

## Computation of Performance Index for Software Manufacturing Company Using JIT Principles

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### Abstract

Organizations are experiencing highly volatile market due to the technological updates, which includes proper training of software developers, changing requirements, government compliance, competitor's product, testing and providing of technical support in an ever-changing environment. The ultimate objective of the software manufacturing today is to provide the market with products of the highest quality, at reasonable prices, at the optimal time preferable first in the market. Just-in-time (JIT) has been widely implemented in software manufacturing as a survival strategy against global market competition as it offers various benefits, such as greater throughput, higher productivity and better quality. The aim of the paper is to discuss few strategic issues and some important rules for getting the system off the ground. The procedure for planning and implementation along with global status and pay off has been discussed critically. A questionnaire for self-test has also been given along with evaluation criteria, in order to identify the weaknesses and strength of the company for successful implementation of JIT manufacturing strategy. It also gives a methodology for computation and improvement of performance index using the principle of continuous improvement.

This paper focuses on how to enhance the productivity/ performance index while applying systematically, scientifically basic principles of JIT approaches. The design guidelines are applied to a small customer as part of development process as a case example.

The ideas presented in the paper will be useful for those manufacturers of software who want to implement JIT manufacturing in their organizations.

### I. INTRODUCTION

Software Manufacturing is the process of producing software in ways similar to the manufacture of goods in a traditional manner. Software has generally been produced in a batch or waterfall method which involves the whole design and development of a software based on needs of an organization. However, the use of software on a day to day basis by general consumers has required the need of the modified process of software manufacturing. In the process a piece of software is sold as if it was a product by itself. The sale is based on per copy or per user license. The software developed in this method are developed by software firms and distributed through retail channels on a per unit basis at a margin price greater than zero. Different processes of development from planning all the way to testing and quality check along with sales and advertising cost are to be accounted for before making up a unit price [1-2].

Software Manufacturing is no longer a local matter [3]. Usages of same kind of software all over the world which can be easily delivered due to advances in communication and transportation have greatly reduced the world's size [4]. Manufacturing should now be considered as a global affair. The consequent variety of choices makes decisions regarding software manufacturing strategy very critical and important to the process. Today software development firms face world competition, and manufacturing and individual pricing is at the heart of the problem. To maintain competitive edge, firms engaged in software manufacturing face the difficulty of reducing costs and improving their quality level along with providing good support [5]. One way to accomplish this is to use the correct strategy during the whole development process. It is necessary to develop a commitment to manufacturing earlier in product development phase [6]. It is important to use common senses in studying the different choices and to carry out decisions that will make the manufacturing process effective, fast and burdened with very low repetition and overhead.

JIT is a new way of thinking about software manufacturing. The challenge of JIT is that it constitutes a complete departure from the old waterfall and batch systems that have been used for many years in the development process. Most of the JIT concepts have been developed in Japan through many years of hard work and attention in detail. Policy makers will have to give careful consideration to the initiation and expansion of JIT in software manufacturing industries.

It is important to recognize that an organization cannot adopt JIT in isolation, but only with the close participation of other involved organizations, particularly suppliers and customers, so that risks of work that

needs to be redone are minimized. Furthermore, it calls for a high degree of organization within the company so that it can respond rapidly to market demands.

Schonberger [7] describes the JIT system as to: "Produce and deliver finished products just in time to be sold, sub-assemblies just in time to be assembled into finished products.

## II. CHANGING REQUIREMENTS

The modern software development process is witnessing an evolution in all stages from design to testing. In the present era of high competitiveness, the winners will be those development firms which will fulfill the following demands of market environment:

- 1) The product should be available as soon as possible in the market with an emphasis on first to the market.
- 2) There should be minimum delay between concept development and delivery.
- 3) Quality and reliability of the software should be high/ consistent.
- 4) Change in design should be incorporated at a faster rate than the competition- flexibility.
- 5) Addition of features should be easily accommodated by the system.
- 6) The price should be competitive and fair to the consumer.

Under these circumstances the right form of technique like JIT could prove an invaluable resource. JIT implementation is not an option but a matter of survival.

## III. STRATEGIC ISSUES IN JIT SOFTWARE MANUFACTURING

Strategic issues in software manufacturing fall into two categories. The first addresses those issues that are related to how an software industry interacts with customers and competition and second is concerned with top management choices and priorities. From experience five key strategic questions have been identified and are:

- 1) How will JIT impact on the software development and market place?
- 2) How suitable is JIT for software manufacturing environment?
- 3) Should investment be made in JIT, AMT or both?
- 4) How should JIT be implemented in software manufacturing industry?
- 5) What fundamental changes are to be made, to make an industry into a JIT software manufacturing industry?

Developing a strategy is a two stage process. First set of goals are defined and second the means of achieving the goals are defined. A development strategy must define the available development resources, their physical and technological capacity to scale up and down, quality goals, and operational environment.

The software should be designed to meet criteria of lowest cost and highest standards of quality and produced only according to demand to meet requirements.

## IV. GETTING A JIT SYSTEM OFF THE GROUND FOR SOFTWARE MANUFACTURING

Some of the most important rules are (list is not exhaustive and there are other rules that will also be helpful):

- 1) Start working on a JIT system as soon as possible. Don't wait until the software is in a later stage.
- 2) Don't use the excuse of low volume to avoid implementing JIT. The system will work in any environment. Remember, the ideal volume in JIT production is one unit.
- 3) Use repetitive development, daily schedules, and daily status updates. It avoids the complexity of rework in design and allows problems to be detected as soon as they occur.
- 4) Get senior executive/ managers involved immediately. Their support is important for the success of the program.
- 5) Start educating middle managers and workers about JIT principles immediately. Their understanding of JIT must be clear, even if they are initially skeptical of results.
- 6) Have senior managers get involved with key base development companies at the beginning of the program. This is essential for motivating the suppliers to support JIT. Point out to suppliers that they stand to gain from having a long term relationship with, and being single source suppliers of the company.
- 7) Don't start with a global program. Choose a few key areas in which to implement JIT. Then pick another area.
- 8) Develop JIT systems and procedures at the beginning, and then provide training before instituting them. As the organization gains experience, review the procedures and look for possible improvements.
- 9) Develop a set of measurable goals for the JIT program. Self-status check and review their status with managers and workers. Allow the goals to be adjusted midstream, if necessary.
- 10) When the goals are being consistently achieved, set new higher goals. Each rule is vital to the survival of the JIT system and should be enforced scrupulously.

## V. SUSTAINABLE SOFTWARE DEVELOPMENT

Many of today's software development process compromise the quality of the product in the race to be first to the market. Globally, and in many regions including USA, software development is taken on by the in-house and external team without giving due care to the result. Development first to the market attitude creates flaws in the system which are sometime difficult to overcome.

Access restrictions and the interconnectedness of global development markets nowadays do not require that the teams be present on-site for development. Communication capacities and non-verbal communication has increased which makes connecting the teams at different locations easier. At the same time lack of proper understanding and management support and lack of vested investment in the software for the end client creates problems which might be difficult to overcome at a later stage. At the same time systems need to be flexible enough to make changes at almost no cost.

What exactly do we mean by 'Sustainable' Software?

There are many different views as to what falls within the scope of the term 'sustainability'. Strictly speaking sustainability implies the increase of cost at rates that do not exceed the sale value of the product. For software, a sustainable and productive system might be seen as encompassing a range of issues such as cost, quality, time to market, being able to handle change to market situations, and at the same time, providing quality support to the customers.

How can we move towards a more resource efficient and sustainable software development? JIT is one of the solutions.

A public consultation was held on this question, and different areas are presented for discussion:

- 1) Better design and development process which make it agile/frugile.
- 2) Stimulating sustainable software development
- 3) Reducing wasted time due to redesign.
- 4) Better quality Control.
- 5) Excellent quality of post market support.

## VI. TOOL KIT DESIGN FOR DATA COLLECTION

The concept of improving productivity / sustainability is the main area of interests for different software development. But in order to do so one has to first determine the status of the concerned development unit with respect to productivity / sustainability. To do that some kind of audit assessment is mandatory. The audit assessment tools will not only give an idea about the status of the development unit, but also will provide the direction to implementation program. Table1 gives the different sub-systems of the tool kit which are applicable, in general, to a software development unit.

TABLE I: DIFFERENT SUB-SYSTEMS

S. No	Key Performance area/ Subsystem
1	Project Scope
2	Business and Organization Knowledge
3	Design
4	Development
5	Testing
6	Quality Management
7	Management Commitment
8	Compliance of Purchased Materials
9	Cost Control
10	Customer Service
11	Labor Relations
12	Compliance with Government Regulations
13	Facilities Management
14	Document Control Process
15	Technical Support

Tool kit has sub-systems and each sub-system will have set of performance objectives / attributes / factors which covers the key performance areas of the firms. The choice of different sub-systems and performance objective attributes / factors depends upon the type of firms. By analyzing the responses of the performance objectives and areas which are low on JIT manufacturing and which need attention are pin pointed. This will give direction to the research work, specifying areas where study should further look into.

TABLE II: STRUCTURE OF TOOL KIT INCLUDING NAMES OF KEY PERFORMANCE AREA/ SUBSYSTEMS AND KEY PERFORMANCE OBJECTIVES

Sr. No.	Key Performance sub-systems and Objectives	Rating				
Sr. No.	Project Scope	1	2	3	4	5
1	Is there a written procedure for creating the project scope?					
2	Is there clarity in the objectives of the project?					
3	Are process controls established at all critical points within the process?					
4	Is the prepared project scope reviewed for accuracy before being presented to client?					
5	Are the associated cost defined at each stage of the project scope?					
6	Does the client sign off on the project scope before design and development process is started?					
Sr. No.	Business and Organization knowledge	1	2	3	4	5
1	Are the analyst and developers familiar with the customers' work areas?					
2	Do we have association with the experts from the industries we serve to gain industry knowledge?					
3	Are we active in the trade groups, technical associations, or trade publications that support the areas we service? Do we provide our customers with insight into market and industry trends and competitive product developments?					
4	Are we working towards best-in-class status in the development areas we service?					
Sr. No.	Design	1	2	3	4	5
1	Has the analysts involved in the process worked on the design process before?					
2	Is the lead analyst on the design process worked in the organization being served or a similar organization?					
3	Is the software design processes written for proper development of the design process?					
4	Is the design process reviewed by peers at each stage of the process?					
5	Are the screen and functional designs reviewed for accuracy at later stages of design?					
6	Is the customer involved in the design process?					
7	Does the customer sign off on the design before development is started?					
8	Are the design changes and history of changes documented for later review?					
9	Does process exist for filing patents for new development?					
Sr. No.	Development	1	2	3	4	5
1	Do we have a defined process for development?					
2	Are the developers experienced in the work areas we serve? Do we have flexibility in the development process?					
3	Are design feedbacks provided during stages of development process?					
4	Are regular monitoring processes set up to establish that the design document is being followed?					
5	Are the deliverables from the development process met on time?					
6	Are design changes during the development process easily implemented in the current developed product?					
7	Are their written documents pertaining to the development standards being followed?					
Sr. No.	Testing	1	2	3	4	5
1	Do the testing methods follow organization standards?					
2	Are the standards documentation defined on writing test cases?					
3	Are the test processes automated?					
4	Are the testing results documented and followed up on?					
5	Is the testing process monitored?					
6	Does the tester have access to design documents?					
7	Is the testing team different and totally unrelated from the design and development team?					
Sr. No.	Quality Management	1	2	3	4	5
1	Do we have a long term documented quality improvement plan?					

2	Is achieving best-in-class status one of our quality improvement objectives?					
3	Is the quality improvement plan broken down into individual departmental objectives with performance metrics to monitor progress?					
4	Has management issued a written quality policy that is consistent with the quality improvement objectives of the company?					
5	Is the quality policy communicated to all levels within the organization?					
6	Is the quality policy understood by all personnel?					
7	Is the quality policy a "living document"; i.e., is the quality policy continually updated to reflect changes in customer requirements, process improvements etc.?					
8	Is quality training documented in our employees' personnel records?					
9	Is our quality system certified by an independent third party or customer?					
10	Do we have a comprehensive quality manual?					
11	Does management take comprehensive action when key customer performance metrics are not met?					
Sr. No.	Management Commitment	1	2	3	4	5
1	Is the Company's Organizational structure well defined and documented?					
2	Does our management support and promote new ideas and concepts for continuous improvement?					
3	Does our management provide employee training that is appropriate and relevant to individual job functions?					
4	Are our training programs available to employees at all levels in the company?					
5	Is management actively involved in the pursuit of quality and process improvements as evidenced by its participation in employee team activities?					
6	Does management promote and support the concept of employee empowerment with a goal of self-directed work teams?					
7	Are we doing business with any of our customer(s) as a partner or as part of a strategic alliance?					
8	Is management receptive to innovation and improvement suggestions from our employees and customers?					
9	Does the management use the results of internal quality system audits to implement corrective actions?					
10	Does management personally visit customers to solicit input about product and process improvement?					
11	Does management give equal importance to administrative systems and practices?					
12	Is the long-term growth of the organization an objective of the management?					
13	Does the management provide proper delegation and an independence to work environment?					
Sr. No.	Compliance of Purchased Materials	1	2	3	4	5
1	Do we have a supplier selection and certification program to qualify our suppliers?					
2	Are complete records maintained on our approved suppliers?					
3	Do we use a supplier rating system, and are suppliers informed of their performance?					
4	Are our suppliers audited by our internal employees or independent auditors on a regular basis?					
5	Do we maintain data on each supplier's process capabilities?					
6	Do we have electronic data interchange (EDI) capability?					
Sr. No.	Cost Control	1	2	3	4	5
1	Is the percentage of goods and services sold to any one customer in excess of half the total goods and services sold to all customers?					
2	Do our accounting functions interact frequently and supportively with our operational functions?					
3	Do we effectively control overtime and other lead time-associated costs?					
4	Do we give importance to the achievement of the goal within the framework of time and financial resources?					
Sr. No.	Customer Service	1	2	3	4	5
1	Can we demonstrate that our customer service function is clearly defined with a distinct organizational structure?					
2	Is a measurement system in place to effectively and consistently evaluate our customers' satisfaction levels?					
3	Are the metrics we use to measure customer satisfaction accurate and complete?					
4	Is our senior management actively involved in customer service?					
5	Are both positive and negative trends in customer satisfaction reported directly to our					

	senior management?					
6	Do we maintain a high level of customer service throughout our entire customer base?					
7	Do we compare favorably with our competition relative to customer satisfaction indices?					
8	When customer satisfaction levels fall short of targeted or expected goals, does senior management direct corrective action efforts?					
9	Does our customer service consistently provide prompt (within 24 hours) resolution of customer complaints and/or requests for information?					
10	Do we have and follow a documented procedure for handling customer complaints?					
11	Is the procedure comprehensive?					
12	Is the procedure followed by all customer service staff at all times?					
13	Are customer service staff empowered to resolve customer complaints on the spot, without seeking management approval?					
14	Do we offer our customers EDI capability?					
Sr. No.	Labor Relations	1	2	3	4	5
1	Do we provide training and educational opportunities for all employees at every level within the organization?					
2	Do we maintain training records on each employee, illustrating the courses and educational opportunities afforded each employee?					
3	Are we an equal opportunity employer?					
4	Have all labor disputes been resolved either with or without outside intervention or mediation?					
5	Are employees involved actively in company decision-making?					
6	Does our senior management keep employees advised of financial and market conditions of the company? Frequently?					
	Can we demonstrate that we can equal or better organization averages for:					
	Employee retention rate?					
7	Employee absenteeism?					
	Employee productivity?					
	Employee advancement?					
8	Do we have any pending or active litigation relating to labor disputes, sexual harassment, discrimination, or unfair labor practices?					
9	Is the average length of services for our employees comparable with other companies in our organization?					
10	Do we have a documented, active cross-training program to broaden employee skill sets?					
11	Is there transparency in performance appraisal?					
12	Is there a method for proper recognition of performance and merit?					
Sr. No.	Compliance with Governmental Regulations	1	2	3	4	5
1	Can we demonstrate that we are in full compliance with all federal, state, and local regulatory requirements applicable to our particular industry segment (EEOC, OSHA, EPA, etc.)?					
2	Do we have documented procedures in place that ensure environmentally responsible and community supportive (proactive) operations?					
3	Have we been cited within the last 3 years or is litigation pending for noncompliance with federal, state, or local environmental or employment regulations?					
4	If no. 3 is affirmative, has corrective action been initiated to effectively address the noncompliance?					
5	Do we have a documented substance abuse program/policy?					
6	Do we have emergency procedures to respond to crisis situations?					
Sr. No.	Facilities Management	1	2	3	4	5
1	Do housekeeping procedures exist in every department?					
2	Are housekeeping audits scheduled and conducted on a regular basis?					
3	Does sufficient space and conducive environment exist for overall growth?					
4	Are computers and information technology new and properly maintained?					
Sr. No.	Document Control Processes	1	2	3	4	5
1	Is there a written procedure that covers the retention period for key documents?					
2	Is there a storage and retrieval procedure for all key documents?					
3	Is there an off-site storage location for key documents and backup copies?					

Sr. No.	Technical Support	1	2	3	4	5
1	Is the scope of our R&D and product development activities enough for the areas we service?					
2	Are our R&D and new product development efforts focused on meeting the stated needs of our customers?					

Answer the questions in table 2 relative to your software company, its culture, its people, and the processes you believe to be most in need of JIT. Assign each question a score of 1-5 using the following criteria:

- 1 = The conditions adamantly disagree with this statement; that is response not adequate.
- 2 = The conditions disagree with this statement; that is response poor.
- 3 = The conditions neither agree nor disagree with this statement; that is response good.
- 4 = The conditions generally agree with this statement; that is response very good.
- 5 = The conditions completely agree with this statement; that is response adequate.

Once you have assigned a score to the individual performance objective, sum the scores for an overall company performance index assessment.

*Mathematical Model for Software Manufacturing Performance Index is given as:*

$$l_{\Omega} = \frac{1}{n} \sum_{\forall i} \left[ \frac{\sum_{\forall k} \left( \frac{\sum_{\forall k} O_{ik}}{k} \right) w}{\sum_{\forall w}} \right] \quad (1)$$

Where:

$\Omega$  = Whole system (organization)

$s_i, i = 1, 2, \dots, n$  be the key performance area/sub-system such that  $\sum_{\forall i} s_i = \Omega$ ,

$O_{ik}$  be the response of the  $k^{th}$  question asked to the respondent of the  $i^{th}$  key performance area,

$O_i = \frac{\sum_{\forall k} O_{ik}}{k}$  be all the responses from the 'k' questions,

$l_i = \frac{\sum_{\forall w} (O_i w)}{\sum_{\forall w}}$  be the JIT index for the  $i^{th}$  sub-system,  $i = 1, 2, \dots, n$ , and

$l_{\Omega} = \frac{\sum_{\forall i} l_i}{n}$  be the JIT index of the organization

By making use of the above mathematical model (equation1) the performance index of Software Manufacturing company of various key performance areas and the manufacturing unit as a whole under consideration are computed.

## VII. SCORING SYSTEM AND GUIDELINES

The rating of performance objectives can be measured subjectively on 1 to 5 scales, refer table 3. Each performance objective / attribute of a sub-system is designed for the responses from "not adequately addressed" to "adequately addressed", as per scale from 1 to 5. When the response is at the rating scale from 1 to 3 i.e. not adequately addressed, it means effectiveness of practices is almost absent & these are the potential areas for improvements. When the response is at the rating scale from 4 to 5 i.e. adequately addressed, it means effectiveness of practices are followed so these areas are slightly covered from a study of effectivity/productivity improvement. Accordingly the required actions may be suggested for sustainability/productivity enhancement.

It will provide the assessor some kind of factual status regarding the efficiency and effectiveness of the manufacturing unit as far as manufacturing is concerned. The scaling of the key performance area of a sub-system will help to measure the performance of the key performance area, which is one of the requirements for assessing performance index.

TABLE III: SCORING SYSTEM FOR DIFFERENT ATTRIBUTES

Performance areas/sub-systems	Attributes/ Performance objectives	Rating				
		Response not adequate	Response poor	Response good	Response very good	Response Adequate
		1	2	3	4	5

## VIII. COMPUTATION OF PERFORMANCE INDEX FOR SOFTWARE MANUFACTURING INDUSTRY

For computing the value of performance index, the multi attribute utility function (MAUF) approach has been used. Accordingly, a tool kit has been designed for collecting data/information pertaining to particular software manufacturing industry.

A typical firm engaged in software development can be considered to operate as a system with different sub-systems and key performance areas.

Depending upon the size and nature of the software and the area it serves, the number of sub-systems and sub-sequent key performance areas may vary.

## IX. ACTION PLAN

Transforming a software enterprise into a JIT waste and high performing one requires building a nurturing organizational culture that embraces change, seeks to seize market opportunities, executes strategy faster, and tolerates risk taking behavior of this complex phenomenon.

The resulting outcome of becoming a JIT software organization yields the competitive advantage that sets the organization apart from its competitors on effectiveness and market performance. Planning for a transformation that requires fundamental overhaul of all aspects of development processes necessitates intentional revamping of the organizational culture. General practices for implementation of JIT software manufacturing system are:

- Do not implement on an adhoc basis, have a plan and see each implementation step as a part of that plan.
- Implementation should start in hostile areas and especially where productivity is lagging.
- Involve from the start all levels of management and the labor force. Total commitment by everyone is necessary for success
- Financial justification in real time economic terms is essential.
- Clear policies and programs are essentials.
- An initial feasibility study is important.
- Provide training and give them tools necessary to perform their jobs.
- Do not forget people requirements. Be honest in answering the questions from the workers in the plant.
- Involve project planner and production people in your efforts.

## X. CASE STUDY

A company engaged in development of tax software was selected for implementation of proposed model. The development and other working data were collected by using designed tool kit. Table 4 depicts the data collected for a particular case under consideration, in column existing situation. By making use of mathematical model the JIT index of various key performance areas as per data/information collected from industry are computed and are shown in table 4 in existing column.

TABLE IV: COMPUTATION OF PERFORMANCE INDEX FOR JIT SOFTWARE MANUFACTURING COMPANY

TABLE IV. COMPARISON OF PERFORMANCE INDEX FOR IT SOFTWARE/INFOSYSTEMS PROVIDING COMPANY																	
Rating		Existing situation					After implementation of I mile stone					After implementation of II mile stone					
Sr. No	Sub systems	Key Performance Objective	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	Project Scope	Is there a written procedure for creating the project scope?			*					*					*		
		Is there clarity in the objectives of the project?		*					*					*			
		Are process controls established at all critical points within the process?			*					*					*		
		Is the prepared project scope reviewed for accuracy before being presented to the client?				*					*					*	
		Are the associated cost defined at each stage of the project scope?					*					*					*
		Does the client sign off on the project scope before design and development process is started?					*					*					*
		Performance index	0.7					0.7					0.7				
2	Business and Industry Knowledge	Are the analyst and developers familiar with the customers' industries?		*					*					*			
		Do we have association with the experts from the industries we serve to gain industry knowledge?				*					*					*	
		Are we active in the industry trade groups, technical associations, or trade publications that support the industries we service?			*					*					*		



		Do we provide our customers with insight into market and industry trends and industry or competitive product developments?				
		Are we working towards best-in-class status in the industries we service?	*		*	*
		<b>Performance index</b>	0.6	0.6	0.6	
		Has the analysts involved in the process worked on the design process before?		*	*	*
		Is the lead analyst on the design process worked in the industry being served or a similar industry?	*		*	*
		Is the software design processes written for proper development of the design process?	*		*	*
		Is the design process reviewed by peers at each stage of the process?	*		*	*
3	Design	Are the screen and functional designs reviewed for accuracy at later stages of design?	*		*	*
		Is the customer involved in the design process?	*		*	*
		Does the customer sign off on the design before development is started?	*		*	*
		Are the design changes and history of changes documented for later review?	*	*		*
		Does process exist for filing patents for new development?	*	*	*	
		<b>Performance index</b>	0.5	0.6	0.7	
		Do we have a defined process for development?		*	*	*
		Are the developers experienced in the industries we serve?Do we have flexibility in the development process?	*		*	*
		Are design feedbacks provided during stages of development process?	*		*	*
4	Development	Are regular monitoring processes set up to establish that the design document is being followed?	*	*		*
		Are the deliverables from the development process met on time?	*		*	*
		Are design changes during the development process easily implemented in the current developed product?	*	*		*
		Are their written documents pertaining to the development standards being followed?	*		*	*
		<b>Performance index</b>	0.6	0.6	0.6	
		Do the testing methods follow industry standards?	*		*	*
		Are the standards documentation defined on writing test cases?	*		*	*
		Are the test processes automated?	*	*		*
5	Testing	Are the testing results documented and followed up on?	*		*	*
		Is the testing process monitored?	*		*	*
		Does the tester have access to design documents?		*	*	*
		Is the testing team different and totally unrelated from the design and development team?	*		*	*
		<b>Performance index</b>	0.7	0.7	0.7	
		Do we have a long term documented quality improvement plan?	*		*	*
		Is achieving best-in-class status one of our quality improvement objectives?	*		*	*
		Is the quality improvement plan broken down into individual departmental objectives with performance metrics to monitor progress?	*	*		*
6	Quality Management	Has management issued a written quality policy that is consistent with the quality improvement objectives of the company?	*		*	*
		Is the quality policy communicated to all levels within the organization?	*	*		*
		Is the quality policy understood by all personnel?	*	*		*
		Is the quality policy a “living document”; i.e., is the quality policy continually updated to reflect changes in customer requirements, process improvements	*	*		*

		etc.?			
		Is quality training documented in our employees' personnel records?	*	*	*
		Is our quality system certified by an independent third party or customer?	*	*	*
		Do we have a comprehensive quality manual?	*	*	*
		Does management take comprehensive action when key customer performance metrics are not met?	*	*	*
		<b>Performance index</b>	0.3	0.4	0.6
		Is the Company's Organizational structure well defined and documented?	*	*	*
		Does our management support and promote new ideas and concepts for continuous improvement?	*	*	*
		Does our management provide employee training that is appropriate and relevant to individual job functions?	*	*	*
		Are our training programs available to employees at all levels in the company?	*	*	*
		Is management actively involved in the pursuit of quality and process improvements as evidenced by its participation in employee team activities?	*	*	*
		Does management promote and support the concept of employee empowerment with a goal of self-directed work teams?	*	*	*
7	Management Commitment	Are we doing business with any of our customer(s) as a partner or as part of a strategic alliance?	*	*	*
		Is management receptive to innovation and improvement suggestions from our employees and customers?	*	*	*
		Does the management use the results of internal quality system audits to implement corrective actions?	*	*	*
		Does management personally visit customers to solicit input about product and process improvement?	*	*	*
		Does management give equal importance to administrative systems and practices?	*	*	*
		Is the long-term growth of the organization an objective of the management?	*	*	*
		Does the management provide proper delegation and an independence to work environment?	*	*	*
		<b>Performance index</b>	0.4	0.5	0.5
		Do we have a supplier selection and certification program to quality our suppliers?	*	*	*
		Are complete records maintained on our approved suppliers?	*	*	*
8	Compliance of Purchased Materials	Do we use a supplier rating system, and are suppliers informed of their performance?	*	*	*
		Are our suppliers audited by our internal employees or independent auditors on a regular basis?	*	*	*
		Do we maintain data on each supplier's process capabilities?	*	*	*
		Do we have electronic data interchange (EDI) capability?	*	*	*
		<b>Performance index</b>	0.5	0.5	0.5
		Is the percentage of goods and services sold to any one customer in excess of half the total goods and services sold to all customers?	*	*	*
9	Cost Control	Do our accounting functions interact frequently and supportively with our operational functions?	*	*	*
		Do we effectively control overtime and other lead time-associated costs?	*	*	*
		Do we give importance to the achievement of the goal within the framework of time and financial resources?	*	*	*
		<b>Performance index</b>	0.7	0.7	0.7
		Can we demonstrate that our customer service function is clearly defined with a distinct organizational structure?	*	*	*

10	Customer Service	Is a measurement system in place to effectively and consistently evaluate our customers' satisfaction levels?	*	*	*
		Are the metrics we use to measure customer satisfaction accurate and complete?	*	*	*
		Is our senior management actively involved in customer service?	*	*	*
		Are both positive and negative trends in customer satisfaction reported directly to our senior management?	*	*	*
		Do we maintain a high level of customer service throughout our entire customer base?	*	*	*
		Do we compare favorably with our competition relative to customer satisfaction indices?	*	*	*
		When customer satisfaction levels fall short of targeted or expected goals, does senior management direct corrective action efforts?	*	*	*
		Does our customer service consistently provide prompt (within 24 hours) resolution of customer complaints and/or requests for information?	*	*	*
		Do we have and follow a documented procedure for handling customer complaints?	*	*	*
		Is the procedure comprehensive?	*	*	*
		Is the procedure followed by all customer service staff at all times?	*	*	*
		Are customer service staff empowered to resolve customer complaints on the spot, without seeking management approval?	*	*	*
		Do we offer our customers EDI capability?	*	*	*
		<b>Performance index</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>
		Do we provide training and educational opportunities for all employees at every level within the organization?	*	*	*
		Do we maintain training records on each employee, illustrating the courses and educational opportunities afforded each employee?	*	*	*
		Are we an equal opportunity employer?	*	*	*
		Have all labor disputes been resolved either with or without outside intervention or mediation?	*	*	*
11	Labor Relations	Are employees involved actively in company decision-making?	*	*	*
		Does our senior management keep employees advised of financial and market conditions of the company? Frequently?	*	*	*
		Can we demonstrate that we can equal or better industry averages for:			
		Employee retention rate?			
		Employee absenteeism?	*	*	*
		Employee productivity?			
		Employee advancement?			
		Do we have any pending or active litigation relating to labor disputes, sexual harassment, discrimination, or unfair labor practices?	*	*	*
		Is the average length of services for our employees comparable with other companies in our industry?	*	*	*
		Do we have a documented, active cross-training program to broaden employee skill sets?	*	*	*
		Is there transparency in performance appraisal?	*	*	*
		Is there a method for proper recognition of performance and merit?	*	*	*
		<b>Performance index</b>	<b>0.7</b>	<b>0.7</b>	<b>0.7</b>
		Can we demonstrate that we are in full compliance with all federal, state, and local regulatory requirements applicable to our particular industry segment (EEOC, OSHA, EPA, etc.)?	*	*	*
		Do we have documented procedures in place that ensure environmentally responsible and community	*	*	*

		supportive (proactive) operations?				
		Have we been cited within the last 3 years or is litigation pending for noncompliance with federal, state, or local environmental or employment regulations?	*		*	*
12	Compliance with Governmental Regulations	If no. 4 is affirmative, has corrective action been initiated to effectively address the noncompliance?	NAP	NAP	NAP	
		Do we have a documented substance abuse program/policy?	*	*		*
		Do we have emergency procedures to respond to crisis situations?	*	*	*	
		<b>Performance index</b>	0.6	0.6	0.6	
13	Facility Management	Do housekeeping procedures exist in every department?	*	*		*
		Are housekeeping audits scheduled and conducted on a regular basis?	*	*		*
		Does sufficient space and conducive environment exist for overall growth?	*	*		*
		Are computers and information technology new and properly maintained?	*	*		*
		<b>Performance index</b>	0.6	0.6	0.6	
14	Document Control	Is there a written procedure that covers the retention period for key documents?	*	*		*
		Is there a storage and retrieval procedure for all key documents?	*	*	*	
		Is there an off-site storage location for key documents and backup copies?	*	*		*
		<b>Performance index</b>	0.6	0.6	0.6	
15	Technical Support	Is the scope of our R&D and product development activities sufficient for the industries we service?	*	*	*	
		Are our R&D and new product development efforts focused on meeting the stated needs of our customers?	*	*	*	
		<b>Performance index</b>	0.4	0.4	0.4	
<b>System Performance Index</b>			<b>0.56</b>	<b>0.58</b>	<b>0.60</b>	

To improve the performance index the availability of technical and financial resources were reviewed and accordingly it was decided that the required improvement in performance index will be carried out in two stages. These stages are categorized as 1<sup>st</sup> and 2<sup>nd</sup> mile stones. Four months were allotted to each mile stone for the implementation of suggested methods/processes for improving performance index.

#### XI. COMPUTATION OF PERFORMANCE INDEX AFTER 1<sup>ST</sup> MILESTONE

Two key performances areas namely Design and Quality Management are identified & certain performance objectives are selected for 1<sup>st</sup> mile stone for implementation and improvement where the response rating is not up to the mark.

##### (i) Design

Design is a very key portion of the software manufacturing process. Involvement of the customer in the design process and significant sign off achieved from the customer who really understands the process is a critical part of the system. At the same point of time the design should be flexible and strong to be agile to later changes.

Design process is not different than planning of any process. Internal JIT buckets are made in small portions of the design. The objective is to make the design very agile to be able to be changed with any requirement changes.

Customer involvement with experience design architects is necessary to understand the whole process. Emphasis should be on developing “partnerships” with customers. At the same point of time the design should be peer reviewed at each design stage to get a better opinion of the design and independent review of the process. Fewer steps being designed in a better way means more agility, better accountability, and fewer changes to manage and more cooperation

Better design process is one of the greatest profit contributors.

##### (ii) Quality Management

In software development world that is now modeled after the first to market mindset, quality management and improvement is a key metric for the success of the software. Key performances areas of Quality are identified & certain performance index are selected for 1st milestone for implementation, where the response rating is not up to the mark. Quality management of the whole product needs to be better broken down in small portions to ensure success of each part.

Having a written quality policy which can change based on the software in ensuring that the quality metrics are met are important part of the process..

Better handling of the Quality management process with a written process, making sure that all the personnel are better trained to understand all aspects of the quality management and involvement of the management in leading the process ensures the success of the product. Software with the better quality also improves the image of the company and the product which make the success easier.

Cellular orientation is an excellent solution. This is becoming a common approach during implementations. The objective is to remove as much space between the design and development possible as well as integrating as much of the individual processes into one area as possible. Compensation and rewards for employees must be based on group performance not on individual performance. This generates differential pride that eventually creates conflict and contention within the group.

Suggestions of 1<sup>st</sup>. milestone have been implemented and the value of JIT index is calculated by using mathematical model and the improved value of performance index is shown in table 4.

## XII. COMPUTATION OF PERFORMANCE INDEX AFTER 2<sup>nd</sup> MILESTONE

Key performances areas of Quality Management and commitment of the management are identified & certain attributes are selected for 2<sup>nd</sup> milestone for implementation, where the response rating is not up to the mark.

Written quality management process along with training of developers and quality assurance people and having equal commitment of the management to implement the solution increases the quality of the product. The true role of JIT quality assurance is to audit and train the participants on quality performance.

The impact of quality on volume throughput is always a problem to overcome quality failure in low volume JIT flows have a devastating effect. In one case study, each of five different sub areas assumed that their own small 3% failure had little effect on the final product. But, the cumulative effect of a 3% failure in each area when multiplied by each other in the above probability statement shows that the software required rework in 35% of the developed product. Test procedures and online checks were instituted to reduce these failures. Inspection of the quality assurance processes and random checks and peer reviews along with management awards to employees with better performance brought up the quality standard of the product.

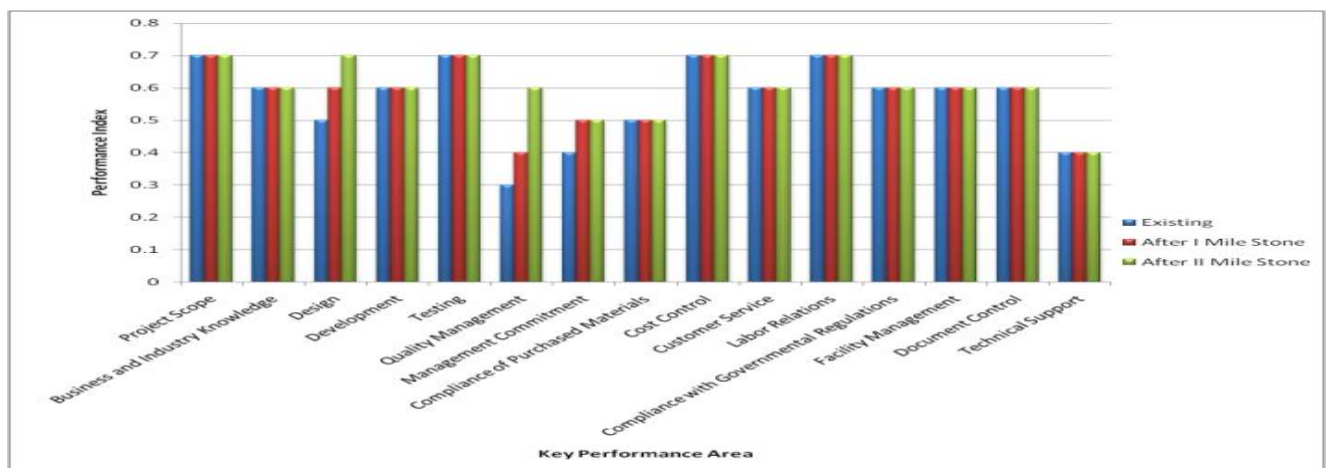


Fig. 1 Performance indices of various key performance areas

Suggestions of 2<sup>nd</sup> mile stone have been implemented and the value of performance index is calculated by using mathematical model and the improved value of performance index is shown in table 4.

Figure 1, indicates the performance index of manufacturing indices of software manufacturing industry of various key performance areas obtained after different milestones. Figure 2 gives the values of performance index of the software manufacturing industry/system after different milestones.

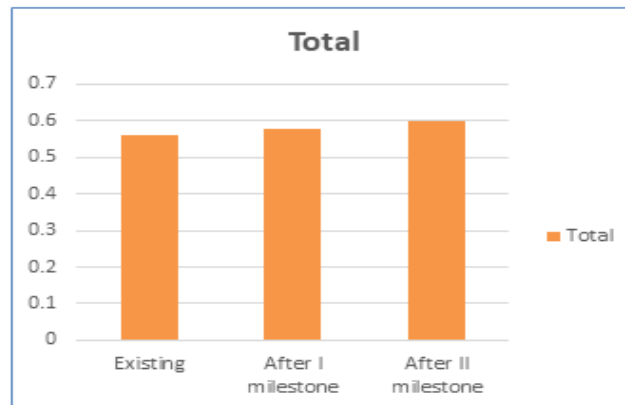


Fig.2 Performance system index after various milestones

### XIII. SUGGESTED PROCEDURE FOR COMPUTATION AND IMPROVEMENT OF SUSTAINABILITY/SOFTWARE MANUFACTURING INDEX[8].

- 1) Decide about key performance areas / subsystems applicable to a particular organization.
- 2) Tool kit design for data collection including key performance areas and scoring systems.
- 3) Chose performance objectives/ attributes for each performance area with a view of JIT thinking in order to measure and monitor performance.
- 4) Measure inputs used in the development systems as per the scoring guidelines.
- 5) Compute software manufacturing sustainability / performance index in order to evaluate each subsystem/ key performance area.
- 6) Understand your results
- 7) Chose opportunities to improve performance and take action to improve productivity index.
- 8) Decide upon implementations having different milestones after choosing opportunities for improving performance.
- 9) Create action plan to implement as a continuous innovative process.
- 10) Revise the process regularly in different milestones to constantly improve your actions for better sustainability/performance index.

### XIV. RESEARCH AVENUES

Researcher has to start thinking from a different view point which includes:

1. Reduce design and development time in the development process by using more experienced resources.
2. Reduce all forms of waste and good to have features while planning the design process.
3. Reuse and design the development of modular code as much as possible for better efficiency.
4. Optimize the process by introducing agility and flexibility in the process.
5. Carry out total product life cycle analysis by considering design, development, quality management, client investment and final setup.

### XV. FUTURE SCOPE

Depending upon the type of software involved the ranking of sub-systems and performance objectives maybe incorporated for calculating the performance Index of software manufacturing industry. It will increase the mathematical complexity but may give more precise result.

### XVI. CONCLUSION

JIT is a revolutionary concept. Making the complex simple is the main goal of JIT. This philosophy is emerging as a concept which facilitates significant improvements in software manufacturing performance. It is an approach to problem solving, the main areas to attack are those identified as wasteful and to eliminate waste. It reduces lead time to zero or as close as possible to that number. JIT represents a genuine opportunity for software manufacturing industry to regain a competitive posture in the international marketplace without investing in high capital cost investment and complex computer systems.

During implementation, compare the progress achieved with the goals suggested. A tool kit has been designed and developed having different key performance areas or sub-systems and each sub subsystems with a different key performance objective for collecting information for a software manufacturing industry under consideration. Performance index, which gives an idea of performance of the system, has been computed by using the mathematical model developed and data collected for the software manufacturing industry under consideration. Depending upon the values obtained, the performance index of different subsystems, and the implementation procedure has been decided.

After the implementation, the performance index improved from existing 0.56 to 0.58 in the first mile stone and subsequently to 0.60 in the second mile stone, for the case under consideration.

The effort does not stop once you have a complete JIT implementation. Like most areas of technology, software technology is constantly evolving and based on the philosophy of continual improvement, it is also closely a “journey without end”. Fortunately, much of the JIT implementation in software technology be regarded as a ‘common sense’ by involved staff and has the advantage of visible results in the short term.

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