Enabling Sustainability through SOA within the AEC/FM Domain

A. Dikbas
Istanbul Technical University, Department of Architecture, Istanbul, TURKEY

P. Ercoskun & K. Ercoskun
Yeditepe University, Department of Architecture, Istanbul, TURKEY

ABSTRACT:

Sustainability is one of the most important research topics for the Architecture/Engineering/Construction & Facility Management (AEC/FM) domain. Two basic factors which enable sustainability are the technology background and the acquisition capability of this technology to the end users – society. Sustainability requires state of the art technologies which reduce the negative impact of population and affiliation. Key aspects of such technology are; it should depend on renewable resources, without waste, cyclical, based on resource productivity rather than labor productivity, and should even be restorative in its effects on the biosphere. The problem is, today establishing such technology is not affordable for the average end user. Development, implication, and acquisition of such technologies takes reasonable time though signs from our earth warns us that we have no more time. The problem itself contains a lot of interoperability challenges in Information Technology (IT), Process and Organizational levels. Although many governments deploy incentives to promote investments on sustainable technologies, money is not the only measure for the market penetration of a technology. A user oriented approach is developed and a proposal is made to elaborate on the problem as a whole within a reference process model. The model determines the key functions, mechanisms and controls, to enable the design and development of sustainable technologies and facilitate the acquisition of those technologies to the society. The process model basically focuses on the Facility Management processes and addresses many aspects of the problem including financial, legal, and ethical issues. The model benefits from Customer Relationship Management (CRM) solutions for construction sector from a previous research and promotes a Service Oriented Architecture (SOA) for tracking the lifetime of sustainable technologies. The model includes decision support functions for the design phase, marketing and competency functions for the implication and acquisition phase, and measurement and evaluation functions for the use phase. The preliminary solution includes business processes rather then IT solutions but interoperability solutions on the IT layer also have been discussed for sustainable development. The model is under development within the joint efforts of a EU funded FP6 project I3CON (Industrialised, Integrated, Intelligent Construction) and a PhD research. It is believed that the model would facilitate the widespread recognition of the requirement of a radical switch to the sustainable technologies.

Keywords: Sustainability, Technology Management, Customer Relationship Management, Facility Management, Service Oriented Architecture

1 INTRODUCTION

Sustainability is one of the most important research topics for the Architecture/Engineering/Construction & Facility Management (AEC/FM) domain. Sustainability has many parameters which explicitly define it as the result of technology based on resource productivity rather than labour productivity, and should even be restorative in its effects on the biosphere. Among all those parameters quality and standardization are gaining much more importance since the underlying technological development not only results in a cleaner, comfortable, healthy, productive and relaxing environment for human beings but also facilitates the development of efficient manufacturing processes, whilst reducing the amount of resources used including manpower. Technology on one hand promises to increase our quality of life while standardization results with production processes which reduces the employment at production lines (Rosenberg et. al. 1992). Within the past decade countries which realized the trend switched to knowledge based economy and transferred their highly automated – standardized production lines to countries which the overall labour is cheap. Recent progress in world economy shows that this transformation deeply affected the economic sustainability of those countries. A knowledge based economy is highly dependent on Information and Communication Technologies (ICT) and ICT is the key driver for the development of advanced solutions for Design, Simulation and Automation. ICT is not only hardware and software but includes business processes, organizational structures and people as well, specifically at the interoperability level. Integrated Design Process (IDP) is a nice example for a typical ICT development. Next phase for ICT development will be based on Service Oriented Architectures (SOA) and cloud computing which helps to increase collaboration within the design team, facilitates platform and location-free interoperability to search for sustainable technologies while promising solutions for economic sustainability of societies.

2 PROBLEM DEFINITION

Although "quality" and "standards" develop in parallel to each other, there is also a "contradiction" between quality (which within the scope of this paper we evaluate as the conformance to the end user requirements including the need for economic survival) and standardization (as a key to automated manufacturing and mass production). This is one of the reasons which makes establishing sustainable technologies harder and non affordable for the average end user. Development, implication, and acquisition of such technologies takes reasonable time (Gerard&Guynor, 1996) though signs from our earth warns us that we have no more time. The problem itself contains a lot of interoperability challenges at Information Technology (IT), Process and Organizational levels. Although many governments deploy incentives to promote investments on sustainable technologies, money is not the only measure for the market penetration of such technologies.

3 BACKGROUND

Each communication solution has a semantic at the background. Each system subject to development of interoperability solutions has ontology. Contemporary Information Technologies (IT) benefiting from semantics and ontology promises enhanced interoperability. Awareness of the available IT for effective ICT system development enables synchronous & asynchronous quality control, and facilitates to optimize 5E (Energy, Exergy, Environment, Ecology, and Economy). The research depends on four distinct topics as Building Information Models and Integrated Design Process (IDP), Service Oriented Architectures (SOA), Customer Relationship Management (CRM) & Sustainable Technologies.

3.1 *Building Information Model (BIM) & Integrated Design Process (IDP)*

IDP is an interdisciplinary collaboration and communication framework for Architectural and Engineering design. IDP enables architecture to be realized as a communication platform within a Building Information Model (BIM) at the background and facilitates Energy Efficient Building Design and promotes the use of sustainable technologies by increasing interoperability & collaboration within the design team.

IDP is effectively employed for design development and construction phase, however as a philosophy, it is a lifetime approach from initial design to demolishment. Measurement and evaluation of these results are essential but there is no applicable mechanism yet to integrate IDP with the occupation phase.

3.2 *Customer Relationship Management (CRM)*

Data capable of improving the performance of an IDP system does not only reside within the process. Facility Management and end user interaction helps us to test the performance of the output of the IDP process. This helps us to understand and learn from use processes to improve design with our next project. Customer Relationship Management (CRM) solutions promise to facilitate information flow from use processes to design processes through Facility Management (FM) integration (Ercoskun 2006).

3.3 *Sustainable Technology*

The core difference between a non-sustainable technology and a sustainable technology is determined with a function of impact (I) which is based on population (P), affluence (A) and technology (T). A non-sustainable technology is defined with the equation: I=PxAxT while a sustainable technology is defined with the equation: I=PxA/T (Ehrlich& Ehrlich, 1990). The approach is our kick off point for the underlying research which initial concepts will be presented.

3.4 *Service Oriented Architecture (SOA)*

Service Oriented Architecture (SOA) is a way of describing a business model that uses cloud computing. In computing, SOA provides methods for systems development and integration where systems group functionality around business processes and package these as interoperable services.

SOA can be realized as "Data as a Service (DaaS), Soaftware as a Service (SaaS), Platform as a Service (PaaS), Communication as a Service (CaaS), Infrastructure as a Service (IaaS) & Monitoring as a Service (MaaS). Although SOA is primarily defined as an IT term philosophically it is applicable to both processes and organizations which leads us to lesser-known services under the umbrella "everything as a service" (IBM, 2009).

4 METHODOLOGY

In this paper we evaluate the state of the art of technology for the construction sector in terms of sustainability. We will identify key metrics (measures) correlative to the acceptance factor of eco-tech technologies. Then a reference process model will be presented (under development) which helps to determine key parameters and metrics that may act as drivers towards sustainability.

5 ENABLING SUSTAINABILITY THROUGH SOA

Within the contemporary business arena, it is rare to find products sold as-is. The direct marketing research transformed even small units of goods to a subset of preconfigured services. Wholesale operations benefit from such approach as well. The main marketing item is usually enriched with up-sell (i.e. including anchored elements like sink, oven, etc as a bonus when you buy a new "kitchen") and cross-sell (i.e. a bicycle or vacuum cleaner is given as a gift with the kitchen you buy) opportunities besides background and foreground services and put into the market as a "value added" package. This approach provides a means of flexibility and freedom for individuals. One can easily procure a specific marketing item; configure it as a package with value added services and resale.

In such scenario SOA becomes an essential foundation. SOA also promise a degree of freedom and flexibility for people helping with "designing" this configuration. SOA enables knowledge brokers to develop on-demand, pay per use services for whom require a specific know what, know why or know how. SOA enables:

- Sharing expertise & tacit knowledge and explicate it
- Facilitate benefiting from pre-existing know-how
- Developing pre-existing know-how with feedbacks
- Guiding individuals to develop their own businesses
- Facilitate the development of Virtual Organizations (VO)
- Cheap, pay per use, use on demand services

The model presented in this paper (under development) presents a process model and the impact characteristics of various controls & mechanisms within an impact function.

6 THE REFERENCE PROCESS MODEL

The technology decision & acquisition is composed of five main processes. These include (Figure 1):

- Inspection: Searching for available technologies (within the scope of this research, sustainable ones)
- Selection: Comparing, scoring and selecting the best or the optimum alternative.
- Decision: Deciding whether if it is possible to obtain financing for the selected technology, and it is implementable with current resources, or otherwise considering to switch to an alternative.
- Implementation: Using the technology
- Testing: Monitoring the performance and proofing that the pre defined requirements match with the actual need.

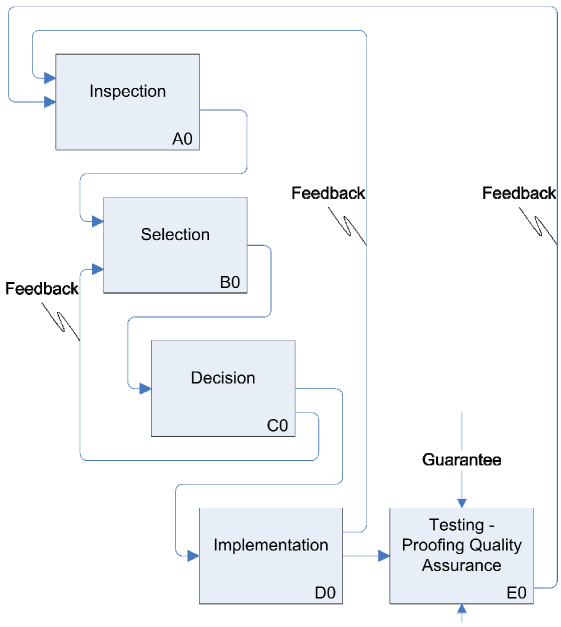

Figure 1 The General Layout of The Reference Process Model

6.1 *The Inspection Phase*

The inspection for a specific technology requires a lot of communication and a network for information and knowledge use (Figure 2, A1, A2, A3). Tacit knowledge of experts and legal atmosphere with the decision makers priorities and risk (Figure 2, A1, A3, A4) defines the boundaries of the knowledge while different methods for evaluation like experiments, recognition, prediction and filtering redirect the whole procedure (Figure 2, A3, A4). The main input is based on socioeconomic factors and personal values and variables. With the contribution of software input from office automation and decision support systems with some coincidences a knowledge scale is defined which leads us to total information we assume that is correct. However, a recent survey assumes that the amount of unique information created in 2009 will be equal to the total of past 5000 years meaning that inadequate information has a potential to easily lead us to wrong results. Today the vision is not query knowledge.

An offer that is lean, appropriate, examined, and beneficial has a high chance for "investment" to the relevant technology. Behaviour against the other party is important, whereas intensives (which we include within benefits) are a strong driver as well for conviction (Figure 3, B1). The output of conviction process is a set of appropriation metrics.

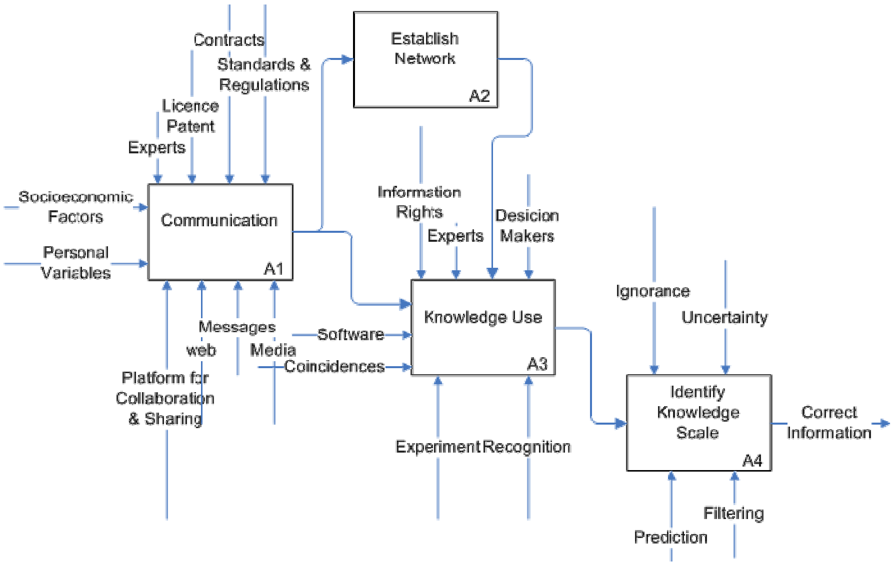

Figure 2 Reference Process Model - The Inspection Phase (A0)

We have to find all the relevant knowledge resources, analyse them in synchronization and retrieve results to be sure we really have the best information. IntelliGrid project is a good example for such efforts (Dolenc et. al., 2007). The requirement emphasizes the importance of SOA.

6.2 *The selection phase*

The selection phase is typically consisted of "Conviction", "Opportunity Definition" and "Selection" processes (Lowe, 1995). The conviction process is where we begin imposing sustainability to the end user.

Appropriation metrics are based on the identified requirements. These metrics are also based on end user needs and wants as sustainability indicators which we define in Section 7.

Opportunity definition (Figure 3, B2) helps enterprises to develop a vision for the sustainability of their business. SOA facilitates and increases the reaction capability of an enterprise against risks. Environmentally sustainable technologies are contributed as a control for this process through product databases. The output is an agenda which figures out all the options, risks and possible preventive actions for selection process (Figure 3, B3).

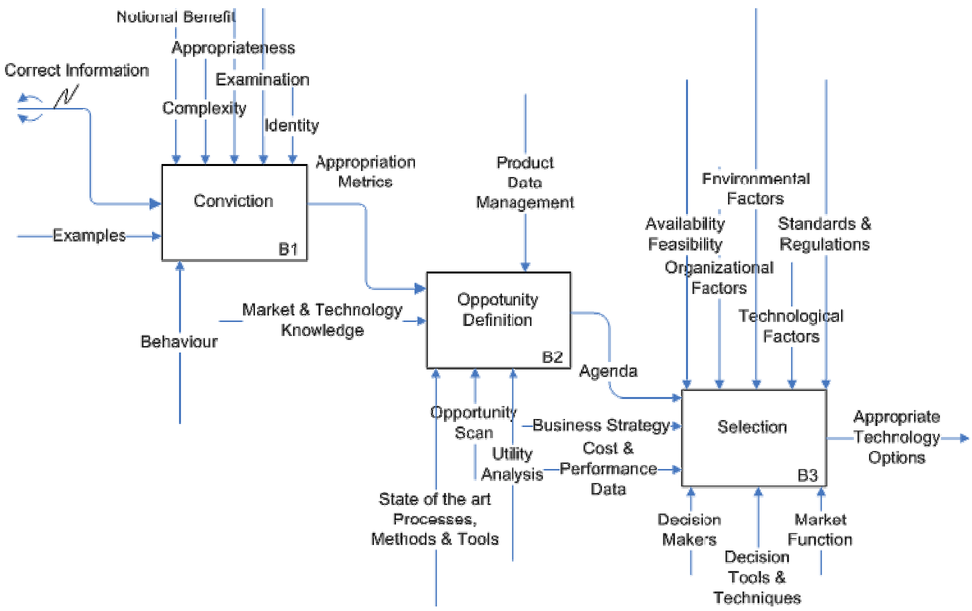

Figure 3 Reference Process Model - The Selection Phase (B0)

6.3 *The decision phase*

The decision phase is consisted of five processes as "Evaluation of Competition Atmosphere", "Evaluation of Enterprise Capabilities", "Gap Analysis" (Rogers, 1962), "SWOT Analysis" and "Final Evaluation" (Figure 4). The cross match of Competitive Atmosphere and Enterprise Capabilities defines a gap which visionary enterprises try to bridge with new products (Harrison & Sumson, 2002).

ration, enabling Integrated Design Process (IDP) and facilitating sustainability. However a location free solution promises a level of productivity increase which would be possible to establish through SOA. Ercoskun is working on an interoperability solution to be used through the lifecycle of buildings from initial design to the end of useful life which would facilitate interoperability between different types of software and knowledge islands based on SOA.

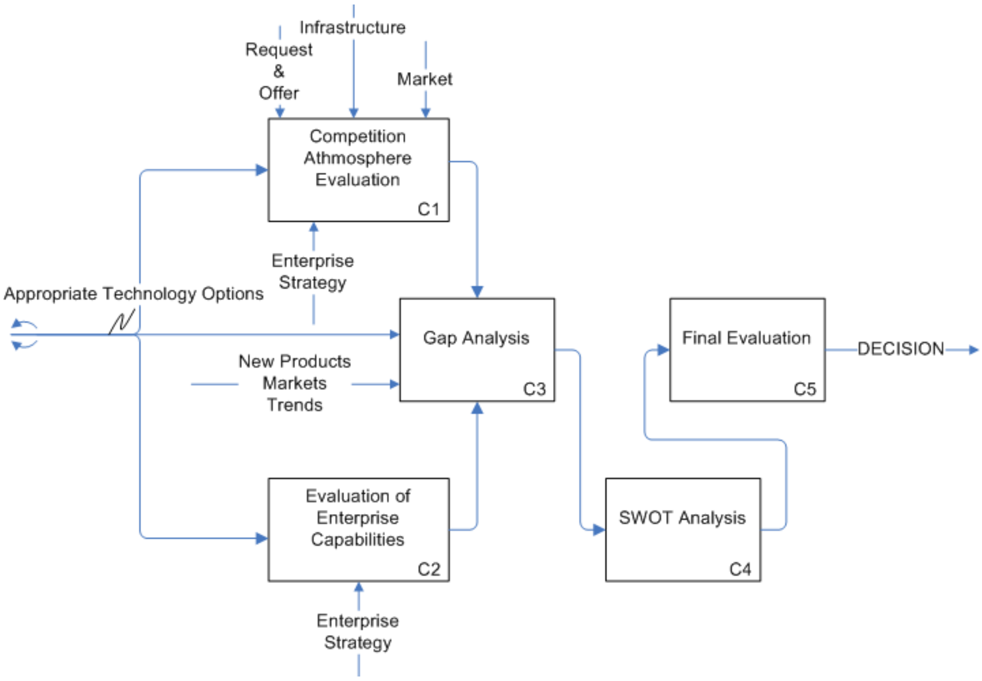

Figure 4 Reference Process Model - Decision Phase (C0)

A controller has to be designed here to redirect trends towards (environmentally) sustainable technologies. A SWOT analysis helps to refine the risk plan and the decision is given as the result of a final evaluation.

6.4 *The Implementation Phase*

While previous processes are applicable for all types of production processes for sustainable technologies, the implementation phase is mainly for construction sector within the scope of the research (Figure 5). For other industries the main factor of manufacturing is the "product" itself (Narayanan 2001) while for construction sector it becomes the "design" (Sözen Z., 1983) and the underlying Building Information Model (BIM). Thus all the controls and mechanisms listed should have a connection to the background BIM.

Here the problem is software vendors configure BIM based products in such a way which prevents interoperability. In order to process a specific Industry Foundation Classes (IFC) file, the underlying software has to support the information within that file. The only completely interoperable part of BIM is the architectural design itself (Wix et. al. 2008).

This is however not a big problem since this issue force design teams to work in synchronization and in collabo-

This model will enable automated, synchronous and abstract information transfer between parties with the help of a technology called the "Virtual Building Information Model (VBIM)". The background data model had been developed within a PhD thesis and the prototype implementation is under development.

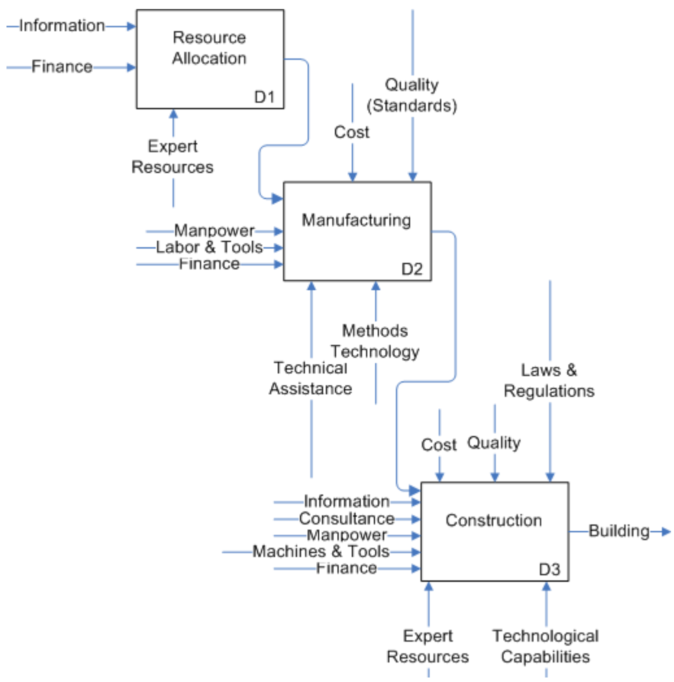

Figure 5 The Reference Process Model - Implementation Phase (D0)

The Implementation phase consists of three main processes as “Resource Allocation”, “Manufacturing” and “Construction”. The implementation phase is based on a standard construction progress though the sustainability measures will be contributed to “Quality” and “Laws & Legislation” controls with underlying metrics associated with the resource inputs in conjunction with technology related mechanisms. Our next section defines the new function of “Impact” based on the reference process model.

7 METRICS AND FUNCTIONS

The metrics being developed within the research are mostly based on the LEED and BREEAM certification systems besides some other examples in the world. What makes them interesting is that a framework is being developed to calculate the weight factor (importance) of each parameter which is based on:

- The location
- The culture
- Input from the end user

The metrics being developed will be input to the European Union 6^{th} Framework Programme project I3CON (Industrialized, Integrated, Intelligent, Construction) (Karvoven et. al., 2008). Within the scope of the research we are seeking the relationship between the usage level of sustainable technologies and the effect of overall performance of the building over its final users in terms of “health”, “productivity” and “Quality of life from the perspective of the end user”.

Based on reference process model, the following parameters are contributed to the predefined Sustainability Function by Ehrlich& Ehrlich, 1990:

- **Intensives for Sustainability (B1) = (Si)** (Governmental support to promote sustainable technologies)
- **Number of Patents (A1) = (Np)** (within the scope of our research this is a coefficient of impact where underlying patent results with a sustainable technology or not. Differentiating from the (T) parameter this is a mean score for all applicable patents within a country)
- **Information Health (A4) = (Ih)** (This is measured with the amount of distributed data used for query and a statistic evaluation of the performance of background algorithms used while this data were being analyzed).
- **Appropriation to Owner (B1) = (Oa)** (This is a parameter measured with the scope change of a project from the initial design to the operational phase of a building, thus has a negative effect over the sustainability)
- **Appropriateness to End User (B3) = (Ua)** (This parameter will be calculated with comparing the defined performance against the en users’ health, productivity and quality of life based on the subjective inputs retrieved. To establish an objective value these inputs will be cross matched with the physical properties of the environment).
- **Interoperability Level (D0) = (I)** (Typically SOA implementations will earn higher scores and this parameter will positively effect the impact).
- **Financing Capability = (F)** (This is a coefficient which tracks if the money is used for the right purpose.)
- **Resource Productivity = (R)** (This is a parameter which is based on overall resource use from design to the end of life of manufactured and/or built entities)
- **Decision Health (C5) = (Dh)** (This is a score attached to clients based on their future performance with their decisions, with the factors affecting their decision through C0 process. Dh contributes as a coefficient to the equation)

No function is designed at this phase of this research hence it requires statistic data and case studies to find the real effect of the parameters. For now we don’t know if the parameters affecting the overall impact exponentially or linearly. What we can do at the moment is to only identify and select the most important variables to design a function of sustainability.

8 CONCLUSION

The process model and metrics represented in this paper are under development. The weight factors of variables and their real effects over the functions are being analyzed. The current state of the research only shows the effect of factors, whether they increase or decrease the “negative” impact over environmental, social or economic sustainably:

- Environmental Sustainability: Reducing the ecological footprint of artificial facts made by human beings. Switching to the environment friendly and preserving technologies.
- Social Sustainability: Continuity of cultures, and nations
- Economic Sustainability: Establishing a financial strength for surviving and maintaining an optimum level quality of life based on the available technology.

Sustainability defines how mankind would maintain its existence on our home planet – earth. Globalization and relevant economic trends threaten the wealth and sustainability of societies while wildly consuming world resources. We need criteria to evaluate new products and services which would facilitate to discard ones threatening our future whilst providing guidance to improve sustainable ones. Although standards, laws, & regulations are formed somehow with the same objective, continuous monitoring is essential. Contemporary ICT with the support of SOA promise effective support to support such monitoring.

9 REFERENCES

BREEAM, *http://www.breeam.org/*, last access: July, 08th, 2009

Dolenc M., Katranuschkov P., Gehre A., Kurowski K. & Turk Z. 2007. The InteliGrid Platform for Virtual Organisations Interoperability, *ITcon,* Vol. 12/2007, pp. 459-477.

Ehrlich P. E., Ehrlich A. H., 1990, *The Population Explotion*, Simon & Schuster, New York, USA.

Ercoskun K., Dikbas A., Turk Z. , 2006, Linking CRM and CAD with IFC-CRM gate*, ICCCBE-XI: 11th International Conference on Computing in Civil and Building Engineering (with) Joint International Conference on Computing and Decision Making in Civil and Building Engineering*, June 14-16 Montreal, Canada

Gerard H., Guynor G., 1996, "*Handbook of technology management*" Mcgraw-Hill Higher education, United States of America.

Harrison, N.; Samson, D.; 2002, "*Technology Management*", Mcgraw-Hill Higher Education, USA.

IBM, Service Oriented Architecture, *http://www-01.ibm.com/software/solutions/soa/*, last access: July, 08th, 2009

Karvonen L., Nissinen K., Kauppinen T., Dikbas A., Ercoskun K., Segarra M., 2008, Towards a Reference Model for Building Lifecycle Performance Measurement, *The 1st International Conference On Industrialised, Integrated, Intelligent Construction*. 14-16 May, Loughborough, UK.

Lowe, P., 1995, "*The management of technology*", Chapman & Hall, UK.

Narayanan, V. K., 2001, "*Managing Technology and Innovation for competitive advantage*", Prentice-Hall, United States of America.

Rogers, E., 1962, "*Diffusion of Innovations*" (www.vikipedia.com, www.amozon.com)

Rosenberg, N.; Landau, R.; Mowery, D., C., 1992, "*Technology and the Wealth of Nations*", Stanford University, USA.

Sözen, Z., 1983, "*Yüklenici işletmelerde örgütsel strüktür, büyüklük ve teknoloji ilişkisi*", PhD Thesis, ITU, İstanbul

USGBC, *http://www.usgbc.org*, last access: July, 08th, 2009

Wix, J. et al. 2008. Using Constraints to Validate and Check Building Information Models. In *ECPPM 2008 Conference, Sophia Antipolis, France.*