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MANAGERIAL SYSTEM FOR 21ST CENTURY CONSTRUCTION OF AFFORDABLE HOUSES

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ABSTRACT
This paper presents an alternative management system for the construction of affordable houses. It is composed of 10 managerial techniques/actions (TBA) that were generated from the observation of biological cell principles in delivering services. The 10 TBAs are: 1-building code optimization, 2-constructibility, 3-systems management, 4-empowerment, 5-cost control, 6-project partnering, 7-work team organization, 8-self-help production, 9-quality, and 10-training. The system calls for interrelation and integration between the 10 sub-systems to maximize output, high correlation of people and communication, safety and quality, and to be used as a standard to evaluate performance of construction organizations dedicated to the affordable housing construction business.

KEYWORDS
Affordable Housing, Construction Management System, Work Team Organization

1. INTRODUCTION

According to the United Nations, more than one-fiftieth of the world's population does not have adequate housing and lives in extremely unsanitary and unhealthy conditions (Erkelens, 1991). A European organization defined the affordable housing availability as one of the major challenges facing mankind in the last decade of the twentieth-century (CARDO, 1991).

The new social-economic-political environment demands new approaches for the solution of an old problem. The need for a new approach in the construction industry has been recognized in the past to change this industry that continually resists innovation and uses old management techniques.

Due to the uniqueness of the construction industry, examples from other industries cannot be applied wholesale; one needs to develop a system that recognizes the unique features of the construction industry. The aim of this study is to generate a set of managerial techniques to build low-cost housing based on cell principles observed in living system organizations.

2. NEW APPROACH METHODOLOGY

In a living system the cell is the lowest living unit of any biological system with the lowest level of complexity (Miller, 1978). The cell has the ability to deliver products/services, moving from point A to point B with the right quantity at the right time and at the right place using the minimum amount of energy. In order to understand which

managerial principles are involved in the organizational process of delivering products/services in a living system, a set of ten cell principles will be analyzed and labeled as biological system principles (living system). From each cell principle discussed, a concept will be generated to create a conceptual framework that will serve as a link between the living system and the new non-living system, which is to be developed and named as an engineering system. Figure 1 shows the transition path from living systems into non-living systems. This engineering system will be a set of managerial techniques related with affordable housing construction management.

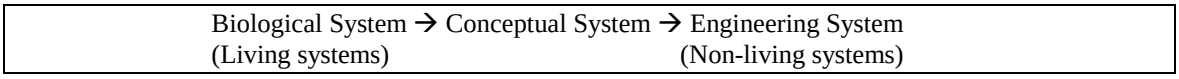

Figure 1: Transition from Living Systems into Non-living systems

3. CELL PRINCIPLES AND CONCEPTS

The ten basic principles identified in the living system in question are: (1) energy optimization, (2) holism, (3) mechanist, (4) survival/death, (5) homeostasis (6) cell integration, (7) cell specialization, (8) self-production, (9) immune response and (10) cell reproduction. The meaning of each cell living system principle was analyzed with the aim to remove the biological connotation, to generate a set of concepts that for this study is labeled as conceptual system (Soares1996). Figure 1 shows all the 10 basic biological principles and its derived concepts.

Table 1: Cell Principles and Related Concepts (Conceptual System)

Cell principles –(biological system)		Concepts-(Conceptual system)
#1	Energy Optimization	Nothing in excess
#2	Holism	Integrated systems
#3	Mechanist	Process flow
#4	Survival/death	Delegation
#5	Homeostasis	Control zone
#6	Cell Integration	Partnering
#7	Cell specialization	Working teams
#8	Self-production	Self-work
#9	Immune system	Quality control
#10	Cell reproduction	Knowledge transfer

4. ENGINEERING SYSTEM

Using the ten conceptual concepts developed previously, an engineering system is generated. Each concept was analyzed with the aim to find in the literature a correlation between the concept in consideration and a managerial technique or action that better translates its meaning when applied specifically into the affordable housing construction management business.

The ten managerial techniques/actions generated are (1) building code optimization, (2) constructibility, (3) systems management, (4) empowerment, (5) cost control, (6) project partnering, (7) work team organization, (8) self-help production, (9) quality control and (10) training. Below are the main justifications found in the literature used to support the connection of the conceptual concepts with the managerial techniques/actions (MTA) of the new engineering system.

MTA #1- Building Code Optimization

The first conceptual concept calls for nothing in excess. A relevant matching found in the literature indicates building code requirements. Building codes are laws made with the approach that “one size fits all’, and for this reason their requirements are evaluated as “in excess” for specific applications, as in the affordable housing business. According to Goldberg (1990) building code requirements are responsible for the cost increase of

affordable housing, decrease in the flexibility of the designer, and reduction in the number of affordable dwelling units. The New Jersey Housing Authority was the first state to take proactive action to overcome this problem by developing and implementing a specific affordable housing building code to remove all the excess requirements, or, as named by them, the non-sense requirements (Connolly,1999).

MTA #2- Constructibility

The second concept calls for integrated systems. A relevant matching found in the literature is the concept of constructibility. According to The Construction Industry Institute (CII), constructibility is the optimum integration of construction knowledge and experience in planning, engineering procurement, and field operations, in order to achieve overall project objectives.

Constructibility is also viewed as a tool able to bring design and construction closer to the level of integration once achieved by the master builder (Russel at al (1994). Some authors are hoping to achieve integration in the construction industry by the use of more computer software applications (Paulson, 1995).

MTA #3 –Systems Management

The third concept calls for process flow. A relevant matching found in the literature is the concept of systems management. Construction of affordable housing can be classified as a system with low level of complexity when compared with the construction of a skyscraper. But even at a low level of complexity it is necessary to know the process flow of the system. According to Latzko (1995) management of a system requires knowledge of the interrelationship between all processes within and of everybody that works in it. According to Deming (1990) management's job is to optimize the entire system and to coordinate the activities of each component. It is their task to see that the activity of each component contributes to the aim of the system.

MTA #4- Empowerment

The fourth concept calls for delegation. A relevant matching found in the literature is employee empowerment. Research suggests that empowerment exists when companies implement practices that distribute power, information, knowledge and rewards throughout the organization (Lawer, et al 1992). However, the construction industry is viewed as organizations that perpetuates the notion that employees shouldn't make decisions; that in fact, they shouldn't even think. The employers have conditioned generations of workers that management knows best (Caudron, 1994). Successful examples of employment empowerment in the construction industry are not the norm, but the trend is to have more and more organizations engage in employee empowerment implementation.

MTA # 5 – Cost Control

The fifth concept calls for control zone. The critical zone to be controlled in the affordable housing construction management process is cost. It is necessary to minimize the costs for a given dwelling space or maximize the dwelling space with the given affordable cost (Chakrabarty, 1996). There are several different proposals to achieve this objective: the use of different construction materials (Tiwari, et al, 1996), the use of optimization models based on systems analysis and design economics study (Chakrabarty, 1996), the use of a comprehensive systematic approach that uses cost-effective measures throughout the design and building process (Caswell, 1997), and the use of Value Engineering/ Value Analyze methodology.

MTA# 6 – Project Partnering

The sixth concept calls for partnering. A direct link with project partnering was found in the literature. The change from adversarial relationship to project partnering is strongly recommended in the literature as a medicine to reduce litigation to resolve disputes in the construction industry with consequent erosion of the profit margin being transferred to the lawyers bank account (Ellison and Miller, 1995).

The Construction Industry Institute(CII) defines partnering as a long term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each

participant's resources. The relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and continuous improvement of quality products and services (Hancher 1991).

Edelman and Carr(1992) point out that partnering requires the continued effort of key stockholders involved in contract performance working together to establish communications, develop a team spirit, identify interests and set mutual goals.

MTA #7 Work Team Organization

The seventh concept calls for work teams. A relevant matching found in the literature is work team organization.

The construction industry traditionally organizes the work through craft skills, however Peter Druker (1974) wonderfully demonstrated that for the building of a traditional single-family house, the work should be organized by homogeneous stages. He suggests four homogeneous stages to organize its production. They are: 1-digging the foundation and pouring concrete for the foundation and the basement floor, 2-erecting frame and roof, 3-installing plumbing and wiring equipment in the walls, and 4-Interior finishing.

Each stage will have one specific team that will be responsible to start and finish the specific stage. At the end of the stage the second team can start their duties and this way at the end of the forth stage the work is completed. Each team is composed of skilled workers. The amount of skills required by each team member, at each stage, should be adequate to perform the work needed within that stage.

This kind of labor organization was used successfully during World War II where they were under pressure to meet output requirements in ship and building production. Ships and buildings are classical examples of unique-product production where labor organization by homogeneous stages can be used.

MTA # 8- Self-help Production

The eighth concept calls for self-work. A relevant matching found in the literature is the self-production or autopoiesis. In the construction industry this concept is know as self-help.

According to Turner (1972) the central idea of self-help is that the dweller controls main parts of the construction housing process. Burgess(1985) defines self-help as one process that allows people to build their houses in accordance with their resource availability. He states that "self-help building is distinguished from other systems of construction in that the family living in the house participates in the construction process by making different contributions (finance, labor, administration, etc.) be this in an autonomous form or as organized by an institution."

MTA# 9- Quality Control

The ninth concept calls for quality control. A relevant matching found in the literature is quality control. According to Juran(1989) quality control consists of three steps: evaluate actual performance, compare actual performance with performance goals, and take immediate steps to resolve differences between planned performance and actual performance. In the construction process of low cost housing, quality control is a critical factor, mainly due to the predominant idea that in order to have quality one needs to increase costs and also the difficulty to measure performance. An effective quality control system should provide automatic answers at any point of the constructive process for the basic questions: "where are we?" and "where should we be?" in order to evaluate the variability level between the two and take corrective actions.

MTA # 10 Training

The tenth concept calls for knowledge transfer. A relevant matching found in the literature is training.

Due to the high level of mobility in the work force of the construction industry, it is common to hear " I will not train my workforce today for my competitor to use it tomorrow", in a clear allusion that it will not be better to

offer training, otherwise one will fortify competitors in the future. However, training is the key word for success in the construction business.

The traditional question to address is, what kind of training? In my opinion it is necessary to provide autonomy for the work force especially in a work environment where traditional obedience and rigid discipline is emphasized. The training should be designed to change attitude and behavior from the traditional rigid discipline and obedience into a responsible autonomous attitude.

Table 2 below presents the attitudes and behaviors traditionally observed in a work force in a construction project and the expected changes after training.

Table 2: Construction Workers Behavior and Attitudes Before and After Training.

From Rigid obedience and discipline (attitude and behavior before training)	→	Into responsible autonomy (attitude and behavior after training)
1. obedient to hierarchy	→	Initiative of action and decision
2. obey norms and standards	→	Autonomy to create and change
3. Centralize controls and information	→	Delegation of control and information
4. low interpersonal communication	→	High interpersonal communications
5. High capacity to do individual work	→	High capacity to generate team work
6. Resistance to change or innovation	→	Flexibility to adopt new methods and attitudes.
7. Passive to professional development action	→	Adopt self professional development
8.low participation on integrated activities	→	Aptitude to work on partnering

5. CORRELATION OF THE ENGINEERING SYSTEM

The 10 managerial techniques/actions (MTA) generated for the creation of the engineering system are shown on Table 3 indicating the correlation of each MTA with people, equipment and government. As can be observed, there is a high correlation of the MTAs with people, which is expected for an industry that is heavily labor intensive.

Table 3: Correlation of the Engineering System with People, Equipment and Government

Engineering system	people	equipment	government
MTA#1-Building code optimization			x
MTA#2 – Contructibility	x	x	
MTA#3- Systems Management	x		
MTA#4-Empowerment	x		
MTA#5-Cost control	x		
MTA# 6 Project Partnering	x		
MTA#7-work team organization	x		
MTA#8-self-help production	x		
MTA#9-quality control	x		
MTA#10- training	x		

The MTA set is the backbone of the theoretical alternative management system with the aim to be used in the affordable housing construction process. It must be viewed as a whole-integrated system where all the parts are inter-connected working and for one objective.

All 10 MTAs developed are correlated with the constructive process actually observed on providers of construction services. The main question to be addressed is if all MTAs are used as a whole-integrated system in adequate dosages for projects focused on affordable housing delivery. In order to answer this question a test has been made using real data from a project delivered by Habitat for Humanity, a classic provider of affordable housing projects.
The following assumptions were used: if the engineering system developed is validated, one can use it as a parameter to evaluate the process integration of a low-cost house provider management system of an organization.

For each MTA a set of attributes were assigned in a total of 57 attributes covering all MTAs. Those attributes were selected from the literature and assumed that their presence was vital for the accomplishment of each MTA.

One sample of the attributes assigned for one MTA that resulted in a total integration in the Habitat for Humanity management system analysis, is presented below on Table 4.

Table 4: Attributes Assigned for Constructibility Integration Analysis

(MTA): Partnering	Provider: Habitat for Humanity	
Are those attributes incorporated in the management system of a low cost house provider?	yes	No
Is Partnering in included in the organization mission?	X	
There is partnering with material suppliers?	X	
There is partnering with service suppliers?	X	
There is partnering with internal customers?	X	
There is partnering with external customer?	X	
Judgment: This MTA is in integrated in the management systems.	X	
Criteria: Integrated: > 70% yes, non integrated: > 60% No, in process of integration up to 50% yes		

A comparative analysis was made to identify if each attribute of the new developed management system was present as an integral part of the Habitat for Humanity management system utilized in the construction project. Using percent levels of inclusion of MTA attributes it was possible to evaluate if the MTA is incorporated, not incorporated or is in process of incorporation on the real provider management system.

Matching the theoretical attributes of the management systems with the ones of the real case derived the percentile. The final results of the level of integration of each MTA in the delivering process of an affordable housing project used by Habitat for Humanity are that only 3 MTAs are integrated, 4 MTAs are in process of integration and 3 MTAs are disintegrated. The results are show in Table 5.

Table 5: Habitat for Humanity Process Integration Correlated with Engineering Systems MTA

Integrated MTAs in the construction process	MTAs with Integration in progress in the construction process	MTAs totally disintegrated on the construction process
Self-help production	Contructibility	Building code optimization
Project Partnering	Systems Management	quality control
Training	Empowerment	work team organization
	Cost control	

It was observed that a strong interrelation exists between two of the MTAs that were classified as totally disintegrated (work team organization, quality control). Since the labor force comes from a volunteer pool that includes homeowners, volunteers and paid professionals, they establish the level of commitment to the project by dividing the volunteer group on three categories of fully skilled, semiskilled and unskilled.

The fully skilled are assigned to be the crew leader that will manage the groups according to the production goals and commitment levels and are responsible for the training of the less skilled. Since it is their policy to rely on this kind of "free" labor to motivate community involvement in the project, it is not possible to organize the work by skilled stages as proposed by the new generated system. Consequently it is expected that the quality level of the output will be lower from the level of quality of a labor delivered by professionals.

In an interview with the Habitat for Humanity project manager at Gainesville, FL, he reported the need to have a special code to attend the affordable housing business in order to reduce the level of friction between inspectors and project managers.

The new management systems correlate safety with the quality control MTA. This connection was derived from the biological immune system basic principle mechanism that chases any abnormality identified in the system and through delegation to other cells it deploys an integrated mechanism to fix the problem. It is interesting to notice that if a sub system is facing abnormality they trigger a help signal for the immune system and vice-versa. In another

words, safety is considered by the biological organism as whole tasks that is shared by each sub system. The translation of this principle into a construction safety program is that safety should be considered as an interrelated responsibility of all players in the construction process in place to be considered as one department's responsibility.

The level of quality enforced by the biological model is intrinsically connected with the physical safety of the organism. If a matter that was not designed to be present in the organism is detected, it will be considered a threat for the system and it will be automatically immobilized or eliminated from the system. If a contractor can use this analogy in a project, it will work with a target of zero non-conformities with the design and in this way it will warranty the physical integrity of the project.

6. CONCLUSIONS

1. The engineering system (non-living system) generated as a base the Atopoietic biological principles (living system) and demonstrated a high correlation between the principles of the living system and non-living system.

2. The living system demonstrated high level of interrelations and integration between the 10 sub systems, which is indicative that the non living system generated should have the same level of interrelations and integration between the 10 sub systems (MTA).

3. The ten managerial techniques/actions generated in the creation of the engineering system are an integral part of a management system dedicated to the construction of affordable housing projects that uses the self-help production.

4. The alternative Management Systems for Construction of Affordable Houses was composed of ten managerial techniques/actions that are known by the construction industry. They are: (1) building code optimization, (2) constructability, (3) systems management, (4) empowerment, (5) cost control, (6) project partnering, (7) work team organization, (8) self-help production, (9) quality control and (10) training.

5. The new management system demonstrated strong correlations with people indicating the need of open and effective communication with all the shareholders of the process.

6. Safety should be considered as an interrelated responsibility of all shareholders in the construction as a whole responsibility to reach total quality versus the traditional view to be considered as one department's responsibility.

7. The new management system can be used to evaluate the performance of construction organizations by changing the self-help production MTA, which is specific for the construction of affordable house, and by other appropriate production systems.

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