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PLANNING PROCESSES FOR ADVANCED MANUFACTURING TECHNOLOGY BY LARGE AMERICAN MANUFACTURERS

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ABSTRACT

In response to an increasingly competitive environment, many manufacturers have invested in advanced manufacturing technology (AMT). While many studies regarding the use of AMT have been performed, little is known about how firms plan and manage their AMT investments. This is surprising given the evidence about the impact such investments can have on an organization.

To address this, a survey of large American manufacturing firms was conducted. Respondents were asked, among other questions, why their firms made such investments and the fit with their business strategy; which functional areas were involved in idea generation, the planning process, and proposal assessment; and what the anticipated risks, difficulties and benefits were from making such investments. The results from this survey are provided along with an analysis of the responses.

Keywords

Advanced Manufacturing Technology, Planning, Implementation, USA, Australia

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1. INTRODUCTION

The competitive environment continues to become increasingly more demanding. The North American Free Trade Agreement (NAFTA), for example, has resulted in a considerable amount of pressure on manufacturers in the USA and Canada to introduce greater numbers of new products, to shorten time to market, to increase customer service levels, to provide higher levels of conformance and quality, and to offer more variety in their product lines. Reduction in trade barriers in other parts of the world have also presented new opportunities for North American manufacturers. In the current manufacturing environment characterised by low volumes and high variety, the adoption of advanced manufacturing technology (AMT) can provide many strategic benefits for the firm.

The introduction of AMT has taken many forms and acronyms. AMTs refer to a family of technologies which includes computer-aided design (CAD), computer-aided engineering, (CAE), manufacturing resources planning (MRPII), automated materials handling systems, electronic data interchange (EDI) and computer-integrated manufacturing (CIM) systems. These technologies enable both economies and scale and economies of scope to be achieved without changing the hardware. The major strategic benefits that these technologies offer are the increased flexibility and the responsiveness, enabling an organisation to substantially improve its competitiveness in the marketplace.

These new technologies require significant financial commitments in terms of hardware, software, support systems, and training. In addition, obtaining the greatest benefits generally requires alterations in other functional areas of an organization, such as marketing and maintenance. For example, firms that have achieved flexibility in their operations have entered market niches that in the past were neglected because the requisite capability to serve these niches effectively did not exist previously. Similarly, more emphasis must be placed on preventative maintenance policies since many of these AMTs account for a substantial proportion of the firm's investment in production technology and any amount of downtime can significantly increase operating costs.

These competitive conditions and internal commitments make planning difficult for investments in AMT. Balancing the need to create a competitive advantage and the investment of time and money is required when AMT acquisition decisions are being made. This study explores the challenges associated with planning AMT investments and reports the experiences of 93 major American manufacturing organizations. In addition, results from the USA are compared with a similar study conducted in Australia.

A number of studies regarding the use of AMT in various forms have been performed (see, for example, Boyer et. al., (1996) for a comprehensive review.) Yet, little is known about how firms plan and manage their AMT investments. This is surprising given the evidence that exists about the impact such investments can have on an organization.

To achieve the system wide benefits from AMT proffered by its exponents, there must be an alignment between corporate and manufacturing strategy. An inadequate appraisal of business needs and the exclusion of such needs in the assessment of AMT has prevented some firms from benefiting from their AMT investments (Zairi, 1992).

Success will also depend on the ability of the organization to assimilate such new technology. It has been argued that firms that adopt AMTs without first redesigning organizational structures and processes risk institutionalizing bad practices (Duimering et. al. ,1993). Bessant (1994) also emphasises the many dimensions of the organisation which are impacted by AMT investments. At the work, management and inter-firm levels, he argues the need for parallel organisational change to accompany the investment. Similarly, Zammuto and O'Connor (1992) draw attention to the importance of organisational design and

culture in their discussion of the relationships among a company's culture, structure and the potential outcomes of an AMT investment. Clearly, companies need to rethink how their inter- and intra-organizational processes will be impacted as a result of AMT investments.

Finally, AMT is not just about technology, organizational structures and business processes. The human element must also be addressed along three dimensions. First, AMT implementation failure has been attributed to the neglect of critical human resource factors (Saraph and Sebastian, 1992). Thomas and Wainwright (1994) also emphasise on the internal politics, especially the link between "people issues" and successfully obtaining the benefits of AMTs. Resistance to change is to be expected, but this resistance can be managed through effective communication programs and the involvement of individuals during the planning process. Second, AMT is successful only when people want to use it (Markus and Keil, 1994). A number of factors can facilitate the acceptance of such investments through incentive schemes and the use of cross-functional teams. Third, most firms with successful AMT implementations enlist champions. These individuals provide a continual driving force throughout the initiative [Beatty (1992), Singh and Sohal (1995), and Sohal (1996)].

In light of the demonstrated importance of the above factors, we were able to identify only a few studies that have examined in detail the AMT planning process. In addition, only two of these few studies were conducted in the US.

Currie (1989) found that the process of decision making for CAD systems was ad hoc in a study of twenty British firms. Technology was often introduced in a fragmented manner and was targeted to achieve narrow operational benefits in most of the firms examined by Currie. In studying how corporate managers evaluated new technologies, Gold (1988) found that the problems were not so much with the technologies as with the misconception of managers both in evaluating capabilities before adoption and in appraising efforts after implementation. Kaplan (1986) calls for more sophisticated financial appraisal of AMT investments and highlighted by Howell and Sourcy (1987) and Adler (1988) , the need to accommodate the less quantifiable effects of AMT. Small and Chen (1995) examined the impact of financial justification approaches and criteria at the plant level on the adoption of more integrated technologies. Their study provides insights into the formation of decision-making teams for the justification process.

In a series of papers, Sohal et. al., have examined the AMT planning process by manufacturers in Australia [Sohal (1997), Sohal et. al. (1991)], New Zealand (Sohal et. al., 1996) and the United Kingdom (Sohal, 1994). This series of studies are more comprehensive than others in that the AMT idea generation, idea development, justification, implementation and post-implementations processes were investigated, and examined from the perspective of senior management of the firms.

A question still remains, however, as to what processes are employed by major American manufacturing firms. In order to examine this question, a questionnaire survey was conducted amongst the largest American manufacturing companies using the survey instrument previously employed by Sohal, et al. in a number of other countries. The next section (Section 2) describes the research methodology. This is followed by the main section of the paper (Section 3) which presents the overall findings from the American study. In Section 4, the key findings from the American study are discussed and a general comparison is made with the key findings from the 1993 Australian study.

2. RESEARCH METHODOLOGY

The survey instrument used for the American study was based on the original questionnaire used by Sohal, et. al. (1991) to study the planning and implementation of AMT in Australia. The questionnaire comprised the following sections:

- Company background details
- AMT investment proposal generation

- Proposal assessment
- AMT implementation
- Post implementation study

The main issues addressed by the research reported on in this article and the earlier article were:

1. Why do companies invest in AMT, and what effects do company factors (e.g., size) have on these decisions?
2. What are the size and nature of AMT investments?
3. Which functional areas generate investment ideas involving AMT and which functional areas are involved in the planning process?
4. How good was the fit between the AMT proposal and the business strategy?
5. Which functional areas were involved with the proposal assessment and which financial techniques were employed?
6. What were the anticipated benefits, risks and difficulties?

The sample for the study was selected from Business Week's 1995 list of the 1,000 largest US companies. From this list, only manufacturing firms were selected. Furthermore, the major operating divisions of the large diversified companies (for example, General Electric's Locomotive, Airplane Engine, and Plastics divisions) were identified as well.

The name of a senior level executive in Manufacturing, Research and Development, Technology or Process Development was researched. A questionnaire was sent only when such an individual could be identified by name. This process resulted in a sample of 446 manufacturing organizations which represented a cross-section of most of the industrial sectors. Manufacturers using all types of production methods were represented in the sample.

The questionnaire together with a covering letter and a pre-paid reply envelope were mailed out during the Fall of 1996. A total of 124 questionnaires were returned and no follow-up was conducted. Of this number, 93 contained useable responses. This resulted in a response rate of approximately 21% which is similar to response rates reported elsewhere for surveys of manufacturing practice [King and Grover (1991), King and Ramamurthy (1992), and Raho et. al. (1987)].

3. SURVEY FINDINGS

This section presents the overall findings from the American study. First, the profile of the responding companies is presented. Then, each of the six research issues presented earlier are discussed.

Respondents Profile

The number of employees and annual sales revenue for the sample are provided in Table 1. More than half of the sample had revenues in excess of $1 billion, and approximately half employed between 1,000 and 10,000 people.

Flowline production is the principal type of manufacturing system used by 35% of the responding companies. Thirty-two percent employed continuous processes, 28% batch production and 5% job-shop type of manufacturing.

Table 1: Characterisitics of Responding Firms

Annual Sales Revenue	n	%
$100M to $1,000M	44	47
> $1,000M	49	53
Employment	**n**	**%**
500 to 999	9	10
1,000 to 9,999	46	49
> 10,000	38	41
Principle Type of Manufacturing	**n**	**%**
Jobbing	5	5
Batch	26	28
Flowline	33	35
Continuous	29	31

Question 1: The purposes of AMT investments.

Investment in AMT is one manner in which manufacturers believe they can improve their competitive position in world markets. This is reflected in the responses to the question concerning the reasons for investing in AMT. Respondents were provided with a list of five reasons for investing in AMT and asked to indicate the importance of each on a scale ranging from one (most important) to five (not at all important). The mean score of the responses was calculated for each reason, and the resulting values are provided in Table 2.

Obtaining financial benefits and competitive advantage were the most important reasons given for investing in AMT with mean scores of 1.15 and 1.16, respectively. The next most important reason cited was to counter competitive threats, followed by countering skill deficiencies and enhancing the company's image. When analyzed by company size (measured both as annual sales revenues and number of employees), no statistically significant relationships were identified.

Table 2: Motivations for AMT Investments

Reasons	Mean Score
Obtaining financial benefits	1.15
Obtaining competitive advantage	1.16
Countering competitive threats	2.06
Countering skill deficiency	3.06
Enhancing company image	3.74

(1 = most important, 5 = not at all important)

Question 2: The size and nature of AMT investments

All respondents indicated that there had been more than one AMT investment in their company in the past three years. The percentage of firms investing in various types of AMT in the past three years is shown in Table 3. Although the percentages are not directly additive, it appears that the rank order of investments is computer hardware, computer software, and plant and equipment.

For computer hardware, shop floor data capture, local area networks and on-line process instrumentation were the most popular areas of investments with 70%, 68% and 54% of the responding companies investing

in these technologies in the past three years, respectively. CAD/CAM, MRP II and quality control were the software invested in by the greatest number of respondent companies. Only 9% of the firms invested in OPT (Optimized Production Technology) in the past three years. The most common investments in plant and equipment were computer controlled testing equipment (41% of respondents, automated assembly (27%), and automated warehousing/order picking (36%).

Table 4 provides data on the size of the largest investments made by these firms in the past three years. Whereas the largest investment for 24% of these firms was US$1 million or less, 36% spent more than US$10 million on their largest investment during this time period.

Table 3: Nature of AMT Investments

Computer Hardware	Percentage of respondents
PCs	100
Shop floor data capture	70
LAN	68
On-line process instrumentation	54
WAN	40
Minis	27
Graphics hardware	25
Micros	20
Mainframe	14

Computer Software	Percentage of respondents
CAD/CAM	79
MRP II	57
QC software	52
Data base mgmt systems	48
MRP	36
Expert systems	32
MAP	13
OPT	9

Plant and Equipment	Percentage of respondents
Computer controlled test equip	41
Automatic assembly	37
Automated warehousing/order picking	36
CNC M/Cs	30
Automatic testing equip	28
Laser measuring	25
AGVs	18
Flexible manufacturing systems	17
Laser cutting	14

Table 4: Size of the Largest AMT Investment Made in the Last Three Years

Investment ($ Million)	Percentage of respondents
< 0.5	19
0.5 – 1	5
1 - 2	18
2 - 10	23
10-20	6
20 - 40	13
40+	17

Questions 3 to 5: The investment planning process

Idea generation. The idea to invest in AMT comes from many sources. Nearly all of the firms (98%) indicated that more than one functional area listed in Table 5 had provided such ideas. While many functional areas provided ideas, the areas that generated ideas in most companies were by personnel directly related with manufacturing (see Table 5). In more than 70% of the firms responding to this question, investment ideas were generated by Engineering, Production Engineering, and Production. Several other groups also generated AMT ideas in a substantial number of firms, including R&D, Data Processing and Suppliers.

Table 5: Functional Areas Involved in Idea Generation for AMT Investments

Functional Area	Percentage of respondents
Engineering	89
Production Engineering	76
Production	71
Research & Development	58
Data Processing	46
Suppliers	44
Consultants	27
Sales & Marketing	14
Personnel	12
Accounting & Finance	10

In a similar manner, 90% of the respondents indicated that more than one level of management was involved in AMT investment idea generation (see Table 6). The most frequently cited management levels where investment ideas were generated were Middle, Senior and Junior. Supervisory and Shop floor level managers were the source of ideas in a number of firms, and were more likely to generate such ideas than Top management.

Training in the management of AMT was perceived to be needed more than training in the technologies themselves. Seventy percent of respondents indicated a perceived need for training in the management of AMT and 65% noted a perceived need for training in the technologies themselves. However, when asked to indicate whether an individual's firm had implemented such training, 57% indicated that training in the management of AMT had been implemented whereas 68% indicated that training in the technologies themselves had occurred.

Table 6: Management Involvement in Generating AMT Investment Ideas

Management Levels Generating Amt Investment Ideas	Percentage of Respondents
Top	15
Senior	77
Middle	97
Junior	54
Supervisory	46
Shop Floor	38

Number of management levels involved in AMT idea generation.	Percentage of respondents
One	10
Two	25
Three	31
Four	29
Five	5

Proposal development. In 84% of the firms, a project team was established for developing the AMT proposal, and all respondents noted that these teams involved more than one of the functional areas listed in Table 6. Similar to the idea generation phase, those functions most commonly involved in the proposal generation were Production (94%), Production engineering (92%), and Engineering (89%).

Proposal assessment. The financial evaluation techniques which respondents used in evaluating AMT proposals are provided in Table 7. Payback period and discounted cash flow were the most commonly employed techniques, although all four methods were utilized by almost three-quarters of the firms. In fact, all firms reported using more than one techniques with 45% reporting the use of all four listed in the table. Respondents were also asked to indicate the importance of each technique on a scale ranging from one (most important) to five (least important), and the results are also provided in Table 7.

Of the responding companies, 55% claimed that the financial assessment had exceeded their normal investment criteria, while 45% claimed that it had just met their financial criteria. No firm indicated that the financial assessment failed to meet its normal investment criteria. This finding indicates that although most companies cited gaining competitive advantage as important, the normal financial investment criteria were applied.

Table 7: Financial Evaluation Techniques Used

Financial techniques	Percentage of respondents	Average level of importance
Payback	89	1.59
ROI (undiscounted)	84	1.56
Discounted Cash Flow	89	2.18
Sensitivity Analysis	74	3.36

(1 = most important, 5 = least important)

Question 6: Assessment of benefits and risks or difficulties

A list of possible benefits resulting from the implementation of AMT was provided as part of the survey instrument. The benefits included in this list were those that had been frequently mentioned in the literature. Respondents were also provided the opportunity to identify additional benefits from their AMT investment under the "Other" category. Respondents were asked to indicate the importance of each item at the time of the assessment on a scale from one (of great importance) to five (of no importance). The resulting mean responses are provided in Table 8 where the items are listed in order of importance. The five items rated of greatest importance were: reduced costs, obtaining competitive advantage, improved quality, increased throughput, and increased sales. The five items rated of least importance were: enhanced company image, overcoming production management skill deficiencies, improved ability to respond to variations in suppliers' lead times, improved ability to respond to engineering changes, and better working relations. These responses suggests that most firms are focusing on improving costs and quality (now generally recognised as order qualifiers) and missing the opportunities in terms of improving flexibility and responsiveness (the order winners).

Table 8: Expected Benefits from AMT Investment

Benefits claimed at the time of assessment	Importance Rating
Reduced costs	1.3
Obtaining competitive advantage	1.4
Improved quality	1.5
Increased throughput	1.7
Increased sales	1.8
Reduced change over/set up times	1.9
Improved response to variation in product volume	2.0
Increased flexibility	2.1
Improved response to variations in product mix	2.2
Better Mgmt control	2.3
Reduced work in process	2.3
Improved integration of manufacturing IS	2.4
Improved integration of IS across functions	2.6
Improved work force attitudes	2.6
Improved working environment	2.6
Widening product range	2.6
Improved ability to respond to variations in suppliers' quality	2.6
Improved ability to implement engineering changes	2.7
Improved Mgmt attitudes	2.8
Reduced product development time	2.8
Improved ability to respond to engineering changes	2.9
Better working relations	2.9
Overcoming skill deficiencies	3.0
Improved ability to respond to variations in suppliers' lead times	3.1
Overcoming production Mgmt skill deficiencies	3.2
Enhanced company image	3.7

(1 = great importance, 5 = no importance)

As with the benefits, a list of potential risks or difficulties anticipated at the time of proposal assessment was also included in the questionnaire. Respondents were asked to indicate the importance of each item on a scale from one (of great importance) to five (of no importance). The mean responses to the items are provided in Table 9. The main risks or difficulties anticipated by the respondents were disruptions during implementation, failure to achieve financial targets, and an adverse affect on the workflow. Of lesser importance were opposition by staff/management, AMT skill deficiencies, and project management skill deficiencies. Concerns about obsolescence of technology and opposition by the workforce were rated as moderately important. It would appear from these responses that managers lack project management skills in effectively introducing and implementing AMTs into their organisations.

Table 9: Anticipated Risks and Difficulties During Proposal Assessment

Anticipated Risks and Difficulties	Importance Rating
Disruptions during implementation	1.68
Failure to achieve financial targets	1.83
Adverse effect on workflow	1.88
Obsolescence of technology	2.33
Problems with interconnection of equipment	2.38
Opposition by workforce	2.67
Lack of integration of Manufacturing IS	2.77
Lack of integration across functions	2.94
Prod Mgmt skill deficiencies	3.00
AMT skill deficiencies	3.06
Opposition by staff/management	3.07

(1 = great importance, 5 = no importance)

4. SUMMARY AND DISCUSSION

The previous section presented the overall findings from the American survey. In this section the key findings from this study are discussed and a general comparison made with the 1993 Australian survey (see Table 10).

As previously mentioned, only a broad comparison will be made between the present American study and the earlier Australian study. The reasons for this are threefold. First, the three-year time difference between the two studies. Second, the Australian responding companies were smaller in size. For example, 86% employed less than 1,000 people compared with 10% for the American sample. In term of annual sales revenue, 53% of the American companies had sales revenue greater than $1 billion compared with only 12% of the Australian companies. Third, the difference in the type of production system used. Nearly two-thirds (64%) of the Australian sample used jobbing or batch production compared with one-third (33%) of the American sample.

In spite of these differences a number of similarities were identified between the two countries. The main reasons for investing in AMT for both American and Australian manufacturers was to obtain a competitive advantage or obtain financial benefits. These reasons appeared independent of company size. For some firms, attaining competitive advantage can be achieved through lowered costs, whereas for other firms, enhanced quality will be needed. Improvements in both costs and quality can be achieved from effectively implemented AMTs. However, the analysis showed that benefits relating to increased flexibility and responsiveness were not being considered by the responding American or Australian organizations (see Table 8). These are the more strategic benefits offered by AMTs and companies must focus on these to

obtain a competitive advantage for the future as cost and quality have become prerequisites in many markets.

Table 10: Comparing American and Australian AMT Practices

	American Study - 1996	**Australian Study - 1993**
Reasons for AMT Investments	• Obtaining Financial Benefits • Obtaining Competitive Advantage	• Obtaining Competitive Advantage • Obtaining Financial Benefit
Size of AMT Investment in the past 3 Years	⟨ US $ 1m : 24% US $ 1 - 10m : 40% ⟩ US $ 10m: 36%	⟨ A$ 1m: 60% A$ 1 - 10m: 24% ⟩ A$ 10m: 16%
Nature of AMT Investment		
Most Popular Computer Hardware	Personal Computers	On-line Process Instrumentation
Least Popular Computer Hardware	Mainframes / Micros	Wide Area Networks
Most Popular Computer Software	CAD/CAM	CAD/CAM
Least Popular Computer Software	OPT/MAP	MAP/OPT
Most Popular Plant & Equipment	Computer - Controlled Test Equipment	CNC Machines
Least Popular Plant & Equipment	Laser Cutting/FMS/AGV's	AGV's/ Laser Cutting
Project Team Established	84% of Responding Firms	83% of Responding Firms
Main Source of AMT Investment Ideas	Engineering/ Production Engineering / Production	Production/ Engineering/ Production Engineering
Number of Management Levels Involved in Idea Generation	One Level Only: 10% Two Levels: 25% Three Levels: 31% Four/Five Levels: 34%	One Level Only: 84 % Two Levels: 8 % Three Levels: 0 % Four/Five Levels: 3 %
Main Functions Involved in AMT Proposal Development	Production/Production Engineering/ Engineering	Production/Accounting & Finance / Engineering
Financial Evaluation Techniques Used	Payback Period: 89% ROI (Undiscounted): 84% Discounted Cash Flow: 89 % Sensitivity Analysis: 74 %	Payback Period: 69 % ROI (Undiscounted): 47 % Discounted Cash Flow: 45 % Sensitivity Analysis: 40 %

Table 10: Continued

	American Study - 1996	Australian Study - 1993
Perceived Need for Training	In AMT: 65% in Production Mgmt.: 70%	In AMT: 55% In Production Mgmt.: 68%
Implemented Training	In AMT: 57% In Production Mgmt.: 68%	In AMT: 60% In Production Mgmt.: 57%
Financial Assessment of Investment	Exceeded Criteria: 55% Just Met Criteria: 45% Failed to Meet Criteria: 0% Missing Data: 0%	Exceeded Criteria: 45% Just Met Criteria: 39% Failed to Meet Criteria: 8% Missing Data: 8%
Implementation Time	Less Than 6 Months: 7% 6-12 Months: 48% More Than 12 Months: 45% Not Yet Completed 0%	Less Than 6 Months: 27% 6-12 Months: 29% More Than 12 Months: 30% Not Yet Completed: 14%
Anticipated Benefits - Most Important	1. Reduced Costs 2. Obtaining Competitive Advantage 3. Improved Quality 4. Increased Throughput 5. Increased Sales	1. Reduced Costs 2. Obtaining Competitive Advantage 3. Improved Quality 4. Increased Throughput 5. Increased Sales
Anticipated Benefits - Least Important	1. Enhanced Company Image 2. Overcoming Production Management Skills 3. Improved Ability to Respond to Variation in Supplier's Lead Times 4. Improved Ability to Respond to Engineering Changes 5. Better Working Conditions	3. Overcoming Production Management Skills 4. Better Working Relationships 5. Reduced Product Development Time 6. Widening Product Range 7. Improved Ability to Respond to Variations in Supplier's Quality
Anticipated Risks and Difficulties - Most Important	1. Disruption During Implementation 2. Failure to Achieve Financial Targets 3. Adverse Effect on the Workflow	1. Disruption During Implementation 2. Adverse Effect on the Workflow 3. Failure to Achieve Financial Targets
Anticipated Risks and Difficulties - Least Important	4. Opposition from Staff/Management 5. AMT Skill Deficiencies 6. Production Management Skills	4. Opposition from Staff/Management 5. Obsolescence of Technology 6. Opposition by Workforce

Although competitive advantage was the most important motivation, conventional financial investment criteria were applied. A higher proportion of American companies made use of the four different financial evaluation techniques listed in the questionnaire. ROI, DCF and Sensitivity Analysis were used by less than

half of the Australian sample. This compares with over three-quarters of the American sample making use of these techniques.

A slightly higher proportion of American companies exceeded the normal investment criteria and none indicated failing to meet their normal investment criteria. In comparison, 8% of the Australian respondents said that they had failed to meet the normal investment criteria.

There are close similarities between American and Australian manufacturers in terms of the types of AMT adopted. Computer-controlled machines/test equipment and CAD/CAM are the most popular AMTs adopted in both countries. However, the size of the AMT investments made by Australian manufacturers is significantly smaller than their American counterparts. For example, 60% of the Australian respondents made investments which were less than A$1 million and only 16% made investments which were greater than A$10 million. In comparison, 24% of the American respondents made investments which were less than US$1 million and 36% made investments which were greater than US$10 million.

A factor contributing to this difference was the worldwide slowdown in economic activity during the 1990 to 1993 period. A comparison of the 1993 and the 1989 Australian findings showed that in 1993 Australian companies were making smaller and fewer AMT investment compared to 1989 (Sohal, 1997).

Another contributing factor is the smaller organizations in the Australian sample. This size difference may also account for the fewer management levels involved in the decision-making process in Australia. Only one level of Australian management was involved in 84% of the organizations whereas in nearly two-thirds of the American organizations, three or more levels of management were involved in AMT idea generation and development.

In both countries ideas for AMT investments largely came from the Engineering, Production Engineering and Production functions and these were also the functions which were mainly involved in developing the proposal. In addition, a large number of organizations in both America (84%) and Australia (83%) established project teams to develop the AMT proposal.

As shown in Table 10, just over one-quarter of the Australian organizations had completed their AMT implementation in less than six months. This compares with only 7% of the American firms. One reason for this could be the smaller size of the AMT investments made by the Australian organizations as well as the smaller-sized Australian organizations themselves. In this case decision-making may be quicker with fewer individuals having responsibility for a greater number of functional areas.

Clearly, there are risks involved if the planning and implementation periods are too long. One risk is that competitors can adopt the same technology quickly and obtain the competitive advantage. The other risk is that the AMT becomes obsolete as the rate of technological advancement has increased significantly over recent years.

Although many American and Australian respondents noted that training is needed in the relevant technology and production management issues, generally fewer companies implemented training. Clearly, workers must understand how to operate effectively new equipment, but to gain the business benefits referred to by Voss (1988), a detailed understanding of a broad range of managerial issues is required. Case study based investigations of AMT implementations have shown that people are the most critical factor for success (Sohal, 1996). The involvement of shop floor personnel must be considered throughout all phases of planning and implementation of AMT. Mechanisms and procedures must be established so that experiences are recorded and shared amongst all employees.

In terms of the anticipated benefits and risks and difficulties, the responses from the American organizations are identical to those given by their Australian counterparts. The more strategic benefits offered by AMTs (i.e. greater flexibility and responsiveness) are being ignored by both American and Australian

organizations and from the responses given to potential risks and difficulties, it appears that managers in both countries require enhanced project management skills.

A major problem identified from both the American and the Australian surveys is that very few organizations undertake a post-implementation audit of their AMT projects. To become a "learning organization" firms must conduct such audits, and by doing so, establish a database which can be used for future AMT investments.

Our studies suggests that organisational change in terms of the company's culture and structure, as suggested by Bessant (1994), and Zammutto and O'Connor (1992), is not taking place in organisations that have invested in AMT. This must happen if the strategic benefits of AMT are to obtained.

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