Strategic importance of team integration issues in product development processes to improve manufacturability

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Abstract

Purpose – The purpose of this paper is to provide practitioners of management with a sense of how collaborative team integration processes were required in order to be reasonably successful in attaining the required manufacturability goals. It aims to accomplish this by investigating: the role of team collaborative efforts in high-technology projects associated with comparing aggressiveness towards and actual achievement on meeting time targets and manufacturing costs; the moderating effects of project-team autonomy and control issues; and management involvement and top management support activities.

Design/methodology/approach – A review of the applied literature on collaborative team integration processes of manufacturers and direct suppliers of the smart card and automatic identification and data capture (AIDC)-related industry in the USA was conducted. Only project managers and/or their designees were asked to complete the survey. The results of two mailings netted a total of 180 usable questionnaires out of an original sampling frame of 311 (response rate of appropriately 58 percent, with some missing data on a number of variables).

Findings – The paper finds that especially the variables of product acceleration, technological uncertainty, complexity, and product newness are traditionally outside the immediate control of the firm's project managers. The team integration variables, as measured by the factor scores of top management. manufacturing involvement, collaborative working environment, and supplier influence, offered the most explained variance in the present study.

Practical implications – By understanding the variety of team performance and integration constructs in high technology-intensive and manufacturing environments, management may be able to take the steps to become more sensitive to the roles of not isolating team members and being able to relinquish control at the appropriate times in order to enhance manufacturability.

Originality/value – The rapid pace of internet products and web-enabled services, especially in the high-technology manufacturing industries, presents new strategic management issues to be addressed in project management. Understanding the many issues associated with project team management and integration within new-product development/new-product manufacturability processes may ultimately decrease the cost and promote timely introduction of beneficial commercial developments, if properly managed.

Keywords Team working, Communications technology, Manufacturing systems, Product development, Supply chain management, United States of America

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Introduction

Managerial approaches to manufacturability in high-technology industries

Applications and integration of automatic identification and data collection (AIDC)-related technologies and their supply-chain subsystems are present in the practitioner literature. But, there is little presence in the academic literature concerning these concepts and development team management, especially within relatively high-technology industries. However, there is a wealth of information on technical team integration and new product manufacturability (NPM) in the academic literature for other more general manufacturing industries. Basic team integration and manufacturing management concepts are of strategic importance in new-product development and new-product manufacturing (NPD/NPM) issues (Alder, 1995; Al-Mudimigh *et al.*, 2001; McDermott, 1999; Smith and Offodile, 2007; Swink, 1999, 2000).

The major thrust of the present study is to the strategic importance of team integration issues in the product development process in moderating the potential threats to improved manufacturability. The empirical research will concentrate on the tenets of strategic manufacturing management issues that promote lean and agile (flexible) manufacturing product development and manufacturability processes though project management and team integration concepts. As suggested by Pilkington (1998, p. 41):

> Closer examination of manufacturing management theory, and its obsession with lean-production, supports the case for integrating manufacturing and business-level strategy.

These key elements are taken into account in dealing with the degree that management relinquished authority to foster technical team autonomy in decision-making activities, as well as the degree of use and impact on goals, and degrees of aggressiveness towards goals and actual achievement of various manufacturing and project management targets. In general, the high-technology manufacturing sector has been relatively neglected in the project management literature in terms of collaborative team processes; since many studies group various types in order to get a sufficient sample size (McDermott, 1999; Swink, 1999, 2000). This study is an attempt to correct that situation.

New product manufacturability and development team processes

The present research effort is to study the apparent gap between innovation through the development and marketing of products and services that has been a key source of competitive advantage for both small and large manufacturing firms. Basically, NPM is a strategic fit between the product design specifications from the NPD team and the actual capabilities of the manufacturing/production processes. Numerous process modifications, modeling and simulation techniques, and design-for-manufacturability (DFM) projects can be found through the academic and practitioner's literature. Smith and Rupp (2002a, b) and Smith (2003) suggested that manufacturability and related manufacturing research into processing technologies and systems analysis must include evaluation of the environmental and energy impacts, as well as economic considerations.

The entire process of manufacturability is complex and requires the ability to assess process or systems modifications in terms of their impacts on resource use, at both the global as well as the local evaluation levels. And, as noted by Smith (2003, p. 33):

> The need to conduct this assessment on several levels induces system complexity. Current models and methods either simplify or provide bulk assessment of events, or serve in a reductionism fashion, providing decision-makers with limited information.

Further, poor manufacturability outcomes due to equally poor levels of NPD and team integration processes can enact significant costs and loss of market share. Consequently, managerial integration issues associated with the ability of a firm to accelerate NPD activities may have significant impacts on dealing with initial production start-up problems, increased employee morale problems, cost over-runs, increased complexity, delays in quality assurance programs, and increased customer dissatisfaction from increased products' defects and resultant failures. These factors are potential threats to the manufacturability of products and delivery of services.

Managerial approaches to manufacturability can be found in the strategic manufacturing literature that specifically addresses cross-functional team integration, concurrent product-process development, and intense supplier involvement (Blois, 1988; Lanigan, 1992; Smith, 2002, 2004; Smith and Flanegin, 2004; Taguchi and Clausing, 1990; Wainwright, 1995). In fact, many interactions among product designers, process designers, production, and market-customer-based personnel in various product development phases are required for sustainable competitive advantage. However, there has been relatively little empirical evidence that these approaches to improve interactions actually improve NPD/NPM processes. The attributes of technical-project management characteristics point to the complex nature of the interaction of these agents that can be attributed to dependency and complexity theories (Smith., 2003; Stacey, 1996a,b; Wah, 1998a,b).

NPD/NPM within an information-intensive environment

The tie-ins to NPD/NPM and technical project team integration processes are project complexity and speed, technical uncertainty, risk, and product innovation. Swink's (1999, 2000) study on NPD/NPM processes dealt with a variety of manufacturers, but mainly within low technology industries. Both the present study and Swink's study focused on team integration issues and characteristics and their impacts on reducing the potential threats to manufacturability. Ultimately, it is hoped that more insight into the measurement of the performance of a technical internal project within a collaborative and supplier-influenced environment, managers must openly provide operational efficiency metrics and share the results and progress of their work.

NPD/NPM processes within a product development team environment represent one of the most significant influences on the firm's success (Besson and Rowe, 2001; Boyer, 2001; Smith and Offodile, 2007). Managerial support of technical projects, in theory, is critical and fairly complex in how it relates to NPD/NPM processes. As suggested by Cua *et al.* (2001, p. 686):

> The support and commitment of management in the institution of new programs has often been heralded as the single most important factor in determining program success.

Methodology

Sample characteristics

The basic tenets of the present study is to investigate the role of team collaborative efforts in high-technology projects associated with comparing aggressiveness towards and actual achievement on meeting time targets and manufacturing costs; the moderating effects of project-team autonomy and control issues; and management involvement and top management support activities. These three concepts are discussed in detail within the basic descriptive results and the exploratory factor analysis and separated and labeled as subheading. A basic survey instrument was created that combines constructs from Complexity Theory (Hamel and Prahalad, 1994; Shiozawa, 1999; Stacey, 1996a, b; Wah, 1998a, b) and Dependency Theory, with the significant research efforts of Swink (1999, 2000). The bulk of the instrument has been successfully field tested with prominent and publishable results (Swink, 1999, 2000) and basic constructs are:

(1) *Authentication and types of automatic identification and data technologies*:
   - types of AIDC-related technologies;
   - manufactured and/or integrated through the manufacturing process; and
   - types of authentication concerns and/or e-security strategies.

(2) *Project-timing characteristics*:
   - project operational characteristics of length and resources used.

(3) *Project personnel*:
   - personnel roles, titles, numbers on core development teams; and
   - technical and labor characteristics.

(4) *Product-performance characteristics*:
   - design, delivery, and process specifications;
   - complexity of parts and assembly;
   - design life of innovation; and
   - sales potential.

(5) *Project priorities and goals*. How aggressive were project goals and how well were they achieved on a variety of target goals?:
   - innovative;
   - product features;
   - cost targets;
   - time targets;
   - manufacturability;
   - quality;
   - customer needs;
   - performance; and
   - reduced project development time.

(6) *Production and marketing considerations*:
   - pilot characteristics;
   - units of measure;
   - production rates;
   - diversity of customer base; and
   - divisional sales due to product.

(7) *Methods and tools*. What are the management methods and tools that were important on the project?:
   - project management methods: resource availability, internet and web-enabled technologies, outsourcing activities, isolating of project members, pre-team training, rewards for speed, omitting non-value added activities, cross-functional teams;
   - design methods and tools: quality function deployment (QFD), ISO certified suppliers, rapid prototypes, design-for-manufacture methods, and production quality tools; and
   - computer electronic tools: computerized electronic project scheduling, CAD/CAM tools, shared electronic databases, internet, e-mail, and e-conferencing techniques.

(8) *Personal project managers' perceptions*.

(9) *Influences of factors on the project*:
   - degree of involvement issues: degree of involvement by top management, early involvement by manufacturing personnel, manufacturing concerns ties to key customer involvement, adequate information and other resources, empowerment issues;
   - team integration issues: accessibility of team members, team sharing of communication, overlapping of authority and duties, compatibility of databases, functional group loyalties; and
   - project outcomes: start-up problems, profitability, number of design chances, financial success.

In terms of the target population, smart card and AIDC-related technologies manufacturers and suppliers associated with institutional membership in the global trade association of automatic identification manufacturers (AIMGLOBAL) (www.AIMGLOBAL.org) and/or co-membership in the Smart Card Alliance (www.smartcardallaince.org) were chosen. The target population also included companies listed in the AIDC-related section as advertisers in SCANTECH (the industry's major technological conference and showcase). Project management's representatives were identified and asked to fill out the survey instrument. Only project managers and/or their designees were asked to complete the survey.

Statistical techniques

The majority of the more comprehensive phase of this research effort was comprised of scale items, many using a Likert-type coding scheme ($1 = \text{low}$ through $5 = \text{high}$). Selected interval scales were employed to simplify the use of statistical database and analysis techniques. The interviewed data were recorded and later used to formulate graphs, run regression and correlation analyses, and complete data-reduction techniques in the exploratory phase on this research project. The dominant statistical techniques used in the present study were regression analyses and principal components analysis (PCA).

PCA offers a convenient way to control the trade-off between loosing information and simplifying the problem at hand. Thus, it may be possible to create piecewise linear models by dividing the input data to smaller regions and fitting linear models locally to the data. However, PCA is only a transformation process and may be used in conjunction with factor analysis. The factor analysis process is a representation of the general case with no regard to which components of the input vector are either composed of independent or dependent variables (Bishop, 1995; Cumming, 1993; Oja, 1989). This arrangement will have not committed the researcher to a certain relationship between the vector components or named any components as the inputs or the outputs of the researched relationships among the many sensitive issues of project team integration and management. Therefore, through these statistical procedures the ability to constrain any component of the input vector to be constant and to fetch the rest of the vector values with the aid of known values was possible.

Descriptive profiles and basic results

Aggressiveness towards and actual achievement on meeting time targets and manufacturing costs

When contrasting the product teams' perceptions of degrees of aggressiveness towards selected goals and their actual achievement on meeting time targets and manufacturing costs, considerable aggressiveness in terms of team integration processes was required in order to be reasonably successful in attaining the required manufacturability goals. In terms of all product manufacturability variables, except the reduced development-time variable, achievement goals were aggressively approached (mostly 4 and 5 with a mode of 4, where 1 = not very aggressive and 5 = very aggressive) and mostly achieved (mostly 4 and 5 with a mode of 4, where 1 = not nearly achieved; 5 = fully achieved). Reducing development time was significantly addressed as a goal, but had mixed goal attainment (mode of 3). Manufacturing costs had mixed results as well.

Interestingly, although there was high confidence on meeting manufacturing and development time constraints reality was slightly different in that the average actual project length (12.3 months) was significantly higher than the intended project length (10.7 months). In terms of the means for the above-mentioned variables and their associated goal aggressiveness and achievement are listed as follows (with means in parentheses):

- aggressiveness on project on time (3.99);
- achievement of project on time (3.71);
- aggressiveness on development costs (3.94);
- achievement of development costs (3.69);
- aggressiveness on product costs (3.95);
- achievement of product costs (3.70);
- aggressiveness on manufacturing costs (3.73);
- achievement of manufacturing costs (3.94);
- aggressiveness on quality targets (3.89);
- achievement of quality targets (3.78);
- aggressiveness on innovative features (3.59);
- achievement of innovative features (3.63);
- aggressiveness on performance goals (4.07);

- achievement of performance goals (3.93);
- aggressiveness on customer needs (4.01);
- achievement of customer needs (4.05);
- aggressiveness on reduce development time (3.57); and
- achievement of reduce development time (3.34).

As evident from the differences among the means, in most cases there was more slightly effort (aggressiveness towards the goal) than actual goal attainment. The noticeable exceptions of attaining higher levels of success than corresponding efforts included the variables of meeting customer needs and achieving manufacturing costs targets.

Project team autonomy and control issues

Another important topic in this study dealt with the assumptions of project team autonomy and control through management actively relinquishing authority, which a major strategic management issue in modern manufacturing environments. Since the concepts of work teams and their integrations are becoming an increasingly important managerial issue, especially in a competitive manufacturing environment, all parts of organizational life should be adept to new ways of strategic thinking. Many organizations are making a deliberate effort to use teams to carry out work efforts as an alternative to more traditional, hierarchical approaches to defining jobs or supervising employees (Lichtenstein *et al.*, 1997; Guzzo and Shea, 1992; Smith, 2003). In general, managers and team leaders should address elements of the team's operation that would reinforce the team's boundary within an autonomous and cooperative environment.

In theory, management and its relinquishment should allow team leaders to be given the formal authority to evaluate and discipline team members and to set their schedules in order to best satisfy their goal achievement plans. In addition, team leaders should also attempt to increase the clarity of the team's goals and to facilitate communication between all team members. Figures 1-4 display varying degrees of agreement that management relinquished authority as a function of agreement on a number of these issues. The issues of particular interest were divided into a series of related construct clusters. For example, in Figure 1, the variables included the following:

- suppliers influenced design;
- customers influenced design;
- manufacturing strong role in design;
- marketing strong role in design; and
- manufacturing participated early in design.

In terms of Figure 2, the variables included the following:

- people accessible;
- design influenced by manufacturing;
- management committed;

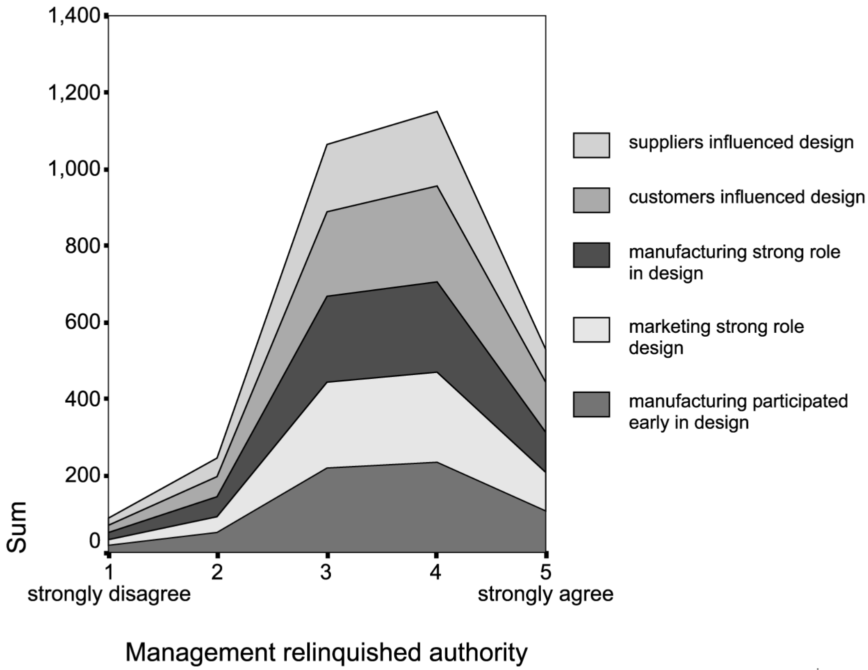

Figure 1. Agreement that management relinquished authority as a function of agreement with a number of selected manufacturability and project variables – suppliers influenced design, customers influenced design, manufacturing strong role in design, marketing strong role in design, manufacturing participated early in design

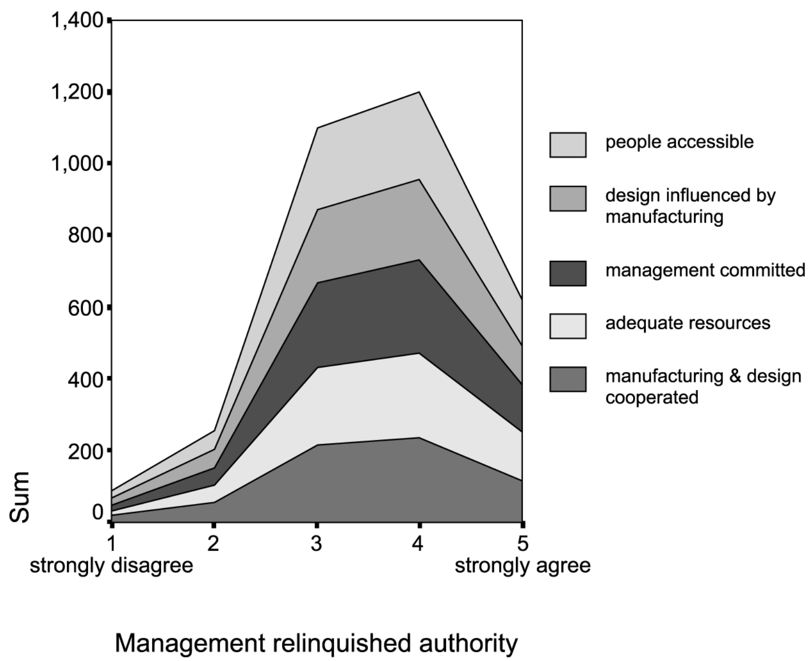

Figure 2. Agreement that management relinquished authority as a function of agreement with a number of selected manufacturability and project variables – people accessible, design influenced by manufacturing, management committed, adequate resources, manufacturing and design teams cooperated

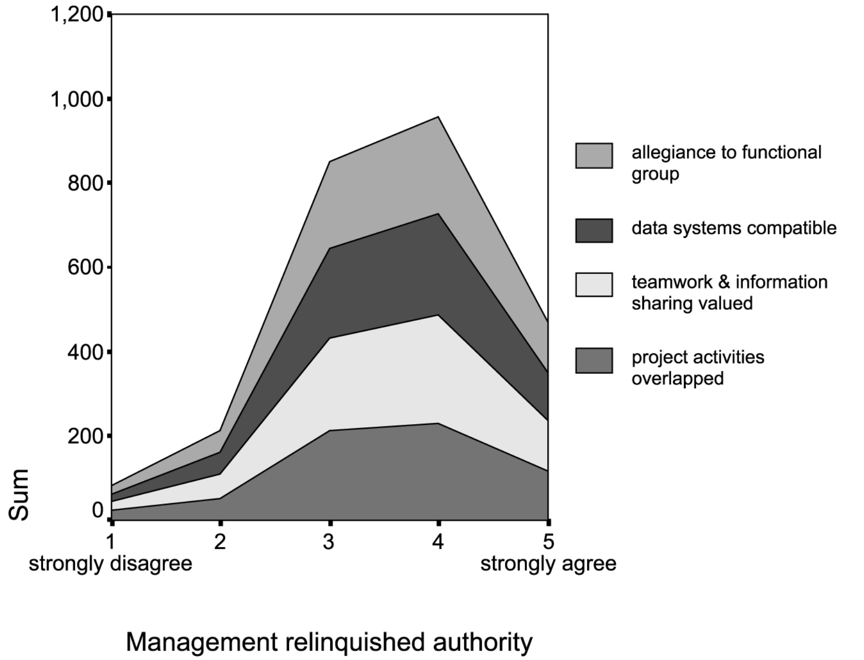

Figure 3. Agreement that management relinquished authority as a function of agreement with a number of selected manufacturability and project variables – allegiance to functional group, data systems compatible, teamwork and information sharing valued, project activities overlapped

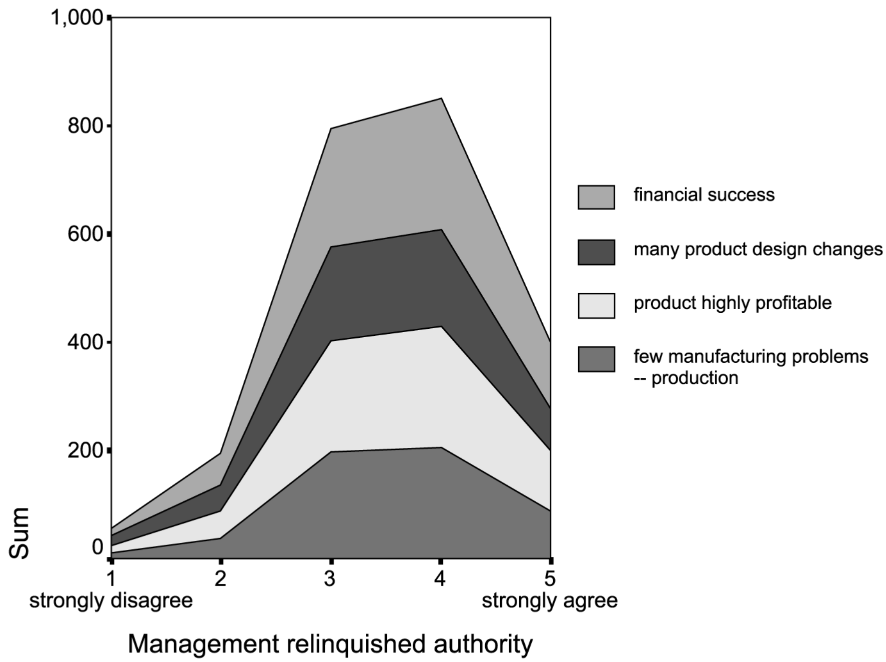

Figure 4. Agreement that management relinquished authority as a function of agreement with a number of selected manufacturability and project variables – financial success, many product design changes, product highly profitable, few manufacturing problems – production

- adequate resources;
- manufacturing; and
- design teams cooperated.

For Figure 3, the variables included the following:

- allegiance to functional group;
- data systems compatible;
- teamwork and information sharing valued; and
- project activities overlapped.

In terms of Figure 4, the variables included the following:

- financial success;
- many product design changes;
- product highly profitable; and
- few manufacturing problems in production.

In virtually all the cases, there was moderate levels agreement that management relinquished enough authority (grand mean of 3.57). The means for the other various factors that were used as a function of agreement that management relinquished enough authority included the following (with means in parentheses):

- suppliers influenced design (2.97);
- customers influenced design (3.79);
- manufacturing strong role in design (3.55);
- marketing strong role in design (3.51);
- manufacturing participated early in design (3.59);
- people accessible (3.80);
- design influenced by manufacturing (3.39);
- management committed (3.89);
- adequate resources (3.66);
- manufacturing and design teams cooperated (3.58);
- allegiance to functional group (3.54);
- data systems compatible (3.63);
- teamwork and information sharing valued (3.84);
- project activities overlapped (3.60);
- financial success (3.76);
- many product design changes (2.83);
- product highly profitable (3.45); and
- few manufacturing problems in production (3.04).

The ability of management to give autonomy and control to product development members is extremely important for the successful transition of design for manufacture (DFM) to actual manufacturability plans. This team autonomy was necessary in order to minimize the detrimental effects of project complexity, acceleration, design outsourcing, technical uncertainty, and supplier involvements on manufacturability.

As an inspection of the means demonstrate, there was moderate to high levels of agreement that management should relinquish command and control on a variety of product development and manufacturability issues with varying degrees of success. The general perception was that the success of NPD/NPM processes is somewhat dependent on product teams achieving certain minimal levels of autonomy.

The last major managerial implication of the results concerning selected project management characteristics and their associate tools generated interesting results in contrasting the degrees of agreement on degree of use and impact on goals. Considerable impact on project performance as based on the degree of use of various tools and incentives to boost performance objectives. There was quite a mixed response on the degree of use on its impact on these variables, unlike the two previous sets of variable combinations and their associated discussions (as shown and discussed concerning Figure 1). In terms of the explicit objectives and goals and the cross-functional teams variables there was very positive results and general agreement that their use significantly impacted the projects' performance [use and impacts were collaboratively and positively received (mostly 4 and 5 with mode of 4, where 1 = used and 5 = extensively used) and positively impacted (mostly consisting of 4 and 5 with mode of 4, where 1 = large negative impact, 3 = no impact, and 5 = large positive impact)]. The adequacy of resources to speed up activities was significantly addressed as positively impacting the project, but had mixed goal attainment (mode of 3). The remaining variables were truly mixed in their results and very difficult to establish reasonable values to be assigned to their associations of use to actual impacts on project performance. Interestingly, the attempts to isolate project team were perceived to negatively impact the success of attaining the projects' goal.

In terms of the means for these variables concerning project members' degree of use and impact on goal attainment, they are listed as follows (with means in parentheses):

- degree of use of explicit objectives and goals (4.02);
- degree of use of resources to speed-up activities (3.27);
- degree of use of omitting normal development steps (2.73);
- degree of use of rewards tied to speed (2.69);
- degree of use - outsourcing design activities (2.70);
- degree of use of pre-project training (2.86);
- degree of use to isolate project team (2.56);
- degree of use of co-locate project personnel (2.97);
- degree of use of cross-functional teams (3.79);
- impact on goals of explicit objectives/goals (3.80);
- impact on goals of resources speed-up activities (3.54);
- impact on goals by omitting normal development steps (3.04);
- impact on goals by rewards tied to speed (3.16);

- impact on goals of outsourcing design activities (3.35);
- impact on goals of pre-project training (3.32);
- impact on goals by isolating project team (3.28);
- impact on goals of co-locate project personnel (3.41); and
- impact on goals of cross-functional teams (3.91).

As evident from the differences among the means, there was a mixed response in most cases and there was extreme difficultly is establishing patterns from these data. The noticeable exceptions, as previously indicated are the adequacy of resources to speed up activities and the use of cross-functions, which were seen as favorably and positively impacting the project. In addition, any attempts to isolate project team were perceived to negatively impact the success of attaining the projects' goals and should be avoided as a manufacturing strategy.

Management involvement and top management support activities

Hence, as demonstrated in comparative analysis of means, strategic manufacturing management appears to begin with the development of a team-integration attitude. Manufacturing partners must be willing to agree on a set of business practices, to share pertinent information, and to compete as if they are essentially one vertically integrated company. As demonstrated in the results of the factor analysis loadings and subsequent hypothesis-testing procedures that will be discussed in more detail in the next section of this section, manufacturing partnering (Bresnen and Marshall, 2000) is enabled by technologies and leveraged through the internet and project management tools that allows for sharing of information that has been traditionally the exclusive domain of the individual departments. Supply-chain transparency and partnering, coupled with increased efficiencies associated with NPD/NPM processes studied in this research effort, manufacturing management traditionally focused on order-fulfillment activities. In today's competitive world, manufacturing management must look at all of the processes involved in getting a product to market and enhancing customer satisfaction activities (Smith, 2007; Smith and Offodile, 2007).

There are a number of management involvement and top management support activities, nurtured in a manufacturing collaborative and accelerated project environment that have implications to strategic management systems. The planning and scheduling activities (including forecasting, positioning of material to fulfill demand, and capacity management activities) are associated with increased agreement with management relinquishing authority to the development and design teams. These are essential items to be considered in the team integration processes, especially new product introduction and information-sharing activities (including bill of materials management; prototyping, design validation, testing, and production validation testing activities) are important characteristics of successful NPD/NPM processes.

Project management activities associated with increased NPD/NPM processes that also seem to benefit from management relinquishing authority include product-content management (including change generation, change impact assessment, and product change release). Outsourcing and supplier involvement activities, including approved vendor management, strategic sourcing, and supplier selection, were also associated with project teams' autonomy and increased team's ability to handle complexity and project acceleration issues as management relinquished authority. A major area that the present study did not directly measure occurred in order management activities. The tools associated with dealing with the numerous complexity and project acceleration issues include an information management system (IMS). Information management system in a manufacturing environment should support functions such as: quality assurance; product optimization and support; stability control; material safety data sheets; vendor monitoring; customer complaint tracking; validation support; and audit trailing, which documents any changes in quality testing.

These activities from order capture to order tracking and exception management are important functions. As manufacturing management continues to leverage the Internet and deal with the complexities of project acceleration and autonomy of project teams, NPD/NPM processes and successful attempts at systems integration will move towards a project term that can instantaneously react to customer demand in real time.

In terms of selected continuous and interval variables of special interest to technical product and development team performance metrics' means are presented in parentheses and are included in the following list. The variables and their associated means are as follows:

- Percentage that product development time was reduced (12.25 percent).
- Intended project length (10.68 months).
- Actual project length (12.2 months).
- Project development projects (20.28).
- Number of projects' reduction in time (7.44).
- Number of persons on core development team (1.90) (1 = 1-59 ($n = 72$), 2 = 6-10 ($n = 67$), 3 = 11-15 ($n = 22$), 4 = more than 15 ($n = 16$)).
- Peak full time persons (1.83) ($1 = 1 - 3$ ($n = 67$), 2 = 4-10 ($n = 71$), 3 = 11-50 ($n = 23$), 4 = 51-100 ($n = 2$), 5 = more than 100 ($n = 4$)).
- Peak part-time persons (1.74) (1 = 1-3 ($n = 63$), 2 = 4-10 ($n = 65$), 3 = 11-50 ($n = 18$), 4 = 51-100 ($n = 5$)).
- Percentage of outside marketing research (11.46 percent).
- Percentage of outside product design research (10.02 percent).
- Percentage of outside product testing (13.09 percent).
- Percentage of outside production process design (9.06 percent).
- Percentage product performance requirements specified prior to start of project (51.84 percent).
- Percentage product's features and function that are based on new technology (24.32 percent).
- Percentage of process technology that was new (16.99 percent).
- Product broken down in terms of parts (2.94) (1 = 1-5 ($n = 23$), 2 = 6-20 ($n = 41$), 3 = 21-100 ($n = 63$), 4 = 101-500 ($n = 26$), 5 = 501-5,000 ($n = 15$), 6 = more than 5,000 ($n = 7$)).
- Percentage of parts/components purchased/off shelf/produced outside (36.42 percent).
- Percentage of parts/components previously designed/borrowed (31.63 percent).

- Percentage of parts/components new designs (32.26 percent).
- Years produced before new design (6.87).
- Total sales business division (2.76) (1 = less than $5 million ($n = 34$), 2 = $5 to less than $20 million ($n = 59$), 3 = $20 to less than $50 million ($n = 26$), 4 = $50 to less than $150 million ($n = 24$), 5 = more than $150 million ($n = 31$)).
- Percentage sales related to project (21.16 percent).
- Percentage of division sales from concept to market (17.80 percent).
- Percentage of division sales derived from product (25.84 percent).

As can be seen from an inspection of the above numbers, the mean percentages of a number of manufacturability measures, based on productivity and performance variables, provide insight to the complexity of the manufacturing process. In particular, a number of manufacturability measures in terms of percentages (parts and/or components purchased or off shelf or produced outside; parts and/or components previously designed or borrowed; parts and/or components that required new designs; sales related to project; division sales based on product; and sales related to project) were determined to be at relatively moderate levels of involvement in the manufacturing process (generally 20 to 40 percent). Also of interest was that the average actual project length (12.3 months) was significantly higher than the intended project length (10.7 months). All of these findings suggest that there are significant levels of complexity and interdependency among the various metrics of projects' productivity and performance. Management of the manufacturing processes has much to improve upon.

As demonstrated from an inspection of the frequencies of selected project management and NPD variables, a number of important trends are evident. For example, a number of highlights were noted from the frequency tables, which are too numerous to be included in the present study, but available upon request. The actual counts out of a total possible of 180, before adjusted for missing cases, are presented in parentheses. The following frequencies were noteworthy:

- Departments that made up the core development team were mainly dominated by marketing and sales (116), followed by the departments of product design and development (32), manufacturing and/or operations (12), finance and/or accounting, and personnel and/or human resources (five). These results were similar to Swink's (1999, 2000) study, indicating the growing importance of marketing and sales to a project's success.
- The various roles on the project team were found to include project team member (98), project manager (49), and functional manager (22).
- The functional area of work was discovered to be manufacturing and/or operations (55), product design and development (57), marketing and/or sales (26), finance and/or accounting (23), and personnel and/or human resources (six).
- In terms of complexity, the numbers of engineering and technical expertise areas required for successful NPD/NPM processes was impressive (for example, one to three expertise areas was the most common (85), followed by four to ten roles (71), 11 to 50 roles (15), and 51 to 100 roles (four)).

Specific references to the frequencies associated with implementations of product goals' aggressiveness and achievement, as well as degree of use and its impact will be discussed in more detail in the conclusions and implications section.

Factor analysis and data reduction results

Statistical procedures

Once the basic tenets of this study were found to be true, a number of data reduction attempts were made to reduce the number of working factors associated with project management characteristics, development team integration issues and NPD/NPM processes into a manageable size. In general, if the data were concentrated in a linear subspace, this provides a convenient way to compress data without losing much information while simplifying the representation. Utlimately by picking the largest eigenvalues (such as 0.5 or greater), little information as possible in the mean-square sense is lost (Bishop, 1995; Oja, 1989). Therefore, by choosing a fixed number of eigenvectors and their respective eigenvalues, hopefully a consistent representation or abstraction of the data will emerge. This procedure preserves a varying amount of energy of the original data. Alternatively, we can choose approximately the same amount of energy and a varying amount of eigenvectors and their respective eigenvalues. This would in turn give approximately consistent amount of information at the expense of varying representations with regard to the dimension of the subspace. Unfortunately, when using PCA, there are contradictory goals. On the one hand, we should simplify the problem by reducing the dimension of the representation. The other choice is to preserve as much of the original information content as possible. PCA offers a convenient way to control the trade-off between loosing information and simplifying the problem at hand.

The factor analysis process is a representation of the general case with no regard to which components of the input vector are either composed of independent or dependent variables. This arrangement will have not committed the researcher to a certain relationship between the vector components or named any components as the inputs or the outputs of the researched relationships among NPM/NPD processes. Therefore, through these statistical procedures the ability to constrain any component of the input vector to be constant and to capture the rest of the vector values with the aid of known values will be possible.

Specifically, PCA and factor analysis techniques were completed to determine major new product manufacturability constructs and team integration issues (Tables I and II). The following subsections contain a discussion of the subsequence analyses; first dealing with product team integration construct, followed by hypothesis testing on manufacturability and related potential threats to manufacturability. The basic extraction method was PCA with the basic rotation method of varimax with Kaiser normalization.

Aggressiveness towards and actual achievement on meeting time targets and manufacturing costs

Tables I and II are associated with the PCA factor analysis of project-goal aggressiveness and achievement variables. These tables illustrate the foundation of the groupings of perceived threats to manufacturability, moderating effects of team integration processes, and the importance of metrics. Table I illustrates the varimax-rotated component matrix of goal aggressiveness and achievement, using

Variable descriptions	Quality and performance metrics	Team coordination	Technology issues
Achievement – quality targets	*0.713*	0.000	0.114
Achievement – performance goals	*0.665*	−0.222	0.137
Impact on goals – explicit objectives/goals	*0.638*	0.100	0.335
Achievement – development costs	*0.610*	0.000	−0.116
Aggressiveness – quality targets	*0.582*	0.000	0.000
Achievement – project on time	*0.577*	0.115	0.000
Achievement – customer needs	*0.573*	−0.158	0.249
Aggressiveness – product costs	*0.567*	0.158	0.000
Aggressiveness – customer needs	*0.563*	−0.139	0.135
Achievement – manufacturing costs	*0.562*	0.177	0.137
Aggressiveness – project on time	*0.537*	0.000	0.000
Achievement – product costs	*0.518*	0.117	0.131
Impact on goals – design-for-manufacture	0.472	0.469	0.275
Aggressiveness – performance goals	0.468	0.000	0.194
Impact on goals – resources speed-up activities	0.433	0.365	0.000
Aggressiveness – development costs	0.426	0.153	0.137
Degree of use – explicit objectives/goals	0.425	0.212	0.324
Impact on goals – certified suppliers	0.401	0.302	0.179
Degree of use – quality function deployment (QFD)	0.000	*0.699*	0.000
Degree of use – rewards tied to speed	0.000	*0.679*	0.000
Degree of use – resources speed-up activities	0.000	*0.605*	0.000
Degree of use – pre-project training	0.000	*0.587*	0.000
Degree of use – isolate project team	−0.379	*0.561*	0.246
Degree of use – design-for-manufacture methods	0.199	*0.550*	0.156
Impact on goals – rewards tied to speed	0.151	*0.546*	0.000
Impact on goals – quality function deployment (QFD)	0.371	*0.544*	0.173
Degree of use – rapid prototyping	0.000	*0.537*	0.125
Degree of use – outsourcing design activities	0.000	*0.525*	−0.299
Degree of use – omit normal development steps	−0.271	*0.504*	−0.242
Degree of use – co-locate project personnel	−0.138	0.483	0.298
Impact on goals – isolate project team	−0.210	0.443	0.300
Impact on goals – omit normal development steps	0.000	0.412	0.000
Impact on goals – rapid prototyping	0.224	0.411	0.172
Impact on goals – pre-project training	0.248	0.410	0.109
Degree of use – certified suppliers	0.258	0.408	0.000
Achievement – reduce development time	0.351	0.375	0.175
Aggressiveness – manufacturing costs	0.274	0.337	0.000
Impact on goals – outsourcing design activities	0.195	0.303	0.000
Aggressiveness – reduce development time	0.199	0.278	0.247
Degree of use – quality tools and full-scale	0.184	0.266	0.000
Aggressiveness – innovative features	0.136	0.194	0.177
Impact on goals – shared design database	0.000	−0.102	*0.730*
Degree of use – shared design database	−0.134	0.128	*0.694*
Impact on goals – internet, e-mail, e-conferencing	0.283	−0.143	*0.662*
Impact on goals – CAD design tools	0.115		*0.614*
Degree of use – internet, e-mail, e-conferencing	0.282	−0.129	*0.571*
Impact on goals – co-locate project personnel	0.000	0.155	*0.562*
Impact on goals – cross-functional teams	0.283	0.000	*0.547*

(continued)

Table I.
Rotated component matrix of factors based on goal aggressiveness and achievement, using three factors based on spree plot results

Variable descriptions	Quality and performance metrics	Team coordination	Technology issues
Impact on goals – computerized project scheduling	0.223	0.122	*0.519*
Degree of use on the project – computerized project scheduling	0.000	0.171	0.447
Degree of use on the project – computer-aided-design tools	0.000	0.000	0.438
Degree of use – cross-functional teams	0.181	0.182	0.345
Impact on goals – quality tools & full-scale facilities	0.200	0.132	0.247
Achievement – innovative features	0.152	0.000	0.163

Notes: Extraction method: principal component analysis; Rotation method: Varimax with Kaiser normalization; Note that rotation converged in five iterations

Table I.

Component	Quality and performance metrics	Team coordination	Technology issues
1	0.717	0.501	0.485
2	−0.473	0.860	−0.190
3	−0.512	−0.093	0.854

Notes: Extraction method: principal component analysis; Rotation method: Varimax with Kaiser normalization

Table II.
Associated component transformation matrix of factors based on goal aggressiveness and achievement

three factors based on Spree Plot results (Cattell, 1966). Table I displays the associated component transformation matrix of goal aggressiveness and achievement. The three major constructs that were generated from the factor loadings of project goal aggressiveness and achievement goals variables included: quality and performance metrics, team coordination, and technology issues. As a general note, several sampled variables were found to be significant but loaded less than 0.5, as evident in the tables. However, listing the factors that loaded 0.5 or greater allows for a discussion of component variables that were considered to be the most dominant, at least in terms of the variance captured, in defining a particular construct.

The following is a listing of the major positive factor loadings of variables in decreasing order in each of the three major groupings that were derived from the tables. As for the quality and performance metrics construct, the specific variables that had a factor loading of 0.5 or greater included (actual factor loadings are in parentheses):

- achievement of quality targets (0.713);
- achievement of performance goals (665);
- impact on goals of explicit objectives/goals (0.638);
- achievement of development costs (0.610);
- aggressiveness associated with quality targets (0.582);
- achievement of project on time (0.577);
- achievement of customer needs (0.573);
- aggressiveness associated with product costs (0.567);

- aggressiveness associated with customer needs (0.563);
- achievement of manufacturing costs (0.562);
- aggressiveness associated with project on time (0.537); and
- achievement based on product costs (0.518).

The quality and performance metrics construct illustrated that quality assurance goals and meeting specified performance targets are important determinants of successful management of the manufacturing processes. Operational effectiveness measures, such as meeting quality and budgeted targets, are extremely important; they are not substitutes for manufacturing strategy. The loading of managerial aggressiveness and achievement of selected manufacturability factors is a good basis for identifying the more tangible aspects of manufacturing performance. As such, this listing should provide a guide for sorting out the more obvious and suitable candidates for further study and metrics' development.

The emergence of the team coordination construct also has significant impact on management in terms of team-integration issues involved in successful manufacturability projects and effective operations. The specific variables that had a factor loading of 0.5 or greater in the team coordination construct included the following and listed in decreasing order (actual factor loadings are in parentheses):

- degree of use of quality function deployment (QFD) (0.699);
- degree of use of rewards tied to speed (0.679);
- degree of use of resources speed-up activities (0.605);
- degree of use in pre-project training (0.587);
- degree of use to isolate project team (0.561);
- degree of use of design for manufacturability DFM (0.550);
- impact on goals of rewards tied to speed (0.546);
- impact on goals of quality function deployment (QFD) (0.544);
- degree of use of rapid prototyping (0.537);
- degree of use of outsourcing design activities (0.525); and
- degree of use of omitting normal development steps (0.504).

For example, the complexity of rapid prototyping and use of rewards tied to speeding the teams' activities require that more people can be involved in any project, making it more likely that something that may have failed will now succeed. Team coordination activities are paramount to deal with the stresses induced by tools that are designed to implement DFM methods and the use of outsourcing to enhance manufacturability that ultimately reduces project's completion time. As firms continue to have more people involved in manufacturing and requirements planning management activities, a significant number of projects may still fail. Proper team coordination and its management are still part of a people-centered process. As vital team members are identified and often removed from a manufacturing project for one reason or another, they take important information with them. Unfortunately, the right people may not be asked to be part of the project in the first place, so more people can offer input at the interface for project and requirements management.

Proper use of rewards, not isolating team members, emphasis on proper leveraging of selected metrics, use of resources speed-up activities, placing renewed emphasis on pre-training activities are important insights for this analysis. Product development team's coordination and integration serve as important insights to successful manufacturing management. The results of the factor loadings into the team coordination construct will serve as a foundation for the hypotheses testing of perceived threats to manufacturability and moderating effects of team integration in the smart card and related AIDC industry.

As for the technology issues construct, manufacturability and its proper management are not without the issues of injecting the proper amount of technology to enhance the NPD/NPM processes for successful completion of the products involved. As previously discussed, by picking the largest eigenvalues, little information as possible in the mean-square sense is lost and allows for meaningful comparisons of the factor loadings. The specific variables included in the Technology Issues construct that had a factor loading of 0.5 or greater included the following in decreasing order (actual factor loadings are in parentheses):

- impact on goals of shared design database (0.730);
- degree of use of shared design database (0.694);
- impact on goals of internet, e-mail and e-conferencing (0.662);
- impact on goals of CAD design tools (0.614);
- degree of use of internet, e-mail, e-conferencing (0.571);
- impact on goals of co-locate project personnel (0.562);
- impact on goals of cross-functional teams (0.547); and
- impact on goals of computerized project scheduling (0.519).

The degree of use and resulting impacts of technology injected into NPD/NPM processes cannot be underestimated. The technologies associated with innovation, communication, and IT transfer (Taylor and Todd, 1995) are important catalysts in enhancing the manufacturability goals of co-locating project personnel, cross-functional teams, computerized project scheduling, and sharing design databases.

Management involvement and top management support activities

There are a number of management involvement and top management support activities, nurtured in a manufacturing collaborative and accelerated project environment that have implications to strategic manufacturing systems. As illustrated from the patterns that emerged and the general agreement that management relinquished authority as a function of agreement with a number of selected manufacturability and project variables, product design activities (including mechanical design, electrical design, test design, and design for SCM-related activities) must allow for team autonomy. The planning and scheduling activities (including forecasting, positioning of material to fulfill demand, and capacity management activities) are associated with increased agreement with management relinquishing authority to the appropriate development and design teams. These are essential requirements that should be considered in the product team integration processes. This is especially true in new product introduction and information-sharing activities (including bill of materials management; prototyping, design validation, testing, and production validation testing activities) that are important for successful NPD/NPM processes.

Development team activities associated with successful design and manufacturing processes that also seem to benefit from management's ability to relinquishing authority include product-content management (including change generation, change impact assessment, and product change release). Outsourcing and supplier involvement activities, such as approved vendor management, strategic sourcing, and supplier selection, were also associated with product teams' autonomy and enhancing team's ability to handle complexity and project acceleration issues as management relinquished its authority.

Limitations of present study

The basic limitations of the present study included data and generalizability concerns. The limitations also include a statement of researcher biases. The scope of a research project investigating an industry such as the smart card and AIDC-related industries could be very large, even overwhelming, but present research only included project planning, team integration, and NPD/NPM processes. The range and scope of the questionnaire data itself were not fully explored. Specifically, the corporate manufacturing and direct supplier response elements within the emergent nature of the domestic smart industry were analyzed. Although the results of this dissertation are very reasonable and inline with previous research studies found in a variety of scholarly and practitioner journals, the developing nature of such an informational-intensive industry may have a number of limitations that prevent its use in other more service oriented and/or less information-intensive manufacturing based industries. In other words, the field of manufacturing technology and strategy is evolving as well and not all industries involved in manufacturing are easily generalized.

The nature of factor scores serving as dependent and independent variables may increase error variance measurements due to off-loadings (generally it was found that a significant percentage of the off-loading factors have loadings of less that 0.25 in creating the independent variable constructs of collaborative support, manufacturing involvement, top management support, technological uncertainty, design outsourcing, project acceleration, product newness, complexity, and supplier influence as found in the previous list of technical and project team integration processes of NPD/NPM within AIDC industries and Table I. In essence, increased error variance was introduced at the expense of reducing multicollinearity. In addition in performing the principle-components factor analyses with a usable sample size of 180, this number was reduced to 127 in the three hypotheses-testing models due to missing data in some pairs of the data for the all the variables in the extensive pairing for the regression analysis. The trade off is a reasonable one to take, but it must be mentioned as a limitation of the study.

Conclusion and implications for collaborative team environments

There is a growing need to develop working models from the manufacturing and related management literature to relate team integration, knowledge-management and leadership strategies within NPD/NPM in general, and specifically within the automatic identification and data capture industry (AIDC). This need is becoming more evident as the world economy continues to be Internet and information systems (IS) driven, and speed-to-market considerations become major inputs into manufacturing strategies. Swink's (1999, 2000) original work dealt with these considerations and their impacts on manufacturability. As evident from the present study, team collaborative efforts in high-technology projects have mixed results in terms of comparing aggressiveness towards and actual achievement on meeting time targets and manufacturing costs, especially dealing with the dynamics of project-team autonomy and managerial control issues. The development of Internet, augmented with auto-identification technologies, has created and enhanced B2B transactions and its SCM-related systems, leading to an increased interest in enhancing NPD processes to ensure success for competitive advantage.

Some of the major success factors related to NPD processes are within the scope of management's control and influence. These factors include technical-project acceleration, product newness and complexity, technological scope and uncertainty, and degree of design outsourcing and/or supplier influences. These factors are related to significant reduction in development lead-time, reduced time-to-market strategies, increased projects' financial returns, and improved responsiveness of basic performance metrics, which have a dramatic effect on product manufacturability.

Especially the variables of product acceleration, technological uncertainty, complexity, and product newness are traditionally outside the immediate control of the firm's project managers. The team integration variables, as measured by top management factor scores, manufacturing involvement factor scores, collaborative working environment factor scores, and supplier influence factor scores, offered the most explained variance in the present study. As noted by Newman and Hanna (1996), Smith (2003, 2007), and Tranfield and Smith (1998), much of the manufacturing strategy literature is concerned with technical aspects of environmental mapping and with locating, classifying, and auditing particular products, processes, businesses and companies against generic externally given criteria. However, by adjusting manufacturing methods, product designs, and team integration processes, manufacturing performance can be improved and competitive advantage regained. Upper management should support a collaborative environment. Earlier and more intense involvement from manufacturing personnel associated with design and production should allow management to better deal with the ever-changing customer requirements in a more efficient manner. Therefore, as noted by Tranfield and Smith (1998, p. 115):

> It is usually implied that this strategy-making process needs to be revisited regularly, although usually there is little guidance available as to how often this should.

Teece and Pisano (1994) offered some additional types of routines in manufacturing that directly impact on coordination problems frequently found in manufacturing environments (gathering and processing information, linking customer experiences with product and organizational design choices, coordinating factories and component suppliers, and bringing new products to market). As found in the present study, the traditional threats of technological and product complexity, product newness, technological uncertainty, design outsourcing, and intentional project acceleration are not the major forces of concern in implementation of successful strategic manufacturing management. These forces may not be generally cost effective to become more manageable in the foreseeable future. However, product team and technical team integration issues are certainly under some degree of control by management and deserve to be treated with proper respect in formulation of manufacturing strategy. As evident in the present study and previous project management studies, team integration and technical-project management play critical roles that should be leveraged for sustainable competitive advantage. These concepts are in agreement with the basic tenets of the resource-based view of the firm (RBV) based philosophy (Michalisin *et al.*, 1997, 2000; Porter, 1996, 1999). Unfortunately, creating a viable list of proven and exploitable manufacturing competencies and/or capabilities in a single model is not yet well articulated and accepted by academics and practitioners alike. The results of the present study do point that a variety of team performance and integration constructs within a collaborative environment are important to high technology-intensive and manufacturing entities and management needs to be sensitive to the roles of not isolating team members and being able to relinquish control at the appropriate times to enhance manufacturability.

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