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Department of Management Studies
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110016
e-mail : giftjournal@giftsociety.org
Tel : 91-11-26591167
Fax : 91-11-26862620

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Leading Organizations to Higher Order 'LIFE'

Though every organization as a living system has life in some form or the other, the challenge lies in leading the organization to higher and higher order of life.

The paradigm of a higher order life is proposed

The paradigm of `LIFE' discussed in the editorial in Vol. 4 Nos. 1&2 (Learning, Innovation, Flexibility and Entrepreneurship) deals with operating characteristics of a living system. Here a next higher order `LIFE' is proposed with four ingredients:

L - Love
I - Inspiration
F - Fun
E - Enlightenment

The most fundamental value is `love'. There should be love and respect for each one involved

At a deeper level, this order of LIFE should be ingrained in the values of the organization. The most fundamental value for a vibrant organization is `love'. It should have love and respect for each one involved, whether internal or external to the organization. Such an organization will care for the people in the true sense and will derive maximum life from the liveliness of the people involved as organization is for the people, of the people and by the people.

Inspiration comes both internal to the people and by external means

`Inspiration' is another major attribute of life in organizations. A visionary leader like Jack Welch could inspire a major global organization. A group of inspired people can do wonders for the organization. Inspiration comes both internal to the people and by external means. Organization should create a working environment in which people can be inspired by leadership, vision and processes, as well as they should feel internally inspired to achieve, innovate and be open and flexible.

The working conditions should make the work full of fun, and make it a fun to work

The organizational working with love and inspiration will be augmented by the third attribute of life, i.e. `Fun'. The working condition and relationships in the organization should make the work full of fun and make it a fun to work. For example, Infosys has created a campus life environment for working which acts as a stress reliever and is very much appreciated by the executives.

An enlightened manager/ organization, is truly liberated and can practice true flexibility

The ultimate objective of any living system is to be enlightened by a continuous quest for learning the truth. Each step towards the reality makes enlightened managers who collectively create an enlightened organization. An enlightened manager/ organization is truly liberated from the forces of nature and can practice flexibility in a true sense.

The four attributes of LIFE are important parts of corporate spiritual training

Love, Inspiration, Fun and Enlightenment are important parts of corporate spiritual training in leading organizations. Many of the leading Indian corporate houses such as Godrej, TCS and Bharti are involved with such spiritual training to provide a new life in the organization.

The significance of these four attributes is reflected in the products of the greeting cards industry

The significance of these attributes is reflected in the greeting cards industry which defines all the four attributes in their products. The companies, such as Archie's, HallMark etc. are using these concepts actively, which reflects the appreciation of these attributes of life in modern organizations. There is a need of creating leadership, processes and culture to lead the organizations to the higher order LIFE.

Sushil
Editor in Chief

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Guidelines for Authors

Aim

The journal is intended to share concepts, researches and practical experiences to enable the organizations to become more flexible (adaptive, responsive, and agile) at the level of strategy, structure, systems, people, and culture. Flexibility relates to providing more options, quicker change mechanisms, and enhanced freedom of choice so as to respond to the changing situation with minimum time and efforts.

It is aimed to make the contributions in this direction to both the world of work and the world of knowledge so as to continuously evolve and enrich the flexible systems management paradigm at a generic level as well as specifically testing and innovating the use of SAP-LAP (Situation- Actor - Process-Learning-Action-Performance) framework in varied managerial situations to cope with the challenges of the new business models and frameworks. It is a General Management Journal with a focus on flexibility.

Scope

The Journal includes the papers relating to: conceptual frameworks, empirical studies, case experiences, insights, strategies, organizational frameworks, applications and systems, methodologies and models, tools and techniques, innovations, comparative practices, scenarios, and reviews.

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- **The paper is original, not submitted anywhere else.**
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- **The title and headings are brief and catchy.**
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- **Abstract and keywords are provided.**
- **Focus on flexibility in management is kept.**
- **The paper incorporates innovative ideas/models in a practical framework.**
- **Mathematical models, if any, are given in Appendix.**
- **Tables/Figures are properly placed and numbered with brief titles/ captions.**
- **References are in standard style.**
- **Few highlights (8-10) of two-three lines are provided to put in boxes.**
- **Few key variables (3-5) are identified for flexibility mapping on a continuum.**
- **Some key questions (2-3) are provided to reflect the applicability in real life.**
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Footnotes: should be used only when absolutely necessary and must be identified in the text by consecutive numbers placed as superscript.

Text: The main text should be more readable and mathematical models, if any, should be provided in Appendix. The ideas proposed should preferably be supported by real life case examples from business situations.

Tables and Figures: All tables and figures should be kept to a minimum and numbered consecutively using arabic numerals. Each table should have a brief title written on the top of the table, and each figure should have a brief caption written on the bottom of the figure.

Photos and Illustrations: must be supplied as good quality black and white original with captions. Their position should be shown in the text by typing on a separate line the words *"take in* ***Plate n"***

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e.g. Mckenzie J. (1996) *Paradox: The New Strategic Dimension*, McGraw -Hill, Berkshire.

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Flexibility in Product Development for Success in Dynamic Market Environment

Narender Singh
Director, Institute of Technology Management
Landour Cantt, Mussoorie - 248179 (Uttranchal)

Sushil
Chair, Strategic Management
Department of Management Studies,
Indian Institute of Technology, Delhi
Hauz Khas, New Delhi - 110016

Abstract

Firms are adopting new product development as a competitive strategy for gaining competitive advantage in the globalized markets. In the highly dynamic environment, markets can undergo considerable change during the period of product development. In such a situation, adequate flexibility in various processes enables the firms to incorporate required changes into the product and production processes without having to pay excessive penalty in terms of time or cost. This paper discusses role of flexibility in various product development factors on the overall project success. The problem has been studied through questionnaire survey among more than 90 product development firms/organizations in India – both in public & private sectors. Results of the empirical study are presented and discussed to bring out dominant flexibility strategies for ensuring reasonable success in Indian business environment.

Keywords : flexible product development, flexibility, innovation management, new product development, technology management

Introduction

The current market environment is characterized by advancing technology, globalization of trade, rising competition, change from sellers' markets to buyers' market, and higher stress on product quality and endurance. As per marketing management fundamentals, there are four pillars or determinants of marketing success. These are: product, price, place and promotion, also known as the four 'Ps' of marketing (Kotler, 1998). The product is the most important factor around which the other 'Ps' are planned and executed. In the knowledged environment, most of the leading firms are fairly balanced on the other three 'Ps' mentioned above. In the highly competitive globalized markets, competition is now centered around the product where there is considerable scope of technological as well product oriented innovations.

In order to gain competitive advantage in the market, companies are attempting to respond with products that have increasingly better quality, lower costs, and shorter development time. New products are now being introduced at much faster rate than before. With advances in information technology and electronic media, customers are becoming more informed than before. Consequently, customers' needs and preferences are now changing at a faster pace than before. Firms are therefore required to adopt flexible process for product development.

Traditionally, product development has been examined by researchers in the context of stable environment, where target customers, target market, product technology and likely competition were not changing fast with time. Such market factors could be easily forecasted and therefore were well understood by the development team(s). In such environment, product development process was generally fairly rigid and was generally evolved with the objective to minimize the design changes in the later stages. The development processes were being planned with an emphasis on 'first-time-right' approach.

Flexibility in Product Development

In the highly dynamic globalized market environment, everything cannot be foreseen and envisaged at the stage of project planning. Some provisions are necessary so that the firm can take appropriate corrective actions, though not planned earlier, to keep pace with the fast changing market environment including technology, competition and customers' preferences. When flexibility provisions have not been made a part of advance planning framework, such changes required at a later stage, may result in large penalties in terms of cost and time.

Though development of new product provides competitive advantage and opportunity for high profits, it is a high-risk activity for the business organization. Firms should therefore use flexible approach in managing product development risks through well-coordinated efforts of various functions namely design, engineering, production, quality and marketing (Zahra et al, 1994). Flexibility is found to enhance both effectiveness and efficiency in innovation for product development projects (Davidson etal, 1999).

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Sushil (1993, 1994, 1997, 2000) has recommended use of systemic/managerial flexibility, which is characterized by three key aspects: options, change and freedom of choice. The identification of flexibility on any plane requires delineation of the range of options. Designing for flexibility in either or all of these components requires examination of options on different dimensions in a multi-dimensional reality.

Flexibility in the context of product development refers to the ability of the firm to change or react with little penalty in time, effort, cost or performance, with respect to the changes in the business environment, during the period of product development and introduction to the market (Upton, 1994). Higher the flexibility, lesser is the 'penalty' for incorporating the required change in the product and the associated processes. It has become increasingly important for firms operating in highly dynamic market environment to have high degree of flexibility in the product development to ensure their market success (Iansiti 1995, Singh and Lewis 1997). Flexibility has to be incorporated in advance through strategic framework to exploit future opportunities (Verganti, 1999).

Product Technology Flexibility

Manufacturers of new products are required to produce at low cost, to ensure rapid and fast-moving items, and to be flexible with extensive and changing product diversity. The production technology and the process should have flexibility that can satisfy the demand for responsiveness in the dynamic market environment (Collins and Schmenner, 1993).

In the highly competitive globalized markets, competition is now centered on the 'product' where there is considerable scope of technological as well as product-oriented innovations.

New product development projects using flexible design technologies out-perform the projects using in-flexible technologies (Thomke, 1997). Technology flexibility reduces the incremental cost and time required to incorporate design modification in the product and enables a firm to gain competitive advantage. Firms also adopt flexible approach in selection of suppliers and employ several criteria for supplier-selection namely technical compatibility, matching aims and objectives, development speed, strategic positioning, management ability, cost of development, security of business information, and cultural compatibility (Bailey etal, 1998)

Japanese firms from electronics industry use certain degree of flexibility in selection of suppliers, particularly when technology is fast changing and some new technology is under development (Fruin, 1998). It is advisable to wait for some more time, without delaying product development to incorporate the new technology from the suppliers, if it can provide competitive advantage to the firm. Flexibility can be achieved both internally and externally. Important flexibility factors are: modular product design, manufacturing technology flexibility, employee flexibility, and flexibility in the organization structure (Das and Elango, 1995).

Developmental flexibility is now becoming even more important due to increased difficulties in anticipating/ forecasting the market competition and the changes in customers' needs. In order to handle such difficulties, Thomke and Reinertsen (1998) have recommended three key steps for improving developmental flexibility: adopting flexible technologies, structuring 'processes' to lower the cost of subsequent changes, and leveraging product architecture to enhance flexibility

Product and Process Flexibility

Firms should also aim at developing flexibility in design architecture that minimizes inter-dependence between its individual parts. High design flexibility enables the designers to manage higher levels of risks relating to technology and the project (Thomke, 1997). For high project success, it is necessary to incorporate adequate product-configuration flexibility in the development cycle (Calontone etal, 1995). Modular design architecture and commonality of parts in finished products help in reducing the overall cost of design changes in the product system (Ulrich, 1995 and Fouque,1999).

Firms should use structured but flexible development process so that appropriate corrections/deviations may be made depending on the change in the market environment (Takeuchi and Nonanka 1986, Jenkins et al 1997). In the dynamic competitive environment, both speed and flexibility are essential for market success. Project management processes should have inbuilt flexibility to handle the likely problems which may not have been planned originally (Millet, 1990). Such flexibility is essential to reduce the impact of unforeseen problems, particularly the slippage in schedule and increase in project cost.

Numbers of firms have pioneered flexible product development process that "allows designers to continue to define and shape the products even after implementation has begun" (Iansiti and MacCormack, 1997). These firms have mechanisms to generate/ acquire new information about the changes in technology or customer's want/preferences over the development period. Designers use such information to evolve and to test the alternate product solution(s) and to incorporate the feasible option(s) into the product for introduction in the market. A flexible product development process delays the commitments regarding product design architecture as late in the process as practically possible.

Japanese firms adopt flexible development process and finalize the product-design at a late stage in the development process (Ward et al 1996, Liker et al 1996). They purposefully use 'flexible set-based overlapping process' for product development where they start with a number of design solutions/options.

In the uncertain market environment, number of firms like Microsoft use more flexible development process in

which 'links with the customer' are established at early design stage and development work then proceeds in the form of number of development iterations (MacCormack et al 2001). Here the customer is purposefully brought inside the innovation process. Development teams work with the customers to "co-evolve the product design" by analyzing their feedback on early product versions developed with 'basic functionality'.

Organizational flexibility should be encouraged and enhanced by adopting entrepreneurial strategies, group based working, proactive approach, commitment and encouragement of risk-taking (Saleh and Wang, 1993). Organization structure should be oriented towards integrating functional expertise, enhancing flexibility in group structure and collective orientation. The work groups should have openness in exchange of information, non-rigid work relationships and supportive rewards system. In deciding the 'best' structure for organizing new product activity, emphasis should be placed upon the product complexity and uniqueness of the internal factors so that product development teams may attack the 'problem' from various angles for finding an optimal solution to respond to market dynamics (McTavish, 1984).

Product managers should build organizations that combine the best of innovation as well as best of mass production (Boynton and Victor, 1991). Autonomous team structure, flat hierarchies and flexibility in organization structure contribute positively towards the product success (VonBraun et al, 1989). However, building flexibility in organizational structure leads to requirements for higher levels of skills and resources in both marketing and technical areas (Calatone etal, 1993).

It has become increasingly important for firms operating in highly dynamic environment to have high degree of flexibility in product development activities to ensure their market success.

Clark and Fuzimoto (1991) have reported negative correlation between 'degree of overlapping' and the development lead-time. However, number of recent research studies (Meyer and Roberts 1988, Krishnan et al 1997, Loch and Terwiesch 1998) have brought out that rather than using concurrent development activities, firms should have flexibility in choice of degree of overlapping and select the same based on contextual factors namely technology, product complexities & newness and market uncertainties. Firms use high flexibility in deciding degree of 'overlapping of development activities', which has a positive influence on project performance in terms of reduced cycle time, enhanced product quality, and reduced project cost (Clark and Fuzimoto 1991, and Krishnan et al 1997). Schilling and Hill (1998) have recommended use of partly overlapping development process for managing the technical and marketing risks involved in the new product development. In practice, operationalization of overlapping phase approach depends on the 'underlying structure of the design problem' (Funk, 1997).

Thomke (2001) has suggested another kind of flexibility in product development through carefully planned experimentation on the available options, to arrive at optimum solution approach rather than following a rigid development process. New technologies are making it easier and cost-effective to conduct experimentation as part of product development innovation process.

Managerial Flexibility

New product-development needs high degree of flexibility in financial delegation and decision-making (Zirger and Hartley, 1996). Decision-making levels need to be pushed downwards in the organization and adequate financial authority has to be provided to project persons working at various levels. Managerial flexibility in terms of decentralization, financial delegation, and non-rigid HR practices facilitate smooth and quick flow of product and project information among team members and therefore enhances the efficiency of the development process leading to higher level of project success (Haddad, 1996).

Product development can be assisted by use of IT and computer based tools and techniques, particularly in increasing the speed of development, improving the efficiency and productivity of development process, enhancing coordination and communication between organizational functions, and dissemination of product/ project information. Flexibility in choice of such tools and techniques enhances versatility and success of product development project (Ozer, 2000).

Flexible use of computer based design tools facilitates in-depth examination and evaluation of product design by allowing changes with greater ease and speed than what is possible otherwise (Robertson and Allen, 1993). Product managers should have flexibility to introduce such tools and techniques at an early stage of the project when the cost of changes and reworking is low (Tennant and Roberts, 2001).

New product designs call for higher marketing role flexibility (Jin, 2001 and Liker etal, 1999). Firms should keep their options open in decision-making regarding target markets and customers upto late stages of development so as to take advantages and respond to the changes in the market environment.

Cooper (1994) has recommended use of flexible approach in management of multi-functional product development teams. It has been reported that successful product development teams are product-focused, accountable for their tasks, led by strong product champion, and enjoy support and backing of the top-management. Team structure should not be rigid but rather flexible so as to meet the project requirements during various phases of development.

Appropriate system and procedural flexibility is necessary for inculcating team culture for promoting openness in information sharing, collegiality of work relations and achievement based reward system (Jenkins et al, 1997).

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Flexibility in terms of individual as well as team empowerment is reported to be a dominant factor for success in promoting collaborative problem solving culture among team-members, which in turn leads to better product quality and reduced development cycle time (Hull et al, 1996). Toyota employs considerable flexibility in employee interaction to build better quality products. While the production process is standardized, it has sufficient flexibility so that 'changes for product improvements' are achieved through persuasions with the employees (Anon, 1999).

When complexities/uncertainties in the upstream activity are high, use of concurrent development phases can lead to substantial deterioration in the product development performance.

In the product development environment, innovative contributions are made both at individual levels and at team levels. Therefore, performance appraisal in product development calls for adequate flexibility in human resource practices (Haddad, 1996). Rigid appraisal systems and HR practices do not provide sufficient motivation to the team members for risk-taking and evolving innovative solutions to the project problems.

Product development in highly dynamic environment calls for appropriate flexibility in human resource management systems, particularly in rewards and recognition approach. Such concerns regarding innovations within workforce are based on the assumption that employees have to commit the innovative efforts to build competitive advantage in the product under development. Organizational and employees' innovations are interlinked. Therefore, innovation is boosted by adequate flexibility in employee related practices (Storey etal, 2002).

Key research evidences regarding various aspects of flexibility in product development, emerging from the literature survey are presented in Table 1 given below. These

Table 1: Key Research Evidences Emerging from Literature Survey

Sl. No.	Macro Flexibility Area/Variable	Micro Flexibility Variable(s) influencing Product Development Success	Authors/Researchers Supporting the Flexibility Variable(s)
(i)	*Product Technology Flexibility*	*a) Flexibility in Product Technology* Thomke (1997), b) Flexibility in *Suppliers/Partners*	a) Collins and Scmenner (1993), Thomke and Reinertsen (1998) b) Das and Elango (1995), Bailey etal (1998)
(ii)	Product and Process Flexibility	a) Flexibility in *Product Design Architecture* b) Flexibility in *Development Process* c) Flexibility in *Organization/ Team Structure* d) Flexibility in *Overlapping of Development Activities*	a) Das and Elango (1995), Ulrich (1995), Calantone etal (1995), Thomke (1997), Thomke and Reinertsen (1998), Fouque (1999), b) Takeuchi and Nonanka (1986), Millet (1990), Jenkins et al (1997), Iansiti and MacCormack (1997), Thomke and Reinertsen (1998), MacCormack etal (2001) c) McTawish (1984), VonBraun etal (1989), Boynton and Victor (1991), Calatona etal (1993), Saleh and Wang (1993), Das and Elango (1995) d) Clark and Fuzimoto (1991), Funk (1997), Krishnan etal (1997), Schilling and Hill (1998), Loch and Terwiesch (1998)
(iii)	Managerial Flexibility	a) Flexibility in *Financial Delegation* b) Flexibility in *Use of IT/ Computer based Tools & Techniques* c) Flexibility in *Target Market and Customer Segments.* d) Flexibility in *HR Practices*	a) Haddad (1996), Zirger and Hartley (1996) b) Robertson and Allen (1993), Ozer (2000), Tennant and Roberts (2001) c) Haddad (1996), Liker etal (1999), Jin (2001) d) Cooper (1994), Das and Elango (1995), Haddad (1996), Hull (1996), Jenkins etal (1997), Anon (1999), Storey etal (2002)

variables and their reported relationship with product development success form the basis of this study.

Hypotheses Formulation

Based on the research evidences and flexibility variables influencing product development success, as presented in Table 1, above, research hypotheses are formulated as under for the purpose of this study:

Macro Hypotheses

H_1 : 'Product technology flexibility' in product development leads to higher level of higher level of project success advantage.

H_2 : 'Product and process flexibility' in product development leads to higher level of higher level of project success advantage.

H_3 : 'Managerial flexibility' in product development leads to higher level of project success advantage.

Micro Hypotheses

H_4 : Higher flexibility in 'product technology' leads to higher level of project success (in terms of quality/ time/cost advantage)

H_5 : Higher flexibility in 'selection of suppliers/partners' leads to higher level of project success (in terms of quality/time/cost advantage)

H_6 : Higher flexibility in 'product design architecture' leads to higher levels of project success (in terms of quality/time/ cost advantage)

H_7 : Higher flexibility in 'development process' leads to higher level of project success (in terms of quality/time/cost advantage)

In the uncertain market environment, number of firms like Microsoft use flexible development process in which 'links with the customers' are established at early design stage and development work then proceeds in form of number of development iterations.

H_8 : Higher flexibility in 'organization structure' leads to higher level of project success (in terms of quality/ time/cost advantage)

H_9 : Higher flexibility in 'overlapping of development phases' leads to higher level of project success (in terms of quality/time/cost advantage)

H_{10} : Higher flexibility in 'financial delegation' leads to higher level of project success (in terms of quality/ time/cost advantage)

H_{11} : Higher flexibility in 'use of computer/IT based tools and techniques' leads to higher level of project success (in terms of quality/time/cost advantage)

H_{12} : Higher flexibility in 'marketing segments' leads to higher level of project success (in terms of quality/ time/cost advantage)

H_{13} : Higher flexibility in 'H.R. practices/procedures' leads to higher level of project success (in terms of quality/ time/cost advantage)

Research Methodology

The unit of analysis for the study is the specific integrated product development project. However, the sampling unit was the organization undertaking the product development project. Snowball random sampling technique was used in the study. The snowball inquiry was started from eminent/ renowned product development professionals and senior Industry men representing all India industry associations. They in-turn provided names of further experts who may be consulted to identify organizations engaged in product development for competitive markets. This snow ball process continued for many stages covering industry professionals, senior/top level product managers, senior level marketing managers, corporate leaders, experts from S&T Departments of the Government of India, eminent technologists and senior technical representatives of all-India industry associations, who provided the names and relevant details of product developing organizations working in the globalized market environment. At the end, a random sample was drawn from the list of organizations so obtained.

The above research evidences were tested empirically in Indian business environment through a mailed-questionnaire survey. The instrument was extensively pre-tested for reliability and content validity. The respondents were requested to give their views regarding influence of flexibility variables on the project success, on a five point Likert type scale. The questionnaire was administered in 92 organizations from engineering and electronics/electrical sectors, located in different parts of India. Respondents from 162 product development projects provided data for the study, which was analyzed using SSPS (version 10.0) statistical software package.

Research Findings & Interpretation of Results

(a) Macro Flexibility Strategy Analysis

As shown in the table 2 below, analysis of data regarding use of macro flexibility strategies indicates that Indian product-developing organizations use fairly high level of flexibility in 'product and process areas' (mean 3.21) and in 'technology related issues' (mean 3.14). However, much lesser flexibility is adopted in the managerial areas (mean 2.82). Use of flexibility strategies lead to high level of project success advantage in terms of product quality, project-cost and cycle-time.

Table 2 : Description of Data on Mean Values for Macro Flexibility Strategies
(Variable Values on the Scale of 0 to 5.0)

Macro Flexibility Strategy & Success Factors	Mean	Median	Standard Deviation	Q_1 - Q_2 Quart. Range
Technology Flexibility	3.1	3.0	0.8	2.67 - 3.67
Product/Process Flexibility	3.2	3.0	0.7	3.0 - 4.0
Managerial Flexibility	2.8	2.7	0.6	2.33 - 3.33
Project Success Advantage	3.4	3.3	0.7	3.0 - 4.0

The correlation of macro variables for 'flexibility in product development' are presented in Table 3.

All three macro flexibility strategy variables 'product technology flexibility', 'product/process flexibility' and 'managerial flexibility' have positive and statistically significant correlation with 'project success advantage'. The summary of regression model for macro flexibility strategy variables with 'project success advantage' is given in Table 4 below. The regression has been concluded in three steps. 'Project technology flexibility', 'product/process flexibility'

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Table 3 : Correlation of Macro Flexibility Strategy Variables for Product Development

Macro Variable(s)	Product Technology Flexibility	Product/ Process Flexibility	Managerial Flexibility	Project Success Advantage
Product Technology Flexibility	1			
Product/Process Flexibility	0.264**	1		
Managerial Flexibility	0.212**	0.236**	1	
Project Success Advantage	0.442**	0.398**	0.319**	1

*p < 0.05, **p < 0.01

and 'managerial flexibility' are the predictors of the dependent variable 'project success advantage', in the order of their prediction strengths. Together, they explain 43.7% variation in the dependent variable. 'Project technology flexibility' is the strongest predictor of 'project success advantage' for project development projects.

Design flexibility reduces the incremental cost and time required to incorporate design modifications in the product and enables the firm to gain competitive advantage.

Table 4 : Regression Model Summary (with Coefficient) for Macro Variables of 'Flexibility in Product Development' with 'Project Success Advantage' as Dependent Variable

Model	R Square	Adjusted R Square	Standared Error of Estimate	Beta Coeffi-cient	t Value	Sig. Level
1 (Constant)					7.4	0.0
Product Technology Flexibility	0.29 3	0.289	0.57	0.442	34 8.1 49	00 0.0 00
2 (Constant)					4.5	0.0
Product Technology Flexibility				0.415	24	00
Product/Process Flexibility	0.39 8	0.390	0.53	0.347	6.2 83 5.2 50	0.0 00 0.0 00
3 (Constant)					2.63	0.0
Product Technology Flexibility				0.369	25	10
Product/Process Flexibility	0.43 7	0.426	0.51	0.296 0.216	5.6 31 4.4	0.0 00 0.0
Managerial Flexibility					3.3 23	0.0 01

(b) Micro Flexibility Strategy Analysis

The correlation of micro variables for 'flexibility in product development' is placed at Appendix-A. All micro variables have positive significant correlations with the three micro success variables namely, 'success in enhancement of product quality' (SuccQual), 'success in project cycle-time reduction' (SuccTime) and 'success in reduction of project cost' (SuccCost), except for 'flexibility in marketing segments', which has significant correlation only with SuccTime and SuccCost. Its correlation with SuccQual is statistically insignificant. The dominant success strategies in this area are: 'flexibility in project technology', 'flexibility in product architecture' and 'flexibility in selection of suppliers and partners'.

Flexibility strategies relating to 'flexibility in development process', 'flexibility in use of computer and IT based product development tools and techniques', and 'flexibility in organization/team structure' have lesser, but significant positive influence on project success in terms of advantages in quality, cycle-time and cost. The impact of flexibility strategies is strongest (highest) on the timeliness (time advantage) performance.

Regression Analysis with 'Success in Enhancement of Quality' (SuccQual) as the Dependent Variable

The regression summary model for micro variables for 'flexibility in product development' with 'success in enhancement of quality' (SuccQual) as the dependent variable is presented in Table 5. 'Flexibility in product technology' has entered the model in the first step, 'flexibility in selection of suppliers/partners' entered in the second step and 'flexibility in development process' at the third step. These are the predictors of SuccQual, with 'flexibility in product technology', being strongest and 'flexibility in development process' being the weakest predictor as also confirmed by their relative 't'-values. Together they explain 28.9% of variation in the dependent variable SuccQual.

Table 5 : Regression Model Summary (with Coefficient) of Micro Variables for 'Flexibility in Product Development' with SuccQual as Dependent Variable

Model	R Square	Adjusted R Square	Standared Error of Estimate	Beta Coeffi-cient	t Value	Sig. Level
1 (Constant)					9.23	0.00
Flex. in Product Technology	0.20 3	0.198	0.69	0.451	1 6.39 2	0 0.00 0
2. (Constant)					6.77	0.00
Flex. in Product Technology				0.311	1	0
Flex. in Suppliers/ Partners	0.26 2	0.252	0.66	0.279	3.95 3 3.53 7	0.00 0 0.00 1
3. (Constant)					4.82	0.00
Flex. in Product Technology				0.281	0	0
Flex. in Suppliers/Partners	0.28 9	0.275	0.65	0.237 0.176	3.57 7 2.99 0	0.00 0 0.00 3
Flex. in Development Process					2.45 9	0.01 5

Regression Analysis with 'Success in Reduction of Cycle-Time' (SuccTime) as the Dependent Variable.

The regression summary model for micro variables for 'flexibility in product development' with 'success in reduction of cycle-time' (SuccTime) as the dependent

variable is presented in Table 6. 'Flexibility in product design architecture' has entered the regression model in the first step and 'flexibility in suppliers/partners' entered in second step. 'Flexibility in computer based design tools' entered the regression model in the third step and 'flexibility in development process' entered in the fourth step. These four variables are the predictors of SuccTime. In the fourth step of regression analysis, it is noted that the variable 'flexibility in suppliers/partners' has higher 't-value' than 'flexibility in product design architecture'. Therefore, the variable 'flexibility in suppliers/partners' is the stronger predictor (of SuccTime) than 'flexibility in product design architecture'. Together, they explain 46.2% of variation in the dependent variable SuccTime.

Table 6 : Regression Model Summary (with Coefficient) of Micro Variables for 'Flexibility in Product Development' with SuccTime as Dependent Variable

Model	R Square	Adjusted R Square	Standared Error of Estimate	Beta Coeffi-cient	t Value	Sig. Level
1 (Constant)					7.312	0.000
Flex. in Product Architecture	0.286	0.281	0.71	0.534	7.997	0.000
2. (Constant)					3.352	0.001
Flex. in Product Architecture				0.433	6.536	0.000
Flex. in Suppliers/ Partners	0.372	0.364	0.66	0.310	4.666	0.000
3. (Constant)					2.804	0.006
Flex. in Product Architecture				0.413	6.482	0.000
Flex. in Suppliers/Partners				0.282	4.417	0.000
Flex. in Use of Computer Tools	0.430	0.419	0.64	0.245	4.023	0.001
4. (Constant)					2.430	0.016
Flex. in Product Architecture				0.290	4.222	0.000
Flex. in Suppliers/Partners				0.302	4.651	0.000
Flex. in Use of Computer Tools				0.231	3.885	0.000
Flex. in Development Process	0.462	0.448	0.62	0.209	3.041	0.003

Regression Analysis with 'Success in Reduction of Project Cost' (SuccCost) as the Dependent Variable.

Systemic/managerial flexibility is characterized by three key aspects: options, change and freedom of choice.

The regression summary model for micro variables for 'flexibility in product development' with SuccCost as the dependent variable is presented in Table 7. The micro variables 'flexibility in selection of suppliers/partners', 'flexibility in product technology' and 'flexibility in product design architecture' are the predictors of SuccCost. 'Flexibility in selection of suppliers/partners' is the strongest and 'flexibility in product architecture' is the weakest among the three predictors. These relative predictive strengths are supported by their respective 't'-values in the third step of the regression model. Together, they explain 22.6% of variation in the dependent variable SuccCost.

Table 7 : Regression Model Summary (with Coefficient) of Micro Variables for 'Flexibility in Product Development' with SuccCost as Dependent Variable

Model	R Square	Adjusted R Square	Standared Error of Estimate	Beta Coeffi-cient	t Value	Sig. Level
1 (Constant)					9.414	0.000
Flex. in Suppliers Partners	0.1333	0.127	0.81	0.365	4.952	0.000
2. (Constant)					5.892	0.000
Flex. in Suppliers Partners				0.315	4,322	0.000
Flex. in Product Technology	0.1892	0.179	0.78	0.2429	3.312	0.001
3. (Constant)					3.660	0.000
Flex. in Suppliers/ Partners				0.242	3.573	0.002
Flex. in Product Technology				0.211	2.912	0.004
Flex. in Product Architecture	0.2269	0.212	0.77	0.201	2.760	0.006

Validation of the Hypotheses

Macro Hypotheses

H_1 : 'Project technology flexibility' has statistically significant correlation with 'project success advantage'. Therefore the hypothesis is found to be true.

H_2 : 'Product and process flexibility' has significant correlation with 'project success advantage'. Therefore the hypothesis is found to be true.

H_3 : 'Managerial flexibility' has significant correlation with 'project success advantage'. Therefore the hypothesis is found to be true.

Micro Hypotheses

H_4 : The variable 'flexibility in product technology' has significant correlation with SuccQual, SuccTime and SuccCost. This hypothesis is found to be true.

H_5 :'Flexibility in selection of suppliers/partners' has statistically significant correlation with SuccQual, SuccTime and SuccCost. This hypothesis is found to be true.

H_6 : 'Flexibility in product design architecture' has significant correlation with SuccQual, SuccTime and SuccCost. Therefore the hypothesis is found to be true.

H_7 : 'Flexibility in development processes' has significant correlation with SuccQual, SuccTime and SuccCost. Therefore, this hypothesis is found to be true.

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H_8 : 'Flexibility in organization/team structure' has statistically significant correlation with SuccQual, SuccTime and SuccCost. This hypothesis is found to be true.

H_9 : 'Flexibility in overlapping of development phases' has statistically significant correlation with SuccQual, SuccTime and SuccCost. Therefore, the hypothesis is found to be true.

H_{10} : 'Flexibility in financial delegation' has low but statistically significant correlation with SuccQual, SuccTime and SuccCost. This hypothesis is found to be true.

H_{11} : 'Flexibility in use of computer/IT based tools and techniques' has statistically significant correlation with SuccQual, SuccTime and SuccCost. Therefore, this hypothesis is found to be true.

H_{12} : 'Flexibility in marketing segments' has statistically significant correlation with SuccTime and SuccCost, but has insignificant correlation with SuccQual. Therefore, this hypothesis is found to be true only for project success in terms of cycle-time and cost performance. It is not found to be true for project success in terms of quality. .

H_{13} : 'Flexibility in H.R. practices/procedures' has low but statistically significant correlation with SuccQual, SuccTime and SuccCost. This hypothesis is found to be true.

Organizational flexibility should be encouraged and enhanced through entrepreneurial strategy, group-based working, proactive approach, commitment and encouragement of risk-taking.

The summary of results of correlation analysis and the regression analysis for 'flexibility in product development' is presented in Table 8 giving relationship of micro independent variables with the dependent variables.

Table 8: Summary of Variables' Relationships with Micro Dependent Variables for 'Flexibility in Product Development'

Description of Micro Independent Variables	Dependent Variables		
	SuccQual	SuccTime	SuccCost
Predictor Variables (for respective dependent variable)	• Product Technology • Selection of Suppliers/ Partners • Development Process – –	• Selection of Suppliers/ Partners • Development Process • Product Architecture • Computer Design Tools	• Product Technology • Selection of Suppliers/ Partners – • Product Architecture –
Variables having Weak but Significant Relationships (but not the predictors)	• Organization Structure • Financial Delegation • HR Practices • Overlap of phases • Computer Design Tools – • Product Architecture	• Organization Structure • Finan. Delegation • HR Practices • Overlap of phases – • Market Segments • Product Technology	• Organization Structure • Finan. Delegation • HR Practices • Overlap of phases • Computer Design Tools • Market Segments • Develop. Process
Insignificant Relationship	• Market Segments	–	–

Discussion and Conclusions

Flexibility in product development is fast becoming an essential success-strategy as the business environment factors including competition, technology and customers' requirements are undergoing fast changes. Three areas of developmental flexibility are found to have strong influence on project success. These are: product technology flexibility, product/process design flexibility and managerial flexibility; of which the first two are stronger predictors of project success. All three factors have medium or high correlation with each-others, and also with 'project success advantage' and are its predictors. Flexibility Influence Diagram indicating associations and correlation values between macro strategy variables and the dependent variable project success advantage (as per appendix-A) is shown in Fig. 1.

Among the micro flexibility variables, four project level factors, namely development process, product design architecture, product technology and selection of suppliers/ partners are found to have very significant dominant influence on project success. Their association/correlation with project success dependent variables (as per appendix-A) is again presented in Table 9:

It is seen that effect of product development flexibility is more dominant on dependent variable SuccTime i.e. on time-compression advantage in the project. The influence is

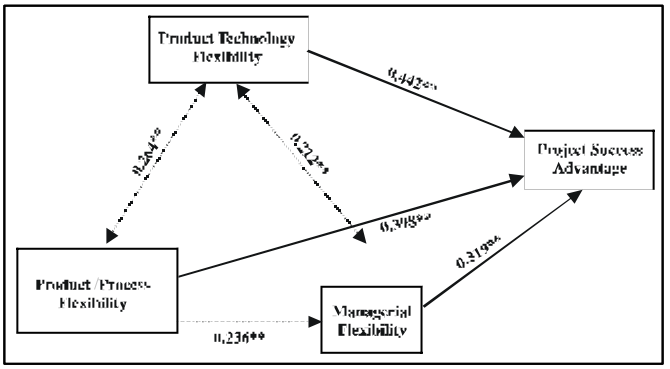
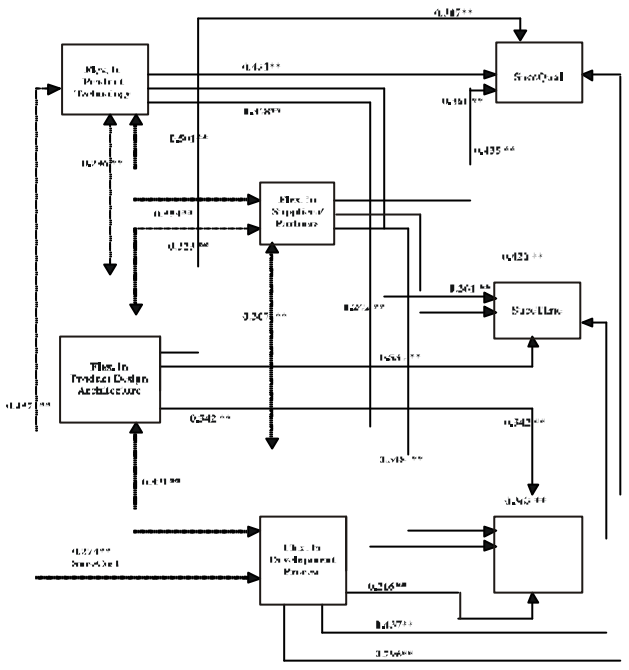


Figure 1 : Flexibility Influence Diagram showing Relationship Among Macro Strategy Variables and the Dependent Variable

Table 9 : Correlations of Independent Flexibility (Predictors of Dep. Var.) Variables With Project Success (Dependent) Variables

Variables	Flexibility in Product Technology	Flexibility in Product Design Architecture	Flexibility in Development Process	Flexibility in Suppliers/ Partners
SuccQual	0.451**	0.307**	0.296**	0.435**
SuccTime	0.361**	0.534**	0.437**	0.420**
SuccCost	0.348**	0.342**	0.248**	0.365**

least on SuccCost variable i.e. on cost management success advantage in product development. These results find support from number of researchers, namely Ulrich (1995), Iansiti and MacCormack (1997), Thomke and Reinertsen (1998), Thomke (1997) and MacCormack et al (2001). Flexibility influence diagram indicating associations and correlation values (as per appendix-A) between the dominant micro strategy variables and the project success variables, (dependent variables) is shown in Fig. 2.



LEGEND:
..... Line Indicating Associations among Micro Flexibility Variables.
Line Indicating Relationship between Micro Flexibility Variable and Project.
_____ Success (Dependent) Variable.

Figure 2 : Flexibility Influence Diagram showing Relationship among Dominant Micro Strategy Variables (Predictors of Success) and the Dependent Variables for Project Success

Project strategies relating to flexibility in micro variables 'use of computer/IT tools/techniques', 'overlapping of development activities', 'team organization structure', 'financial delegation', and 'HR practices' have also been found to have good influence on project success, though these variables are not found to be predictors of project success. These results find support from research findings reported by Bailetti et al (1998) and MacCormack et al (2001).

The study has brought out two-tier flexibility-strategy model for success in product development under dynamic business environment. The first tier strategies are the dominant success strategies and can be called as the flexibility drivers of project success. These include: flexibility in development process, flexibility in product design architecture, flexibility in product technology, and flexibility in selection of suppliers and partners. The second-tier strategies are not predictors of project success, but have significant relationship with project success. Their use enhances the success potential of product development project and therefore can be called as the flexibility enablers for project success. These include: flexibility in use of special computer/IT based tools, flexibility in overlapping of development activities, flexibility in organization/team structure, flexibility in financial delegation, and flexibility in HR policies for project personnel.

Another important research finding from this study is that use of concurrent development phases is not always a beneficial success strategy. Flexibility in deciding optimal degree of overlapping among development phases/activities is found to have positive influence of project success, contributing in higher quality and reduces project cost as well as timeframe. Therefore, firms must have flexible approach and should decide degree of overlapping on the basis of project and product related contextual factors.

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References

Anon (1999) Toyota Finds that Conflict Can Pay, *Human Resource Management International Digest,* 7 (6), Nov-Dec, 31-34.

Bailey W.J., Masson R. and Raeside R. (1998) Choosing Successful Technology Development Partners: A Best Practice Model, *International Journal of Technology Management,* 15 (1/2), 124-138.

Boynton A.C. and Victor B. (1991) Beyond Flexibility: Building and Managing the Dynamically Stable Organization, *California Management Review,* 34 (1), Autumn, 53-66.

Calantone R.J., di Benedetto C.A. and Divine R. (1993) Organizational, Technical and Marketing Antecedents for Successful New Product Development, *R&D Management,* 23 (4), Oct., 337-351.

Calontone R.J., Vickery S.K. and Droge C. (1995), Business Performance and Strategic New Product Activities: An Empirical Investigation, *Journal of Product Innovation Management,* 12 (3), June, 214-223.

Clark K.B. and Fuzimoto T. (1991) *Product Development Performance: Strategy, Organization and Management in the World Auto Industry*, Harvard Business School Press, Boston, Massachusetts, 64-97.

Collins R.S. and Schmenner R. (1993) Achieving Rigid Flexibility: Factory Focus for the 1990s, *European Management Journal,* 11 (4), Dec., 443-447.

Cooper R.G. (1994) Debunking the Myths of New Product Development, *Research Technology Management,* July-Aug, 40-50.

Das T.K. and Elango B. (1995) Managing Strategic Flexibility: Key to Effective Performance, *J. Gen. Manage.,* 20 (3), Spring, 60-75.

Davidson J.M., Clamen A. and Karol R.A. (1999) Learning from the Best New Product Developers, *Research Technology Management,* 42 (4), Jul-Aug. 12-18.

Fouque T. (1999) In Search of Flexible Products, *Rev. Fr. Gestion,* Mar – May, 80-87.

Fruin W. M. (1998) Smart Card and Product Development Strategies in Electronics Industry in Japan, *IEEE Transactions on Engineering Management,* 45 (3) Aug, 241-249.

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Funk J.L. (1997) Concurrent Engineering and Underlying Structure of the Design Problem, *IEEE Transactions on Engineering Management,* 44 (3), Aug, 305-315.

Haddad C.J. (1996) Operationalising the Concept of Concurrent Engineering: A Case Study from the U.S. Auto Industry, *IEEE Transactions on Engineering Management,* 43 (2), May, 124-132.

Hull F.M., Collins P.D. and Liker J.K. (1996) Composite Forms of Organization as a Strategy for Concurrent Engineering Effectiveness, *IEEE Transactions on Engineering Management,* 43 (2), 133-142.

Iansiti M. (1995) Shooting the Rapids: Managing Product Development in Turbulent Environment, *California Management Review,* 38 (1), 37-58.

Iansiti M. and MacCormack A. (1997) Developing Products on Internet Time, *Harvard Bus. Rev.*, Sep-Oct, 108-117.

Jenkins S., Forbes S., Durrani T.S. and Banerjee S.K. (1997) Managing the Product Development Process (Part II: Case Studies), *International Journal of Technology Management,* 13 (4), 379-394.

Jin Z. (2001) The Nature of NPD and Role Flexibility of R&D/ Marketing in a Fast Growing High-Tech Setting, *R&D Management,* 31 (3), July, 275-285.

Kotler P. (1998) *Marketing Management: Analysis, Planning, Implementation and Control,* Ninth Edition, Prentice Hall of India, New Delhi.

Krishnan V., Eppinger S.D. and Whitney D.E. (1997) A Model Based Framework to Overlap Product Development Activities, *Management Science,* 43 (4), April, 437-451.

Liker J.K., Sobek D.K.-II, Ward A.C. and Cristiano J.J. (1996) Involving Suppliers in Product Development in the United States and Japan: Evidence for Set-Based Concurrent Engineering, *IEEE Transactions on Engineering Management,* 43 (2), May, 165-178.

Liker J.K., Collins P.D. and Hull F.M. (1999) Flexibility and Standardization: Test of a Contingency Model of Product Design-Manufacturing Integration, *Journal of Product Innovation Management,* 16 (3) May, 248-267.

Loch C.H. and Terwiesch C. (1998) Communication and Uncertainty in Concurrent Engineering, *Management Science,* 44 (8), August, 1032-1048.

MacCormack A., Verganti R. and Iansiti M. (2001) Developing Products on "Internet Time": The Anatomy of a Flexible Development Process, *Management Science*, 47 (1), Jan.

McTavish R. (1984) Approaching the New Product Organization Problems: Favor Flexibility and Variety of Attack, *European Journal of Marketing,* 18 (6/7), pp 30-42.

Meyer M. and Roberts G. (1988) Focusing New Product Strategy for Corporate Success, *Sloan Management Review,* 29 (2), Summer, 07-16.

Millet S.M. (1990) The Strategic Management of Technological R&D: An Ideal Process for the 1990s, *International Journal of Technology Management,* 5 (2), 153-163.

Ozer M. (2000) Information Technology and New Product Development: Opportunities and Pitfalls, *Industrial Marketing Management,* 29 (5), Sept., 387-396.

Saleh S.D. and Wang C.K. (1993) The Management of Innovation: Strategy, Structure and Organizational Climate, *IEEE Transactions on Engineering Management,* 40 (1), 14-20.

Schilling M.A. and Hill C.W.L. (1998) Managing the New Product Development Process: Strategic Imperative, *Academy of Management Review*, June.

Singh K.J. and Lewis J.W. (1997) Concurrent Engineering: Institution, Infrastructure and Implementation, *International Journal of Technology Management,* 14 (6/7/8), 727-738.

Storey J., Quints P., Taylor P. and Fowle W. (2002) Flexibility Employee Contracts and Their Implications for Product and Process Innovation, *Int. J. Human Resour. Manage.*, 13 (1), Feb., 1-16.

Sushil (1993) Flexible Systems Approach to Management in Borderless World, *Proceedings of IEEE International Engineering Management Conference,* New Delhi, 207-211.

Sushil (1994) Flexible System Methodology, *System Practice,* 7 (6), 633-652.

Sushil (1997) Flexible Systems Management: An Evolving Paradigm, *System Research & Behavioral Science,* 14 (4), 259-275.

Sushil (2000) Concept of Systemic Flexibility, *Global Journal of Flexible Systems Management,* 1 (1), 77-80.

Takeuchi I.H. and Nonaka I. (1986) The New Product Development Game, *Harvard Bus. Rev.,* Jan-Feb, 130-137.

Thomke S.H. (1997) The Role of Flexibility in the Design of New Products: An Empirical Study, *Research Policy*, March, 105-109.

Thomke S.H. (2001) Enlightened Experimentation-The New Imperative for Innovation, *Harvard Business Review*, February, 67-75.

Thomke S. and Reinentsen D. (1998) Agile Product Development: Managing Flexibility in Uncertain Environment, *California Management Review,* 41 (1), Fall, 8-30.

Ulrich K. (1995) The Role of Product Architecture in the Manufacturing Firm, *Research Policy,* 24 (2), 419-440.

Upton D.M. (1994) The Management of Manufacturing Flexibility, *California Management Review,* 36 (2), 72-89.

Verganti R. (1999) Planned Flexibility: Linking Anticipation and Reaction in Product Development Projects, *Journal of Product Innovation Management,* 16 (4), July, 363-376.

Von B.C.F., Fischer H.G. and Muller A.E. (1989) Integrated R&D Planning in Large Corporation, *International Journal of Technology Management,* 4 (3), 559-579.

Ward A.C., Liker J.K., Cristiana J.J. and Sobek D.K. II (1996) The Second Toyota Paradox: How Delaying Decisions Can Make Better Car Faster, *Sloan Management Review,* 36 (3), Spring, 43-61.

Zahra S.A., Nash C. and Bickford G. (1994) Creating Competitive Advantage from Technological Pioneering, *IEEE Engineering Management Review*, Spring, 76-83.

Zirger B.J. and Hartley J.L. (1996) The Effect of Acceleration Techniques on Product Development Time, *IEEE Transactions on Engineering Management,* 43 (2), 143-152.

Appendix - 'A' : Correlation of Micro Flexibility Variables for Product Development (N = 162)

Flexibility Factor	Product Technology	Product Architecture	Overlap of Dev. Phases	Development Process	Orgn & Structure	Finan. Delegation	HR Practice	Supplier/ Partner	Computer Tools	Market/ Customer Seg.	Succ Qual	Succ Time	Succ Cost
Product Technology	1												
Product Architecture.	359**	1											
Overlap of Dev. Phases	.290**	.385**	1										
Development Process	.274**	.321**	.297**	1									
Orgn. & Structure	.263**	.390**	.377**	.513**	1								
Financial Delegation	.287**	.362**	.276**	.298**	.401**	1							
HR Practices	0.124	.225**	.255**	.169*	.296**	.327**	1						
Suppliers/ Partners	.501**	.323**	.321**	.242**	.197*	.184*	.206**	1					
Computer Tools	.263**	0.124	.217**	.225**	.194*	.207**	.213**	0.142	1				
Market/ Customer Segment	.183*	0.143	0.045	0.141	.276**	.218**	.281**	.176*	.191*	1			
SuccQual	.451**	.307**	.234**	.296**	.237**	.220**	.209**	.435**	.246**	0.134	1		
SuccTime	.361**	.534**	.299**	.437**	.370**	.291**	.254**	.420**	.336**	.244**	.510**	1	
SuccCost	.348**	.342**	.248**	.216**	.265**	.240**	.192*	.365**	.206**	.191*	.517**	.545**	1

*p<0.05, **p < 0.01

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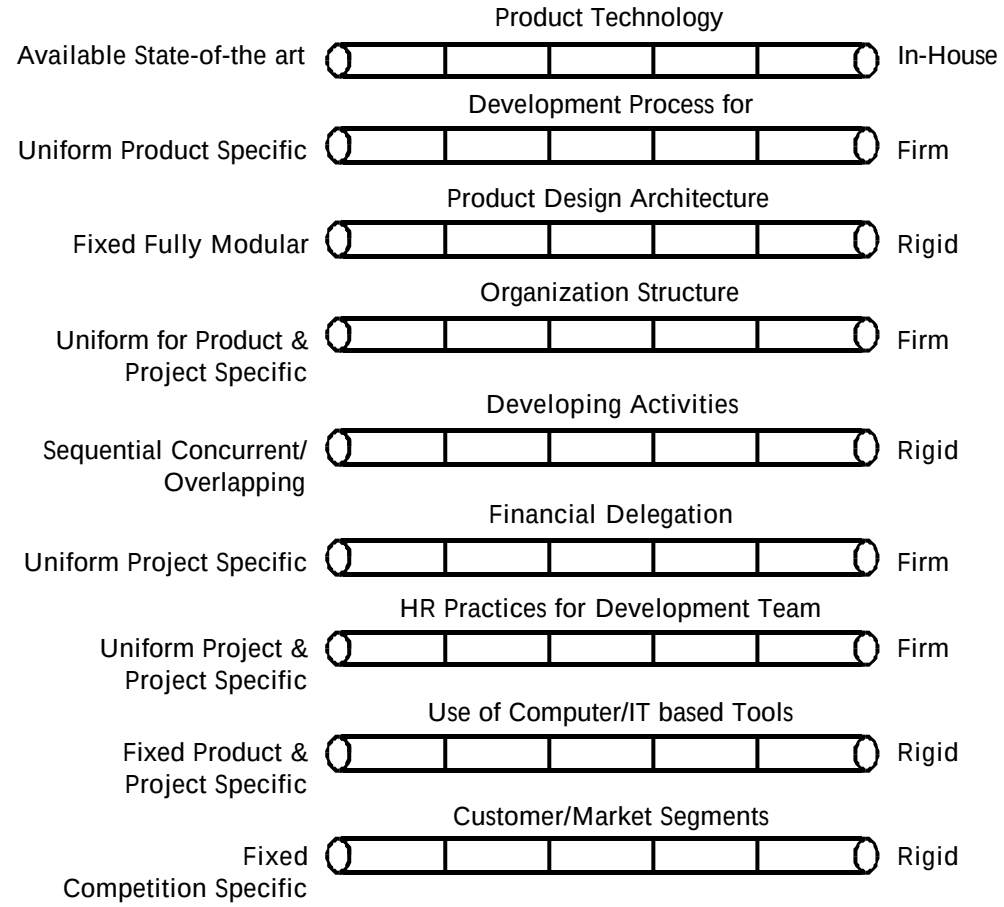
Flexibility Mapping : Practitioner's Perspective

1. What types of flexibilities do you see in the practical situation of product development? projects, particularly under developing economy environment on the following points:
   - Flexibility in terms of "options"
   - Flexibility in terms of "change mechanism"
   - Flexibility in terms of "freedom of choice" to participating actors.
2. Identify and describe the types of flexibilities in 'product development' that are relevant for your own organizational context? On which dimensions, flexibility should be enhanced!
3. Try to map your own organization on the following continua (Please tick mark in the appropriate boxes)



Reflecting Applicability in Real Life

1. How important is the ability to fine-tune the 'product' to match with the 'dynamic market competition', for your organization?
2. Does your organization value 'competitive edge' over the competitors in product development?
3. Does your organization desire to enhance flexibility in product development for higher success in the dynamic globalized market?

giftjourn@l
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The 'I' in it A Pancha Kosha View

K.R. Srivathsan
Indian Institute of Information Technology and
Management – Kerala

Abstract

Thus far Information Technology has grown mostly from the 'T' or Technology side of IT. As this technology is becoming mature and supply of the same is exceeding demand, it is becoming a superspecialty. The 'I' side of IT is steadily becoming more important. Subjects like taxonomy, metadata frameworks, information systems organization, semantic web, knowledge management, etc. are getting increasing attention. In future, the 'T' will be more and more shaped by ways the 'I' is generated and used in different domains of real world and activities of daily life. The dynamics of 'I' or information as driven by those who use it requires relevant practical paradigms that are aligned with knowledge based wealth creation activities. Present approach of pushing more technology in the form of Enterprise Applications Integration [EAI] has to be integrated with processes that sustain effective Knowledge Management and culture of learning organizations. In this paper we bring out that the ancient Indian Vedic view of Pancha Kosha, i.e. the five-layers view of conscious human existence, together with a 'Knowledge Plant' (K-Plant) management model to provide some deep insight into how we holistically integrate people, process and technology with capacity to drive the information space in ways that sustain knowledge enabled wealth creation by organizations. The same approach is also useful in building virtual knowledge-driven enterprises. We also refer to implementations of such virtual enterprises supporting knowledge management systems in three kinds of organizations. All the three implementations support the information-interaction-collaboration framework for the kind of K-Plants approach stated in this paper. The three are generic enough to cover a wide variety of real-world organizations.

Keywords : knowledge management, information systems organization, enterprise applications Integration, decision support systems, virtual enterprises, information systems, information sciences, systems thinking, learning organizations, organizational behaviour, pancha kosha.

The Need

As the world hurtles from computers and networks through Information – Communication Technologies (or ICT) and convergence towards the emerging Knowledge Society era, we need appropriate paradigms that help us master and sustain knowledge based wealth creation. Knowledge in a domain is used collectively by members of any group that works focused in wealth creating activities. They act in the real world in ways that sustain value propositions for the customers and stakeholders of that group. Knowledge based wealth creation depends upon understanding information and the capacity to use the insight gained from it in a given context to arrive at right judgments. Further, any group using information to create wealth should be equipped to act upon such judgments in ways that create value for the beneficiaries and stakeholders it serves. The tools and systems provided by ICT and convergence should be so deployed and made available such that they facilitate such collective insight-driven actions. In this paper we propose a Pancha Kosha paradigm that allows us to integrate the complex information systems and processes, the organization and management of the people or groups that use them such that IT can sustain effective value propositions to all concerned.

Information of value is that which effects a change of state of a user or a group that becomes aware of it. Henry Kissinger, in a speech delivered in Aug. 2003 at New York stated that, "The role of technology should be to bridge the gulf between the availability of information and the ability to use it." Bridging this gulf is the key to building enterprises in the Knowledge Intensive Products and Services area. President of India, A.P.J. Abdul Kalam constantly lectures upon building a knowledge driven economy as the central theme of his Vision-2020 (Kalam A.P.J.A. and Rajan Y.S., 2002; Kalam A.P.J.A. and Pillai A.S. 2004, http://www.presidentofindia.nic.in). The capacity of any organization to exhibit the characteristics of a Learning Organization (Senge P. 1994) depends critically on systems thinking and knowledge management within the organization driven in relation to the wealth-creating activities it is engaged in.

It is increasingly recognised that such capacity is enhanced very substantially by groups working focused in knowledge driven activities and create value by the systematic practice of Knowledge Management. [or KM], KM the art of involving in every organized activity of an institution or organization the People, Process and Technology to

a) Capture and accumulate knowledge of people in an organization.
b) Disseminate knowledge where and when it's needed.
c) Enable people to re-use the knowledge work of others.
d) Provide an environment to collaborate.

We call the above aspects as the CDRC (for capture, disseminate, re-use and collaborate) functions of KM. Current KM literature (Tiwana A. 2000) deals with how to (a) set up an IT framework to facilitate this CDRC; (b) how to build KM practices over an Intranet of any given company or organization that facilitates retention of organizational knowledge; and how to factor it into

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the management business and its growth (Natarajan G. 2001).

However, we say that the above four CDRC functions are effective only if the group's management of the information dynamics (i.e. the information generation and utilization processes) obeys the following five 'fundamental Rights': Right Information to the Right Person or Group at the Right Time, Right Place and in the Right Context. We call these five rights as the 5Rs. The effective application of KM by any group not only respects the CDRC functions, but also drives the capacity to sustain the 5Rs in ways that sustain the value propositions for the customers and stakeholders served by the group. The challenge that we address in this paper is to extend the KM paradigm from a purely technology driven, or, 'platforms' based intranet approach into a holistic Pancha Kosha paradigm wherein the people and processes in organizations are aligned with the facilitations provided by ICT and convergence. Such organization is necessary to build and efficiently manage Knowledge Intensive Products and Services [KIPS] as often referred to by Abdul Kalam (visit www.presidentofindia.nic.in).

We need appropriate paradigms that help us master and sustain knowledge based wealth creation.

In the global web-based information space with access to the ever-expanding horizon of information, the only efficient way for groups to work focused is to build their own relevant Knowledge Estates [K-Estates] over which they support their own KM functions. Our approach is to enable each organized group that uses ICT and convergence to build and manage its own K-Estates over which they manage their own Knowledge Plant [K-Plant] that help them drive their KIPS functions. Such knowledge estates are capable of aligning quickly with the people and processes that support KIPS functions. The usage of the phrases K-Estates, K-Plants or K-Citizen will become in the context of this paper will be clear as we further go through this paper.

The Three Tiers of Convergence

Convergence in Technology is now well established and getting deployed rapidly. It is coming in the form of multimedia integration, IT, communication, and entertainment over the global net. Its very success has paved the way for studies and methods on how to exploit it in the different domains of business, economics, industry, education and diverse services. At a higher level, we are now deploying this ICT or convergence in different forms of Enterprise Applications Integration (EAI see Dataquest Magazine) for coverage on different aspects of EAI), web-enabled services in the form of e-commerce, e-governance, e-learning, etc. At this higher level, we may call this as Convergence in Management. It is about integrating the people and processes in any organization over the technology framework of convergence.

To effectively bring about this convergence in management, we need to build several component information systems that are aligned with the logic of the business and associated processes. In some sense, this is already happening in systems that support workflow, document management, web-enabled databases, learning management systems, digital library, etc. However, when we have to customise these enterprise applications for target domains (such as health, education, manufacturing, agriculture, finance, etc.), considerable work needs to be done in the development of appropriate classification methods. In fact the logic behind the classification itself delineates the boundary on the kind of knowledge questions that the systems is capable of supporting. This subject or domain specific knowledge map or taxonomy often has to be developed over a confluence of disciplines. For example, let us take the case of developing a knowledge portal for agriculture trade. Such a portal needs to have underneath information systems built upon the classification of components related to the particular kind of trade, the related agriculture domain and finance or business related information. We may call such confluence of disciplines as the Convergence of Disciplines.

In the emerging knowledge driven economy, we have to master all three tiers of convergence in prototyping and managing the corresponding systems that support enterprise application integration.

People, Process, Technology and Convergence in Management

Today the true or market value of any company or organization is not so much judged by the physical and financial assets it commands, but by the ability it has to create wealth and sustain value propositions through their capacity to mobilise human and relations capital. This is illustrated by the Skandia's (http://www.skandia.com) model given in Figure1.

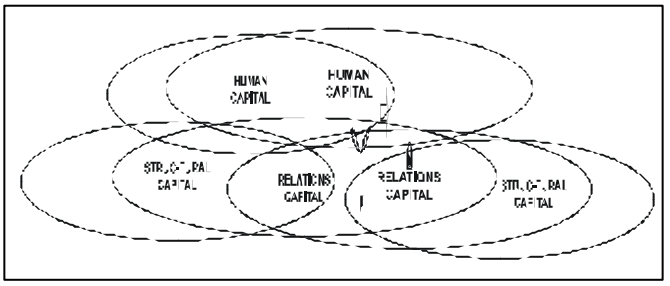

Figure 1: Skandia's Model

Traditional view of assets is shown on the left. Most companies treated and managed the three assets they possessed – the financial or structural, the human and the relations – separately by different management groups. The human and relations assets were not really treated as capital assets in a demand driven economy. Development of human capacity was and is often relegated to the human resources development functions. Customer and stakeholder relations, i.e. the relations, were largely driven by marketing and public relations. Since the 1990s, the weight assigned to structural capital has drastically dwindled. Today companies

are assessed not by what they possess, but by what they can deliver competitively with what they are equipped with. With globalisation and competition, migration of talent has become a serious issue. Retention and building organizational knowledge has become a major priority. Hence an integrated approach to managing all three capitals of an organization – the physical and financial assets, human and relations capital has become a necessity. This need for holistic management of the three capitals is at the root of most organizations going for EAI. This integral perspective of capital management is forced by the need to be strongly competitive in a global marketplace where supply of goods and services is in excess and knowledge-worker retention a major concern for every industry.

It may be useful to point out that the present audit mindset of governments in India, coming from the imperial days of the Raj accounts mainly the structural capital. It was a system designed by the empire to help measure what share the ruler could take in the form of some tax. Capacity for knowledge enabled wealth creation and sharing were outside the purview of such audit. It is a tragedy in India that even in the democratic framework of today with concern for development, our government continues inertially to a large extent this audit mindset and only feebly addresses how we promote and empower people through knowledge and skills to create wealth. This attitude of government is what makes governance ineffective and very expensive. A positive audit attitude needs to provide indicators through assessment, accounting the capacity that is built and the capacity to retain the human and relations capital of an organization to generate real (not speculative) wealth. Such audit will help align the management to steer the organization in ways that maximizes wealth creation within the constraints it is forced to work. This is the role of effective knowledge management and convergence of people, process and technology. This potential is realized only when the leadership and management of the organization is driven with objectives in consonance with vision and value propositions. Organizational learning needs to be a part of the culture to sustain this convergence as it is becoming essential for its healthy survival in a competitive and global environment.

"The role of technology should be to bridge the gulf between the availability of information and the ability to use it."

The Pancha Kosha Model of Knowledge Societies

In the context of the three tiers of convergence stated earlier, there is a need for appropriate information organization and knowledge management paradigm. The paradigm should reflect the ways people are engaged in any focused wealth creating activity. It should delineate the boundary between the technology facilitation part of knowledge connectivity and the people driven organizational and processes part that uses the technology to create wealth through knowledge interactions. In this paper we present a Pancha Kosha paradigm to structure knowledge driven organization that allows for human values to command attention over the value propositions that drive future knowledge enabled businesses and activities. This addresses to some extent the difficult issue of how to efficiently combine human values driven social context of interaction and collaboration in a globalised economy with business value-propositions driven organizations of knowledge activities.

The Pancha Kosha Description

According to Indian tradition, every conscious and intelligent being is equipped with Pancha Koshas, i.e., five sheaths or layers. This model is stated in the Taitriya Upanishad (Sri Aurobindo 1981) and interpreted in many Indian texts. These are respectively stated as follows.

(i) Annamaya Kosha, or the physical body that is sustained by food (or Anna). This is the gross or body of the individual.

(ii) Pranamaya Kosha, or the vital energies (i.e. Prana) provided by the harmonious functioning of the different component 'pranas' - breathing, circulation, nervous systems, digestive and inner organs like the liver and the glands that endows the body with life. Without prana, the body is dead and not alive.

(iii) Manomaya Kosha, or capacities like reflex, emotion, and similar functions of the mind and the system that sustains the instincts for self-preservation, perpetuation and related expressions. With Manomaya, the being responds to stimuli – both of the external world and of the instinctive or emotional world .

(iv) Vigyanamaya Kosha, or the discriminative faculty that helps in undertaking action according to what is 'right' and what is 'wrong' in the course of thinking and action. It is said that this aculty is dominant among human beings and weak among animals. It is also said that if humans do not use this faculty with wisdom and compassion, they may be worse than animals!

(v) Anandamaya Kosha, or the sheath of bliss. This corresponds to the state of bliss one attains when one is in total harmony with the internal and external environment even as one is engaged in action as necessitated by our state of living in the world. At this level, the person who works, the object of his work and the process of work itself constitute one holistic entity.

A small clarification is needed at this point in applying this concept of Anandamaya to people, processes and systems. One may say from a systems perspective that a human being exhibits the characteristics of Anandamaya as an emergent state. The main philosophical difference is that in the Indian and eastern traditions, this Anandamaya, or the state of bliss is the natural innate state of the conscious being. But this state gets masked by the conditionings one is born with and induced by the conflicting desires and reactions while living in a material world. It is also stated to be elusive unless one follows righteous actions with the right attitudes as dictated by conscience and discriminative faculty.

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What is important in the above five-layer view of one's existence is the capacity for a holistic understanding of ourselves in all our aspects of life. In the systems thinking perspective the five have to function together harmoniously. This subject of sustainable attitudes – individual and collective – for harmony, happiness, need for a compassionate approach, etc. is vast. Indian tradition – from Vedas to Puranas, Upanishads, Bhagavat Gita, and the different schools of philosophy with many a sage or scholar – have been writing and interpreting this field. It is in no way the author's aim to write any commentary on any aspects of these under the context here. But with the increasing interdependence of modern life, we have little choice but to take cognisance of the intensely individual and spiritual ways of conducting our lives that has a base on which to build a model for practicing in modern times a collective behavioural version of the Pancha Kosha description stated above. To understand the functions and purpose of one layer we have to take cognisance of its relations with the immediate one or two neighbouring layers. The functions of each layer need to be practiced in the appropriate spirit. This is beautifully stated in the following two lines from the Yogavaasishta (Sri Jnanananda Bharati (2002).

Right Information* to the *Right Person or Group* at the *Right Time, Right Place* and in the *Right Context.

Bhaaro vivekina: shastram bhaaro jnanam cha raagina: |
Ashaantasya mano bhaaro bhaaro naatmavibho vapu: ||

In our context, we may broadly translate this as, "For one without discrimination (of what is right action or understanding), the capacity to apply sciences or scriptures is a burden; for one who possesses knowledge but is unwilling to quit old ways and act in the light of one's knowledge, the knowledge itself is a burden; for one who is agitated, the mind is a burden, and for one who does not understand oneself, the body itself is a burden". In essence, the wisdom spelt out above is that mere possession of faculty and capacity, no matter how awesome it may be from a materialistic perspective will not lead us to prosperity and well-being unless we also drive the same with the right values and processes that sustain our collective harmony and prosperity. The challenge is to build systems and institutions that address the complement of the spirit embodied in the above shloka.

Today we speak about Learning Organizations. In the emerging Knowledge society paradigm, what our ancient scriptures speak as quoted above in the light of 'Atmavidya' or self-knowledge at individual level is becoming even more true of organizations (i.e., groups engaged formally in wealth creation activities) themselves. Lou Platt, former CEO of Hewlett Packard once stated that, "HP would be better off if HP knew what HP knew." In some sense this practice of Atmavidya increasingly becoming a necessity in organizations or companies is what constitutes a Learning Organization. It is important to note that in the recent investigation of NASA's Shuttle disaster, the investigating committee stated that, "NASA has not demonstrated the characteristics of a Learning Organization". Hence the above Pancha Kosha model has much to offer and guide the paradigm for structuring and orienting companies and organizations to build in organizational learning as part of their people and processes management. It is a good sign that in the increasingly globalised knowledge economy, those enterprises, which are ethical, accountable and socially responsible, are the ones that are steadily growing.

In some sense, the above is reflected in the state of confusion prevalent in our modern society. With all its possession of information, immense amount of knowledge of the material world, ICT, capacity to carry out Herculean technological feats, etc., we appear to be at a dead-end when it comes to integrating people, processes and technology in ways that build and sustain harmonious, happy and prosperous societies built upon sharing and caring over a democratic and honest business or enterprise framework. The reason for stating the above paradigm is to help us build a practical reference framework that helps our human values and concerns to arrive at right value propositions which in turn drive the 'New Society of Organizations' as Peter Drucker (Drucker P. 1992) describes the emerging knowledge centric era. Such propositions should drive our knowledge activities at different levels – government, business, enterprise, societal or individual – over an integrated global knowledge-managed convergence framework.

As a first step, we develop in this paper a model for knowledge societies that is built over the global network upon an analogous framework to the Pancha Kosha of human existence described above. In arriving at this framework, we assume that we have little choice as human society but to live with the reality of increasing globalisation and all that related to the needs of societies functioning in healthy interdependent ways. Mahatma Gandhi once stated that, "It is every man's right to be independent; but it is every man's duty to be interdependent." What we try to arrive at is a structure that helps in managing such interdependence over a knowledge framework supported through convergence of people and processes over the vast network and knowledge connectivity underneath. It is essential that we all be intensely aware at this point that we are building together a paradigm of living that is at the intersection of technology, management, governance, society, sciences and culture that is driving every corner of collective human activities.

The Five Layers of Knowledge Driven Organizations

ICT and media are fast growing from their infancy and adolescence period to the more mature adulthood era of being driven by knowledge management and knowledge enabled societies over virtual organizations. Ganesh Natarajan, in one of his 'Ganesha' columns in Dataquest articulates on how driving sustainable value propositions in IT is really the need of the hour. He goes to the extent of suggesting that something like a Knowledge Enabled

Operational System (calling it KEOS) is necessary in all IT driven organizations to effectively manage the activities of economic importance. We may then ask where exactly in the hierarchy of information collection, processing, interaction, collaboration or knowledge management are the functions of such KEOS can be imbedded. Such imbedding should be natural in ways that we as individuals function in the kind of organizations and daily life we are likely to confront with. In this context, we present a five-layer view– a material knowledge interaction view analogous to the Pancha Kosha stated earlier – for a society that is engaged in knowledge enabled wealth creation over a convergence framework. It is illustrated in Figure 2. The order of the layers is presented in reverse in conformance with the layers in networks.

In this figure, we have delineated the boundary between the 'Technology' side of IT and the 'Information' side of IT from the following consideration. The lower three layers consider themselves with the collection, processing, presentation and interaction within the information space. The functional considerations and the different logic associated with each of the diverse systems of these layers are no doubt inspired by the need to address the real world problems. Each of them is much like the assumptions, models and approximations that we make to build a branch of science. These assumptions and models in turn are inspired by the need to address a class of problems. The class of such problems addressed becomes a branch or subject in itself. However the structure and behaviour of the upper two layers are more determined by the real world needs of people using the system to solve real world problems. Another way to see it is that while roadways are laid to principles of Civil Engineering and Town Planning and cars and trucks are designed and manufactured in factories, the rules of traffic discipline, fleet management, vehicles and driver registration, traffic governance and policing belong to the real world of people who use it. The upper two layers in Figure 2 more belong to the latter. However, the design of automobiles and trucks is no doubt partly dictated by the associated real world uses, nature of the roads and traffic discipline.

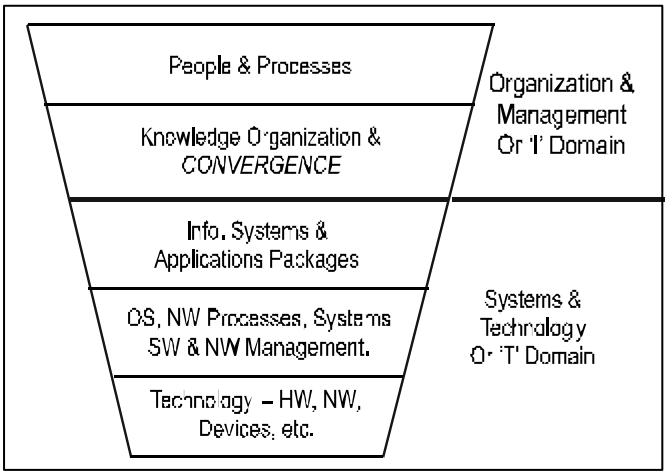

Figure 2 : The Five Layers of Knowledge Managed Organizations

In our presentation, the 'Information' side is taken to be the way people will use and apply it to solve real world problems and needs. It is the discipline behind such information management that is at the substratum of knowledge based wealth creation paradigms. The 'T' or Technology side of IT concerns with building the information infrastructure, the mechanisable parts of the information processing, communication and presentation of information. With the progress of technology, goods and systems on the 'T' side are available like commodities. The 'I' side of IT is about enabling and building capacity of people to use ICT and convergence in diverse ways to sustain knowledge enabled wealth creation in their respective domains, i.e. to serve the associated Knowledge Intensive Products and Services functions.

Pancha Kosha and Three-way Communications in Organization

The Pancha Kosha model has much in common with the conventional management hierarchy. For example in an organization, the lowest corresponds to the physical infrastructure, real estate, transport, the equipments and facilities, etc. The second layer is the administration and offices, personnel management, recruitment, etc. The third layer is the set of facilities and systems that focus on the business and services provided by the organizations. Fourth (the vigyanamaya) is the set of processes and capacity of the management and groups to act with wisdom and discrimination that provide or sustain the value propositions of the business or services offered. The uppermost, i.e., Anandamaya is achieved and expressed in the share-and-care attitude and the feel-good-factor of triad of the people in the organization, the stakeholders and its customers or beneficiaries.

> ***"The role of technology should be to bridge the gulf between the availability of information and the ability to use it."***

Maslow's hierarchy of needs of employees in an organization – consisting of physiological, safety, social-esteem and self-actualisation - also corresponds to the Pancha Kosha description in the organizational behaviour context (Robbins S.P. 2001). However, the real test and taste of a successful organization is the perceptible feeling of Anandamaya, something like the collective 'feel good factor' that pervades it. It may be viewed as an emergent property of correct implementation and practice of KM in the right spirit at all levels. We may also take the stand that the goal of any organization is to attain this Anandamaya in consonance with the purpose for which the organization has been set up. Such Anandamaya is elusive unless the organization, the attitude of serving its customers and the feel-good-factor of its stakeholders are all integrated in every substantive decision and action.

Anurag Srivastava of Wipro Infotech says that the spirit of KM in an organization is something amorphous and pervades like the protoplasm in a living cell. It pervades

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everywhere within the cell, is the medium that nourishes the health and in which the cell's genes grow and multiply. Analogously, the spirit of KM should pervade an organization at various levels and ensure that the behaviour of a living healthy organism is exhibited and felt by all who constitute it. Not to take cognizance of this pervasive aspect of knowledge management is akin to developing real estate indiscriminately without the environment or ecological impact that will forebode a future disaster in globalised world. This requires that effective communications exist both vertically and horizontally in every group driven activity. First is the communications within members of the group that is sensitive and respects the right information at the right time and the right context. The second is the communication across related groups for effectiveness. The third is the communications between the group and its stakeholders in the context of the vision, mission and objectives of the organization. Effective EAI implementation in every enterprise should facilitate this three-way communications. To ensure such communications, we need to understand the information – knowledge interactions in any knowledge enabled wealth creation activity.

Information and Knowledge Interactions Environment

In any job, whenever we work in knowledge driven tasks or activities, we are engaged in either self-study mode, or, in group-study mode wherein we communicate and collaborate with other members of the group. The first happens when we study reports, books, journals, technical documents, etc. The second happens when we work over email, message boards, groupware, etc. Whether the group is formal or informal, it is bound by shared responsibilities among the members of the group. Healthy groups stay focused in delivering the service they are intended to execute.

To extend the KM paradigm from a purely technology driven, or, 'platforms' based intranet approach into a holistic Pancha Kosha paradigm.

Hence we state that in a Knowledge Society, the Knowledge Citizen, or K-Citizen as we shall refer, is the focused group that is attending to the different tasks associated with sustaining the services or values delivered by the group. In developing information systems for enterprises, the author finds that this notion of a K-Citizen is very useful. We as individuals work in different roles within an organization. In the different roles, we contribute by providing our expertise or skill-set to the corresponding K-Citizen as suited to its tasks and objectives. The best help an enterprise information system can provide is to assist us in the context switching involved in moving from one K-Citizen activity to another.

This notion of K-Citizen is useful to understand, groom, equip, and ensure collective accountability of every activity over the K-Estates of a knowledge society. Till date our management, legal and accounting mechanisms have focused too much on individual responsibilities and propriety. Oftentimes how well an individual is equipped to carry out the assigned tasks through his being part of a K-Citizen hardly gets the attention. In a knowledge economy, how well the K-Citizen is equipped to manage and benefit from the 5Rs (see Section 1) is central to the processes of wealth creation. If we are to build the culture of learning organization, it is as important to educate the K-Citizens and empower them as we do to educate individuals. In other words, every organization must impart education in two levels – one at the individual level and one as being part of a K-Citizen. The K-Citizen needs to be educated constantly in its own rules, roles and processes. Education and transfer of tacit knowledge at individual level takes place more often due to oneself being a part of K-Citizen. In fact the context in the education at individual level comes mostly from the kind of K-Citizen association he/she is likely to be engaged in. In the emerging era, h K-Citizen is nurtured and aligned with the organizational objectives even as some of its members may leave and others join, will determine the health of the organization.

The terms K-Estates and K-Citizen need some elucidation. A K-Citizen is a formal or voluntary group of members engaged in organized wealth creation activity. A member of such a group is an individual who is a Knowledge Worker as Peter Drucker often refers to. Wealth creation refers to not only material wealth; it may be any activity that the K-Citizen and its customers find mutually rewarding and of value. For example, it may be a group project of students working for a term-paper in a class, or a troupe teaching best practices in public health in the rural area. It may also be a marketing group or a products design and development group in a company. The longevity of the group is determined both by the nature of the group activity and its health. In a business with significant demand for its goods or services, the quality of knowledge management and culture of learning organization imbibed by the members of the group determines how healthy a K-Citizen the group is. The utility for such a K-Citizen notion is based upon the following characteristics of group driven activities and the need to nurture such groups as single beings.

i) In any knowledge-enabled activity, the knowledge worker is a member of some specific group that is engaged in focused work to deliver a service or achieve results. Such a focused working group may be within an organization, or have members from different organizations.

ii) In a deeper sense, it is focused working groups that generate wealth by applying its collective capacity, core competency and knowledge. Hence it is correct to state that a Knowledge Society or Knowledge Economy is driven by K-Citizens. An individual is a reduced case of a one-member K-Citizen.

iii) An individual as member of a K-Citizen alternates between self-study and group-study supported by the lower three layers of the ICT framework shown in

Figure 2. In the group study mode, he is engaged in different forms of collaboration over synchronous or asynchronous convergence driven framework.

iv) Every K-Citizen must also be a continuous (group) learner. This brings in the broader aspects of nurturing the collective learning, or the capacity of a learning organization to be sustained as part of the work environment.

v) The distinction between the citizen of a Civil Society and the K-Citizen of a Knowledge Society needs to be kept in focus. A civil citizen as Knowledge Worker contributes to several K-Citizens' activities through his/her membership in the groups. But a K-Citizen has several civil citizens as its members and is a focused group that generates and uses collective knowledge to create and sustain wealth generation activities.

vi) The people and processes (the fifth layer in Figure 2) is the way the K-Citizen uses the facilitation provided by the Knowledge Organization layer and benefit from using the convergence supported by knowledge sharing and judgment driven actions using the technology underneath.

vii) In the web-accessed knowledge management world, the interplay between an individual's self-study and his/her group collaboration activities in a given K-Citizen context evolves naturally, each reinforcing the other. The individual himself/herself is able to switch contexts with efficiency from one set of group activities to another set of group activities.

Today companies are assessed not by what they possess, but by what they can deliver competitively with what they are equipped with.

In the context of our learning and doing – taking place over a convergence powered knowledge estate framework – we may say that we alternate between individual, or, self-study and collective, or, group-study. When such self-study or group-study happens, there is a qualitatively new dimension of accountability that gets added with regard to the footprints such activities leave behind over a K-Estate.

To understand the above we illustrate in Figure 3 the two (non-orthogonal) dimensions of self-study and group-study and the kinds of component knowledge interaction spaces in which the objects of the study and interaction are placed. This explanation of the functions shown in Figure 3 (a modification of an old illustration obtained from M/s Aptech's website) is given below.

When we work over our own configured K-Estate, we use a variety of information access, interaction, collaboration procedures and tools. When these are done in a web-enabled work, we use E-Mail, Digital Library, Internet Radio, message boards, groupware etc. In a web-based knowledge estate, what may normally be called as self-study also becomes implicit collaboration. For example, in a company's enterprise portal, when we access a work specific document of interest, we also leave a trace behind as a log of activity. If the portal is smart, it will also add the user name as a tag

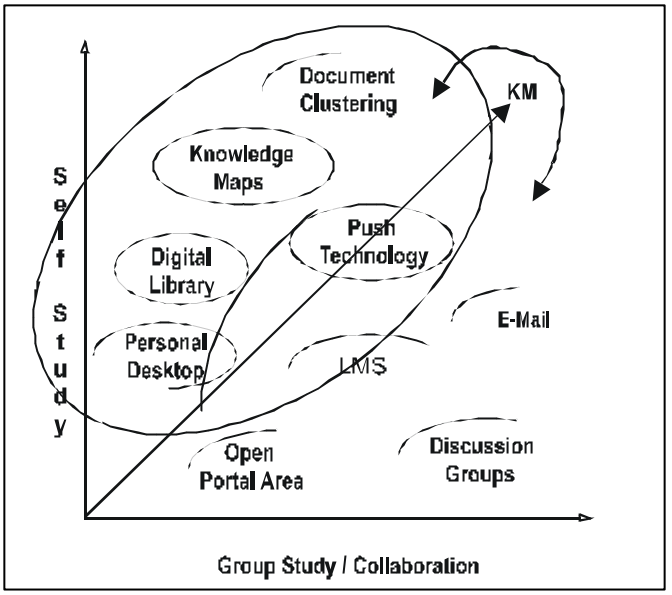

Figure 3 : Personal and Group Interface for Knowledge Interactions

to include the user name as a person interested in the subject. This helps enterprise build an implicit collaboration that enhances capture of tacit knowledge. This happens by informing other interested readers that so and so may be a person who has some knowledge about the subject of the document. The different knowledge interactions components shown in Figure 3 are briefly explained below.

1. *Digital Library:* Refers to the electronic form of library where classification of documents (multimedia included) follows conventional library sciences principles. There is much more flexibility available under an online Digital Library. The view and classification may be generic like a Dublin Core, and also custom made to suit the company's way of looking at archival document clusters. Further, personalised view and e-publications related workflow are useful additions in this kind of library. This subject is still evolving.

2. *Personal Desktop:* A personalised organization consisting of component knowledge interaction functions, links to current active documents and work areas and links to sites of interest to permitted sites. This is a feature that becomes possible because of the web-enabled organization of all documents.

3. *Knowledge Maps:* There are two types of knowledge maps. One is enterprise specific and relates to the ways the business and processes related knowledge is generated and organised. It will include a navigational map for the different of knowledge areas in an enterprise. A second type of knowledge map is more generic or pertains to very large volumes of information as in datawarehouses. It may denote any custom

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classification in a subject area based upon custom classification. For example standards pertaining to a design and development process may be classified into a knowledge map that describes better the relevant organization of knowledge pertinent to the subject, it could be the way plant species are classified in Botany, or a class of molecules in Chemistry. The latter leads us to building custom data warehouses. Such a classification helps will lead us to use imbed efficient search tools and the present developments in Semantic Web.

4. *Document Clustering:* This refers to the way a group, or K-Citizen organizes informally the different kinds of documents relevant for managing and generated by its activities. This is best done under specific groupware area. Here we may cluster project report, group findings, guidelines, progress reports, tasks related documents, customer requirements, etc. Each K-Citizen activity will require its own document cluster and some of its documents will be visible to the entire organization.

5. *E-Mail:* This has been a major collaboration tool and will continue as such. However, from a K-Citizen interaction and the individual's requirements, the present email clients are poor in design and need much improvement. The logic of E-Mail interactions between groups juxtaposed with a K-Citizen's internal knowledge requirements is not well supported. Capacity to organise single view access from multiple mail accounts for the individual is yet to get adequate attention.

This integral perspective of capital management is forced by the need to be strongly competitive in a global marketplace where supply of goods and services is in excess and knowledge-worker retention a major concern for every industry.

6. *Discussion Forums:* Tools such as usenet and message boards have been quite popular. These allow informal socialisation that is important to engage the employees and management to discuss openly issues of common interest.

7. *Open Portal Area:* The public pages of a portal or shared across employees within an organization helps new employees and recruits align themselves quickly to the company's vision and objectives. It also helps build the image of the organization and sell its differential or value proposition to the world at large. It may also have interaction areas that help the outside world interact with the organization.

8. *Push Technology:* This is a reference to the ability of any smart Enterprise Portal to observe identified activities and alert corresponding person(s) or K-Citizen who have to act upon such activities. For example, the administrator of a particular service will be alerted automatically whenever a new employee leaves or an old employee joins who should be added to / deleted from the service with a log of the action taken. Various task assignments, monitoring of exception events, etc. are efficiently built using appropriate alert systems. Alerts may also be coming from external world through call centre activities, SMS messages or customers' requests over a portal interface.

9. *Learning Management System (LMS):* Since continuous education and retraining forms an essential part of any learning organization, LMS should form a natural component of any Enterprise Knowledge Portal. In academic and training establishments, LMS together with the Digital Library form the central components of the EAI.

The different components need their respective metadata structures for their organization. Hence any EAI will have to build upon appropriate mix of metadata databases. It helps to appreciate that every piece of information, knowledge component or interaction belongs to one of the three classes: (a) Knowledge Archival Class; (ii) Utilitarian Class (iii) Events or Transactions class. Archival knowledge classification is more like the conventional library. It may further be classified into generic and application or domain specific (like classification of legal documents under e-Governance) classification. Utilitarian class is like document clustering, where different kinds of documents (e.g., project proposal, task management, reports, relevant subject documents, training plans, etc.) are co-located as part of groupware. Events or transactional information provides logs of events, alerts against relevant new events, etc.

A KM platform (local or virtual) is one that facilitates the functions of the members of a K-Citizen to work seamlessly and efficiently to offer knowledge intensive products and services. In the figure, we have delineated two groups of knowledge interaction objects in two ellipses. This is only to indicate that some of them are more of group study and less of self-study oriented and vice-versa. The 45o line is annotated by KM for Knowledge Management to indicate that the entire Knowledge Interaction Interface is driven underneath by a KM paradigm as practiced in the concerned organization. The dynamics of this paradigm is reflected in the switching between the group study mode of the K-Citizen and the self-study modes of the citizens who drive the component functions of the K-Citizen.

What Figure 3 illustrates is the kind of knowledge interactions that any good Enterprise Application Integration [EAI] should support. Just like the Web browser or windows like GUI used in PCs for a personal computing environment, we may call Figure 3 as the Knowledge Interactions Interface or KII that is important for a Knowledge Interaction Environment over seamless Information-Interaction-Collaboration Spaces of the future. This is precisely the kind of interface that is needed to drive the 'Knowledge Enabled Operating System' stated by Ganesh Natarajan over which the EAI is built. The curved arrow in Figure 3 is shown to illustrate that an activity in self-study mode may lead to

some group study mode and vice versa either explicitly or implicitly.

K-Citizen and the Knowledge Plant Model

There is even more close analogy between the behaviour of an intelligent healthy individual in real world and that of a K-Citizen. In an ideal learning organization, every K-Citizen will be a healthy organism that reacts to stimuli from the external world or be directed by its own initiatives to drive the objectives it has been given or set for itself. Every K-Citizen is set up by the organization's executive to sustain specific focused set of activities or tasks. The management and the K-Citizen's leadership itself sets the objectives and deliverables from time to time. Such a K-Citizen is equipped with its own K-Estate accessed and managed through its EAI area. Over such a K-Estate, the K-Citizen manages its own 5Rs – Right Information at Right Time, Right Place(s), Right Person(s) and in the Right Context – as relevant to the tasks at hand. Managing the 5Rs requires corresponding processes. Our aim here is to study the nature of such processes of a K-Citizen both in the 'T' or technology and in the 'I' information side of IT functioning over its own Knowledge Estate facilitated by the EAI.

Today companies are assessed not by what they possess, but by what they can deliver competitively with what they are equipped with.

In Figure 4 we illustrate a familiar idiom used by teachers in Knowledge Management with some enhancements. The horizontal axis in the figure refers to the increasing level of human understanding – from amorphous data to the human level of wisdom. The vertical axis is variously presented as connectedness, or context intelligence. We have used the term perspective dimensions indicating that with increasing level of abstraction, connectedness and context intelligence, the better will be the quality of judgment and knowledge driven action. Below the line AB is the area where ICT is used to gather data and process the same (including advanced tools such as Artificial Intelligence, Software Agents, etc.). AB represents the boundary at which such processed information is presented to the K-Citizen, or person(s) who benefit from the information. Above the line AB are the areas where it is humans who act upon such information as presented and act upon it for generating value or wealth.

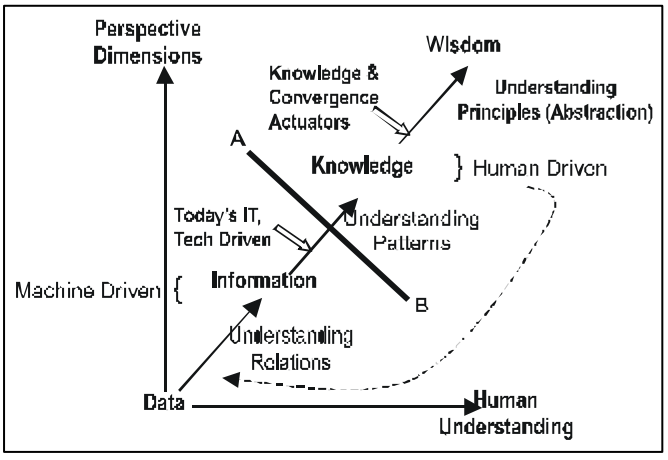

Figure 4 : A View of Information–Knowledge Interactions

Humans use convergence (i.e. pushing new information, using communication, media appliances, network services, interactive content, etc. combined to provide different services) to facilitate knowledge based wealth creation. When humans use convergence driven tools of ICT, more data gets generated and this is put back into the data processing and communications area again. The curved dotted arrow indicates this. Below line AB is where much of today's IT is developed. When it comes to activities above line AB, we are now moving into subjects like EAI and Knowledge Management. However these subjects are not effectively practiced. Without such practice, the value proposition offered by IT is rather limited.

When viewed in the manner as illustrated in Figure 4, and explained as above, we will be in a position to appreciate that every K-Citizen is actually driving its wealth creation activities over a K-Plant in which the constituent members of a K-Citizen are measuring, estimating and taking appropriate actions to achieve the intended objectives. In such a K-Plant, the indicators and actuators used by the K-Citizen are provided by the IT (below AB in Figure 4) and ICT (above AB) respectively by the technology framework underneath. The middle layer of Figure 2 provides the mechanisable parts of such indicators and actuators. Figure 5 illustrates a simplified and abstract view of such a Knowledge Plant.

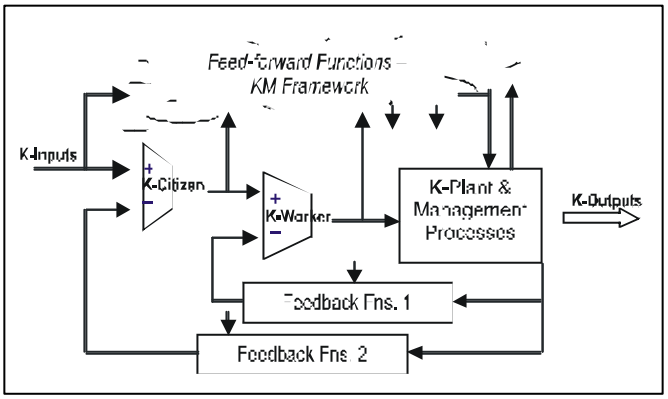

Figure 5 : Knowledge Plant Model

No doubt every K-Citizen as a focused activity group has its manager or leader at its top, middle level managers and the field level of workers. But it is ultimately the coherent group, i.e., the K-Citizen that manages and drives the K-Plant. Hence the model also brings about collective accountability of the members who constitute the K-Citizen of the associated K-Plant. This model aligns well with the observation of Peter Drucker [6] when he says that in the society of organization, every knowledge worker lends his services or expertise to the organization. Such fundamental change in organizational behaviour brings its own ethics and code of conduct, accountability and discipline related issues. Such issues are best addressed from the role of what

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each K-citizen performs and the relation between collective responsibility and individual responsibility.

There are several implicit functions and behaviour that are immanent in the K-Plant model of Figure 5. Firstly, the plant has a corrective feedback part in the lower half. K-inputs like targets to be met, time schedules for the different activities, etc. are given to the K-Citizen. The K-Plant itself is equipped with its own knowledge base, indicators and actuators needed by the K-Citizen to drive the K-plant. It is a multiple corrective feedback loop with their overlapping observables and controllables. The observables at different levels are provided through the feedback functions and indicators used by the K-Citizen over a typical EAI Portal and otherwise. The individuals working within get their own indicators. Their actuators are the various convergence tools available and accessible over the Knowledge Interaction Interface, or, KII as we had illustrated in Figure 3 earlier.

The K-Plant also has the feed-forward functions shown as a cloud in its upper half. We may say that this corresponds to the monitoring and control functions exercised by the senior management or executive of the organization in which the K-Citizen and its K-Plant are a part. As a K-Plant is driven, monitors of its state are constantly furnished to the executive. Normally the executive that sets up the K-Citizen functions does not intervene in its day-today functions. However whenever the K-Plant falters, or the executive wishes to change the state of the K-Citizen – like enhancing its scale of activities, closing its operations, mid-course corrections, or, changing its portfolio, it may intervene using its authority and carry out the desired change.

A positive audit attitude needs to provide indicators through assessment, accounting the capacity that is built and the capacity to retain the human and relations capital of an organization to generate real (not speculative) wealth.

One of the hottest topics in IT today is the Enterprise Applications Integration, or EAI. EAI is becoming a necessity for every organization, enterprise or e-governance. How the K-Plant model of Figure 5 with the KII of Figure 3 allows us to develop effective EAI is briefly described in the next section.

EAI and Development of a Platform for K-Plants

In any organization, EAI attempts to provide an environment for knowledge and business management in an integrated sense. True KM is not merely about setting up shared repositories, groupware or providing group mail and convergence technology support. It is the capacity to set up and efficiently administer a K-Plant for every K-Citizen in an organization. Each K-Plant will have its own KII view of its information over the total knowledge space of an organization. Such organization may extend beyond the boundaries of its workers and include its stakeholders and customers. Since every knowledge worker is a member of more than one K-Citizen, the associated KII of the K-Plant should help the knowledge worker to switch efficiently across the different contexts associated with the respective K-Citizens in which he has membership.

Current approach for implementing EAI in industry is to make custom EAI portals for each organization. Typically these are built over a J2EE platform with an object database underneath. However without building the KII driven dynamics of K-Plants organization, each such portal stands alone and difficult later to link to other K-Plants' domains. Till date these EAI are used only within Intranets and hence such a need to build K-Estates by cross-linking shared knowledge domains in different organizations are given minimal attention. However the demand for such linked K-Estates is already there. For example these are very much in need in areas like Education and E-governance where knowledge activities transcend boundaries of component organizations. In such cases the custom EAI portal approach is expensive and later gets stuck due to rigidity. Hence there is a strong need to build a commodity like enterprise applications software where we can address the Knowledge Organization and Convergence functions that help implement the 4th layer of Figure 2 for any organization.

IIITM-K, through its technology and business incubation program nurtured the development of a new class of Education Servers with practically full KM capabilities. The group that worked under the program later launched itself successfully into the company Transversal E Networks (P) Ltd. (TeN, see www.transversalnet.com). The Education Servers were based upon concepts that were originally developed at the author's ERNET facilities at IIT Kanpur. In early 2002 these servers were installed in leading institutions like IIT Madras, IISc Bangalore, and M/s US Software in Technopark. Trial versions were given to M/s Tata Infotech, ER&DC (now Centre for the Development of Advanced Computing, or, CDAC Trivandrum) and some others for study, testing and comments. Later these led to advanced versions and variants of the Education Servers to cover KM applications, Digital Libraries and Data Aggregation and Dissemination Portals.

In the next section, we briefly review three leading implementations among over 25 such installations, each different, of the KM servers where they support the K-Plant based activities for diverse groups within the member organisation(s). Each of them is managed in different ways over a mix of networked servers. It is shown that such K-Plant managed behaviour amounts to creating and sustaining virtual enterprises.

Early Attempts at Implementations of EAI

In all three cases cited here, the methodology adopted was based upon identifying the functional groups that gain from having its associated IT facilitated K-Plant equipped with relevant indicators and actuators. The KII for the different functional groups was configured using the TeN platforms over a suitable middleware. IIITM-K having incubated the TeN platforms has also built good command and capacity

in the area of web-based information and interaction systems developments. The examples are given here as case studies to show how the concept of K-Plants may be implemented and managed in different ways over either a central server or to support an expert group with members from different organizations facilitated by a network of enterprise servers.

The first case is an Intranet based EAI for a large R&D and projects management organization. The second is from the higher education sector where groups of teachers in a particular subject and working in different colleges may form a virtual enterprise through a course knowledge and collaboration space spread over multiple EAI servers. The third case is one of supporting multiple virtual enterprises using both EAI servers and ICT tools likes television broadcasting, mobile messaging, etc. Here the challenge is to provide K-Plants driven by experts and program managers that reach out to those who will gain by its functions.

Allows for human values to command attention over the value propositions that drive future knowledge enabled businesses and activities.

Case Study 1: Aeronautical Development Agency (ADA)

ADA serves as a major project coordination and R&D centre of the Defense Research and Development Organization (DRDO) of the Govt. of India. They are a premier R&D body engaged in the design and development of the Light Combat Aircraft (LCA) and many cutting edge Aerospace related software, hardware, materials, manufacturing and systems developments. They have a few hundred eminent scientists and engineers with some of the best R&D facilities and CAD/CAM environment of the country. They also fund R&D in dozens of other R&D organizations, industry, premier institutions such as the IITs that carry out complex systems design, modeling, simulation and analysis. In 2002 ADA decided to establish their EAI for providing an integrated KM environment for their different projects and development groups. It was based on a single central server with Apache and Tomcat running over a Linux environment. The EAI platform was built over the Trans-E server package. It was customised over a period of several months with its standard Groupware, Digital Library, etc. It provided the kind of KII depicted in Figure 3, served through a personal browser based desktop for every user.

ADA had built over time a rich collection of enterprise utilities in the form of different in-house developed MIS components that served the needs of its employees to interact and access most of the administration and other services. Practically all of them were integrated into the EAI Portal for viewing over a standard web-browser from any client system on the LAN. The platform supports terminal mobility to the user within the Intranet for the KII functions. Today all ADA employees access the diverse services through the EAI Portal. Several key groups are using the groupware for knowledge sharing and interactions. While the KM part is supported by the groupware, the KII was made available seamlessly across the organization with personalised components. Such total integration was achieved by a joint team of ADA systems engineers, engineers of TeN and IIITM-K with no outside inputs.

This early implementation of the EAI for one of the country's largest R&D and projects agency validated the open architecture called the Info-Space Operating System (iSOS) developed at IIITM-K and TeN. The iSOS based Trans-E server systems are now well proven in ADA and several other places as a convenient and quick way to implement and launch advanced EAI in complex organizations at near commodity level prices. The experience demonstrated that users quickly adapt to the new EAI services. It provides the kind of integrated KII based environment described in section 4 without recourse to configuring or customisation of commercial enterprise packages most of which support only one or two component KII functions, inflexible and expensive to maintain. Another significant advantage of the iSOS based implementation is that the different component services are maintained and serviced by the respective domain-specific administrators over the web. The system administrators need only to maintain the underneath systems, network and hardware. This decoupling of services from systems and hardware is very essential in maintaining complex information and computational systems. In this case study, the members of the different K-Citizen group are under one coherently managed organization.

Case Study 2: Kerala Education Grid (KEG)– Example of Virtual Enterprise

KEG (see www.edugrid.ac.in) is the first project of its kind in India in the Higher Education sector. The focus of the project is to support quality education through Technology Enhanced Learning and Teaching (TELT). The aim is to support learning-centric education with the vision, "Quality Education to all independent of geography". There are several major problems in the colleges with regard to providing quality education. First is the lack of experienced and knowledgeable teachers. Second is the near absence of IT facilitated tools and services in the learning aspects of education. Even most of the IITs have not adopted TELT as a way of life. Thirdly an examination & marks oriented culture that stifles even bright students from striving for true scholarship. Fourthly, lack of resources and inefficient use of resources like labs and libraries where they exist. There are several more problems not listed here. In the KEG project, an approach is being taken to promote use of TELT in each subject area. The best way to tackle this problem is to provide a web-enabled environment in each course where the teachers of a subject in the different colleges form a group, or, K-Citizen and function as a community of practitioners. The way this problem is addressed in the KEG has two important components as stated below.

(i) Establish and manage a Course Knowledge and Collaboration Space (refer to Figure 6 for CKCS) in each

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subject that is linked suitably in the education servers of every member institution. Over this space, the community of practitioners involving the teachers of the subject from the different colleges and the KEG supported subject experts share and collaborate for creating, exchanging content, teacher training and support asynchronous interaction over group specific message boards and email. KEG itself has central portal that facilitates and coordinates such collaborations.

(ii) The CKCS environment needs one EAI like education server with associated backend systems for different kind of services in each member-college that allows us to manage a distributed K-Plant for each subject area that is managed by group of teachers (the K-Citizen here) across the different institutions.

The K-Plant associated with each subject needs to be managed over the CKCS that runs across multiple Education Servers located in the different colleges and institutions. Different functions of the K-Plant may be managed by different persons located in the different institutions. For each subject area, there is one central EAI server that supports the CKCS coordination. Users may access its services from their respective local servers. It is an area where we are gaining experience. The details of what the Education

Integrating people, processes and technology in ways that build and sustain harmonious, happy and prosperous societies built upon sharing and caring over a democratic and honest business or enterprise framework.

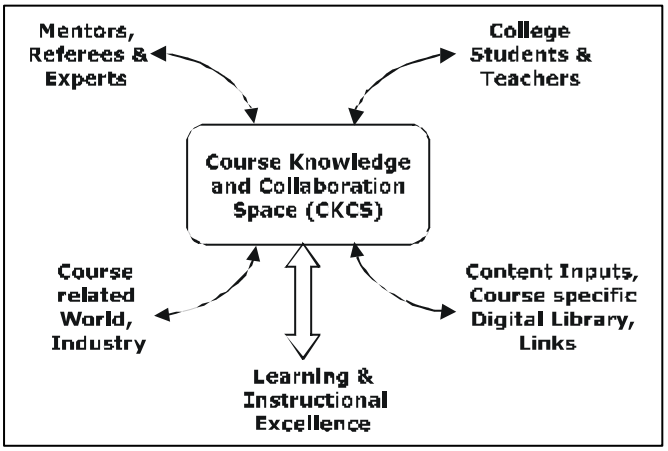

Figure 6 : CKCS in Education Grid

Grid is about are given in (Srivathsan K.R. 2003). The iSOS platform based EAI like education servers from TeN allows us to establish such extranet based virtual enterprise solutions.

Education Grid poses several challenges and vast opportunities for the Education sector and the Knowledge industry in general that are barely addressed today. When properly driven with vision, the Education Grid is will result in making institutions and universities to Knowledge Resources Centres that will enable all learners to access over the net computational and knowledge resources of immense value. This will make academic institutions into knowledge services providers, blurring the divide between academics and industry. The reader is referred to (Srivathsan K.R. 2004) where the concept of virtual learning campuses is developed as an extension of the Education Grid. A national thrust in this area has the capacity to launch India as the leader in the emerging knowledge driven world and economy of the future.

Case Study 3: KISSAN–Example of Virtual Enterprise with unknown Members

The Karshaka Information Systems, Services and Networking (KISSAN-Kerala) project was launched a few months ago to address the empowerment of farmers and farm related government and business activities using IT.

Unlike the Education Grid, in the KISSAN case the K-Citizen members for any focused activity come from heterogeneous organizations or individual farmers located anywhere in the state. For example, the members of the K-Citizen that address best practices, supply and trade related issues in, say the banana crop in Kerala, may come from (i) the Kerala Agricultural university, (ii) the Farm Information Bureau, (iii) the Agricultural Extension Field Officials, (iv) the Directorate of Agriculture of the Government, (iv) Banana related traders' association, (v) Agriculture Products Export Development Authority, (vi) related supply chain organisations for Banana cultivation who provide inputs such as controllers, tissue culture plants, nutrients, etc., (vii) information providers such as market prices, weather, the banana related interaction portal management, (viii) invovled NGOs like the Krishi Vigyan Kendras, etc.

The variety of activities such members of the K-Citizen should address is illustrated in Figure 7. The K-Citizen identity and its virtual EAI support are provided by the KISSAN Project management centre. A major issue is how to address those members of the K-Citizen such as the

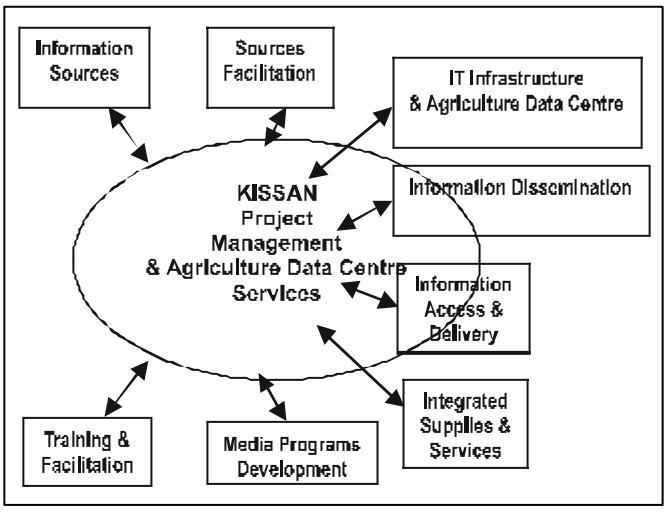

Figure 7 : Component Activities in Kissan

banana farmers whose identity is not always known. Here, we have used some ICT tools effectively to reach out and equip them with the 5Rs. We propose to achieve this using the following combination of component solutions.

(i) Besides the central portal EAI portal for the KISSAN project, the project plans to install several satellite EAI portals in the concerned agencies. All of them are linked over the Internet or a VPN as needed. Adequate localization of the EAI portal has been achieved for interactions in Malayalam.

(ii) Conduct regular telecasts and mass media programs to alert the unknown members of the K-Citizen on the programs and services that are offered. In the telecast, the farmers may be guided as to how to interact with the concerned experts and support group.

(iii) Multiple ways of querying and interacting with the different experts groups are being supported. A farmer or interested person may request for attention through call centre, or through the central Agri-Portal (see http://www.kissankerala.net/), or even by SMS from a mobile phone. For example in the SMS mode, the message with a published (and informed over a television program) prefix code and received by the central server is automatically routed to the concerned members of the expert group and the nearest field person or extension official. The nearest field person visits or calls the farmer and initiates necessary action that addresses his concern. The field person may interact with appropriate ICT tools to interact with the remote experts to provide the best solution to the farmers.

The KISSAN project aims to support arbitrary number of strategy focused expert groups who help drive the numerous and different kinds agricultural activities. It is possible to adopt the KISSAN approach in many areas of e-governance such as community health, disaster management, etc. The description of the KISSAN project here is kept brief and only to the point that the concept of K-Plant and K-Citizen membership may be extended beyond today's practice over a centralized intranet. A separate detailed paper is under preparation on the extranet and ICT based virtual enterprise solution developed under the KISSAN project.

What the KISSAN Project illustrates is that in the implementation of EAI supported K-Plant activities, one is not and should not be restricted by Portals only. We expand the scope of the EAI immensely by optimally combining mass media, consumer devices and services like the mobile phones, smart Call Centre concepts, etc. However the paradigm and model of K-Plant is the central concern that needs to be driven in productive and accountable ways.

Conclusion

In this paper we have brought out that the concepts of Knowledge Management are best extended and practiced along the line of a Pancha Kosha model as applied to focused groups whom we call as K-Citizen. Such K-Citizen groups consisting of Knowledge Workers are the ones that sustain the knowledge based wealth creation processes. Each K-Citizen has members who are close knit and work in a share-and-care environment supported by a group collaboration space over an EAI Portal that acts like the fulcrum of the K-Plant environment. Such group space should be equipped with the IT and ICT facilitated appropriate indicators and actuators over a knowledge organization and convergence framework. The members of the K-Citizen access and manage their concerned K-Plant by a Knowledge Interaction Interface over the EAI system.

In the last part of the paper three sample cases where such K-Plants have been set up in different ways and managed in three kinds of enterprises. The first is a centralised large R&D and follows conventional EAI implementation. The second is the example of the Kerala Education Grid where teachers of each subject specific course across homogeneous organisations form K-Citizen like groups as a virtual enterprise over distributed EAI like Education Servers. The third is the case of KISSAN project where we show how multiple complex virtual enterprises whose roles and objectives are managed by respective strategy-focused groups are sustained over a set of heterogeneous organizations and possible unknown members in the community at large.

The models and concepts proposed in this paper are helpful in taking the field of Knowledge Management towards understanding and managing knowledge enabled wealth creation paradigms in any human endeavour. It is about time that we study the organization, study and management of the 'I' in 'IT' along the above lines and make IT useful and productive for the welfare in the context of the increasingly globalised economy. The approach shown here has the potential to address the capacity building and as effective management base for the emerging knowledge driven economy. The concepts and the framework presented here will be of some help in building a Knowledge Society Vision for the country as a whole.

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Services team of IIITM-K exhibited remarkable ability to assimilate and build systems and services under the author's mentoring guidance. Their successful assimilation again helped the author to develop new directions in the development of concepts in Knowledge Management and understand some of the dynamics in knowledge enabled wealth creation. The author wishes to acknowledge their contributions that helped build the thinking presented in this paper.

References

Kalam A.P.J.A. and Rajan Y.S. (2002) *India 2020: A Vision for the New Millennium*, Penguin Books.

Kalam A.P.J.A. and Pillai A.S. (2004) *Envisioning an Empowered Nation: Technology for Societal Transformation*, Tata McGraw Hill– 2004.

Reader is also referred to the site: http://www. presidentofindia.nic.in/

Senge P. (1994) *Fifth Discipline*, Doubleday.

Tiwana A.(2000) *Knowledge Management Toolkit*, Prentice Hall, 2000

Natarajan G. (2001) *Knowledge Management: Enabling Business Growth*, McGraw Hill.

Dataquest Magazine, Oct. 2003 Issue with special coverage on EAI.

The figure was taken from Dr. Anurag Srivastava's presentation. The reader is also referred to http://www.skandia.com/

Sri Aurobindo (1981) *The Upanishads–Texts, Translation and Commentaries*, Sri Aurobindo Ashram, Pondicherry.

Sri Jnanananda Bharati (2002) *The Essence of Yogavaasishtha*, Samata Books, 1998.

A recent commentary from a KM perspective by Prof. P.N. Murthy on Yogavaasishtha published by Bhavans Books (2002) is recommended.

Drucker P. (1992) *The New Society of Organizations*, Harvard Business Review.

Robbins S.P. (2001) *Organizational Behaviour*, 9th Edition, See Ch. 6, Prentice Hall.

Srivathsan K.R. (2003) Management of Refereed Content Generation and Utilisation in Formal Higher Education, *Global Journal of Flexible Systems Management*, 4(1&2), January – June.

Srivathsan K.R. (2004) Future ICT Infrastructure for Education, Jan., paper available for circulation.

Book Review

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2004, Vol. 5, No. 1, pp 27-28

Innovation by Design

by

Gerard H. Gaynor

The author has stressed the importance of innovation in today's world. According to the author the four inputs to innovation are Resources, Processes, Infrastructure and Culture. The author has defined innovation as 'invention plus implementation/commercialization'. The innovation begins with a raw idea which is developed into a concept which yield some type of invention and which is finely implemented and commercialized.

The author has emphasized the importance of innovation in words of Peter F. Drucker, “Every organizationnot just businessneeds one core competence innovation”. According to the author an innovative organization is governed by four major considerations, viz. understanding innovators characteristics and working relationship, developing an environment that fosters innovation, integrating organizational activities, function and disciplines, and managing from system's perspective. The author has also warned about the pitfall/myth of innovation. As per author's main reason some companies such as HP and IBM are called innovative are because, over the period of time they have encouraged and developed the culture that foster innovation.

The author has discussed various historical theoretical form of innovation and explained them by way of innovation matrix. The innovation in author's words is upsetting the status quo. Innovation is discussed in different kind of organization such as established organization, in start-up organization and a discussion is done on independent innovators as well. Innovation could be bottom up or top-down with each having its pros and cons. The author very rightly said that innovation starts with an individual, as any idea is generated by an individual, but require a team to convert idea to final form in terms of a product or service.

Author further points out that top-down innovation has an advantage in terms of resource fulfillment and it has blessings of the top management, while in bottom-up innovation, it requires a lot of convincing to get resource/ funds allocated. The process of innovation need to keep in account the organization resources, sources of innovation, type of innovation, organization infrastructure etc. along with other parameters. Further, the author talked about the model of innovation provided in literature. The model discussed were Roberts and Frohman Model, James Bryan Quinn's approach, Van de Ven study and Cooper's Stage Gate system.

The author has emphasized on developing metrics for measuring performance, because measurement of success is important part of successful innovation equation.

The author suggested four stages for innovation process, viz. ideaconceptinvention (ICI), pre-project, project and launch along with the time line for four stages. According to the author the innovation system process model importance is more in ICI and pre-project stages as project and launch stage primarily require project management skills. The pre project stage must cover technology marketing, sales, distribution and customer service. Successful innovation according to author require merger of triad of - resources, infrastructure and information that governs innovation process. Author has also suggested some parameters for measuring success for implementing an innovation.

The author has discussed organization culture in detail and presented the results of three researchers, namely, James P. Kotter and James L. Heskett, Judith M. Bardrwick, and D.R. Dension. The author has further stated that culture could be changed and has well supported by an example of IBM Rochester. The author has given few cultural and historical examples of companies such as IBM, 3M and Xerox. The author has raised a very important point and correctly warned that comfort zone can undermine performance and finish the innovation capacity, this is explained by the author with the example to provide more clarity to this important point.

The author has identified three major areas to become innovative or improve on level of innovation. The three areas identified are People, Management and Attitude. These three makes a culture triad. Everyone feels and agrees that Human Resource is most important asset for any company, but saying alone doesn't help much, it has to be reflected in actions also. The author has suggested the means and approach to actually turn it into action. Also the culture of the organization is determined by the management practices the organizations follow. The author has illustrated few such practices which could be helpful in creating innovative culture in the organizations. The author has rightly pointed that the importance of the attitude, as one's attitude with which an activity is approached makes a marked difference in the outcome. The author has discussed some of the essential attitude for fostering innovative culture and has rightly said that building innovative culture begins with

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management at all levels but building a culture that fosters innovation is both complex and simple.

The author also looks closely on resources which are important for innovation and outlined few resources such as, Intellectual Property, Technology, Marketing and Sales, Time, Customer, Supplies, Finance etc. which help in fostering innovation.

Once the organization has the resources, it need proper infrastructure to let innovation occur. The author has discussed in detail the twelve issues identified for organizational infrastructure, viz. purposes, organizational vision, objectives, strategic planning, organization structure, management attributes, uncertainty and risks, support for innovation, role of policies, procedures and practices, essential partnership, leadership and commercialization.

The author has tried to answer the question such as who could be an innovator and what different characteristic does such people have? According to the author, an innovator needs skills, characteristics and attitude with knowledge. The author has further described what skills, what characteristics, attitude and knowledge. The author has given a tool in form of an innovation survey that could be carried out within the organization to see if there exists any opportunities for innovation in organization.

The author has also brought to notice that there would always be people who would prevent innovation to happen. The author has given an interesting term to such people collectively “Virtual Innovation Prevention Department” and also given various roles of this department. This department put hurdles and obstacles for innovators which the innovator has to overcome. The organizations which work towards minimizing the impact of these negative factors can have culture that encourages innovation. The author has provided with quite exhaustive 'Innovation Audit'. It is a tool with which manager/organization can find if the organization has the required resources, culture, infrastructure and processes to be innovating organization or to improve on present state of innovation. This audit, according to author, provide a means to identify problems and corrections needed to rectify those problems. The innovation audit questions are on organizational resources, infrastructure, culture, leadership, management, tolerance for failure, Power and Policies, level of business, innovation initiative and risk, quality of work life etc.

According to the author for making innovation to happen, first thing to be asked is, is innovation is on the organization priority list? The process to make innovation is same for all organization. (Four inputs to innovation are culture, infrastructure, process and resources and integration of all four is key to successful innovation.) The first step in the process is the beginning the process itself, then understand the limitations of the organization followed by innovation audit, feasibility analysis, innovation actions which include organizing critical mass, identifying key players, supporting a proactive attitude, communicating the vision and the plan, developing sense of ownership, understanding employer attitude, assessing performance, defining roles, educating about the business, encouraging thinking outside the box. Last and the very important process is designing a transition model and then finally measuring the innovation success on various parameters illustrated by the author. The author has finally suggested `NOT TO DO' list for fostering innovation.

The book is relevant, keeping in mind the present environment, the organization functions. The innovation could provide the organization with a competitive edge over others. It's a good reading and learning providing insights to designing, managing and enhancing the innovation in the organizations.

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A Unified Framework for Manufacturing and Supply Chain Flexibility

Dr. S. Wadhwa
Professor, IIT, Delhi.

K. S. Rao
Research Scholar, IIT, Delhi.

Abstract

This paper proposes a unified conceptual framework for understanding flexibility in manufacturing systems as well as supply chains. The framework is based on identifying the key elements and basic constructs for analysing their interrelations for possible flexibility types. With the help of this framework, several flexibility types possible in manufacturing systems and supply chains could be identified and related with the flexibility types commonly found in the literature. This framework is found to be useful as it could encompass many of the known flexibility types. It also helps in identifying some flexibility types that were not hitherto discussed in the literature. It is envisaged that developing a unified framework for understanding the supply chain flexibility and manufacturing system flexibility has significant benefits for industry. Our aim in suggesting one such framework is to motivate similar efforts for wider benefits.

Keywords : flexibility, conceptual framework, manufacturing and supply chain flexibility

Introduction

Conceptual frameworks have been an important part of the flexibility research throughout. Literature indicates several efforts in this direction (for example, Gerwin 1993, De-Groote 1994, Nilsson and Nordahl 1995, Correa and Slack 1996, Tincknell and Radcliffe 1996, Koste and Malhotra 1999a, Browne et al 1984, Wadhwa and Browne 1990, Sushil 2000, Wadhwa and Rao 2000 etc.). Several authors made a rich contribution to this domain and highlighted the need for further enrichment of this domain, especially the conceptual framework that may be more universal in nature and help in understanding flexibility in a more intuitive manner. For example Benjaafar and Ramakrishna (1996) observes that *current literature on manufacturing flexibility, while offering several competing definitions, classifications and speculative conjectures, has been unsuccessful in providing a unified framework for understanding and evaluating the importance of flexibility to a manufacturing system*. Several other researchers also indicated usefulness of research in this direction (e.g. Koste and Malhotra 1999b).

Keeping the above in view, the paper proposes a more generic conceptual framework that could help in understanding flexibility both in manufacturing systems as well as supply chains. The objectives of the proposed conceptual framework are; (a) To capture and convey the idea of flexibility in manufacturing systems and supply chains in a more generic manner. (b) To propose a common conceptual framework for flexibility in manufacturing systems and supply chains. (c) To identify various possible types of flexibility in manufacturing systems and supply chains. (d) To relate the proposed flexibility types with the flexibility types commonly found in the literature. (e) To indicate some useful directions for further research.

The proposed conceptual framework is presented in various parts. The first part presents a possible generic view of flexibility where flexibility is simply perceived as something that provides multiple alternatives at decision points. The later parts attempt to interpret this generic view in the context of manufacturing systems and supply chains to understand various possible types of flexibility. Towards this, the second part attempts to identify the key elements and the basic constructs that could form part of the proposed conceptual framework. Next we present the conceptual framework and identify various possible types of flexibility in manufacturing systems and supply chains. It is then attempted to relate the proposed types of flexibility with the flexibility types commonly found in the literature. Finally we propose the need for unified frameworks towards more effective knowledge management for flexible systems.

Part-1 : A Generic View of Flexibility

The conceptual framework is based on the propositions motivated by works of Wadhwa and Browne (1989) where flexibility is viewed as the control on flow of various entities in a flexible system. We propose (a) The functioning of a system (manufacturing system or supply chains system) may be viewed in terms of the interactions between five kinds of flows, namely, the *material flow, the resource flow, the information flow, the decision flow and the money flow*. The intersections of the material flows and the resource flows constitute the action points and the intersections of the information flows and the decision flows constitute the decision points. (b) Flexibility may be viewed in this context as something that provides multiple alternatives at the *decision points* in such a way that these alternatives, when exploited with the help of an appropriate decision making system, would lead to enhancement of the performance at the action points. Wadhwa (1988) and

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Wadhwa and Rao (2000) have emphasized the role of decision points in exploiting potential flexibility in a system. Flexibility and decision making system are two inseparable elements of performance enhancement. Together they improve the decision effectiveness at a decision point. The main contribution of flexibility is to provide more and more alternatives, so that the decision-making system can evaluate these alternatives and arrive at more appropriate decisions, leading to an enhanced system performance. Based on the above perspective, a generic view of flexibility has been developed as discussed below.

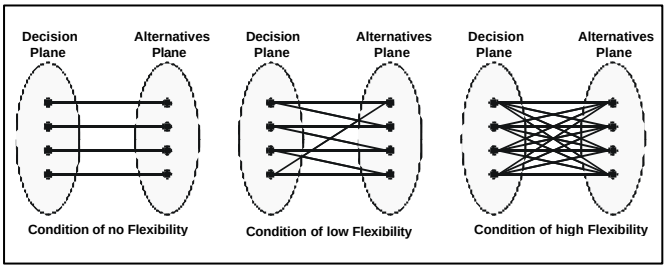

Figure 1: A generic view of Flexibility

In a generic view of flexibility, the idea of flexibility can be viewed in terms of the relation between two sets of elements on two different planes as shown in Figure 1. One of the planes may be called the decision plane and the other may be called the alternatives plane. A decision plane is a plane in time and space containing a set of decision points. A decision point is a point in time and space where the information flow and decision flow intersect. An Alternatives plane is a plane in time and space containing a set of alternatives. Alternatives are a set of choices available at a decision point at a given point of time at which a decision is to be made. The process of decision-making involves evaluation of each alternative in terms of a predefined objective function and selection of the best alternative. Under the condition of no flexibility, every element of the decision plane is related to only one corresponding element on the alternatives plane, whereas under the conditions of flexibility, one or more elements of the decision plane are related to more than one element on the alternatives plane. It is also possible that the same plane may contain both the decision points as well as alternatives as shown in Figure-2.

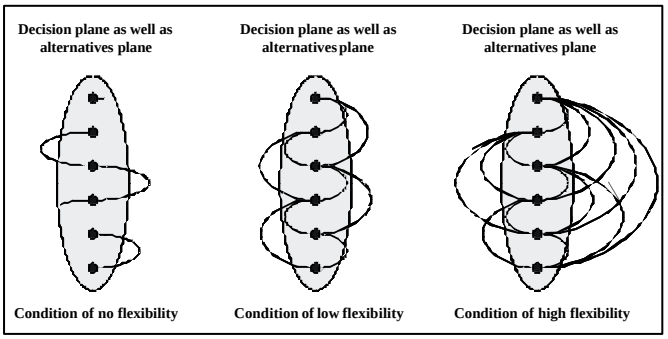

Figure 2: A Generic View of Flexibility in a Single Plane

In order to help researchers and new learners to expand upon various flexibility options, it may be useful to introduce and define few relevant symbols. Let us denote a set of decision points with S_1 and a set of alternatives with S_2, the relation between these two sets may be denoted by a set of relations $R_{S_1}^{S_2}$ such that for every ordered pair (a $\in$ S_1, b $\in$ S_2) if alternative b $\in$ S_2 is available at the decision point (a $\in$ S_1, then (a $\in$ S_1, b $\in$ S_2) $\in$ $R_{s_1}^{s_2}$ other wise (a$\in$$S_1$, b$\in$ S_2). $\notin R_{S_1}^{S_2}$. The set of relations $R_{S_1}^{S_2}$ may also be denoted by a relation matrix $\left[R_{S_1}^{S_2}\right]$ such that the elements of set form the rows and the elements of set forms the columns of the matrix, and for all ordered pairs a $\in$ S_1, b $\in$ S_2, the existence of a relation is represented by "1" and the non-existence of a relation is represented by "0". Thus $R_{S_1}^{S_2}$ represents the set of all the ordered pairs (a $\in$ S_1, b $\in$ S_2) with non-zero entries in the relation matrix $\left[R_{S_1}^{S_2}\right]$. In a similar manner, the set of relations between a given decision point a $\in$ S_1 and the set of alternatives may be denoted by $R_a^{S_2}$ and the corresponding relation matrix may be denoted by . $\left[R_a^{S_2}\right]$ In general, if both S_1 and S_2 are finite sets and are non-empty set, and for every element a $\in$ S_1, there exists an element b $\in$ S_2 such that is related to as a necessary and sufficient condition, and the nature of relation between a $\in$ S_1 and b $\in$ S_2, is such that, either "a DEMANDS/ SUPPLIES b" or "a PRECEEDS/SUCCEEDS b", then: whenever an element a $\in$ S_1, is related to more than one element of a set S_2, the element a $\in$ S_1, is said to be flexible with reference to set S_1. That is $n(R_a^{S_2}) > 1 \Rightarrow F_a^{S_2}$. Similarly for two sets, if all the above conditions are true, then whenever an element a $\in$ S_1 is related to more than one element of a set S_2 , the element a $\in$ S_1 is said to be flexible with reference to set . That is s_2. $n(R_a^{S_2}) > 1 \Rightarrow F_a^{S_2}$. Later we will use some of this knowledge with a set of proposed basic constructs (BC) and Key Elements (KE) from a flexible system context to evolve a unified framework of potential flexibilities.

In our opinion, this way of looking at flexibility has certain advantages. Firstly, from a new learner's perspective, it is very intuitive and can be easily applied to develop ones own framework of potential flexibility types relevant to a given industry. From a generic point of view, flexibility means having more alternatives at a decision point and being able to exploit them through an appropriate decision-making system. Similarly more decision points offer greater opportunity to exploit potential flexibility. Secondly, it will provide some kind of a direction for building and exploiting flexibility in a more effective manner. For example, practitioners will know that to increase flexibility they have to increase alternatives at a decision point with a corresponding increase in the capability of the decision system. The decision system can offer better results only if decision-information synchronization (DIS) is well managed (Wadhwa and Bhagwat (1998)). The latter is important because having multiple alternatives alone will not be able

to enhance the performance. An appropriate DIS system is required to evaluate these alternatives and arrive at more appropriate decisions in a timely manner. This viewpoint is relatively generic as it may apply to flexibility with respect to any entity in a system. In industry there are often only a limited number of critical entities that require greater flexibility focus. For discrete entities, the above framework offers a way to consider deployment and exploitation of entity flow flexibility towards greater enterprise synchronizations leading to improved performance.

Some of the previous researchers have also found a similar approach useful in modelling flexibility. For example Wadhwa and Browne (1990) indicate that flexibility can be properly exploited through decision points where the control rules must be implemented at the operational level. Also, this approach gives rise to new research challenges concerning the understanding of inter-relationship between the flexibility and the decision-making system. Also it is important to evaluate the effectiveness of flexibility in the systems operating under partial level of automation involving the decision-information synchronization (DIS) delays. In the Indian industry context, most of the manufacturing systems have a partial level of computer supported decision automation, leading to unavoidable DIS delays. This is generally the case when a high level of computer supported decision automation and information integration along with their synchronization may not be economically justified. It is therefore considered that a more generic concept in industry may be that of a partial level of DIS system. This is proposed and described by Wadhwa and Bhagwat (1998) as a Semi-Computerized Flexible Manufacturing (SCFM) system. Similarly Wadhwa and Bhagwat (1999) and others studied the effect of decision-information synchronisation (DIS) in flexible systems. Wadhwa and Rao (2003) studied enterprise modelling of supply chains as flexible systems involving multiple entity flows. It is suggested that explicit modelling of the flow of entities such as material, resources, decisions and information in the flexible system is important for both manufacturing and supply chains.

The above generic view needs to be interpreted in the context of manufacturing systems and supply chains to identify and understand flexibility in manufacturing systems and supply chains. The following discussion helps in this direction.

Part-2: A generic view of Manufacturing Systems and Supply Chains

Manufacturing systems and supply chains are a set of interdependent entities that exist to meet the perceived market demand for products. Realization of products and their distribution to meet the market demands is the main purpose of manufacturing systems and supply chains. Products are realized from materials through a series of transformations in their states, brought about by performing certain processes on them, with the help of certain resources, and during this, certain time, cost and effort are consumed. This core idea forms a base for the proposed conceptual framework.

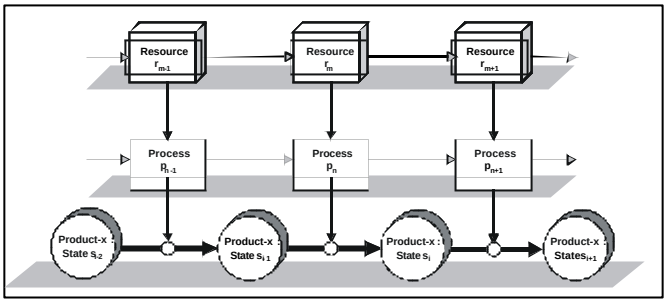

Figure 3 : A Generic View of a Manufacturing System or a Supply Chain

In the context of the generic view presented in Figure 3, the notions of product, transformation, process, resource may be interpreted as follows; A product is anything that can be sold to a market and that might satisfy a want or need. A transformation is something that happens to the product when it undergoes a process. Transformation of materials into products requires a set of partially ordered transformations to be carried out on the materials. This transformation sequence is something that guides the development of process plans or process maps in a manufacturing environment. A process is any operation through which a set of inputs goes through one or more steps resulting in a more valuable set of outputs. A resource is a means to perform a process on a product. Each resource will have certain capabilities to perform these processes. A process requires one or more resources to perform the required operations. The converse also may be true. A resource may be able to perform operations required for one or more processes. It follows from the above that resources with overlapped or identical process capabilities will be able to substitute for each other. Under some circumstances, it is possible to substitute a resource with one or more alternative resources, to perform a given process. This idea is key to understand some resource related flexibility.

Manufacturing systems and supply chains function through the interactions of products, transformations, processes and resources. The interaction between these elements described above can be viewed from multiple perspectives to understand different aspects of the manufacturing systems and supply chains. Three such important views are Resource View, Process View and Transformation View. In resource view, the system is visualized as a set of interconnected resources through which the products flow. Typical examples of resource view are flow shop, batch shop, job shop, flexible manufacturing system and supply chain. In process view, the system is visualized as a set of interconnected processes through which

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the products flow. Typical examples of process view are process plan, project plan and process map. The transformation view is the most fundamental view based on which the process view is developed. In the domain of discrete part manufacturing, this is called methods engineering, where specialized manufacturing engineers study the product designs and develop a transformation view and the corresponding resource view for manufacturing of the products. Thus the same system is viewed by different names and notation in different views. But whatever may be the view; the underlying elements and the structure may remain the same for the manufacturing systems and supply chains. This idea motivated the development of the proposed common conceptual framework of flexibility in manufacturing systems and supply chains, which is presented in this paper.

It is now useful to define few key elements and basic constructs that could help in building the conceptual framework. Key Elements (KE): Product (KE-01), Product-Type (KE-02), Material (KE-03), Material-Type (KE-04), Transformation-Sequence (KE-05), Transformation (KE-06), Transformation-Type (KE-07), Process (KE-08), Process-Type (KE-09), Resource-Type (KE-10), Resource (KE-11). Basic Constructs (BC): A set of given products (BC-01), A set of products of a given product-type (BC-02), A set of given product-types (BC-03), A set of given materials (BC-04), A set of given material-types (BC-05), A set of given transformation-sequences (BC-06), A set of given transformations (BC-07), A set of transformations of a given transformation sequence (BC-08), A set of given transformation-types (BC-09), A set of given processes (BC-10), A set of given process-types (BC-11), A set of given resource-types (BC-12), A set of resources of a given resource-type (BC-13), A set of given resources (BC-14). These can help to define several flexibility types.

The Proposed Conceptual Framework

The proposed conceptual framework emerged as a result of an analysis of various possible inter-relationships between the key elements and the basic constructs identified above. The objective is to provide a more intuitive and simple framework that could be common for both manufacturing systems and supply chains and at the same time provide useful directions to identify various possible flexibility types. The proposed conceptual framework shown in figure-4 includes the following interactions. The most basic elements of the conceptual framework are products and resources, each of which is represented at three levels in the framework. In the case of products, the three levels of representation are: a given product, a set products of a given product type and a set of products. In the case of resources, the three levels of representation are, a given resource, a set of resources of a given resource type and a set of resources. Both manufacturing systems as well as supply chains function by processing the set of products through the set of resources to meet the market demands. However, these two sets are related through number of intermediate constructs namely, product types, material type, transformation sequence, transformation type, process type and resource type. Many of these relationships give rise to flexibility. The purpose of this framework is to highlight these relationships to enable better understanding of flexibility.

Every product is of a particular product type and hence the relationship between the product and the product type has no flexibility. This is indicated through a rigid connection (horizontal bar) in the framework. The product type is related with the material type. Since it is possible that a given product type may be manufactured using more than one type of material, this relationship is shown as a flexible connection (vertical bar). For every combination of product type and material type, there will be a transformation sequence. However, it is possible to have alternative transformation sequences. Hence, this relationship is shown as a flexible relationship. Transformation sequence contains transformation of different types. Each type of transformation is connected with a type of process that is required to be performed to bring about the required transformation. Here again there is a possibility of alternative process types being able to perform the required transformation and hence this relationship is also shown to be flexible.

Process types are related with corresponding resource types that are capable of performing these processes. Since it is possible that more than one type of resources may be

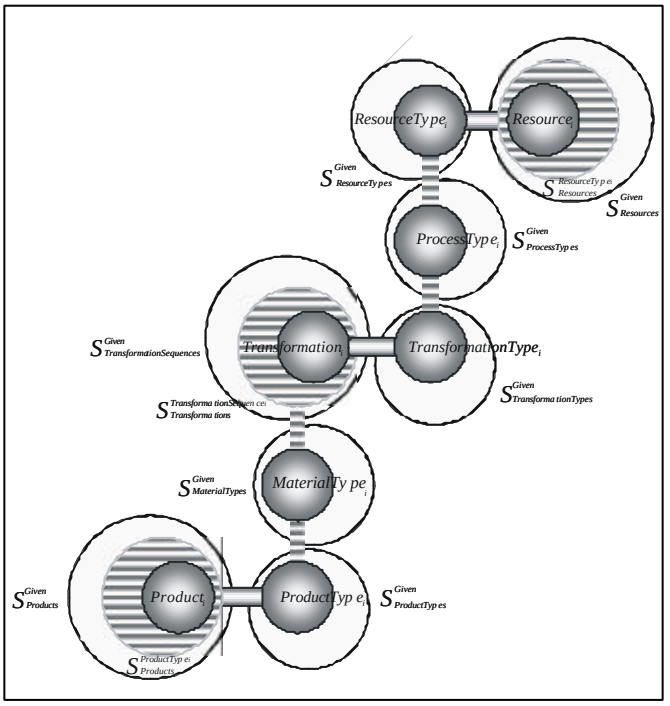

Figure 4 : The Proposed Conceptual Framework

able to perform the same process or there may be resources with overlapped process capabilities, this relationship is also shown to be flexible. Beyond this, the relationship between the resource and the resource type is not flexible. There may be more than one identical resource. To cater for this the framework represents the set of resource of the same type with a separate construct. Thus, the framework pictorially represents the relationships among the key elements and the basic constructs and the flexibility built into these relationships. Based on the above framework several flexibility types could be identified. The framework considers three sources of flexibility; (a) The flexibility originated from relationship between the key elements and basis constructs (b) flexibility originated from the magnitude of the basic constructs themselves and (c) the flexibility originated from the ability to change certain basic constructs. This analysis indicated the possibility of 174 flexibility types in the proposed conceptual framework. However, these are only possibilities. It may be useful to develop relevant guidelines or theorems to guide the actual existence of a flexibility types under a set of given conditions. Similarly, the flexibility types discussed above are not all inclusive. They are only indicative of the usefulness of the proposed framework to understand flexibility in manufacturing systems and supply chains. Among the 174 possible types of flexibility, 147 flexibility types could be identified from the inter-relations between the key elements and basic constructs as summarized in Table-1.

Table-1 : Summary of Falexibility Types based on Inter-relations of KEs & CEs

Flexibility Type		With reference to Basic Construct													
		BC 01	BC 02	BC 03	BC 04	BC 05	BC 06	BC 07	BC 08	BC 09	BC 10	BC 11	BC 12	BC 13	BC 14
Type of Flexibility due to Key Elements	KE-01	S01	S 03	R86		R20	R80		R85	R84		R81	R82		R83
	KE-02	R17		R93		R01	R87		R92	R91		R88	R89		R90
	KE-03														
	KE-04	R94		R15		R95	R03		R99	R98		R30	R96		R97
	KE-06	R100		R101		R13	R102		R106	R105		R28	R103		R104
	KE-06	R107		R108		R109	R110		S07	R111		R27	R112		R113
	KE-07	R114		R115		R116	R34		R32	R119		R05	R117		R118
	KE-08														
	KE-09	R120		R121		R122	R123		R124	R11		R125	R07		R126
	KE-10	R127		R128		R129	R130		R133	R131		R09	R132		R22
	KE-11	R134		R135		R136	R137		R140	R138		R25	R139	S 06	S04
Type of Flexibility due to Basic Constructs	BC-01					**R21**	R36					R37	R38		R39
	BC-02	S02				R19	R40					R41	R42		R43
	BC-03	R18				R02	R44					R45	R46		R47
	BC-04														
	BC-05	R79		**R16**			R04					R31	R48		R49
	BC-06	R78		R77		R14						R29	R50		R51
	BC-07														
	BC-08														
	BC-09	R76		R75		R74	R35		R33			R06	R52		R53
	BC-10														
	BC-11	R73		R72		R71	R70			R12			R08		R54
	BC-12	R69		R68		R67	R66			R65		R10			R23
	BC-13	R64		R63		R62	R61			R60		R24			S05
	BC-14	R59		R58		R57	R56			R55		R26			

Table - 2 summarizes the 6 possible flexibility types originating from the magnitude of the basic constructs and 20 possible flexibility types originating from the ability to change the basic constructs. Under some circumstances, the ability of not having to change certain elements may also be considered as a type of flexibility. An example for this is the "programming flexibility" which refers to the ability of a system for being programmed to work for longer periods of time without any human intervention. This category of flexibility types may be referred to as C21.

Table-2 : Summary of Flexibility Types based on Cs

Flexibility Type		Based on Magnitude (M)	Based on Ability to Change (C)				
			Aggregate Changes			Individual Changes	
			Change in Magnitude (Volume)	Change in Composition (Mix)	Change in Structure (Layout)	Modify Existing	Add New or Remove Existing
Type of Flexibility due to Basic Constructs	BC-01		C01	C05			
	BC-02		C02				
	BC-03	M01				C09	C15
	BC-04						
	BC-05	M02				C10	C16
	BC-06	M03				C11	C17
	BC-07						
	BC-08						
	BC-09	M04				C12	C18
	BC-10						
	BC-11	M05				C13	C19
	BC-12	M06				C14	C20
	BC-13		C03		C07		
	BC-14		C04	C06	C08		

Levels of abstraction and interpretation contexts

The next two dimension of the proposed conceptual framework are the levels of abstraction and interpretation contexts. Each of the key elements and the basic constructs of the conceptual model can be interpreted in multiple ways. For example a resource (KE-11) may mean a CNC machine, an AGV, an ASRS or a human operator. Each of these may be referred to as the interpretation contexts. Now, it is also possible to look at a resource (KE-11) as a machine, a cell, a manufacturing system, an enterprise or a supply chain. Each of these may be referred to as a level of abstraction. Understanding of a particular flexibility type varies depending upon the level of abstraction and the context of interpretation with in that level. This idea is indicated in Table-3

Relating the Proposed Framework with the Flexibility Types Commonly Discussed in Literature

In order to demonstrate the usefulness of the framework, the proposed flexibility types have been related with those commonly found in the literature. For this purpose, four well known frameworks; the flexibility taxonomy of Browne et al (1984), modifications proposed to this framework by Sethi and Sethi (1990), strategic flexibility framework of Gerwin (1993) and the framework of Benjaafar and Ramakrishnan (1996) have been related as given in tables 4 to 7. A unified flexibility view is that various relationships between defined BCs and KEs offer various flexibility types.

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Table-3 : Levels of Abstractions and Interpretation Contexts

Level of Abstracton	Basic Constructs				
	Resource	**Set of Resources**	**Process/ Transfor-mation**	**Product**	**Set of Products**
[illegible]	Machine	Cell or Manufac-turing System	Machining	Part	Buffer
	Automatic Guided Vehicle (AGV)	Flexible Manufacturing System	Transportation	Part	Pallet
	Automatic Storage and Retrieval System (ASRS)	Warehouse	Storage / Retrieval	Part	Pallet
Cell Level (Level-2)	Group Technology Cell	Manufacturing System	Machining	Part Family	Set of parts
Manufacturing System Level (Level-3)	Flexible Manufacturing System	Enterprise	Manufacturing	Product	Loading Station
Enterprise Level (Level-4)	Manufacturing Enterprise	Supply Chain	Production	Product	Orders for products
Supply Chain Level (Level-5)	Supply Chain	Supply Chain System or Supply Web	Supply of products	Product	Orders flowing into the Chain

Table - 4 : Relating with the Flexibility Type as Proposed by Browne et al, (1984)

	Flexibility Type as per the proposed conceptual framework	
Machine Flexibility	Flexibility of a given resource (KE-11) with reference to a set of product-types (BC-03)	R135
Process Flexibility	Flexibility of a set of product-types (BC-03) with reference to a set of material-types (BC-05)	R02
	Flexibility of a set of product-types (BC-03) with reference to a set of transformation sequences (BC-06)	R44
Product Flexibility	The ability to add or remove a given product type (KE-02) into the set of product-types (BC-03)	C15
Routing Flexibility	Flexibility of a set of product types (BC-03) with reference to a set of resources (BC-14)	R47
Volume Flexibility	The ability to change the magnitude (volume) of the set of products (BC-01)	C01
Expansion Flexibility	The ability to change the magnitude (volume) of the set of resources (BC-14)	C04
	The ability to change the composition (mix) of the set of resources (BC-14)	C05
Operation Flexibility	Flexibility of a given transformation (KE-06) with reference to the set of transformations of a transformation sequence (BC-08)	S07
Production Flexibility	The magnitude of the set of product types (BC-03)	M01

Tables 4 to 7 outline the various flexibility types described by some of other researchers. It is possible to map these with the proposed framework. In our opinion, manufacturing enterprises can be seen as internal chains with predefined autonomy where control on flow of entities

Table - 5 : Relating with the Flexibility Type as Proposed by Sethi and Sethi, (1990)

	Flexibility Type as per the proposed conceptual framework	
Material Flexibility	Flexibility of a given resource (KE-11) with reference to a set of product types (BC-03) (the resource is abstracted as the material handling system)	R135
Program Flexibility	The ability of a system for being programmed to work for longer periods of time without any human intervention	C21
Market Flexibility	Flexibility of a set of resources (BC-14) with reference to a set of products (BC-01)	R59

Table - 6 : Relating with the Flexibility Type as Proposed by Gerwin (1993)

	Flexibility Type as per the proposed conceptual framework	
Mix Flexibility	The ability to change the composition (mix) of the set of products (BC-01)	C05
Changeover Flexibility	The ability to add or remove a given product type (KE-02) into the set of product-types (BC-03)	C15
Modification Flexibility	The ability to modify a given product type (KE-02) in the set of product-types (BC-03)	C05
Volume Flexibility	The ability to change the magnitude (volume) of the set of products (BC-01)	C01
Rerouting Flexibility	Flexibility of a set of product types (BC-03) with reference to a set of resources (BC-14)	R47
Material Flexibility	Flexibility of a set of product types (BC-03) with reference to a set of material types (BC-05)	R02
Overall Res-ponsiveness	Flexibility of a set of resources (BC-14) with reference to a set of products (BC-01)	R59

is exercised at various decision points in the flexible system. The framework suggested in the paper is easily extendable to external supply chains where each node represents greater autonomy with respect to decision choices to control the flow of entities. In supply chains the decision points must put greater focus on the flow of decisions, information and money apart from the conventional focus on materials alone. We envisage that future flexible systems (both manufacturing systems and supply chain systems) will evolve towards more dynamic decision points and the entity flows that they control. Further new entity types such as knowledge and innovations will be added, leading to greater focus on knowledge management in flexible systems. Since our proposed framework is based on the concept of entity types and its relationships with other entity types towards greater synchronization, it is envisaged that the concepts can be easily expanded to future enterprises. We suggest that there is a need to develop more unified frameworks such as our humble attempt in order to enrich the understanding of flexibility to the evolving domains for system performance improvement benefits. While research can offer more generic efforts, the industry may use the guidelines towards more domain specific models involving the most critical entities that they need to control more effectively. Our framework may help in innovating and characterising such entities and

Table-7 : Relating with the Flexibility Type as Proposed by Benjaafar and Ramakrishnan, (1996)

	Flexibility Type as per the proposed conceptual framework	
Operation Flexibility	Flexibility of a given process-type (KE-09) with reference to a set of resources (BC-14)	R126
Sequencing Flexibility	Flexibility of a given transformation (KE-06) with reference to the set of transformations of a transformation sequence (BC-08)	S07
Processing Flexibility	Flexibility of a given transformation Type (KE-07) with reference to the set of process types (BC-11)	R05
	Flexibility of a given transformation Type (KE-07) with reference to the set of transformation sequences (BC-06)	R34
Processor Flexibility	Flexibility of a given resource (KE-11) with reference to a set of product-types (BC-03) (The authors used the first level of abstraction, and indicated different Interpretation contexts as machine, material handling equipment, fixture, tooling, and labour)	R135
Mix Flexibility	The ability to change the composition (mix) of the set of products (BC-01)	C05
Volume Flexibility	The ability to change the magnitude (volume) of the set of products (BC-01)	C01
Layout Flexibility	The ability to change the structure (layout) of the set of resources (BC-14)	C08
Component Flexibility	Flexibility of a set of product types (BC-03) with reference to a set of material types (BC-05) (This is the closest notion. Components are also inputs and therefore may be considered as a part of materials)	R02

in identifying the closest known flexibility already defined and studied. In this manner we will be able to re-use, develop, classify, apply, innovate and yet unify our flexibility knowledge for wider benefits. This implies enriching the knowledge management endeavours in future flexible enterprises. While we have just attempted to propose the need for one such unified framework and offered one such initial framework, it is expected that future research may be directed towards more suggestions and evolutions in this direction.

Conclusions

This paper proposed a unified conceptual framework that may enrich our understanding of flexibility, both in manufacturing systems as well as supply chains. With the help of this framework, several flexibility types possible in manufacturing systems and supply chains have been identified. These flexibility types, together with the abstraction levels and interpretation contexts, will be able to map most of the flexibility scenarios in manufacturing systems and supply chains. The proposed flexibility types have also been related with the flexibility types commonly found in the literature. This framework is found to be useful as it could encompass many of the known flexibility types and also helps in identifying some flexibility types that were not hitherto discussed in the literature. There is a need to evolve a unified framework to understand supply chain flexibility as well as the manufacturing system flexibility. This paper is an attempt in this direction and hopes future research will offer and extend this humble attempt for wider benefits.

References

Beach R., Muhlemann A.P. and Price D.H.R. (2000) Manufacturing Operations and Strategic Flexibility: Survey and Cases, *International Journal of Operations & Production Management*, 20(1), 7-30.

Beach R., Muhlemann A.P., Price D.H.R. Paterson A. and Sharp J.A. (2000) A Review of Manufacturing Flexibility, *European Journal of Operational Research*, 122, 41-57.

Bengtsson J. and Olhager (2002) Valuation of Product-mix Flexibility Using Real Options, *International Journal of Production Economics*, 78, 13-28.

Benjaafar S. and Ramakrishnan R. (1996) Modelling, Measurement and Evaluating of Sequencing Flexibility in Manufacturing Systems, *International Journal of Production Research*, 1195-1219.

Braglia M. and Petroni A. (2000) Towards a Taxonomy of Search Patterns of Manufacturing Flexibility in Small and Medium-sized Firms, *The International Journal of Management Science*, 28, 195-213.

Browne J., Dubois D., Rathmill K., Sethi S.P. and Stecke K.E. (1984) Classification of Flexible Manufacturing Systems, *The FMS Magazine*, 114.

Carlsson B. (1989) Flexibility and the Theory of the Firm, *International Journal of Industrial Organization*, 7, 179-203.

Chatterjee J. (2000) Balancing External and Internal Flexibilities – Emerging Strategy Paradigms for Indian Organisation, *Global Journal of Flexible Systems Management*, 1(1), 1-11.

Chen I.J. and Chung C.H. (1995) An Examination of Flexibility Measurements and Performance of Flexible Manufacturing Systems, *International Journal of Production Research*, 34(2), 379-394.

Cheng J.M.J., Simmons J.E.L. and Ritchie J.M. (1997) Manufacturing System Flexibility: the "Capability and Capacity" Approach, *Integrated Manufacturing Systems*, 8(3), 147-158.

Correa H. L. and Slack N. (1996) Framework to Analyse Flexibility and Unplanned Change in Manufacturing Systems, *Computer Integrated Manufacturing Systems*, 9(1), 57-64.

D'Souza D.E. and Williams F.P. (2000) Toward a Taxonomy of Manufacturing Dimensions, *Journal of Operations Management* 18, 577-593.

Das S.K. (1996) The Measurement of Flexibility in Manufacturing Systems, *The International Journal of Flexible Manufacturing Systems*, 8, 67-93.

Das S.K. and Patel P. (2002) An Audit Tool for Determining Flexibility Requirements in a Manufacturing Facility, *Integrated Manufacturing Systems*, 13(4), 264-274.

De Groote X. (1994) The Flexibility of Production Processes: A General Framework, *Management Science*, 40(7), July.

Dyer S. (1990) Flexibility Models: A Critical Analysis, *International Journal of Manpower*, 19(4), 223-233.

Golden W. and Powell P. (2000) Towards a Definition of Flexibility: In Search of the Holy Grail ? *The International Journal of Management Science*, 373-384.

Grubbstrom R.W. and Olhager (1997) Productivity and Flexibility: Fundamental Relations between two Major Properties and Performance Measures of the Production System, *International Journal of Production Economics*, 52, 73-82.

Katok E. (1996) *Planning Manufacturing Flexibility in an Uncertain Production Environment*, Ph.D. Thesis, The Pennsylvania State

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University, The Graduate School, The Mary Jean and Frank P.Smeal College of Business Administration.

Koste L.L. and Malhotra M.K. (1999a) A Theoretical Framework for Analyzing the Dimensions of Manufacturing Flexibility, *Journal of Operations Management*, 18, 75-93.

Koste L.L. and Malhotra M.K. (1999b) A Perspective on Research Opportunities in Manufacturing Flexibility, *Decision Line*, July 1999.

Koste L.L. and Malhotra M.K. (2000) Trade-offs Among the Elements of Flexibility: A Comparison from the Automotive Industry, *The International Journal of Management Science*, 28, 693-710.

Narain R, Yadav R.C., Sarkis J. and Cordeiro J.J. (2000) The Strategic Implications of Flexibility in Manufacturing Systems, *International Journal of Agile Management Systems*, 2(3), 202-213.

Nordahl H. and Nilsson C.H. (1996) Managers' Perceptions of Flexibility in Manufacturing: A Study in the Swedish Engineering Industry, *Integrated Manufacturing Systems*, 7/4, 22-33.

Olhager J. and West M.B. (2002) The House of Flexibility: Using the QFD Approach to Deploy Manufacturing Flexibility, *International Journal of Operations & Production Management*, 22(1), 50-79.

Ozer M. (2002) The Role of Flexibility in Online Business, *Business Horizons*, January-February.

Pagell M. and Krause D.R. (1998) A Multiple-method Study of Environmental Uncertainty and Manufacturing Flexibility, *Journal of Operations Management*, 17, 307-325.

Parker R.P. and Wirth A. (1999) Manufacturing Flexibility: Measures and Relationships, *European Journal of Operational Research*, 118, 429-449.

Schewchuk J.P. and Moodie C.L. (1997) A Framework for Classifying Flexibility Types in Manufacturing, *Computers in Industry*, 33, 261-269.

Shewchuk J.P. and Moodie C.L. (1998) Definition and Classification of Manufacturing Flexibility Types and Measures, *The International Journal of Flexible Manufacturing Systems*, 10, 325-349.

Schneeweiss C. and Schneider H. (1999) Measuring and Designing Flexibility as a Generalized Service Degree, *European Journal of Operational Research* 112, 98-106.

Sethi A.K. and Sethi S.P. (1990) Flexibility in Manufacturing: A Survey, *The International Journal of Flexible Manufacturing Systems*, 2, 289-328.

Storey J. (1997) Radical Change or Business as Usual: Flexibility in Non-union SMEs, *International Journal of Entrepreneurial Behaviour & Research*, 3(4), 157-167.

Sushil (2000) Concept of Systemic Flexibility, *Global Journal of Flexible Systems Management*, 1(1), 77-80.

Sushil (2001a) Enterprise Flexibility, *Global Journal of Flexible Systems Management*, 2(4), 53-58.

Thomke S.H. (1997) The Role of Flexibility in the Development New Product: An Empirical Study, *Research Policy*, 26, 105-119.

Tincknell D.J. and Radcliffe D.F. (1994) A Generic Model of Manufacturing Flexibility based on System Control Hierarchies, *International Journal of Production Research*, 34(1), 19-32.

Tsourveloudis N.C. and Phillis Y.A. (1998) Manufacturing Flexibility Measurement: A Fuzzy Logic Framework, *IEEE Transactions on Robotics and Automation*, 14(4), 513-524.

Vokurka R.J. and O'Leary-Kelly S.W. (2000) *A Review of Empirical Research on Manufacturing Flexibility*, 18, 485-501.

Wadhwa S. and Rao K.S. (2003) Enterprise Modelling of Supply Chains Involving Multiple Entity Flows: Role of Flexibility in Enhancing Lead Time Performance, *SIC Journal*, 5-20, 12(1), March, 2003.

Wadhwa S. and Srinvasa R.K. (2000) Flexibility: An Emerging Meta-competence for Managing High Technology, *International Journal of Technology Management*, 19(7/8), 820-845.

Wadhwa S. and Bhagwat R. (1999) Semi-Computerized Manufacturing Systems Under Alternative Status Monitoring Modes, *Studies in Informatics and Control*, 8(2), June 1999, 87-96.

Wadhwa S. and Bhagwat R. (1998) Decision Delays in Semi-Computerized Flexible Manufacturing (SCFM) Shops, ASI'98, Bremen, Germany, June 14-17.

Wadhwa S. and Browne J. (1989) Modeling FMS with Decision Petri Nets, *International Journal of Flexible Manufacturing Systems*, 1, 253-280.

Wadhwa S. (1988) Development of Generalized Simulators for Design Evaluation of Robot Based Flexible Assembly Systems, *Ph.D. Dissertation*, National University of Ireland.

Short Communication

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E-Value to Stakeholders of Global Institute of Flexible Systems Management

Rajeev Dwivedi
Research Scholar, Department of Management Studies, IIT Delhi

Introduction

E-Value is the mantra of nirvana for enhancing flexibility.

Global Institute of Flexible Systems Management (GIFT) is the global forum of professionals from academia as well industry to promote the paradigm of flexible systems management globally. The institute was formed five years back by the professor of Department of Management Studies, IIT Delhi with some collaboration from industry. Since the birth of GIFT, flexibility in systems and flexibility related issues in management practices are promoted with its vision and mission. Today, GIFT is a major forum across the world, which promotes flexibility in business and management, and all related fields of life of management. The website model of GIFT is shown in Figure 1.

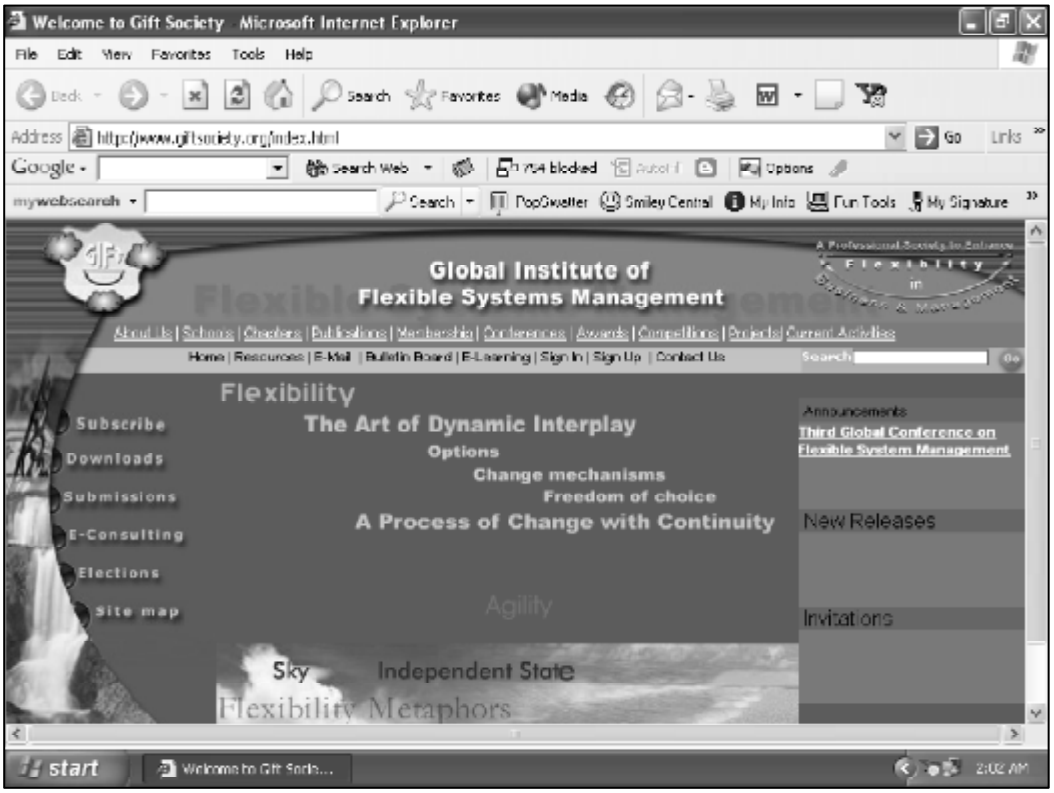

Figure 1: The Home Page of GIFT E-Model

Stakeholders of GIFT

Stakeholders are the asset of an organization

Gift has different kinds of stakeholders for making a rich forum for sharing the concept of flexibility with stakeholders and also learning same practices form them to enhance the concept of flexibility in turbulent, dynamic, uncertain and complex world of competition for businesses and management. GIFT Stakeholders are divided in various categories. They are employees and governing body of GIFT, individual members, student members, corporate members, institution members, publishers, web developer, researchers and contributors, online databases, editorial boards and event based stakeholders. The aim of this short communication is to address value proposition offered by website of GIFT or will offer in near future to stakeholders. The

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E-value is available in-terms of e-products, e-programs and e-services to GIFT stakeholders

e-value for all the stakeholders will be created through e-model that enriches their flexibility approach in a more systematic manner. The e-model will address the dual nature of value of stakeholders, i.e. from GIFT to stakeholders and from stakeholders to GIFT.

E-Value for GIFT Stakeholders

Information technology is enabling every business into e-business for better services and value added services to stakeholders particularly. If the business want to sustain in present environment, have to satisfy all stakeholders by providing value through e-system and also could get the value from stakeholders from same e-system.

This article briefly points out the number of options available to GIFT as well to stakeholders using www.giftsociety.org for creating value. This e-value is mutual as far as GIFT and its stakeholders are concerned.

Employee and Governing Council

Employees and governing council are driving force behind the success of GIFT

Employees and governing council are driving force behind the success of GIFT and if success has to retain with growth in long-term, both have to use e-world. This will be helpful for enhancing e-brand, e-marketing and r-revenue.

E-value to GIFT	E-Value to Employees
• Dedicated and hardworking team • E-leveraged team • E-marketing • E-content • E-Skilled Team	• Growth along with GIFT • E-learning while making e-enabled services to GIFT • Experience • Enhancing contribution • Updated and IT knowledge and trends

Members- Individual and Student

Students and individual members will be key contributors for enhancing e-value by sharing e-resources available with them during study and finding new dimensions of flexibility.

E-model of GIFT provides opportunities to stakeholders for publishing thoughts and research related to flexibility

E-value to GIFT	E-Value to Individual and Student Members
• Latest and updated knowledge from students and members using e-discussion forum • Contribution in research • Contribution in e-resource development on flexibility • E-mail promotion about GIFT among peers and non GIFT members • Huge database on flexibility in different fields and different dimensions of flexibility	• Growth along with GIFT • E-learning on flexibility • E-mail account and e-account for members for accessing services • E-experience • E-relay chat with flexibility experts • E-opportunities for publishing thoughts and research • E-resource available on GIFT website • Enhancing and practicing flexibility • life long journal and newsletter subscription

Corporate Members

The ultimate use of flexibility goes to corporate members because they practice flexibility in real life with real problem. Such members can get e-value in several ways. This includes the members from industry as well as corporations itself.

Institutional Members

Institutional members spread the flexibility concept in young generation of students, who are the future managers and will use the concept of flexibility. The institutions will spread the flexibility knowledge by becoming member of the GIFT.

e-value of GIFT is directly or indirectly related with the stakeholders growth

E-value to GIFT	E-Value to Corporate Members
• Real world problems and solutions • Industry interface • E-training for Corporate • E-consultancy for Client • E-lectures for Learners • E-conferences for community • E-workshop for concepts • Real world flexibility learning • Industry to industry promotion • Research opportunities and consultancy opportunities	• Practicing the flexibility in the real life • E-learning among workers and employees saving various costs • Flexibility experiences with such organization • Appropriate solution of the problem • Joint events with GIFT for various purposes • Cost reduction, time saving • E-marketing through GIFT website

E-business created new channels for value propositions to stakeholders

E-value to GIFT	E-Value to Institution Members
• Dedicated institutions • Young talents from institutions • The institutional contribution in terms of providing more assignments to GIFT • Flexibility events can be jointly organized	• E-courses for students and available in institute • E-Discussions and Quarry • Updated knowledge and trends • Opportunities for joint events • Lecturer series advantage • Best academicians available for guest lectures • E-Marketing through GIFT website and banners

Editorial Board

Editorial board plays an important role for providing valuable feedback and evolution of research papers and articles for publishing the GIFT journal. Generally it takes time. E-account of editors as well as contributors will be easier for doing this work in less time.

E-value to GIFT	E-Value to Editorial Board
• No reminders • Fast reply to contributors • Contributors may submits the papers online with log in	• Free access of the site • Easily available documents • Easy comments and feedback system • Timely review process

GIFT stakeholders must have access to flexibility related information through e-model so that timely and accurate understanding can be developed

Publishers, Online Database and Web Developer

The GIFT as well as the e-publishing or physical publishing stakeholders will get also value in-terms of easy and fast access of content and readymade content available on the website under login section. They may have their different login account to access this facility.

E-value to GIFT	E-Value to Publishers, Online Database and Web Developar
• No extra management of publishing • Publishers satisfaction • E-Sales and revenue sharing	• Readymade content available • E-marketing of the product through GIFT website • Recognition from GIFT and worldwide presence • E-Sales and revenue generating

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The E-Revenue Model for GIFT

GIFT is having revenue model but how to enhance its revenue system using e-opportunity is shown in Figure 2. The main purpose of any organization is depending on revenue and growth centered strategies.

GIFT is thriving in e-world for achieving growth and revenue centered strategy

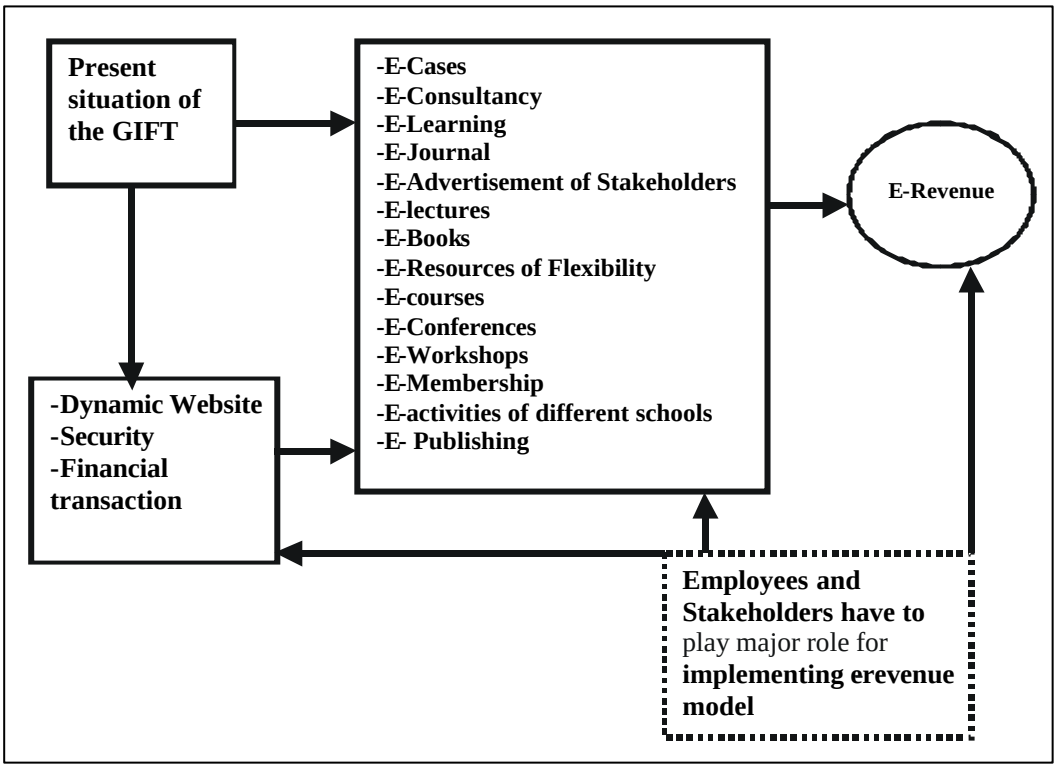

Figure 2 : E-Revenue Model for GIFT

Concluding Remarks

E-Value is the synonymous to agility, flexibility, productivity, scalability, profitability and growth centered strategies

Stakeholders are the assets and real value of the GIFT for achieving growth and revenue centered strategy in e-world. Each and every stakeholder has to promote the forum either by word of mouth way or through e-way because directly or indirectly it links with the stakeholders' growth. If all stakeholders will put small-small drops, time will make it big lake and ocean of flexibility.

All the Stakeholders are requested to communicate their feedback or comments on the proposed e-model for GIFT to giftjournal@giftsociety. org

Event Diary

Event	:	PICMET'04 Symposium
Dates	:	August 1 - 4, 2004.
Place	:	Seoul, Korea
Theme	:	Innovation Management in the Technology-Driven World
Contact	:	**Dundar F. Kocaoglu**
Event	:	Sustainable Innovation 04.
Dates	:	October 25th - 26th, 2004.
Place	:	UK
Theme	:	Creating and developing sustainable and responsible new business models Towards Sustainable Product Design
Contact	:	**Professor Martin Charter** Director The Centre for Sustainable Design The Surrey Institute of Art & Design, University College Tel: + 44 (0) 1252 892772 Fax: + 44 (0) 1252 892747 Email: mcharter@surrart.ac.uk Website: www.cfsd.org.uk
Event	:	10th Commemorative International Conference on Productivity and Quality Research (ICPQR 2004). .
Dates	:	**February 15-19, 2004**
Place	:	Miami, Florida, USA
Contact	:	**Dr. David J. Sumanth** Professor of Industrial Engineering, and Founding Director, Productivity Research Group University of Miami, U.S.A.; and Founding Conference Chairman Tel.: 305-284-2366 Fax: 305-284-4040 E-mail : info@ispqr.com.

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