SYNCHRONOUS INNOVATION – THE NEW TREND IN MANUFACTURING MANAGEMENT

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W P No. 902
November 1990

The main objective of the working paper series of the IIMA is to help faculty members to test out their research findings at the pre-publication stage.

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ABSTRACT

In this paper, we discuss a recent development in the area of manufacturing management-aptly called "Synchronous Innovation". This is a strategy which calls for synchronous deployment of technological and administrative innovations during modernization programs in manufacturing organizations. The spectacular growth in organizations worldwide adopting the New Manufacturing Technologies (NMTs) has led to a growing body of research on effective implementation of the NMTs. One after the other, NMTs such as Group Technology (GT), Just In Time (JIT), Flexible Manufacturing Systems (FMS), CAD/CAM, Computer Integrated Manufacturing (CIM), have grown in tremendous popularity in the past decade. One can safely predict that the nineties will see the drive towards new Manufacturing Revolution become much more vigorous, and widespread, with a growth many orders of magnitude higher than we witnessed in the previous decade.

The foremost question that arises now is "how should the NMTs be effectively deployed ?" An organization committing substantial investments for modernization is naturally concerned about effective deployment of the modernization program. This paper discusses the synchronous innovation strategy which has been advocated for this purpose. We look at a number of administrative innovations which were successfully integrated with the technological innovations to make the modernization program a success by many leading organizations. We provide evidence by briefly reviewing a few case applications. Finally, we provide guide-

lines on implementation of synchronous innovation strategy.

The individual references are too many to cite. However, a good compilation of these may be found in the book "Taking Charge of Manufacturing" by John Ettlie, Jossey Bass Publishers, USA (1988).

ABBREVIATIONS

In this paper, we have adopted several abbreviations for some commonly known systems and technologies. The abbreviations along with their meaning are as under:

NMT - New Manufacturing Technology
GT - Group Technology
FMS - Flexible Manufacturing System
CAD - Computer Aided Design
CAM - Computer Aided Manufacturing
CIM - Computer Integrated Manufacturing
IM - Intelligent Manufacturing
TI - Technological Innovation
AI - Administrative Innovation
DMI - Design-Manufacturing Integration
DFM - Design for Manufacturing
R&D - Research and Development
JIT - Just in Time
AGV - Automatic Guided Vehicle
PPM - Parts per million
FAS - Flexible Assembly System
IEC - International Electro Technical Commission

Synohronous Innovation -the new trend in Manufacturing Management

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The introduction and implementation of new manufacturing technologies (NMT) typified by GT, FMS,CAM, CIM, intelligent manufacturing (IM) etc. is by now a fairly wide spread, global phenomenon. In step with the arrival of the NMTs, we are now witnessing a new wave in manufacturing management - one which focuses more on the organizational and administrative innovation for achieving success with deployment of NMTs. This is referred to as **Synchronous Innovation**. Broadly defined, it is the planned, simultaneous adoption of congruent technological and administrative innovations during modernization. These two types of innovations work together to create a synergistic effect on performance. The administrative innovations have been as broad in range and variety as the technological innovations themselves. They have varied from a single quality circle that configured and designed an FMS to a completely new organizational structure for deploying a large CIM system Empirical evidence suggests that the administrative innovations follow typically the following pattern:

i) The more radical the new technological innovation, the more radical the administrative change.

ii) Forging of a link between administrative innovation and technological innovation is often stimulated by an increasingly competitive environment, as well as more demanding technological environment.

iii) Administrative innovations to deploy the enabling technologies of CIM proceed with integration of hierarchy of an organization first, the design manufacturing integration next and finally integration with customers and suppliers.

1. The Synchronous Diagonal

The synchronous innovation strategy for modernization calls for careful matching of technological innovation (TI) and administrative innovation (AI). Figure 1 presents the rough guideline. In this figure, degree of radicalness of TI is plotted on the horizontal axis and degree of radicalness of AI (new policies, practices, contracts and structures) is plotted on the vertical axis, The synchronous diagonal represents the theoretical matching of both dimensions in the degree of departure from standard practice. Thus the modernization cases expected to be most effective are those lying on or close to the diagonal: cases of low technological change low administrative change, medium change on both axes, or high change on both axes.

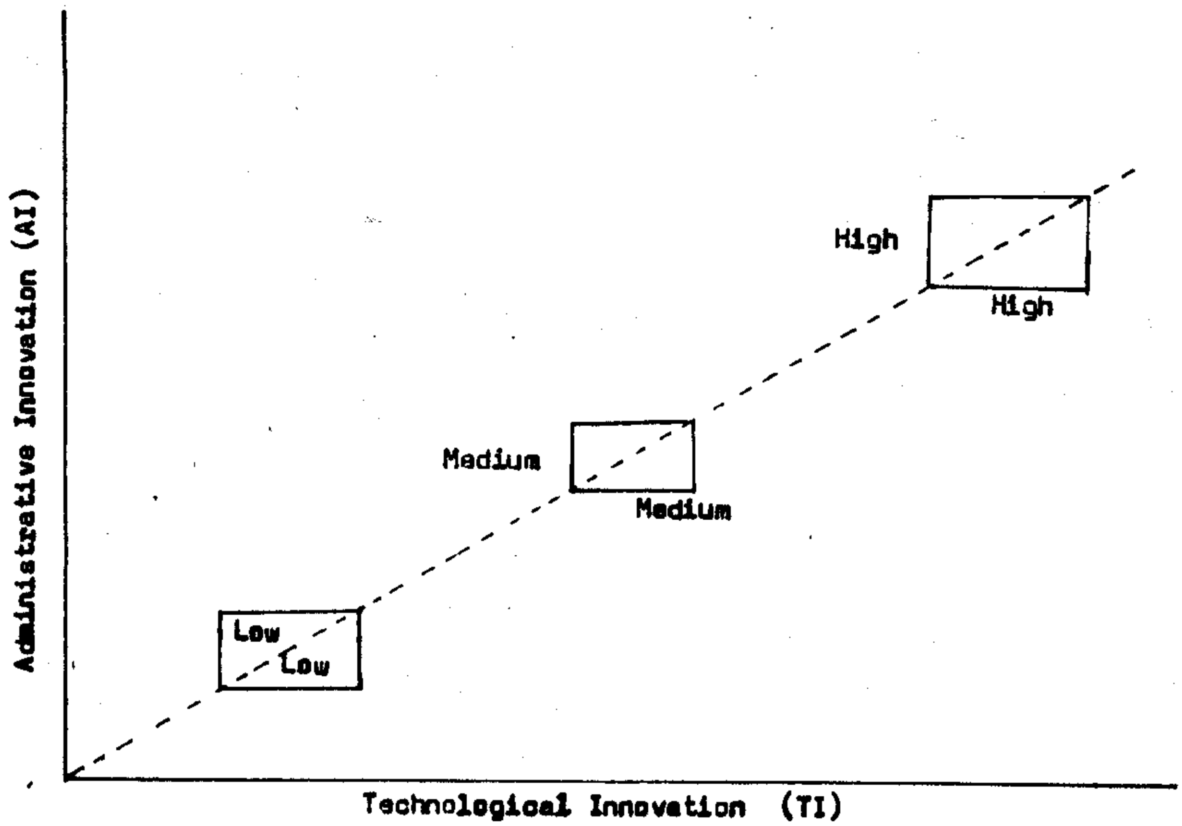
As stated earlier the key features of administrative innovations which form part of synchronous innovation strategy are :

i) Integration of hierarchy of an organization

ii) Design manufacturing integration (DMI)

iii) Integration of customer and suppliers

Figure 1: **The Synchronous Innovation Diagonal**



Later in the appendix we will review a few case histories of companies who have successfully implemented the Synchronous Innovation strategy. Presently, we focus the discussion on the key features of the synchronous innovation.

2. Hierarchical Integration for Modernization

Synchronous Innovation is really a strategy that to begin with, aims at integrating the organizational hierarchy to support the technological innovation. Table 1, below gives a summary of the AI's that have supported such integration in a number of well known modernization programs. We briefly discuss these below .

2.1 Engineer-Blue Collar Teams: The most commonly cited AI is the Engineer-Blue Collar Teams. A "green house" approach to significant technological change, is often the most suitable one for formation of such teams. A green house is an area in an older plant that is set aside for prototyping process technology before it is installed on the shop-floor. This allows vendors, in house manufacturing, systems engineers, operators, skilled trades supervisors a chance to participate in technology deployment from the outset of a major program . Firms that use this approach seek the following:

i) They want the technology to work before it is released to production and becomes visible.

ii) They are attempting to obtain the optimum design and implementation possible.

iii) They generally like to be in the forefront of innovation.

Table 1: **Administrative Innovations that support Hierarchical Integration for Modernization**

Hierarchical Administrative Innovations
1. Engineers - Blue Collar Teams
2. Productivity Teams
3. Others - Training in stress reduction; significant structural change; blue collar design; formalized selection test with FMS as strategic goal.
4. Autonomous work groups
5. Technology agreements
6. Flatter plant structure
7. Compensation Experiments
8. Quality Circle for FMS design
9. Broader job descriptions

2.2 Productivity Teams

This is the second most frequently observed AI. It is a variant of team concept, with application to slightly larger issues, and with broader representation on the team. Usually, the teams are functional, with inputs form concerned areas such as quality control, supervision, skilled trades, engineering, production planning, etc. Vendor involvement is often critical for the success of these teams. Selecting the core members of the team, timing of participation by functional representatives and their scope of authority are amongst the crucial issues in forming the productivity teams.

2.3 Technology Agreements

Explicit technology agreements between unions and management regarding technology for modernization is another important AI often cited. Such agreements may involve i) job reclassifications and reallocations, ii) clauses to save jobs in return for concessions on job categories and conditions of deployment of new technology, allowing more start-up flexibility for the installation iii) defining criteria for advance notice, training, selection, transfer, and outsourcing . The experience to date suggests that it is more a myth than reality that unions prevent modernization from occurring. In general, plants reporting technology agreements in use for modernization, attempt to create new expanded job categories as part of the program to deploy the new processing technology. In fact there are examples of over 100 job categories being collapsed into 5 or even 3 broad job titles in course of modernization.

2.4 New Jobs for Modernization

There appears to be an increasing tendency to deploy new technology using newly created, more broadly defined jobs. These are not restricted to shop floor operators alone, but extend to skilled trades, first line supervisors, managers and engineers as well.

Research points to the following correlates of new and changed jobs:

i) Firms that use administrative experiments of all types in modernization programs favour creation of new jobs as opposed to changing the existing ones. These could be hourly or salaried, depending on the circumstances.

ii) Firms that pursue aggressive manufacturing technology policy are more likely to change existing jobs than create new ones. When they do create new jobs they are likely to be salaried. Such firms are usually the first to adopt new processing technology, they often recruit the best engineering and manufacturing personnel, they advertise their processing technology to customers, and are committed to technological forecasting.

iii) Firms depending on vendors for modernization are less likely to report new job categories. When they do, they are likely to be salaried.

iv) Firms taking more calculated risks with new processing technologies, are more likely to create new hourly jobs, are more committed to training, integrating technology islands and use of group technology.

Table 2 gives typical examples of new job categories in modernizing plants.

Table 2: **New Job Categories in Modernizing Plants***

(based on survey studies of modernizing plants)

New Occupational Category	Number of mentions	% of mentions
Operator	18	.45
Manager or Engineer	7	18
Supervisor	6	15
Other (for example, Staff)	5	13
Skilled trade	2	5
Materials handling	2	5
Total :	40	100

*Even though the job titles themselves are not new, what is new the expanded versions of these jobs.

Examples of expanded job titles are "group machine operator including job setter", "FMS operators broader, bare maintenance", "operator - set up combined, broader description", "operator - set up", "operator - upgraded, objective, maintenance".

However, skilled trade category is largely unaffected by new title additions. Examples of very radical shifts in new job titles took place in the so called sociotechnical plants, where job titles such as "team member" are typical.

At higher levels, typical examples of new job titles include:"CIM training expert", new product manager", "matrix manager".

2.5 Other Innovations

There are examples of many other types of administrative innovations being attempted for hierarchical integration. Some of these are summarized below:

i) Building greyfield plant (i.e. plant which is usually built alongside or within an existing, older manufacturing facility. This is an example of plant within a plant or focussed factory. Specific experiments tried out in one such plant included videotape presentations on new jobs for orientation and selection of employees stress monitoring and reduction programs and product-process teams.

ii) Restructuring a division to deploy a full integrated manufacturing system - involving broadening of both blue collar and while collar job descriptions for all levels of the plant and division.

iii) Use of autonomous work groups, as part of sociotechnical programs targeted at changing social and technical systems at the same time. Experiments such as self-direction and rotation of tasks among group members, engineer - blue collar teams are common.

iv) Design of an FMS by a quality circle.

v) Work redesign - one experiment included articulation of the firm's mission, reframing the technical process of manufacture, and redesign of operator jobs into much broader category of "manufacturing technicians".

3. Strengthening Links between Design and Manufacturing

As we said earlier, to achieve synchronous integration, apart from integration of organizational hierarchy, it is very important to bring about a design-manufacturing integration (DMI). Studies show that a lack of integration between product development and process development is often the primary cause high manufacturing cost. Nearly as much as 70 to 80% of a product's manufacturing cost is determined very early in the design stage, and design for assembly alone is known to potentially reduce manufacturing costs by as much as 20 to 40%. Let us first consider a few of the emerging patterns and then review briefly a few case histories of companies who have attempted design manufacturing integration.

Table 3 gives examples of the different types of administrative innovations tried out by a few U>S firms to bring about Design Manufacturing integration.

Table 3 : **Administrative innovations to enhance Design-Manufacturing Integration (DMI)**

Company/Mfr.	Design-Mfg. teams	Compatible CAD systems	Common reporting positions	Design for Mfg.	Engineering generalists	R & lead Time redution
Off-road vehicles	X	X	X			
GE Stem Turbine		X				
Components Supplier	X			X	X	

Company/Mfr.	Design-Mfg. teams	Compatible CAD systems	Common reporting positions	Design for Mfg.	Engineering generalists	R & D lead Time reductions
Chrysler	X			X		X
Tool manufacturer	X					
Appliance Division				X		
Rockwell space		X	X			
Allen Bradley	X		X			X
Amana	X			X		X

Let us briefly consider each one these innovations.

3.1 Design Manufacturing Teams

As seen in Table 4, in 6 out of 9 cases cited, an unprecedented developmental team was put into place to facilitate Design-Manufacturing Integration (DMI). In this, core members of the team who are representatives of design and manufacturing engineering are relieved of day to day preoccupation. They are dedicated to strategic and advanced development work. There is no common criterion or pattern for inclusion of members of other functional areas. For example, some teams include people from purchasing, others do not. Thirdly, the standardization of simple, repetitive design features such as bolt-holes, rounds and fillets is often taken for granted.

Such team effort has often come to be known as "simultaneous engineering" or concurrent engineering". This is the most common method of DMI. Team building ability of the modernization project manager, and risk taking climate of the firm have been found to influence the shapes the teams take on in competitive situation. Such teams are considered crucial for manufacturers' competitiveness in future.

3.2 Compatible CAD Systems for Design and Tooling

A common pattern for deployment of CAD technology todate has been to let a centralized R & D design function to take full responsibility for CAD Manufacturing engineering. As a result CAD was rarely integrated with product manufacturing design base. CAD/CAM integration is one of the distinct goals pursued by some firms to bring out DMI. Such integration however may require longer time to accomplish and will depend upon external information available, availability of CIM expertise, etc.

3.3 Common Reporting Position

Some firms have attempted to create a common, consolidated organizational reporting relationship to achieve DMI. Such co-ordination is achieved in a number of ways such as i) information division as the coordinator ii) formation of a new coordinating group such as Advanced Automated Technology Systems Group (for example: Case of GE steam Turbine) iii) Creation of a new position to co-ordinate such activities iv) creation of a temporary task force with a manager to head the task force. A few characteristics of these arrangements are noteworthy.

First, these attempt to create common reporting for at least some related functions like advanced process engineering and information technology. Second, this adaptation illustrates one emerging solution to the growing conflict between MIS and CIM functions in to-day's organizations. As further step in this direction, some firms require design engineer to have a "dotted line" relationship to the CIM plant manager. Finally, this type of structural adaptation usually does more than integrate design and manufacturing and typically involves co-ordination of marketing, planning and quality control.

3.4 Engineering Generalists

This is indicative of a very definite trend being witnessed towards development of engineers needed to integrate design and manufacturing. Experiments made in this direction include the following:

i) Movement of engineer from design to manufacturing engineering.

ii) Creation of a position called "producibility engineer" to support DFM effort.

iii) Imparting special training to product and process engineers on design for manufacturing.

iv) Creation of specific job titles called "engineering generalist".

These experiments have established the need for longer training and development periods on the job, perhaps less specialization, but a specialist with a broader background.

3.5 R & D Lead Time Reduction

The R & D lead time to launch product depends on vendors, manufacturing facilities, distribution system and a variety of other factors, in addition to lead time from the laboratory to the shelf. Evidence shows that a plan to reduce R & D lead time is part of DMI.

Firms generally tend to formulate a plan to reduce product launch lead time, which includes strategic actions such as setting up planning committees, creation of special positions for modernization, technology sharing programs across organizations,and formulation of more aggressive manufacturing technology policies.

3.6 Design for Manufacturing (DFM)

It has been observed that many of the problems connected with DMI are successfully resolved with **corporate commitment** to Design for Manufacture (DFM) - this **simply means**, to have a product that is designed to be manufactured, assembled, inspected and tested in an unattended or partially attended plant environment.

Standardization of fasteners, elimination of awkward design features, elimination of processing steps and specially the substitution of new materials are paramount examples of new philosophies that emphasize DFM in durable goods sector. Concurrent engineering, and Group Technology are important parts of the philosophical shift to DFM. Nevertheless, a DFM program to be really successful in the long term must not ignore the **"flexibility"** aspect. The right amount of flexibility and the **strategy for migration** to the next generation technology are priority elements. That should be considered in a DFM program.

4. Using Suppliers and Customers to Enhance Synchronous Integration

Any modernization effort takes place in the broader context of the firm's strategy. Consequently, the history of the firm is important to a modernization program. Understanding the past is essential to customizing a synchronous innovation approach to the future. Second, the suppliers of technology, parts, services, or advice constitute an important dimension of modernization. Customers are the third element.

Perhaps, the most significant trend in supplier integration today is the shift to **JIT purchasing**. While discussion of JIT itself is not the subject matter here, but many aspects of JIT manufacturing such as JIT purchasing, flexible work teams, waste elimination techniques, etc. provide an ideal foil to synchronous integration strategy. JIT purchasing necessitates development of new relationships with vendors based on trust and shared commitment to defect-free, on time deliveries. Long term contracts, rationalized supplier base, relocation of JIT supplier, co-operative transport arrangement, more vigorous vendor development are crucial elements of JIT purchasing. They will clearly go a long way in bringing about supplier integration as part of synchronous innovation strategy.

Secondly, almost every effort towards large scale modernization program is to-day accompanied by integration with a JIT manufacturing philosophy, so that the two corner stones of this philosophy, namely **"elimination of all waste" and continuous improvement"** are sought for, to obtain optimum results with the implementation of advanced manufacturing technology. Naturally this results in fostering a strong relationship with the customers. In the final analysis, the very fundamental rationale of JIT philosophy and NMT is to seek highest levels of customer satisfaction. Marketing participation in modernization is a concrete way of focussing modernization to meet customer needs. Advertising the new process technology to the customers is a common approach to make customers aware of the organization's pride and success in a modernization program. Often the valuable feedback obtained from the customer helps turning a failing modernization program into major success.

A very good example of directing synchronous innovation to achieve customer integration is provided by Campbell soup Company (Camden, New Jeesey). This Company launched a 5-year $1.2 billion program of change called **"Total Systems Approach"**, in response to foreign and domestic competitive pressure. The approach was an organized plan to improve the quality and consumer value of products by being more sensitive to the needs and wants of customers and consumers. The program involved efforts to enhance production, distribution, quality, and value while maintaining competitive cost. Beginning with distribution logistic team, an agenda was developed to identify customer needs via personal visits to more than 100 customer locations and interviews with customers. The team found that the customers valued most highly on time delivery, completeness of orders and assistance in attaining high product turnover. The team set out tasks in two areas: development of data base for analysis of Campbell operations and concentrated approach to integrate corporate activities. A distribution and logistic department was formed to manage total work flow from ingredients to finished goods. An SQC system was developed which reduced the damage rate by one third by the end of the fiscal year. A Logistic Control Center was developed, which functioned as the intelligence center for the entire company.

Initial success stimulated Campbell to go for more radical changes such as: small batch flexible production with minimum changeover times, integration of worldwide sourcing, and a total reorganization of the sales force, which enabled sales personnel to tailor local promotions to local market segments via satellite dishes at regional offices. This is an excellent example of customer-driven organizational experiment in synchronous innovation.

4.1 Relationship with Technology Supplier

Of special importance in modernization program is the relationship with technology suppliers. No program is free from stress at the technology vendor user interface and considerable attention is paid to manage this interface. Joint ventures, buy-outs, special partnerships, personal sharing are among the tactics used for acquisition of Advanced technologies.

Table 4 summarizes results of some survey studies on effects of modernization on relationships with vendors.

Table 4: **Effects of Modernization on Relationships with Vendors (based on Surveys reported by Ettlie).**

Survey Date	Type of System	Effects
1971 (Ettlie)	9 NC installations	Plant shop floor people learn most from OEM Service people.
1975 (Ettlie & Rubenstein)	6 NC, CNC plants	OEM and user interface is key for learning
		Previous Experience with NC helped firms to attain higher utilization rates faster with CNC.

Survey Date	Type of System	Effects
1983 (Ettlie)	21 Suppliers & 17 users of FMS & robots	Vendor user relationship is prime cause of success or failure.
1984-86 (Ettlie)	39 domestic plants installing flexible systems	Good vendor user ties are associated with shared influence in system design.

All the surveys point to the need for a strong vendor user relationship for achieving success in deployment of new technology.

The last of the surveys mentioned above led to the following important conclusions:

i) Technology vendors and users that share equally in designing the system are reported to have the best relationship.

ii) Users who embarked on some type of administrative experiment at the same time as they deployed the new system reported a high quality vendor user relationship.

iii) An on-budget project was associated with a good vendor user relationships.

iv) When technology vendors and their customers have a good working relationship, the customer plant's engineers and skilled trade personnel report lower role stress.

v) In the opinion of plant personnel, team building ability is the single best indicator of a project manager's success.

5 Changes in people and jobs during modernization

In developing a synchronous innovation strategy, it is pertinent to take into account the nature of changes that could occur among people and jobs involved in modernization. When manufacturing technology changes, jobs also are expected to change, but not always in predictable and easily defined ways. Two simple but pertinent questions arise in this context: **What do people have in common during modernization? What are the differences among these broad job categories during modernization?** "Role Stress" is a good criterion to make comparisons among people during modernization. Stress is encountered by all members of the implementation team on large modernization projects. "Job routines" is often used as a good indicator of the stress and job routineness during modernization is a U-shaped curve, as shown in figure 2 below.

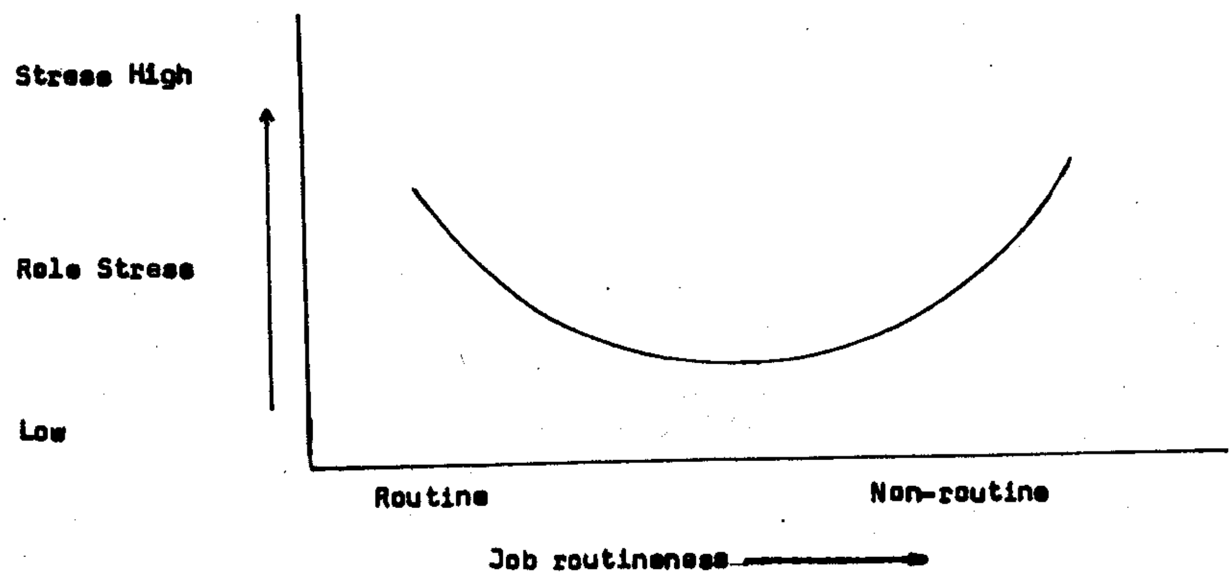


Fig. 2: Role stress and job routineness relationship.

This implies that most people on a job with new processing technology experience stress when there is not enough to do as well as when there is too much to do. Jobs with a moderate amount of routine are associated with the lowest reported stress levels. Thus, in terms of stress there is an optimal amount of routine in modernization jobs. So if a low level of stress promotes learning, then gradually increasing job challenge is the prescribed course of action. This finding is regardless of the occupational category of jobs.

Another important finding is with respect to the autonomy on the job (decision-making freedom). Over time for all members of the implementation team, the job autonomy decreases, regardless of the occupation. As interdependence between jobs and integrated functions or relationships increase in modern manufacturing organizations, there is trade off of some decision making freedom in order to achieve coordination. Skilled trades and operators seem to give up more autonomy than others. (see figure 3 below).

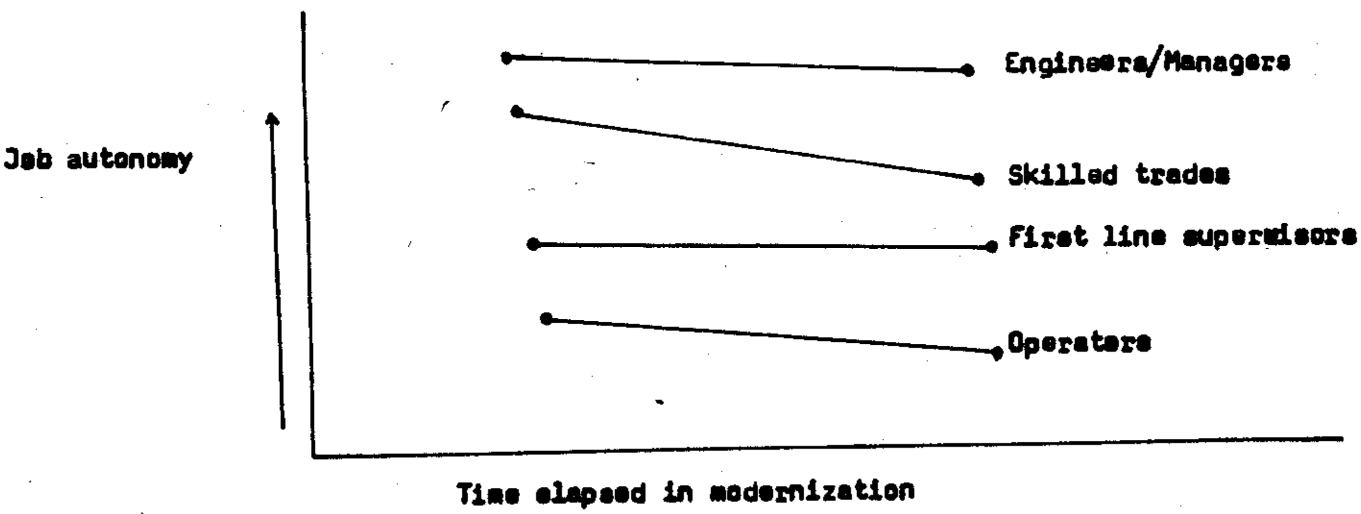


Figure 3: Variation of Job autonomy during modernization

Even though the trends in respect of role stress and job autonomy are similar across occupations, there are interoccupational differences also. To analyze these, it is useful to form the following occupational groups:

i) Managers and engineers

ii) Operators and first line supervisors.

iii) Skilled trades

5.1 Managers and Engineers

Taken together, they are quite different from employees in other job title classifications involved in modernization. They have consistently more autonomy (fig. 3) require and use more skill variety on the job (fig. 4) and report greater personal satisfaction (fig. 5) than other members of the modernization team. Also they show considerably reduced stress as modernization progresses (fig. 6). An important issue arising out of this is how to effectively form teams that involve occupations outside of management and engineering. Engineer - blue collar teams perhaps provide the most effective answers to this. As regards job security, there is some anxiety about job loss amongst managers & engineers (fig. 7).

5.2 First line Supervisors and Operators

Supervisors and operators show approximately the same level of personal satisfaction (fig. 5), stress (fig. 6) and about the same amount of decrease in them as modernization progresses.

However, supervisors use a much higher variety of skills on the average (fig. 4). For both occupations, as modernization progresses, the skill variety decreases (fig. 4). Further, supervisors experience a much higher job autonomy than operators (fig. 3). Interestingly, supervisors experience greater job security with the progress of modernization (fig. 7). Overall as modernization proceeds, supervisors are less disadvantaged than other occupations in coping with stress. But it is important to note that supervisors reported the lowest level of personal satisfaction, and a role stress next only to skilled trades with the progress of modernization. These findings might be linked to the erosion of autonomy experienced by supervisors. Also generally supervisors tend to be isolated during early stages of deployment process and are less likely to be exposed to training, or participation in planning of modernization. These factors probably contribute to a higher perceived stress on the part of supervisors.

5.3 Skilled Trades

Skilled trades are perhaps the most difficult to make predictions about. They are the only group that experience sharply higher role stress (fig. 6) with modernization. This may be because the burden of implementation falls squarely on skilled trades. Their autonomy decreases during implementation (fig. 3) as they are frequently required to report to more than one supervisor. The skill variety is however affected very little by the progress of modernization (fig. 4). Surprisingly, they report higher personal satisfaction (fig. 5). This is probably due to important, though altered role played by skilled trades in modernization. They are most likely to be the beneficiaries of training and participation in planning and to play a crucial role in implementation. The most significant finding is the skilled trades experience sharp increase in role stress, primarily caused by role conflict.

Two general recommendations emerge from these studies. First, all members of the group responsible for implementing new manufacturing technology should be trained initially by the technology vendor or a qualified alternative source of development. In house training and development will needed in addition. Secondly, the modernizing firms should develop and implement a policy that will minimize and accommodate any displacement or dislocation caused by modernization for all occupations.

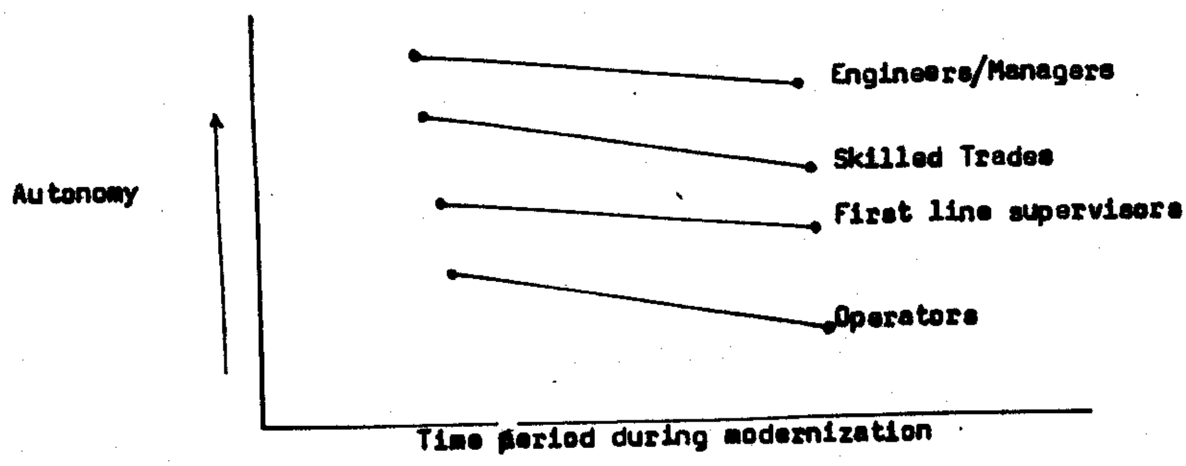


Fig. 3 Autonomy by Job title

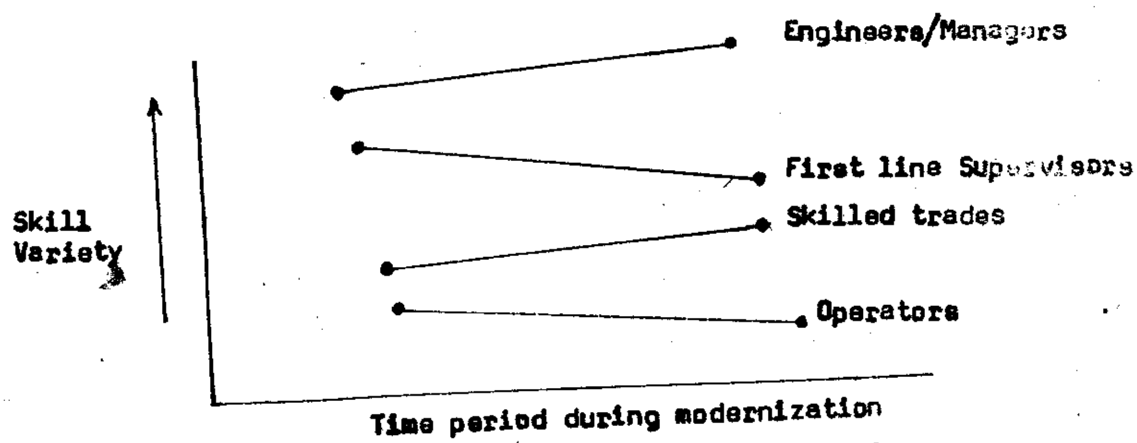


Fig. 4 Skill Variety by Job Title

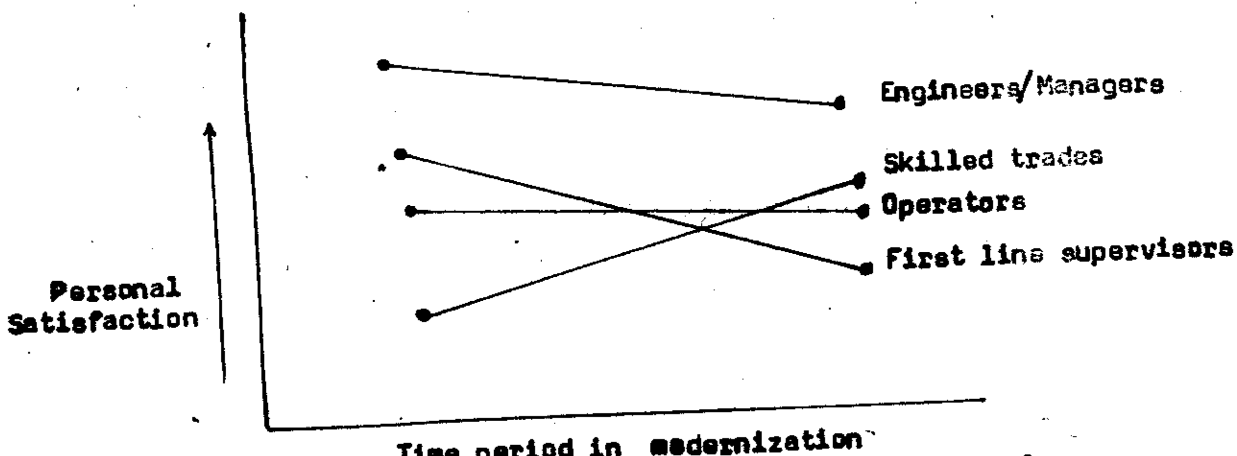


Fig. 5 personal Satisfaction by Job Title

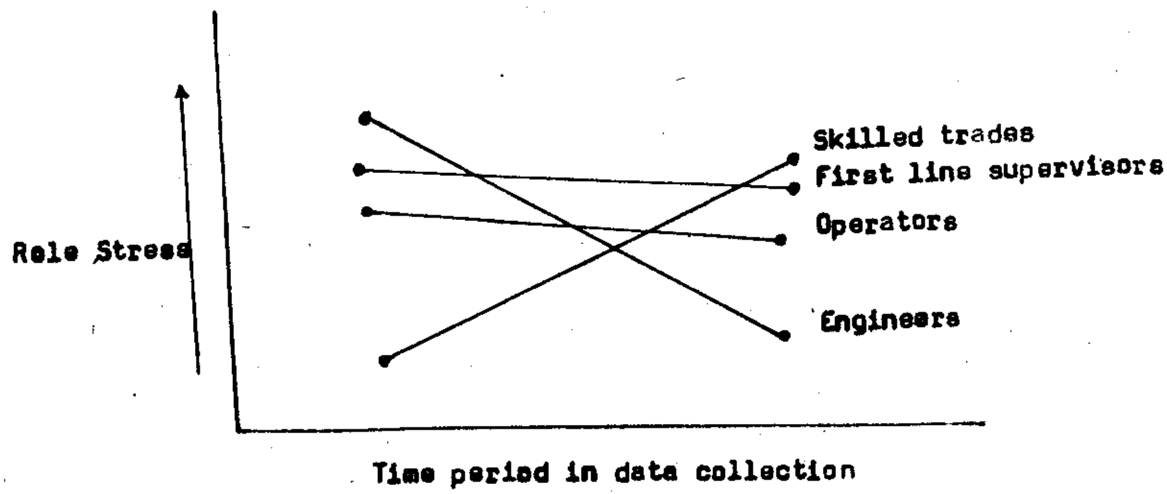


Fig. 6 Role stress by Job Title

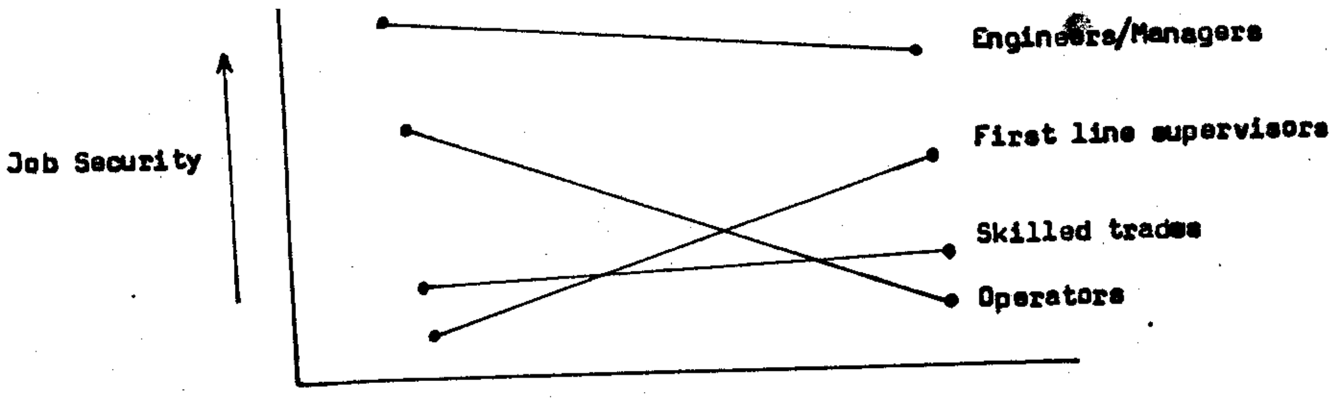


Fig. 7 Job security by title

6. Guidelines for adopting synchronous innovations

Foregoing discussions on analysis of empirical evidence and experiences regarding technological and organizational innovations during modernization help formulate a few guidelines for adoption of synchronous innovations in manufacturing modernization programs.

i) First, there should be a way of coordination of all designs of a manufacturing company - both product and process designs. Concurrent engineering, design for manufacture, creating a coordinating position in the hierarchy are some ways of doing this. A good indicator of effectiveness of such design - manufacturing integration effort is the successful use of group technology.

ii) There should specific attempt to control the overhead. Increase in the productivity of white collar staff and manager. Inventory control is at the heart of the emerging success pattern. The modernizing firm should aim at continuous overhead reduction through successful connection between quality, inventory management and managerial/professional productivity.

iii) Human resource (HR) policies should be in step with the nature of change being brought about. Some desirable elements of HR policies are:

a) Recruiting important new talent into the firm
b) Developing existing talent within the firm
c) Accommodating graceful retrenchment to smaller staff with more productive individuals in newly created positions.
d) Move towards multiple, permanent assignments through expanded job descriptions, for development and work performance.

iv) Success is found to depend a great deal on the degree to which general managers model the behavior they expect of the rest of the organizations. For example if they seek participative decision making, they should demonstrate the same, rather than order someone else to practice it.

v) Successful organizations put considerable emphasis and develop competence in management of core and emergent technologies including those in materials, product, and support activities, apart from automation. Successful firms therefore continuously seek integration with suppliers and customers to give directions to their technology enhancement programs.

vi) Pursue a synchronous innovation strategy i.e. match the degree of radicalness of change in the two areas: i.e. technology and organization, by staying on or close to the diagonal between technological and administrative innovation. Thus firms that use low-low, medium-medium and high-high approach are more likely to be successful. This assumes that firms have made a correct assessment of the technological change necessary.

References

1. John E. Ettlie - **Taking charge of manufacturing (1988) Jessey - Bass Publishers, USA**

APPENDIX

Case Histories in Synchronous Innovations

In this appendix, we briefly review a few case histories reported in the literature on the adoption of synchronous innovation.

1. **Xerox Corporation:** Xerox's case pertains to the successful introduction of its 9900 copier in two and a half years, instead of the normal 5 years required for a new product of this type. Since 1980, the company spent nearly $100 million to automate manufacturing and materials handling. It cut the manufacturing costs in half for its $8.79 billion copier business. Some of the administrative innovations introduced were as follows:

   i) Use of a complex network of product-process development teams, crisis teams and problem solving teams.

   ii) Switch to JIT purchasing, reducing the vendors from 5000 to 300.

   iii) Restricting the new components to only 30-40% of the total, thus emphasizing the DFM approach. Apart from cost reduction, Xerox improved the product quality and enhanced customer satisfaction by nearly 30%.

2. **General Electric (GE) Bromont:** This plant is a division of GE's Aircraft Engine Group. It began operations on airfoil sets

in 1983, with plans to automate 35-40% of the operation by 1988 and eventually to have 46 robotic centers. A "CIM dream" facility incorporating integrated fool and guage control factory management, purchasing, shipping, and CAD/CAM was the goal. When Automation proceeded to the extent of 6 robotized systems with 17 robots, 2 vision systems, 5 programmable controllers, including hot forming and laser marking, the plant reduced the manufacturing time from average 540 hours/blade set to av. 520 hours and improved quality greatly so that the return rate of parts was just 30 ppm. The administrative innovations adopted include:

i) Semi-autonomous work teams consisting of representatives of production workers, support staff, and management who were responsible for scheduling, budget, personnel and a wide range of other decisions.

ii) Employee sharing in the savings resulting from reduced expenses at the plant.

3. GM's Linden and Wilmington Plants

GM's Chevrolet-Pontiac-Canada (CPC) Group's Linden (New Jersey) and Wilmington (Delaware) plants launched a $300 million automation program at the two plants to produce Chevrolet four-door Corsica and two-door Beretta automobiles, with plans to produce 250000 Cars per year. An addition $340 million was spent at the

CPC Tonawanda, New York engine plant. In conjunction with the technological modernization program, the following administrative innovations were used:

i) 3700 employees at the Linden plant received an average of 200 hours each of training, including training in interpersonal and technical skills.

ii) Every employee was a quality inspector and could correct problems on line.

iii) Water Jet Cutting was used for finished composite parts to produce safe, quiet, dust-free environment. The Linden Plant's technological program included 219 welding robots, 115 automated guided vehicles (AGVs), parallel processing line that integrated robots,and AGVs with artificial intelligence software. Additional administrative innovations were:

a) Flexibility in engineering and automation to respond to market changes on very short notice.

b) JIT deliveries from 40 suppliers, reducing inventories and expenses by more than 40%.

c) A team approach to design and launch the product and the plant simultaneously.

d) Analysis of competitors' components and prototype testing.

e) Line speeds deliberately reduced (from 60/hr to 50/hr.) to maintain quality.

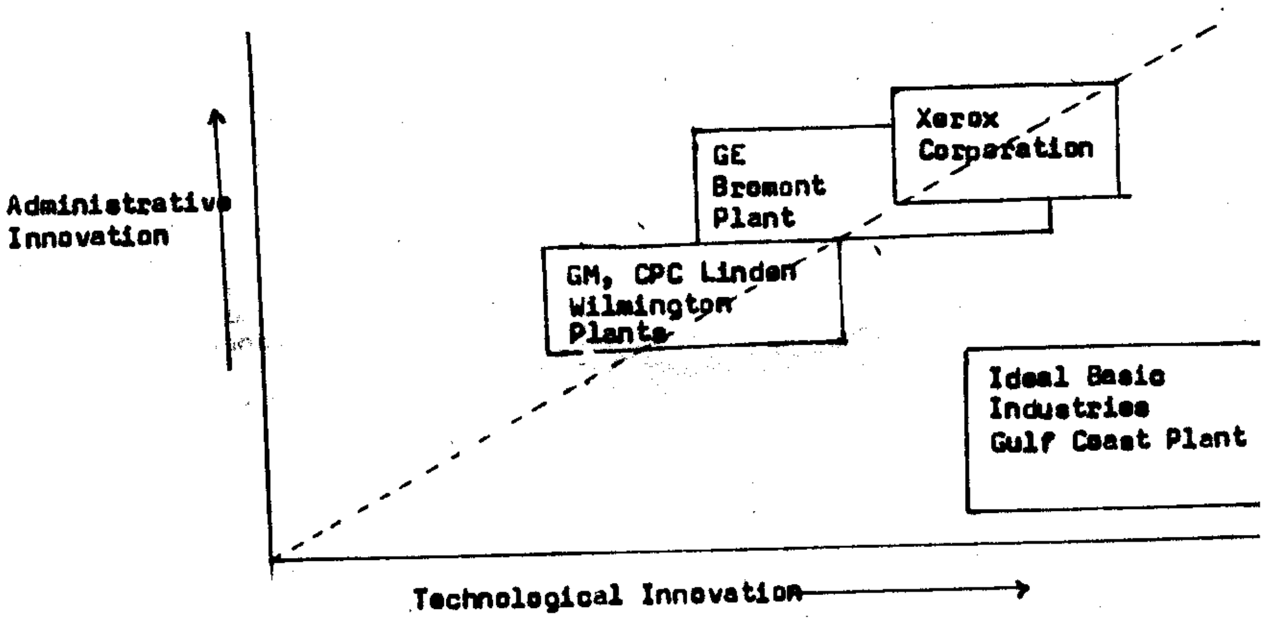
f) "Stop the line" cords or buttons every 200 feet so that workers could interrupt production if needed to maintain standards.

4. **Ideal Basic Industries**

This is a Denver Cement Company that flourished until the cement market collapsed in 1982. It built a "State of the art" plant that turned out to be " engineering disaster".

The plant completed (100% over budget) in 1981 at a cost of $350 million had to idle since it could not process local raw material and lacked AI for dealing with environment requirements - a clear example of lack of synchronous strategy.

The four cases cited above can be represented on the AI-TI matrix as shown below.



We can see that Xerox, GE Bromont, GM's CPC Linden and Wilmington plants all of which were successful fall on or close to the synchronous diagonal. Ideal basic industries which innovated exclusively in technology and failed, does not.

Hierarchical Integration in Synchronous innovation-

5. Case study of GM's Saturn Division

This is one of the most visible attempts to create a new form of organization for a high tech manufacturing facility. Saturn was initiated in 1984, with the promise of direct involvement in the planning of a Japanese high tech, modular construction approach. It sought to create a new work culture, unique to American manufacturing and GM. Reduction of direct labour time from 55 hours to 20 hours, operating in a "paperless" environment (thus reducing indirect costs to 30% of total work hours needed to build an automobile) were amongst the major goals. Although the original $3.4 billion budget was later cut in half to $1.7 billion (in 1986) and the planned capacity was scaled down from 50000/year to 250000/year, the Saturn case is still a good illustration of an attempt at creating an egalitarian corporate environment and emphasis on more efficient organization of human workers. Much of the success of the Saturn culture is attributed to three characteristics: i) that it is considered valuable in its impact on financial performance ii) it is rare or uncommon iii) it is imperfectly imitable so that others are at a disadvantage in copying it.

6. Case of Westing house Nuclear Fuel Plant in Columbia (South Carolina - 1986)

This is a highly automated plant installed within an existing plant, designed to expand capacity by one third. Only one job classification "team members" was used in the plant. The project titled "Manufacturing Automation Project" had two goals - maximize productivity and employee participation. The team managers were selected on the basis of 14 capabilities including communication, coordination, creativity, delegation styles, and stress tolerance. The reward system sought to promote learning of new skills, reinforce excellent performance, promote cooperation.

Design Manufacturing Integration - DMI

7. Case Study of off Road Vehicles

The off road vehicles division of a large, diversified manufacturing corporation installed an FMS to machine large geometrical cast parts that are then welded in a nearby robotic cell. It started an integrated CAD program in which programmers did both graphics and NC tape preparation. At the engineering level, design and manufacturing engineering were required to work together as a "coordinated team". Simultaneous product and process design & engineering were adopted.

8. GE Steam Turbine Division

GE's Steam Turbine Division was the winner of 1984 CASA/SME LEAD award for excellence in CIM deployment. When the 10 year program was half completed, it had realized a 35-40% increase in throughput for the manufacturing function. The Turbine division created one system manager position to head a new Advance Automated Technology Systems Group that was established to deploy CIM. This group integrated manufacturing and engineering through 5 teams: i) advanced engineering and manufacturing for group technology, integrated data base and automated process planning ii) advanced systems design responsible for emerging technologies and coordinating the master plan iii) Systems applications for advanced plant engineering and for hardware and software installations iv) NC programming and v) data administration.

9. **Chrysler Corporation**

Chrysler recently announced that its Trenton, Michigan plant is tooling up for a 3.3 litre V-6 gasoline engine. This was Chrysler's first tooling program to employ simultaneous engineering in which manufacturing engineering played a role in designing the product in order to ensure that it can be built efficiently. Other automobile manufacturers namely GM & FORD are now practicing this approach to integrate design and manufacturing.

10. **Allen - Bradley**

Allen Bradley (AB) produces a diverse line of electrical and electronic equipments with head quarters in Milwaukee. It started implementing a "strategic business objective" of installing a fully automated assembly line for new line of motor contactors in late 1984. Implementation was carried out by forming "planning teams" and appointment of a CIM project manager to whom all the teams reported. When the program began, the planning teams consisted of more than 25 people representing "all the departments being affected" including finance, marketing, quality control, MIS, cost control and development. The actual task force of 8 members formed the successful design-manufacturing link. It consisted of manufacturing, production, plant equipment engineering purchasing and inventory control, testing ad AB's special Industrial Automation Systems (IAS) group, which acted as AB's system integrator. The system design enabled AB to i) use no direct labour ii) produce 600 contactors per hour iii) make any of 125 varieties of International Electro technical Commissions (IEC) contactors. iv) assure high quality v) produce and ship an order in 24 hours vi) produce and ship on a first come first serve basis vii) produce in lot size of one and move to stockless production. The $15 million world contactor line now produces 143 variations and AB aims to capture 30% of worldwide market share.

The field failure rate of products coming off the world contactor line averaged 15 units per million shipped, compared to AB's average field problem incidence rate of 120 units per million shipped. Careful scrutiny of AB's case by researchers reveals that the world contactor line was probably an incremental departure in technological innovation. Consequently, according to the theory of synchronous innovation strategy, a modest administrative innovation strategy ought to be used to deploy the flexible assembly system (FAS). Indeed such an approach was followed . The FAS was run by non-union employees for first 18 months of its operation as part of the Technology agreement with the union. A large cross-functional team was created to plan and install the system. The person responsible for much of equipment design took over as manager of the line. Some amount of concurrent engineering was practiced.

Thus, the AB's world contactor line case can be take as a powerful illustration of the effectiveness of the synchronous innovation strategy.