractal structures of various shapes;
- the identification of key players / autonomous agents within the structure;
- improved accuracy of resource management;
- the introduction of theories such as finite element analysis, and string theory, which will allow for testing of hypothetical as well as real organisational structures under varying conditions – internal and external; and
- the incorporation of individuals' characteristics through personal profiling, psychometric tests, etc.

It is the integration of a number of theories from different fields of engineering, physics and psychology which allows for a holistic and non-mechanistic view of structuring project organisations.

Resource limitations as well as the extent of this research have not allowed for the testing of the above proposal, however, the remaining steps will be described below as part of the recommendations for future research.

The analysis and discussion of the research results indicated clearly that PM practitioners are not considering the current approach to project structuring as a process that contributes as much as it should / is described in project management literature.

Literature review also established that '*new models of human organisation are needed to replace hierarchical bureaucracies*' (Belbin, 2000) and studies carried out (Shirazi et al, 1996; Andersen, 2003; Green, 2006) indicate clearly that '*hierarchical elements of the project must be eliminated for a project to move closer to the prevalent task culture*' (Andersen, 2003). Belbin (2000) also confirms that 'i*f jobs are not formulated to hang together as a dynamic entity within a coherent system, the effectiveness of the whole will be severely weakened*' (Belbin, 2000). This is confirmed by the findings of the quantitative and qualitative results indicating that when structuring project teams PM practitioners simply follow experience and are not able to express this in such research methods as interview questionnaires, because of the effect of the observer and observed syndrome.

The above together with the demanding requirements transpiring from the definition of project management stated and below require a different approach to structuring projects. The new approach should be one that will encompass the latest thinking and above all earn the confidence of the PM practitioners that as a project management sub-process it addresses the issues raised.

> Project Management definition
> The management of transient, dynamic and complex adaptive systems/agents, so as to deliver the expected change within certain parameters that are set by a seemingly ordered and stable environment

In order to provide clarity and a holistic view to what will be proposed from this research for further investigation a brief review of the relevant topics in the supporting literature will be carried out, followed by the proposal for a Finite Structure (FS) approach to organising and structuring projects in construction.

Ap6.3.2 Review and Initial Concepts

Social Network Theory

The Social Network Analysis (SNA) properties, attributes and roles identified by Tichy et al., (1979), Loosemore (1998) and others and shown in Appendix 5, can be utilised to describe a number of properties within Finite Structure (FS). The extensive correlation between SNA and complexity can be appreciated when considering the basic principles in SNA (Loosemore, 1998:316):

- *People are interdependent rather than dependent*; Therefore establishing interconnections and supporting the complexity of interconnections characteristic of autonomous agents;
- *People are embedded in complex and dynamic social networks which influence their behaviour*. Since people deliver projects and people form complex and dynamic social networks complexity characteristics apply;
- *Relationships*, considered as behavioural interconnections, *are as important as individuals in determining behaviours*;
- *The change is a constant feature of social life and must be accounted for in a research context*. This also supports Lucas' (2000a) definition of complexity.

Considering the above one of the SNA tools that can be used in conjunction with FS is the 'Network Sociogram' (Mead, 2001), which gives a graphical representation of the linkage between the team members. The communicational characteristics of each node could be

combined with the other characteristics to create a much more accurate picture of the Complex Adaptive System (CAS).
What also has to be considered is the effect, or rather how, the node (the individuals) with its distinctive characteristics will affect the link(s) / interconnections and even more, what link(s) is it likely to set up. For example an extrovert will, very likely, set up links with high intensity and reciprocity, express affect and attempt to influence others. However, an introvert is highly unlikely that will be comfortable doing so. Therefore we see that for the appropriate links are very much dependant upon the characteristics of the node.

This is where the FS contributes to a holistic approach to organising in dynamic environments. In FS the whole concept will be represented for both the linkages and the nodes and we are able to define at an earlier stage the required structural characteristics of the system.

By setting up clusters, within the project, it will be possible to define a number of structural characteristics that the project network (of people) should have. This is not necessarily a set up to predetermine the project outcome and each move during the project life, because this will be defeating the object in a Creative Reflective framework, but rather as an initial guidance to a successful outcome.

The properties of centrality and its sub-processes (Loosemore, 1998) can be considered and resolve a number of details of the FS, as will be described below.
The properties of centrality can be one of the characteristics on the FS clusters. As information flows in the FS clusters centrality will be one of the fundamental drivers for the self-managed units. It will be important to define the degree of that flow which could be to individuals or groups respectively. The former will be when the project is in the construction phase where extensive levels of information flow to different clusters. The latter will be during the very early phases or during commissioning, where a smaller number of groups have to interface and retrieve information generated at early project phases.
Some of the most important properties of centrality that can be considered are reviewed below:

- Degree centrality (Loosemore, 1998). This property will be used at a lower level within the clusters to indicate which member of the cluster, or even which cluster should have a high index of in-degree or out-degree centrality. This SNA property will be combined with the groups' or individual's characteristics in order to match the individual's strength to that required by the role.
- Closeness centrality (Loosemore, 1998). The level of working independently in the FS cluster will not be an issue because the members of the cluster will have to work independently carrying out the task for which they have been brought into the cluster. What will be utilised here is the rapid dissemination of information between the members. Therefore the degree of closeness centrality will be a characteristic of the framework.

- Betweenness centrality (Loosemore, 1998). This characteristic will be a safeguarding characteristic within FS. Identifying the level of acceptability of betweenness centrality within the framework will allow for triggering an alarm when this is exceeded by any member of the cluster. It will also be a testing trigger when setting up the FS cluster.

Sub-assemblies / Clusters

By creating low level stable subassemblies and then linking those together to create larger ones, until the overall structure has been formed, enables the creation of a very stable and flexible / adaptable structure with fewer interdependencies (Breuner, 1995).

The concept of subassemblies / clusters, as will be described below, can support the FS approach to structuring a Project Team. The size of the subassemblies could contain up to ten individuals, which as indicated by Maylor (1996) is the size of a team that works best in construction. Weick's (1979) rules will also be used for setting up interacts / dependencies in the FS mesh (individuals and subassemblies) and in particular for assembling the double interacts.

Emergence

To overcome the organisational inadequacy (Shirazi et al, 1996) the PM is required to organise a self managing / self organising system in a distributed responsibility approach and the inclusion of autonomous agents. Establishing clusters and in particular multi-skilled ones and relying on autonomous agents (diversity agents – Breuner, 1995) creates emergence, improves the problem solving capacity and minimises complexity both in the construction as well as the human system (Bertelsen, 2004).

Differentiation and Interconnections

Clustering introduces differentiation which requires more integration (Lawrence and Lorch, 1967), in order to bring together the various teams. However, the demand for more integration increases administration (Yuan and Pheng, 1992) and complexity of interconnections (Lucas, 2000a) and because interconnections expand, information / communication demands more. However, complexity of interconnections will be managed with the framework (F4MCI) proposed this thesis and the information demands will be managed using Weick's (1979) rules.

In addition to the required integration the proposed changes introduce more 'weight' / cost to the project and as a consequence another problem is added. However, if we consider the parallel of the aircraft frame where the use of a lighter frame, honeycomb structures, enables the plane to fly, a similar structure can be set up in teams.

The honeycomb structure panels provide the required strength, can take the required load and perform in a similar manner to solid panels. This 'property' will be discussed further below.

Fractals

In addition to the above, Moore (2002) describes how by using the fractals theory, structural chromosomes can be linked via the strange attractors, which are points towards which systems are drown to. Depending on the complexity of the project organism genome these could have single point of attraction for a simple genome and the more complex ones a larger number of attractors.

This is where a parallel with the Mandlebrot fractal can be drawn (Williams, 1999). The multiplicity of goals and the stakeholders as well as the multifaceted / multi-project environment within which the individual project exists can be visualised in the M-fractal.
However, whereas the structure of the M-fractal in infinite, a project structure is finite, therefore it should be possible to establish a solution at / from the right level upwards and towards the centre. The M-fractal approach to Project Management allows also the concept of multiple PMs within a project (Williams, 1999).

Strange Attractors

The importance of the strange attractors was reviewed in the Complexity Chapter.
Human / social systems are dynamic and complex and project structures are no exception to this. Identifying the strange attractor in which the project operates will be very difficult. However, understanding and accepting their existence will allow team members to explore the patterns and use appropriate behaviour(s), focus on the real dynamics of human interactions and even identify individuals (autonomous agents) that will drive towards acceptable patterns. In the case of construction projects the industry has designed a number of roles which are there to minimise instability, introduce mutability and non-uniformity to avert 'flipping' into chaotic status. For example Health & Safety Managers and Quality Managers could be considered for such roles. The important action is to define such roles at the lower levels, within the clusters / subassemblies, which are not necessarily carried out by the team leaders.

Cross-functional Team Behaviours

Johns (1995) indicates that within teamwork cross-functional teams improve the quality of the work. This, however, requires people with different '*cognitive problem solving styles*' and Johns (1995) identified two different types, the N-type and the S-type. These two types could be considered in FS when establishing / identifying autonomous agents. The N-Type / Intuitive one is looking at the big picture attempting different approached, and the S-Type / Systems – Sensation type who pay attention to the detail and prefer stable conditions. A balance of these two types in a cross-functional team will produce the best output.

In addition to the role that the two types of autonomous agents will have on the clusters it will mean that each party to the project has selected its project team members using personal profiling and / or team selection techniques.

Ap6.3.3 The proposed Finite Structure (FS)

From 2D to 3D Structure

The current approach to project organisational structures is hierarchical and two dimensional. Project structures are drawn at the beginning of the project and at high levels (Moore, 2002), introduced in Project Management Plans (PMP) and most of the times are never to be revisited. At most, resource profiles are provided but these do not provide any information with regard to organisational structure. The only level where detailed team information exists is for cost reports, which have nothing to do with structuring project team.

Therefore, and as discussed earlier, the process is not providing any support and does not give any confidence to PM practitioners. Also the lack of depth, in terms of organisation levels and the static approach taken does not help either.

A new approach would have to consider:

1. Depth of the Organisational Breakdown Structure (OBS), as the structure is considered to the lowest level
2. Length of the OBS, as the project (therefore the structure) travels in time through the phases and stages of the project.
3. Width of the OBS, as the structure is considered in terms of the number of teams / clusters that are operating on the project.

A pictorial view of the 2D (from bullet points 1 and 2) and 3D (all three bullet points) are shown below in Figures Ap6-6.1 and Ap6-6.2.

Therefore, from Figures Ap6-6.1, the structure is travelling on a time axis and obviously changes and varies in depth as the project progresses. It includes the whole of the organisational structure not only the project's (that is all the contributors to the project) at the appropriate level of responsibility, e.g. the owner of the project from every organisation, which is the person that can make decisions. With this approach the problem of 'lack of responsibility' within the various levels of the project is minimised.

The level of the organisational structure is on y-axis so that it depicts the depth of the structure.

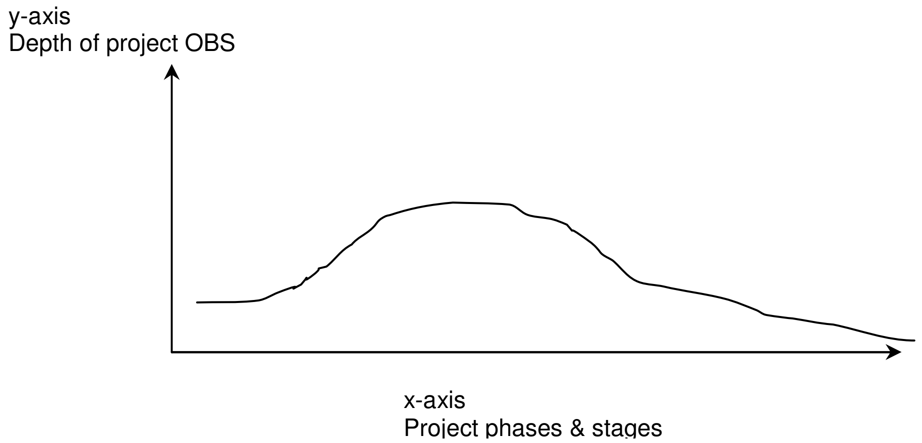

Figure Ap6-6.1. Pictorial representation of the 2D proposed approach to presenting project structuring

The proposed approach will also highlight and support the importance of early involvement of contractors – at design stage - and continuous support by the design team – during handover – as well as flexibility in starting works early (e.g. enabling works).

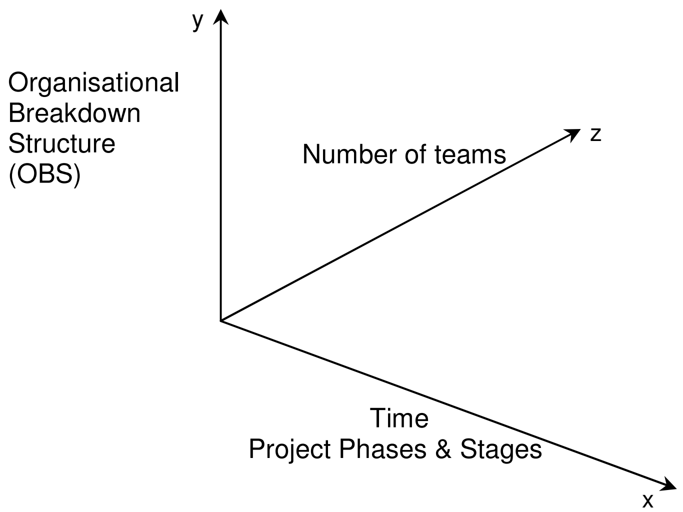

Figure Ap6-6.2. Pictorial representation of the 3D proposed approach to presenting project structuring.

In terms of presenting the structure in 3D it will:

- in the x-axis: enables for improved understanding of team / cluster contribution to project, time management and delivery of the project;
- in the y-axis: allows for improved responsibility, accountability, and coordination. It will also set the OBS in a continuous time axis, indicating that is a live structure and not something that is set up once;
- in the z-axis: it will allow for:

- easy formation of clusters;
- more accurate resource management with improved certainty;
- the use of different methods of forming clusters;
- reduction of fragmentation

The whole 3D approach allows for faster and better understanding of the teams involved (and by all parties), establishing requirements early in the project and improving earlier involvement of the required parties.

As the various organisational levels of the project are represented in 3D it will be easy to form clusters according to the project requirements and at different levels. Also it will be possible to form clusters between the teams at different stages, e.g. design and construction, or construction and commissioning. Additionally, since individuals are identified as nodes, then it will be possible to identify each individual's required characteristics. The significance of this point will be described below. It should also be easy to identify and plan for interconnections between different clusters, groups of clusters and companies at the different phases and stages. Thus, using the F4MCI to manage complexity.

Since each node is identifiable as a person and the whole represents a project organisational structure there are techniques - to be described below - which can test structures down to node / individual's level, on requirements, prevailing conditions, or other possible scenarios.

The proposed 3D finite structure can also be depicted as an elliptical shape, see figure Ap6-6.3. The reason the project structure is depicted as such is because most of the teams are present towards the middle of the project life cycle (as also shown in figure Ap6-6.1). The structure flattens on the sides because it is populated by either the suppliers or the support and overhead departments or disciplines that are there in order to provide material or services.

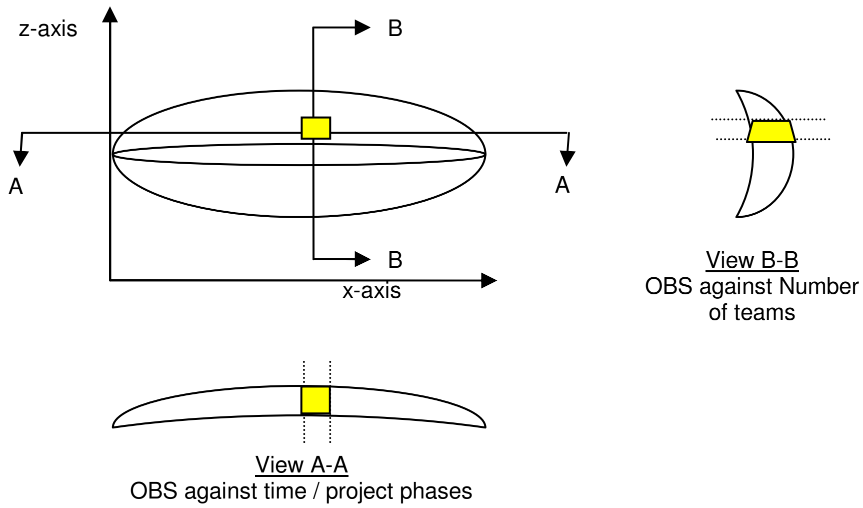

Figure Ap6-6.3. Pictorial view of the structure in 3D, with sections A-A and B-B

Viewing the structure in the x-z axis (see view BB in figure Ap6-6.3) presents pockets of clusters (at different levels) with different content.

At the fringes of the structure we find, as said above, the small suppliers / sub-suppliers / consultants with their small teams that also contribute towards the project and they were never before indicated in the Project Organisational Structure.

Finite Element within Finite Structure (FS) – the future

Generating a finite structure will mean that the following will have to be reflected on:

1. At a higher level a cluster of professionals / managers is set up.
2. At the lowest level there are team clusters.
3. Each cluster is made up of 6 and up to 10 multi-skilled individuals, which in an FS are considered as individual ‘nodes’.
4. At all required levels companies provide individuals who populate team clusters of multi-skilled teams which form and carry out work at the lowest level of the project.
5. Clusters are formed by selecting the individuals that fit the environment.
6. The environment has been considered and analysed by the enterprises (including the Client) that come together to deliver the project.
4. Contractual obligations do not interfere with the work that the team is delivering.
5. Work is coordinated by the clusters in a self-organising, self-maintaining approach, and depending on the size of the project, by a cellular approach.
6. As far as the Delivery clusters/teams is concerned <u>Management is a virtual team.</u>
7. The Management team points outside, towards the environment. Delivery clusters point inside, towards the deliverable. This is in a similar manner to that described by Walker (1996) – management and operational systems - but the management team incorporates other managers and not just those from the client.
8. The Management team also forms cluster.
9. The Management team meets the Operational teams in predefined intervals to give guidance only on questions raised, or changes that will be feasible to be implemented at that stage.
10. The Management team, which comprises from the enterprises that are to deliver the project, meet separately to review progress, financial matters, change and Risk management at higher level. They also consider possible effects from the external environment, which could require change in the team, the approach, the influence of the process within the clusters
11. The interface between the Management cluster and the Operational cluster is through the Project Leader of the Phase. The types of interfaces and the structure at the lowest level are presented in figure Ap6-6.4 and described in the following sections.
12. The teams / clusters are given:
    a. The scope

b. The proposed work breakdown
c. The necessary parameters and the software systems

13. The clusters interact continuously and if required virtually. For example during Design the design-cluster is in frequent contact with the construction-cluster(s) in order to obtain practical advice, or establish a datum. During Construction the construction-cluster(s) obtains advice regarding finishes from the design-cluster.
14. Clusters are provided with an interactive system for placing orders for delivery of materials, through the Management Cluster
15. The Delivery teams/clusters are incentivised by a mutual establishment of performance targets – not to pressurise / penalise them.
16. Autonomous agents have been identified, within the cluster(s) and for each phase. When uncertainty arises autonomous agents understand or even drive towards the prevailing strange attractor and provide the necessary bifurcation points in order to minimise complexity until stabilisation returns.

Clusters

Complex Adaptive Systems (CAS) have many autonomous parts, which self-organise to improve functionality, they are able to respond to external changes and form self-maintaining systems with internal feedback paths.

CAS are not fixed; they might require more or less freedom depending on the conditions and they change their composition "*to fit the changing patterns they encounter*" (Lucas, 2000b). Therefore it can be said that in construction we have clusters which change their composition to fit the landscape or the changing pattern of the project. So as the project moves between phases and within these between stages the composition changes fitness to the environment is achieved and the cluster moves on progressing with the project.
Lucas (2000b) indicates that "*this adaptation internalises environmental information, the system generates a model of the world outside, a distributed set of rules corresponding to the interesting or valuable aspects of their context*".

The FS generates '*a model of the world outside*', with a distributed set of rules which could be set up prior to the project commencing and with the clusters been set up '*corresponding to the interesting*' aspects, e.g. progress, fit out information or valuable aspects of their context which is the final outcome - the project.

Lucas (2000b) identified three types of interactions which involve the agents of a CAS at any level:

1. Intrasystem, or Intralevel: for interactions within the system, which he supports the view that this is about self-organisation to an internal attractor.

2. Intersystem: for interactions between systems, which he states is co-evolution, “*changing the fitness landscape*”.
3. Interlevel, or Hierarchical: for agents interacting within vertical hierarchies, which is emergence.

When considering the above interactions a factor that has to be understood is the strength of the interlinks between the different interconnects as it is highly possible that these could exist between individuals in a cluster.

Figures Ap6-6.4 and Ap6-6.5 depict the structure and the interconnections at the lowest levels for construction (Figure Ap-6-6.5) and the generic one as described by Lucas (2000b) (Figure Ap6-6.4)

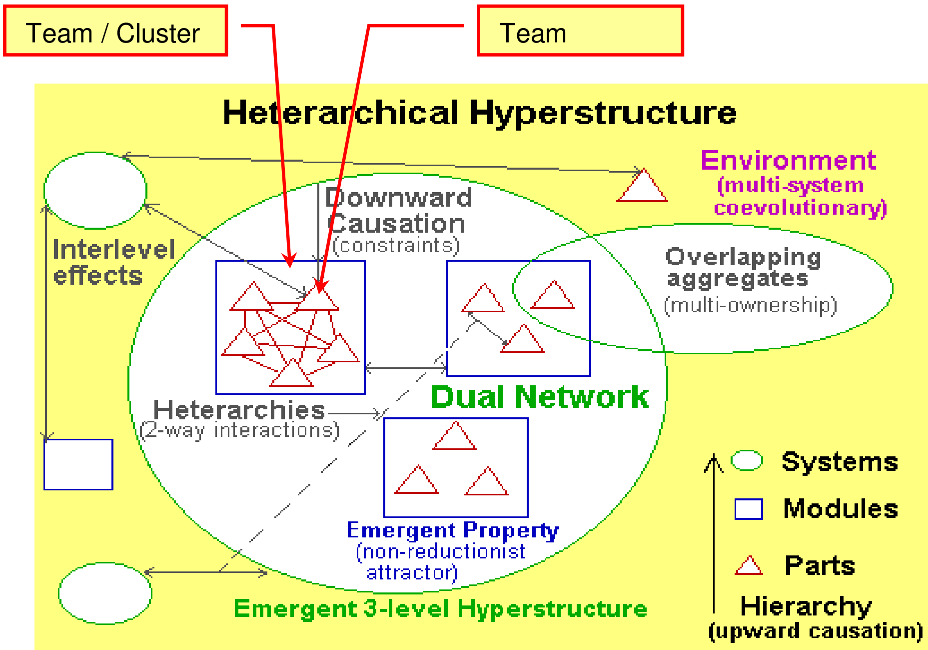

Figure. Ap6-6.4 Heterarchical Hyperstructure as described by Lucas (2000b)

Figure Ap6-6.5 below highlights the importance of the interlinks (or interactions) and how clusters or a number of them would link up or sideways to others in order to deliver a project. Therefore management of complexity of interconnections becomes an important sub-process for the delivery of the project.

In terms of construction the three characteristic interlinks can be presented as follows:

- Intrasystem: will represent interactions / interlinks within the project
- Intersystem: will be the interlink(s) between project and supplier(s)
- Interlevel: will be the interaction/interlinking between cluster(s) (or project team members / agents) and management clusters.

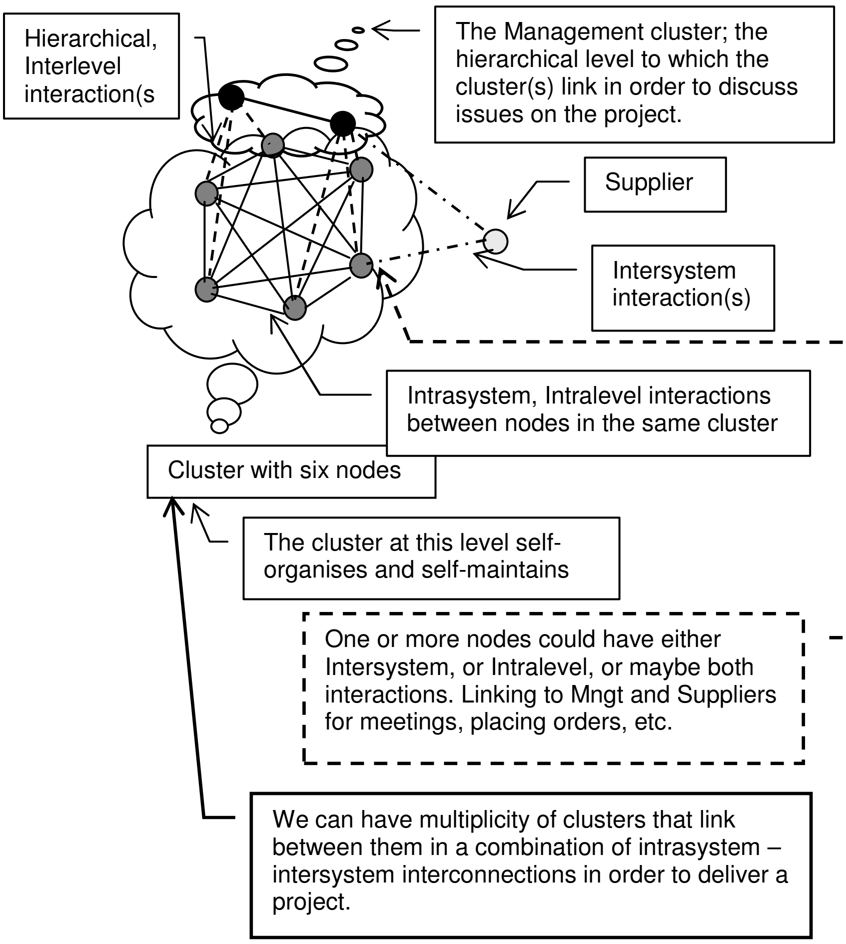

Figure. 10.5 depiction of interconnections between construction clusters at various levels.

The honeycomb structure

The honeycomb structure panels, mentioned previously, provide the required strength, can take the required load and perform in a similar manner to solid panels. Therefore the parallel of a structure with such properties could be (physically and metaphorically) considered in the structuring of project teams / clusters.

Considering the above Figure Ap6-6.6 provides a pictorial view of a honeycomb structure of the project organisation – at cluster / subassembly level.

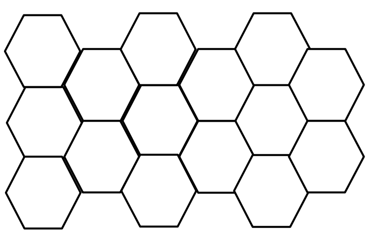

Figure. Ap6-6.6 Proposed honeycomb project organisational structure

The proposed structure provides:

- clear and minimum number of communication lines, therefore interconnections
- rigidity as well as flexibility
- prevention of deformation which cannot propagate through the structure (advantage of the hollow cells / team clusters)
- the benefits of the fractal structure which serves several purposes:
  1. replication of the structure throughout the project organisation levels
  2. reduction of risks by insulating other subassemblies or agents from the failure of any other one;
  3. allows for information to be passed easily between subassemblies or agents since it is highly reusable given the similar structures of the others; and
  4. allows the independent entities to be loosely coupled and not over-connected, providing stability.

The functions of organisational structure within Finite Element

Three major functions will have to be defined to enable the finite structure to be tested.

Points that will have to be considered and which define the three functions in terms of analysing, selecting and forming teams are:

1. Individuals: Function: $\{\underline{\mathbf{R}_{(x)}}\}$

Each enterprise and the Client have carried out personal profiling and each person, from management to worker, has a technical and behavioural profile.

2. Project Environment (which considers the stakes for the Client and the enterprises that are to deliver the project): Function: $\{\underline{\mathbf{I}_{(x)}}\}$

The project has been analysed in terms of its importance to the parties that come together and the internal factors that influence its delivery have been specified.

3. External Environment (external factors that affect the Client, the enterprises that come together and the Project): Function: $\{\underline{\mathbf{E}_{(x)}}\}$

The external environment has been analysed in terms of its importance to the Project, the Client and the enterprises and the level of influence / factors have been identified (as described by Hughes, 1989).

Having identified the functions that will affect each node within each cluster and the environment within which the cluster of nodes will have to function we use Finite Element Analysis (FEA) to identify:

a) The nodes that could prove problematic
b) The appropriate structural elements to be used. In terms of loading (preferably under heat/thermal loading) and how FEA will be implemented.

Considering the structure of elements within the FS we can easily extrapolate similarities between them and fractals. Taking this approach further, fractals are two dimensional (2D) whereas FS is three dimensional (3D) and therefore it deals with all the dimensions which could be taken to be the other organisations' structures and not only the project's.

Different geometrical shapes, in addition to the honeycomb structure, could be selected to represent the different (types) of organisations, e.g. construction, manufacturing, consultancies, client, that come together to deliver the project. Thus allowing for the project to accommodate for a parent organisational structure (at higher levels or points of intersystem links) and taking care of the problem identified by Moore (2002) where parent organisations impose their structure on the project.
Using the three functions [{$\underline{\mathbf{R}}_{(x)}$}, {$\underline{\mathbf{I}}_{(x)}$}, {$\underline{\mathbf{E}}_{(x)}$}] the FS will enable better understanding of the behaviour of the project structure in its environment.
The basic characteristics that need to be defined and to which parallels can be seen in FEA theory are:

- Stiffness matrix and Internal forces
- External forces and Boundary conditions (External environment)
- Internal forces (Project Environment)
- Boundary conditions (from intersystem links)
- Reactions known from particular loading (or characteristics of clusters which are explained below under 'strings')

Figure Ap6-6.7 below, provides an example of the possible FS of a project with two 'square' shaped clusters at the lowest level.

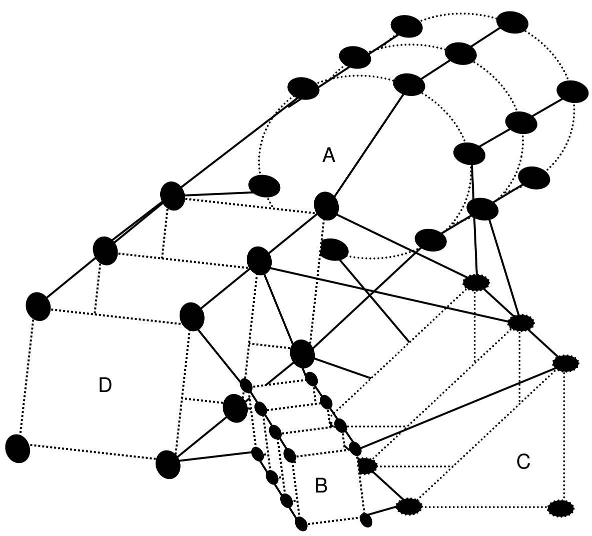

Figure Ap6-6.7 Example of a possible finite structure of a project with two square shaped lower level clusters

Autonomous Agents

One of the important facets of FS is self-organisation. Therefore the need to identify what are / could be the internal attractors and appoint roles of autonomous agents is of paramount significance.

Autonomous agents have to carry, within FS, important characteristics which will become pivotal when the 'heat-load' (representing complexity) increases. They could be:

- People, with specific tasks and maybe special characteristics
- A 'cause', which during uncertain conditions, unites clusters of various levels and at different stages and becomes an attractor towards which people autonomous agents drive the cluster (for some if not for all nodes in a self-organising approach),
- A company / project mission (similar to the above more higher in level)
- A deliverable / product placed above everything for / by the cluster.

Strings

Individuals come together, or join existing groups to form a company.

Consider these individuals as strings (or loops as described by string theory, Greene (1999)). Each individual / string has its own characteristics, drives behaviours, thus it has a frequency of vibration (as part of the 11 dimensions defined by string theory, Greene, 1999). The aggregation of frequencies defines a company frequency which means that the company also has its own characteristics and by certain means enforces certain characteristics on individuals.

For the individuals (strings) vibrations occur because in each physical dimension the string is attempting to balance between the absolute position (what is commonly acceptable or theoretically right) and the one the string itself believes to be right. It could even be that in each physical dimension the vibration is caused by the string as it pulsates between three points:

1. the absolute position
2. the current position and
3. the position the string is aiming to attain/achieve.

The important element here is the individuals' unique frequency / characteristic that develops the 'string's characteristics' and how this then is combined with the other strings to form an organisation.

When considering a construction project, made up of a number of strings (nodes), forming clusters, which are part of the finite structure, the nodes in a cluster are not motionless but they have a unique frequency characteristic. These unique frequencies identify 'reactions known from particular loading', as mentioned above, and other characteristics that will enable the implementation of FEA.

An example of what is proposed, where string theory is combined with Finite Element theory (through the finite structure) and the Organisational theory can be found in the automotive industry. There individuals / strings come together to form multi-skilled 'clusters' that deliver a complete car from beginning to end. The cluster contains all the necessary skills that can complete the job. Each string has its own characteristics and skills (unique frequency) and the whole unit then integrates to perform as a cluster that delivers a car. In the case of Toyota (Liker, 2004) it takes up to 2 years to train each string so that it can be positioned at the right place within a cluster.

However, construction cannot be considered the same with the automotive industry. One of the reasons it is different is the fact that at the highest level (the project level) it never delivers the same exactly overall product. Nevertheless at a low enough level the tasks performed are always the same. In some occasions an attempt to manage technical complexity is through the use modular products (e.g. BAA, McDonalds, etc.). It is this modularisation of the product as well as the standard / simple activities that will enable clustering of personnel at the lowest level. By identifying the individual string characteristics and knowing the overall standardised requirements we will be able to build clusters that will perform to the required level.

This is where FEA can be used because by knowing the overall characteristics clusters and individual strings (nodes) can be tested by imposing output requirements / functions.

String theory at company level

At company level each organisation can be represented as a group of strings with an overall frequency. This overall frequency, which is an amalgamation of frequencies from all the personnel, equipment, technology and everything else that makes a company, still has 11 dimensions and each dimension represents a characteristic or a quality like, Organisational structure, Stakeholders, Behaviour (e.g. is the company an IPP - Investors in People – company?), Cost, Quality, Standards, etc.

So in construction when a Client organisation issues a tender it defines parameters against which the Construction companies are trying to much their frequencies, or the frequency of the particular bid, in order to win the job. Therefore the characteristic of 'frequency of the job/project' is one of the parameters.

The process of bidding becomes one of looking for and identifying the right frequency.
A number of steps that have to be taken are:

- Establish how are these frequencies defined and what are the characteristics;

- Identify how do these frequencies come together to form one common profile;
- Identify how each job/project gets its frequency, or that unique client characteristic; and
- Finally identify which are the prevailing characteristics that shape the frequency.

Therefore the overall approach should be to differentiate down to elemental level and then integrate these elements in order to display an overall view of the Company.

Ap6.3.4 Conclusion

This approach could be considered as a mechanistic view of an organism, however by introducing elements to the lowest level and considering the individuals' characteristics we take into account the individuals' contribution(s) towards the 'organism'. Therefore we have a 'live' system. The type of organisation being that organic, bureaucratic, adhocracy, or any other one, will be defined by the 'Organisation frequency'.

The above can be brought together with the string theory approach and whatever the type of organisation each organisation represents a living organism and not a rigid formation, as presented by the current organigrams. The structures are continuously moving (using their frequency), re-shaping themselves. Therefore what we have is a real representation (model and perhaps a computerised model) of an organisation and in particular a project organisation.

Therefore the proposed Finite Structure can enhance the approach to organising projects and enable a number of processes to be combined so that structuring project teams remains a 'live' process throughout the duration of the project. However, this proposal will have to be finalised and validated.