

## **Remote Collaborative Product Development – A Landmark Survey**

Ronald Lasser, Ph.D.

[rlasser@pdcinc.com](mailto:rlasser@pdcinc.com)

Product Development Consulting, Inc.

84 State Street

Boston, MA 02109

617 723-1105

[www.pdcinc.com](http://www.pdcinc.com)

### **Abstract**

The competitive nature of global markets is causing firms to accelerate their product development activities. Companies are utilizing remote collaborative product development (RCPD) to harness time in multiple dimensions—across their own firms and with partners—to build competitive advantages by leveraging expertise, sharing knowledge, and mitigating risk. Companies are expanding their product development capabilities to anticipate customer demands for mass customizations by sharing core competencies among partners. The degree to which information is shared and communications are synchronized, not the distance separating partners, is the chief distinguishing characteristic of RCPD. The primary driver is the ability to harness diverse specialized resources and compress time so as to reduce the *time-to-profit*. The metric is a combination of cycle time, return on investment, knowledge turns, and quality measures. Operationally, this reduction in time-to-profit is achieved by leveraging every means available to shorten every aspect of the product development cycle. In the spring and summer of 2001, 23 companies engaged in remote collaborative product development participated in a benchmark study designed to examine the benefits, obstacles, and enablers to adopting this new method of doing business. The results of this benchmark study are reported and analyzed, and a new theoretical model of the RCPD environment is presented to describe the interconnectivity among the mutually dependent supporting elements and independent partner activities. Finally, managerial implications and a set of best practices for use in any remote collaborative situation are discussed.

## Introduction

The competitive nature of global markets is causing firms to accelerate their product development activities. Their goal: to commercialize more products in a shorter period of time. Concurrent engineering—combining product design and manufacturing system planning—was the beginning of the time saving revolution by overlapping tasks and working cross-functionally. Today, companies are adopting remote collaborative product development (RCPD) to increase efficiency of diverse resources and compress time to gain competitive advantage. Firms are seeking the ability to leverage the expertise of multiple partners to gain new proficiency beyond their own core competencies in shorter intervals. The objective is to divide project work among partners to develop product components in parallel, shortening cycle time. The hope is to reduce the time to market acceptance as partners work together to provide access to new markets for total customer solutions. Companies able to generate, transform, and distribute knowledge to increase their own capabilities and the value of the products and services offered to their customers will gain advantage in the marketplace. This ability to exploit time as a competitive edge is the significance of RCPD.

This project began during the investigation of the problems faced by mechanical engineers in sharing three-dimensional computer aided design (CAD) representations of prototype parts with suppliers separated by distance. The modeling of the three-dimensional image of a part using computer-aided engineering (CAE) tools over the World Wide Web was too slow. The exchange of data with suppliers was error-prone, due to different visualization software applications, data formats, and design rules. Software tools providing data format translation introduced conversion errors. Design intent was often misunderstood during telephone conference calls as verbal descriptions and visual drawings were not synchronized. This verbal/visual mismatch caused surprises and led to additional development iterations. Part modification and problem resolution often required face-to-face meetings to resolve subtleties. Travel time increased delays and costs. Design engineers spent the majority of time debugging problems with computer systems or producing workarounds to get electronic fabrication drawings to remote model shops. The sequence of steps from specification to finished part did not simplify the process, make it shorter, or cost less. Instead, it created new problems. Suppliers had their own process. Developers had to adapt their own process multiple times. These adaptations impacted other departments, breeding chaos in the organization. Engineers became frustrated. Supplier competence and the cooperation of other departments were called into question. Management was at odds with requests by developers to reestablish a collocated model shop and to work with machinists they knew and could trust. The promise of saving time and cost by working with external suppliers quickly vanished.

These problems, albeit stemming from a specific example about the design of mechanical parts, afforded insights into the heart of remote collaboration and led to a search to develop a set of scalable best practices to unify working beyond the enterprise. A search to find existing best practice methods to apply to this scenario revealed neither a holistic

approach, nor a model of remote collaboration. Much information did exist on virtual teams, virtual organizations, virtual communications, and virtual offices. However, this approach appeared merely to extend collocated processes and environments by simulating them in computer systems and over networks. The virtual concept promoted the idea that the solution lay in increasing the reliance on interpersonal and cultural diversity skills to address the lack of face-to-face contact and the adverse impact on trust among remote participants. This was not the whole story. It did not address the dynamic conditions introduced by Internet connectivity—real-time problem solving—challenging the ability of traditional face-to-face collocated processes to work beyond the enterprise. Nor did it scale these concepts to resolve the complex integration and variation of product development, project management, resource allocation, and decision-making processes in the extended enterprise. Lastly, none of the existing approaches suggested a governance to measure time against a set of parameters and to gauge progress toward achieving a competitive advantage or strategic goal.

The research and benchmark survey described in this paper was developed in order to promote an understanding of product development beyond the enterprise. The goal was to develop a set of scaleable best practices to be used across different industries and among companies of various sizes. A search in trade publications, industry periodicals, scholarly journals, and books demonstrated that this field of study was in its infancy. The literature did not provide the answers to questions emphasizing the importance of the whole and the interdependency of its parts.

The search to identify a set of scaleable best practices began by identifying current practitioners of remote collaborative product development. The approach was to obtain a description of the environment from senior executives who possessed first-hand knowledge of the drivers, benefits, enablers, and problems from their own experience. The objective was to derive an understanding of the underlying themes and root causes. The findings are descriptions of what is occurring in industry today. New insights are drawn from actual practice. A new theoretical model of the RCPD environment was then developed to describe the interconnectivity among the mutually dependent supporting elements and independent partner activities. Finally, managerial implications were drawn from the model and the insights to present a set of best practices for use in any remote collaborative situation.

## **RCPD and its Significance**

Remote collaborative product development (RCPD) is a single robust environment extending beyond an enterprise created to achieve a shared objective. People collaborate across several firms to develop and commercialize products for the marketplace. Information technologies, communications, culture, management and processes bind environment and people together. This approach involves geographically dispersed teams, shared databases, conventional and Web-based communications, and limited face-to-face contact. An extreme form of RCPD is the open source software environment responsible for the development of Linux and other software essential to the Internet

[MockusWP]. RCPD is not equivalent to outsourcing. Outsourcing shifts partial or total responsibility for an internal project or function from a firm to an external company.

Companies outsource for different reasons: e.g., utilize economies of scale, deep expertise, better processes, newer technology, higher productivity and quality, or service capabilities of a provider. For example, an electronics manufacturer procures built-to-order power supplies for its television and entertainment product lines. The purpose is to achieve a competitive cost for the components by taking advantage of the economy of scale of a power supply provider. The responsibilities to design, manufacture, and deliver power supplies have been transferred to an external firm. Another example is a telecommunications networking firm focusing its efforts on innovative R&D by transferring its entire manufacturing and service operations to third-party providers to access better services and capabilities. The company has transferred two operational functions to two external firms.

RCPD shares the risk and responsibility among a firm and its partners rather than transferring them. For example, a biotech company works with smaller firms to develop new drugs. Biological and chemical data is distributed among scientists and engineers to determine the molecular structure, develop the validation tests, and design the manufacturing process. Employees from several companies share in the work activities to achieve a combined objective. A second example is an ink jet printer manufacturer. Ink is developed jointly with a chemical firm to determine the requirements of the dispersion mechanism, while real-time software control is developed with a third partner. Ink viscosity, temperature, droplet size, electronic control of the process, loop timing are some of the critical parameters which impact sharing intellectual property and contributing to the failure or success is shared jointly among each partner.

The shift to RCPD grew out of necessity. Shorter product life cycles place new demands on management to launch products more quickly [Amaldoss00, Bhattacharya98, MacCormack01, MockusWP, Smith92, Ward95]. The rate of technological change forces companies to expand on their core competencies. However, scarce R&D funds limit investment to all but a few core competencies in product development. This compels firms to grow their capabilities by the synergistic combination of strategic complementary core competencies with partners beyond the enterprise. The survival of small R&D organizations depends on their ability to increase both the scale and scope of their operations to build more complex products faster by accessing both technology and the rights to intellectual property.

Dynamic customer preferences demand that firms provide a continuous stream of broad offerings and total solutions to the marketplace. Uncertain actions by competitors drive companies to look for stable and new revenue streams to fund ensuing product cycles and meet stakeholder expectations. Partnerships enable them to access new markets. The previous sentence is not within the same context as the rest of the paragraph. The presence of local development teams permits participation in certain local markets, for example by meeting local governmental regulations. Mergers, acquisitions, and alliances

expand opportunities for growth and merge complementary product lines by distributing product development around the world [HerbslabWP].

The Internet and the World Wide Web provide critical new communications and information technologies that impact the coordination of worldwide business activities. Increased information bandwidth connects continents via asynchronous and synchronous technologies, such as email and instant messaging. Round the clock product development (24/7), passing the baton from one development team to the next, contributes to performance gains. A second contribution is three-shift product development identical to traditional factory work cycles; for example, in India and China three teams of engineers working eight hours per shift utilize computers, CAD software and CAE tools, and laboratories. The benefits are twofold: assets are utilized continuously and developers are in contact with their counterparts at remote locations and companies around the clock and around the world.

Why RCPD? All of these new developments stress and strain traditional collocated product development organizations, forcing firms to stay at the cutting edge and to shorten the cycle time of their processes. The hope is to improve financial and project performance, access best-in-class expertise and technology, expand into local markets, deliver on rapid innovation, acquire competitive advantage to consolidate power in the marketplace, and harness time. These are all good reasons, but reality is different. Companies are being forced to invest in remote collaborative product development environments because they have no choice: not to do so means they will not stay competitive for very long.

## Survey

During the spring and summer of 2001, a benchmark study<sup>1</sup> was conducted on RCPD to understand the scope and degree to which companies were utilizing this new methodology. The intent of the survey was to identify the:

- Benefits, problems, obstacles, and enablers associated with implementation of a collaboration strategy
- Measures for success in terms of the predictive metrics utilized to monitor the process associated with remote collaboration
- Results and experience, particularly to discern the best practices employed by companies developing products
- Environment and culture attributes and enablers, which differentiated RCPD from traditional and collocated implementations of product development.

The key criteria for the selection of the participants in this study was their previous experience in completing a product development project either over multiple sites within the enterprise, with a partner<sup>2</sup> beyond the enterprise, or both. A strong extended

---

<sup>1</sup> A small follow up study was conducted in the spring of 2002 and 2003 to discern trends and to explore additional companies adopting this methodology.

<sup>2</sup> The term partner defines a specific shared relationship: an enterprise and an external company are engaged in a collaborative activity having a formal relationship that shares in the outcome. Short or long-

enterprise presence was favored over working at multiple sites in the same organization. Collaborative projects required the involvement of multiple levels in the company's management hierarchy. It was essential that senior executives or key managers possess knowledge of direct results, personal experiences with the process, and insights about the benefits, approaches, obstacles, and best practices involved in RCPD. A product development focus, rather than an R&D or Engineering perspective, was necessary for this study of collaboration. This provided more inclusive and cross-functional access to project results and impacts. Knowledge of strategic initiatives within a company was indispensable, for it afforded a familiarity with business trends and broad picture influences on collaborative project implementation. The interconnection of collaborative product development with product portfolio and related processes, such as resource capacity and allocation, was particularly valuable because it brought a complete view of product life cycle management.

Approximately one hundred companies were identified and evaluated against these criteria to determine their suitability for inclusion in this study. Financial analyses, newspapers, periodicals, and annual reports were reviewed to verify which companies were engaging in remote collaborative product development. Fifty-eight potential candidates met the criteria and were contacted by telephone and email to introduce the study. Twenty-three agreed to participate. The list of companies that participated in this study appears in Table 1.

<b>Agilent</b>	<b>Maytag Corporation</b>
<b>Alticor / Amway</b>	<b>Medtronic</b>
<b>Bausch &amp; Lomb</b>	<b>Motorola</b>
<b>Becton-Dickinson</b>	<b>Neurogen</b>
<b>Boeing</b>	<b>Pitney-Bowes</b>
<b>Eastman Kodak</b>	<b>PowerSteering</b>
<b>Eli Lilly</b>	<b>PPG Industries</b>
<b>Fisher Controls</b>	<b>Remington</b>
<b>Ford Motor Company</b>	<b>Thomas Built (DaimlerChrysler AG)</b>
<b>General Motors</b>	<b>Sara Lee</b>
<b>Invensys—The Foxboro Company</b>	<b>Xerox</b>
<b>Lucent Technologies</b>	

## **Data Acquisition, Analysis, and Synthesis**

One on-one interviews lasting approximately one hour were conducted with senior executives<sup>3</sup> for the contextual interviews. A small set of questions formed the interview guideline and is presented in the Appendix. While the guideline represented the areas of

---

tern partners are not differentiated. The term supplier is a generic term representing a spectrum of possible relationships with an external company. An outsourced supplier participates in a business relationship where there is a transfer, not a sharing, of responsibility for a product or service.

<sup>3</sup> Several interviews were conducted with multiple executives and managers participating in the conference call. The point-of-contact felt that a broad perspective would be a richer and more robust description of their RCPD experience.

interest, its primary purpose was to initiate conversation. Interviews were conducted in a style to let the participants drive the discussion. As information was revealed, the interviewer asked for specific examples, probing to reveal critical information beyond the expressed data. The interviewer specifically asked for descriptive examples whenever possible. Doing so revealed the nature and impact of enablers and obstacles. Further, this assisted gathering data about lessons learned and insights gleaned from experiencing the specific example. No two interviews were the same. The participants, in their own words, defined the description of RCPD at each company. A companion questionnaire completed the data collection. Questions were in multiple-choice, fill in the blank, or level of importance format. This data was correlated to the associated interview and to the responses of the other participants using graphical and statistical methods.

A modified form of the KJ method was used to obtain and process a portion of the data for the benchmark study [Shiba93]. This method has been successfully utilized in gathering and analyzing field data for quality improvement and “Voice of the Customer” research. The qualitative nature of the interview data was transformed using Language Analysis, which is a tool for organizing diverse observations and qualitative information into useful facts. Common themes and significant perspectives were drawn out of the different expressions appearing across the interviews and grouped together. Affinity diagrams were constructed to acquire insights. Inferences were identified from the graphical representation of this affinity data. The questionnaire provided quantitative data and a means to correlate the information derived from the interviews. While semi-scientific methods were used to understand the data, human decision-making played a role in the analysis to realize the significance of individual participant insight. Four individuals conducted the interviews, recorded the data, analyzed the transcripts, and synthesize the findings. Decision-making was by consensus after much discussion, deliberation, and review. See Acknowledgments.

Follow-up calls were made to a sample of the participants to explore specific topics after a preliminary review of the interview transcripts were reviewed. The participants were contacted within a month after the distribution of the final report to obtain their comments on the study and to gain any additional insights from their on-going experience.

## **Findings**

A company takes on the challenges of RCPD because they desire to be a driver, not a merely a player, in the marketplace. “It is a new market opportunity we have to get into, we have to get into it very quickly, ...and from a business point of view, we are much better off working with others who offer that...capability. The business strategy, and again looking toward growth, there is a whole new set of rules that evolved out of the Internet,” as a senior executive said. When looking for specific causes for this desire, the typical business reasons—e.g., changing customer preferences, uncertainties about competitive plans, ability to react rapidly to highly dynamic market situations and discontinuous product introductions, limiting market share competition, keeping pace with the proliferation of new technologies—does not sufficiently explain the shift to

RCPD. The shift to RCPD is a strategic commitment: nearly all participants recognized that worldwide real-time connectivity was irreversibly changing the business landscape and the way product development is conducted. Specifically, the time frame for product development was becoming shorter and more continuous in nature.

The primary driver for RCPD is the ability to harness time and to reduce the *time-to-profit*. This is the strongest finding from the study and the most cited reason for engaging in RCPD. The metric is a combination of cycle time, return on investment, knowledge turns, and quality measures. Also increasing customer value can increase revenues and margins and reduce time-to-profit. Operationally, this reduction in time-to-profit is achieved by leveraging every means available to shorten every aspect of the product development cycle. The goal is to push beyond the leading edge and leave rivals behind by deriving advantages from time. Time has become the overarching measurement of performance by customers. Increasing the performance of specific parameters per unit of time—not cost—becomes the critical metric. The shift to RCPD is driven by recognition that the old adage is true: time is money.

Time-to-profit is visible across all interfaces of the extended enterprise. This metric decomposes into intermediate targets to be achieved along the way to meet the result. The intermediate targets extend visibility into suppliers acting as leading indicators to predict the final outcome. Predictive metrics for cycle time, cost, resource allocation, and quality can be directly linked to performance, and can signal an out-of-bounds condition. Such metrics support strategies designed to meet customer requirement timelines. Time performance plays a strong role in being first to market with innovative solutions that leapfrog the competition.

RCPD was not driven by the conscious decision of all the participants in the study. For a large subset of the participants, RCPD was the consequence of some other competitive actions. Whether the lead in was due to merger or acquisition, local participation in a market, balancing resources due to product demand or restructuring, or alliance with a geographically separated partner, the realization occurred that remote participants expect a response to their interaction in real-time, distance notwithstanding. This changes the game. Once it does, irrespective of RCPD being adopted by choice or imposition, harnessing time becomes the common denominator to making choices on how to proceed.

Most participants agreed that RCPD is fundamentally a new way of doing business and represents a new paradigm in the approach to creating and launching products. The biggest transformation, according to one senior executive in the study, is to “change the business practices and understand you are in a new world”. *The degree to which information is shared and communications are synchronized, not the distance separating partners, is the chief distinguishing characteristic of RCPD.* Other descriptive attributes are geographically dispersed resources, little face-to-face contact, loose coupling and control, and complementary expertise. Senior management is tasked to define a shared objective and path forward with partners. The bulk of their time is spent in constructing and enabling the environment rather than in supervising project details. Constructing an



RCPD approach involves building a shared workspace where information is accessible and communication is routine. Enabling it means transforming intellectual property knowledge into tangible value while minimizing cost, time, and risk across the extended enterprise. Project management is the responsibility of the dispersed, nearly autonomous, team.

Some team autonomy is a necessity when management authority is allocated across the extended enterprise. Compensation for the loss of control in such a domain is handled by a locally known methodology, such as project and team management methods, and expected discipline surrounding project execution. The survey found that process rigor and resource integration in a shared workspace are greater indicators of success than infrastructure and technology improvements. In the experience of one senior executive, “You have to have agreed upon procedures on how you work together, how you initiate projects, how you manage projects, and how you reach decisions”. Also, a formal management policy is the strongest predictor of effective intellectual property control and protection. These observations occurred in nearly 75 per cent of the interviews. Loose project control and tight coupling of partners occurs naturally in an RCPD environment. Project managers have no authority in a remote partner’s organization, but the future success of the project is highly dependent upon each partner’s performance. Structured and routine communications at all levels of the extended enterprise strengthen the relationships while providing the independence of action on both sides of the interface. This also has the effect of increasing the frequency of knowledge transactions during project execution. The quality of such frequent and routine communication appears to improve performance, but none of the participants had metrics or other hard data to support this impression. This perception is supported by an empirical [Ahuja98] investigation of communication network structures in distributed organizations.

Approximately 87 percent of RCPD companies saw their supplier relationships changing from arms-length to risk/reward affiliations. The trends in supplier relationships will be discussed later in this section. These firms worked with a limited number of suppliers, possessing complementary skill sets, to build closely-knit and long-term relationships, and to minimize the number of interfaces. Upfront supplier selection criteria, designed to evaluate a supplier’s ability to accomplish a shared objective, required modification of traditional arrangements. Since the stakes, dependency, and integration was higher, companies sought to determine more definitively a supplier’s capabilities. However, most participants disclosed that they had to learn how to interact with an external company to build such a relationship. This was especially true for large companies working with smaller firms. They were more interested in promoting their own systems than in learning about the methods they originally sought out at suppliers. This approach frequently resulted in getting off on the wrong foot at the start, causing suspicion and frustration for both sides. Nearly all firms acknowledged that interpersonal and cultural diversity skills are more critical in early project stages than definitive commitments. Understanding philosophy, processes, and skills of partner organizations yields greater results faster. Projects were completed in less time than when working in a collocated environment.

Metrics are catalysts for bottom line results and tracking progress toward the shared objective. They are effective when they have visibility across all partner interfaces. This is a key distinction to metrics used in traditional collocated product developments. An integrated governance methodology is necessary to bring predictive and result metrics together within an organization, across an interface, and into a partner organization. Just over a third of the participants had some form of measurement in product development, but deployment of metrics in RCPD organizations is spotty. Those participants who reported using metrics had better overall performance with fewer complications. The strongest metrics were traceable to customer objectives using a combination of results and predictive oriented metrics. One participant as summed this approached up: “You measure their ability to deliver what you had asked them to deliver.” Results metrics measure the outcome of a process, while a predictive metric focuses on the actions leading to the result. The latter metric acts as a leading indicator, signaling if corrective action is necessary. Examples are listed in Table 2.

<b>Table 2—Metrics Utilized in Remote Collaborative Product Development*</b>	
<b>Percent reuse of native intellectual and manufacturing processes</b>	<b>Percent of interoperability of IT backbone</b>
<b>Number of trips to partners; amount of money spent on travel</b>	<b>Percent of total partner business tied to one customer</b>
<b>Amount of time to resolve issues of given complexity</b>	<b>Number of programs per connected partner</b>
<b>Number of engineering changes orders (ECO) during system test phase</b>	<b>Number or percent of connected partners</b>
<b>Resource utilization across the extended enterprise (percent and absolute)</b>	<b>Percent collaboration tool usage; percent bandwidth matched communications</b>
*Note: This is an aggregate of all companies. No one company looked at all these metrics.	

Senior executives admit that RCPD is an effective methodology, but it is emerging as a business practice more rapidly than their company cultures are capable of assimilating the changes. These leaders feel they lack sufficient information to set policy and manage risk effectively. The lack of data comes from two primary sources. First, the habit to capture data at a regular rhythm does not exist. It was not demanded in traditional design environments, nor was there capacity or capability to gather and process such data. Extended environments both magnify the amount of data and complicate data collection and analysis by proliferating a variety of formats. Second, today’s information technologies are not robust enough to simulate face-to-face conversations and interpersonal activities, so some critical project data is lost. These tools are changing rapidly, but habits to capture data and the type of data that will be most useful are still evolving.

Managers acknowledge there is resistance to embrace the new paradigm. This limits the scope, adoption rate, and scale of results. Sharing and distributed decision-making

(public exposure and giving up control) requires a difficult transition from “silos where information is power” and controlled design processes. The transition is more complicated when it involves cross-functional teams at multiple sites within one company, or a distributed cross-functional team a multiple partner sites. One participant’s summed it up as: “You have different cultures in terms of risk levels...different management styles in different parts of the world...What I believe is that you also have the issue of this is mine, this is yours, [and] I am not sharing mine with yours. [It is] not abuse of power, it’s just not willing to share.” Further investigation is necessary to understand the impacts from differences in culture, product development methods, and organizational dynamics.

Developers believe that RCPD is another manifestation of management’s desire to eliminate the “not invented here” syndrome. Many developers are threatened by a loss of job security, sense of value, and ability to contribute. Information not disclosed in a timely fashion or lost when design control is distributed across the enterprise creates opportunities for sharing blame and may seemingly justify claims that RCPD does not work. Learning to tolerate failure and working to resolve problems is more difficult when work sites are dispersed. Communications drops off with distance and time differences, people become indistinct, and informal conversation delays the propagation of critical information. While it is easy to transfer problems to a remote site, it is difficult to find new methods to stop those problems from occurring again. Time zones exacerbate the distance problem, although many companies first extended north/south, to minimize this problem. Firms exchange representatives, called ambassadors, to bridge differences in cultures, methods, and communication and to make the remote team “more real.” This helps significantly when the individuals are strong in technical expertise and leadership ability.

Shared project management workspaces reduce cost and ease coordination. Fifteen percent of the participants reported savings for face-to-face travel by up to 40% and cycle time reduction by as much as 25%. Continuous project updates of critical metrics are more effective in achieving progress and anticipating problems than managing teams from traditional status meetings. All participants reported that there is a significant loss of visibility of tasks and schedules at remote locations. This inhibits reliable tracking of project progress. Development schedules became out of date more quickly than in traditional collocated projects. Project manager roles changed to tracking deliverables and adjusting resources to resolve problems, for it was impossible to chase updates and validate task dependencies. Threaded discussions are used by most distributed teams to capture issues, share ideas, obtain feedback, assign priorities, and manage commitments in real time. They are most effective at resolving problems. Publishing the issue throughout the domain reduces delays, since all resources have immediate knowledge of the problem. Acquiring ideas from all resources capable of contributing to a potential solution optimizes problem solving. Ramp up time is decreased since a history exists of what has and has not been previously attempted. “In a threaded discussion, which is not only how you communicate,” said a CEO participating in the study, “but how you raise issues that are eventually going to be addressed... You have a freeform threaded discussion, and the project manager...can go through, pick out discussion items as being

issues, bugs, or features, that someone has clarified. Mark that...prioritize it...[and] that is the work stack. People can ...assign a task against an [issue], not to the people, but an issue. That actually is a huge breakthrough and advance right there, for it is a very simple workflow.”

Participants found that project coordination requires less time when product functionality and features match team skills and deliverables. Project managers achieved project objectives more frequently when coordinating milestones leading to deliverables, than when working to expand visibility into partner’s domain to track progress on tasks. Project completion assessments performed at a regular frequency increased the convergence to the shared objective. A temperature sensor product development will serve as an example to demonstrate the assessment.

The temperature sensor consists of four modules: printed circuit board and electronics, software, the temperature probe, and enclosure. The project team is divided into four groups each responsible for a module. Every three days the groups are required to assess against a set of criteria the degree to which their module is complete. Differences in the metric criteria vary among project, technical discipline, module type, management considerations, business information, and market data. The purpose of the assessment is to determine the critical issues that are outstanding, which might require additional assets or resources to resolve to keep to the milestone and final project completion. The strongest usage occurred in distributed environments where “pure” software products were being developed. Software environments executed an assessment every day by simulating a final compilation of the software application. This “daily build” compared the project’s current state to the product release state for a set of critical parameter. Development projects requiring multi-disciplinary technologies utilized a formal project completion assessment less frequently, although it was part of their stated project oversight governance model.

An extended project team exists when effective partner representatives are capable of making decisions with some level of autonomy. Remote team meetings limited to resolving complex issues impacted the result more dramatically than when such meetings were used for status reviews. Team communication is largely asynchronous due to time zone considerations. Many participants had a steering team providing oversight to protect the boundaries of the firm, not for authority or oversight of the project. Its primary set of responsibilities was to build cohesive performance among remote project teams, to design continuously shared information channels with frequent feedback, and to protect the scope of information and partnership agreements.

One of the critical attributes of RCPD is to actively manage an open environment with partners and share all project intellectual property within the scope of a project. Many participants had a formal knowledge policy to define intellectual property protection in terms of ownership, usage, improvements and access. Shared databases with rights of entry, formal access controls, and a structured depository process were included. The ability to arrange, move, operate on, and control data from remote sites drives data format, tools, and security. A long-term archive acting as a formal data vault with

transparent accessibility from anywhere in the extended enterprise improves project performance. One participant stated it this way, “Everything from participating in remote meetings . . . to input on our electronic forms . . . to propose, review, and approve change orders . . . requires transparent resources involvement—you cannot tell where the developer is, but the work is getting done.”

The survey found that enterprise level web tools offer daily monitoring of critical measures and acquisition of information, but organizations lack the discipline and formal practices to capture and analyze such data. The enterprise level application software was not being utilized to the fullest. Participants held several perceptions about web tools:

- Vendors are selling solutions to problems that are not the most critical to solve or automate;
- Enterprise level applications extend collocated methods into collaborative workspaces injecting problems rather than solving them;
- Web tools are rarely used for social contact, causing more formal and business oriented interactions; and
- Acquisition by individual adoption based upon usefulness and allowing this desire to propagate through the organization was better than by mandate.

“You rate a tool,” said one participant, “Or application of a tool [by asking] does it collapse timeframes in the process. You’re out to make the engineer or the project participant more effective in terms of reducing the amount of time spent on a particular activity, or if you are talking about a broader group of people, collapsing the effective time spent to achieve a milestone in the project.”

Information technology (IT) architectures, firewalls and web tools act at cross-purposes for sharing and security. None of the participants offered adequate solutions. Many participants experienced problems with the existing technology: the inability to handle multiple supplier access to product data management systems causes delay to deliverables; data formats limit real-time sharing and visualization; access privileges are not dynamic, requiring upfront active support from IT groups and limiting real-time problem-solving; and firewalls prevented operation of certain communication software and long data transfers. Some participants found that data shared on connected servers makes distributed information more vulnerable to attack, or at least more susceptible to unauthorized access. Concept development and troubleshooting during module integration are intense periods of collaboration. Real-time exchanges are often limited by the functionality of web tool and the bandwidth of the technology. For example, control of a visualization application must be passed from one user to another to modify or annotate an image being reviewed and large amounts of data and a long period of time is need to update and repaint the image. This simplex form of communication caused frustration because participants were accustomed to full duplex communication: either face-to-face or via the telephone. When using web tools that require large amounts of data transfers to update all users, voice conversation and the pace of the meeting were often out of synchronization.

Email, one-to-one telephone, shared project space, group teleconferencing, and web-based applications were the most utilized forms of communication. See Table 3.

Successful information interchange required upfront planning. A strong bias to over-communicate greatly helps to focus information transfers, for it allows time to understand, clarify, and acknowledge comprehension. Chat software usage is growing, especially as an indicator for awareness, while video conferencing is being replaced by web-based meeting application software enhanced by a group teleconferencing. People preferred to work at their own computers using an application to share presentations, documents, spreadsheets, or drawing software. Meetings held in this latter format were more focused and most attendees appeared engaged.

Communication Medium	Percentage
Email	76
One-to-one telephone	61
Shared project information system	57
Group teleconference (voice only)	53
Web-based application (conference, threaded discussion, chat)	39
Video conferencing	37
Graphical collaboration software	34
FAX, Face-to-face (travel)	32

Only five percent of participants actively encouraged personal relationship development among remote team members. One company promoted social interactions via chat software with an “e-HappyHour” event. The company took a proactive approach. Coordination of time zones let one subset of remote team members relax after work, while another subset had breakfast. The interaction allowed team members to become familiar with each other’s perspectives. The social interactions focused on sports and recreation, hobbies and interests, and family background. The perception among participants is that teams that developed close personal ties were more likely to anticipate problems and to have more frank and open communications.

Nearly 25% of the survey participants instituted reward and recognition systems that extended beyond the enterprise for RCPD. These companies struggled to access performance, participation, and contribution. Only one company and its partners had a cross-enterprise rewards and recognition system. While the data is limited, it is highly suggestive that recognition of a partner’s resources develops the relationship and builds credibility.

The survey revealed that RCPD takes three discrete forms: multiple sites within a company, multiple sites beyond the enterprise, or a combination of the two. The criterion for this distinction is based upon sharing of intellectual property. Legal and security provisions are paramount for the latter two types since the border of the firm has been compromised. Most other attributes, enablers, or obstacles are consistent across all three situations.

Knowledge<sup>4</sup> development and sharing classifies a company in its form of RCPD. The scale is continuous, not absolute. However, categories are defined to delineate the spectrum (see Figure 1).

1). An *intrinsic* company is one that develops knowledge within a strategic business unit and limits sharing to within the business unit itself. Business units may be spread over multiple locations, but the corporation does not benefit as a whole from the acquired knowledge since it is retained locally. A *strategic* company

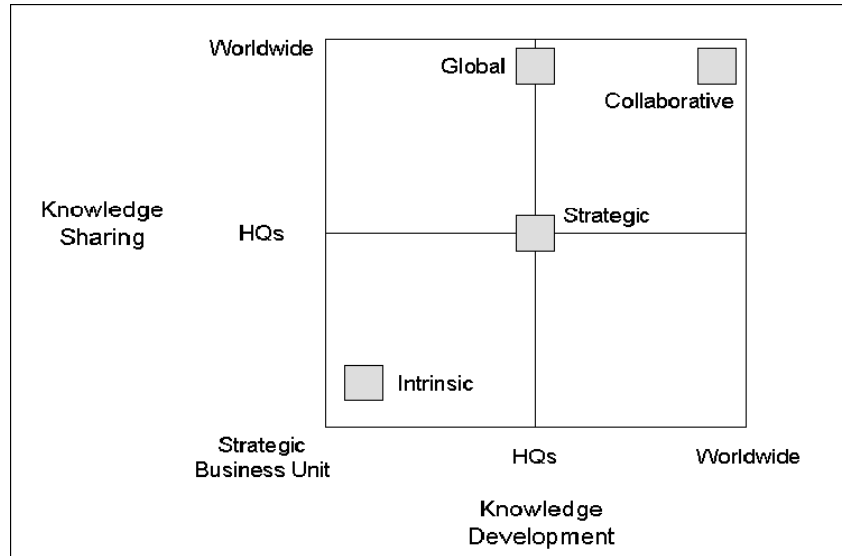


Figure 1 – Classification of Information Sharing

develops knowledge at headquarters and shares it within headquarters. Centralized planning and decision-making characterize such companies, although implementation is executed at distributed sites. Absorption and utilization of information lags transfers and the impact of real-time data is diminished. While *global* companies develop their knowledge at headquarters, they disperse it to all worldwide locations. Research laboratories at this type of company are centralized, while decision-making is stratified and development is distributed. Although channels exist to disseminate information, there is a lag in its utilization. A *collaborative* company develops and shares knowledge worldwide. Shared databases and a strong development focus incorporating information technology infrastructures integrate all sites and provide access. The entire enterprise utilizes real-time information to make decisions.

Synchronized communications acts as the binding and status agent for a collaborative firm. One participant’s comments were representative: “What you want to do is set up a communications network that allows you to communicate often, frequently, and as easy as possible. The communications network cannot get in the way. It has to be there. And people have to be comfortable using it to develop the relationship.” Each distributed site has its own internal clock, the rate at which work is accomplished, documented, and posted to databases. The more sites and the more dynamic the overall environment, the more the knowledge base changes. Synchronization is vital to keeping all locations updated, getting the noise out of the system, focusing on what is relevant and discarding what is out-of-date. The frequency of synchronization is dependent upon the number of partnering firms or locations, the type of work, and the sensitivity of the product

<sup>4</sup> Data is defined as raw facts; information as the grouping of data into recognized themes or patterns; and knowledge is actionable and the focus of decision-making.

development and the information to time. A rapidly changing situation will require more frequent synchronization cycles than conditions that are more stable.

The benchmark survey revealed clear trends regarding the impact of RCPD on the utilization of employees (see Figure 2). The usage of collocated employees, on average, is decreasing sharply. Replacement of these workers is expected over the next several years by either employees at remote sites or short-term remote non-employees integrated for specific work assignments on local projects. Companies are seeking expertise from worldwide locations and are not requiring that expertise to collocate. The extent of RCPD in industry and its annual growth rate is difficult to ascertain, although several authors report that local activity is widespread [Fritsch01, Kleinknecht92]. This estimation difficulty is due in part to alliances, joint ventures, strategic partnerships, outsourcing agreements, and certain supplier arrangements present the perception of collaboration, but in fact in many of these arrangements sharing is nonexistent. Further, collaboration may not occur throughout the product development process, rather for only specific activities or objectives.

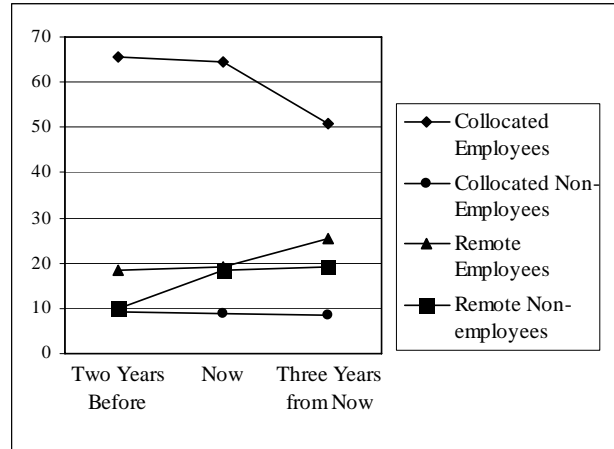


Figure 2 – Remote Resource Usage

A second set of trends revealed by the benchmark survey is the integration of suppliers into product development projects. An *arms length* supplier provides goods and services on a case-by-case basis against specific criteria. A *trust-based* supplier has a proven track record and operates under a project based, fixed duration contract to supply goods and services. Finally, a *risk / reward* supplier assumes their share of the risk and investment, being rewarded when both enterprises succeed in achieving the commonly desired result. This data pictured in Figure 3 strongly suggest that firms are moving to arrangements that imply collaboration. It forecasts that suppliers will be more tightly integrated to a firm's product development work and will share skill, knowledge, and investment to achieve the rewards associated with the outcome.

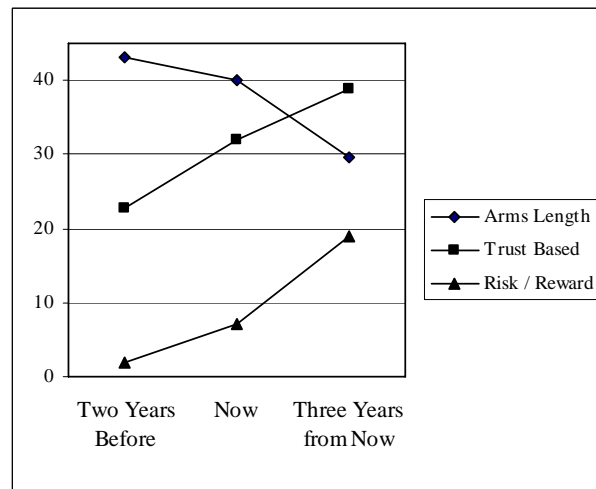


Figure 3 – Supplier Trends



# Insights

## Theoretical Model

A remote collaborative product development environment is complex and varies from company to company. Among the contrast are strong similarities. The structure of the organization and its interconnection to external partners form the backbone of remote collaborative product development. “I think two things: one, you have to have established procedures on how to work and, two, you have to stress communications,” said one participant, while another felt the dynamic is “the ubiquity, the accessibility, and the common tool set that you have to make this...the strength of the infrastructure and the common tools sets that are agreed upon for a [remote] team to communicate.”

Sharing and synchronization are the means through which RCPD is accomplished as one senior level director reflected: “It was more explicit than implicit that you were going to collaborate, you were going to synchronize, you were going to check in your data. [There were] far fewer assumptions and [the team] clearly defined what their requirements were then expectations and [project management] held them to it and themselves.” A vice president summarized as: We do the electrical design of an instrument here ... but the boards -- the layouts and the board manufacture is done [overseas] so when you’re

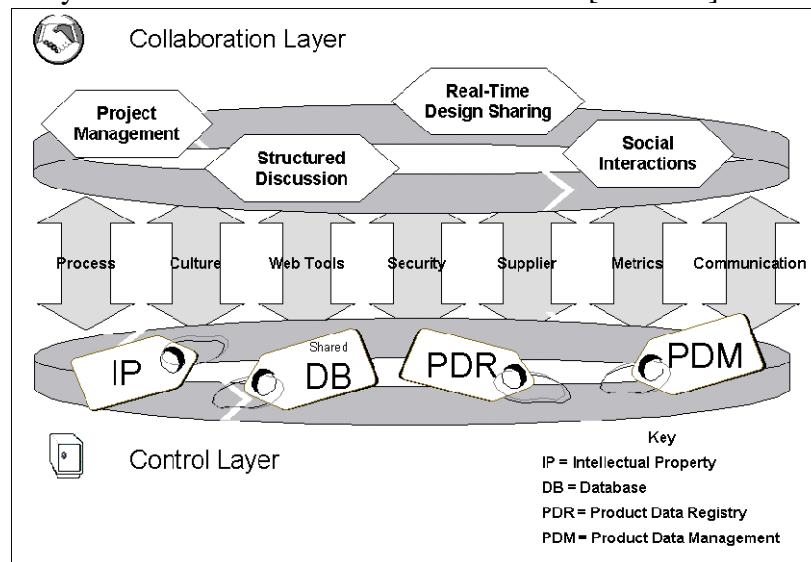


Figure 4 – RCPD Model

working on a production problem or you’re developing a prototype, the fact that those [remote] teams are working together, you’ve got the guy who’s seeing the results out on the production floor talking right to the guy who designed the product [in] real time, sharing files, sharing data, you can resolve that issue in a matter of a couple of days, whereas the old method would take you a couple of weeks.”

The presence of the four elements was evident at all participating firms, although appearance and strength varied in each instance. These elements form the foundation for the theoretical model shown in Figure 4. The gray circular bands represent the

relationship among partners. The double-headed arrows define the structure and interconnections. Sharing and synchronizing occur within the bands and along the arrows. These facilitate the collaboration and control of projects and information in the environment.

A practical perspective is established from these theoretical considerations. The model is composed of three parts: the collaboration layer, the infrastructure, and the control layer. The collaboration layer is human-resource intensive. Project management, structured discussion, real-time design sharing, and social interactions make up the interpersonal and decision-making activities. The control layer contains the book of knowledge made up of the intellectual property, shared databases of project information, product data registry of temporary work items, and product documentation archive. The types of control include access, disclosure, organization, management, authority, and ownership. The infrastructure connects the two layers via a seamless mesh of components: process, culture, web tools, security, supplier, metrics, and communication. These components are highly dependent upon the companies themselves and the relationships among the partners. The dynamic nature of the model is from left to right and top to bottom. For example, project management is the most volatile set of interactions, while data stored in a PDM vault are the most static.

The collaboration layer is where the dispersed team does its work. RCPD project management necessitates the continuous updating of critical milestones to define status and track progress among all partners. Milestones may be deliverables, documents, or decisions. Structured (or threaded) discussions capture team issues and ideas concerning the intermediate objectives leading to the milestones. Real-time design sharing is the focus for RCPD. Information is shared to transform design work into new products. Social interactions are critical to forging long-term, tightly held, and highly valued relationships across partners. The social dimension enhances work performance by clarifying expectations, establishing confidence, and building dependency.

The control layer provides the structure to the set of intangible knowledge assets. Intellectual property is the collection of proprietary knowledge of the firm, and must be protected. Formal policies and procedures define data formats, access privileges, methods of transfer, and how sharing occurs among partners and with project teams. Shared databases synchronize the current state of knowledge in form and function. Data storage formats are driven by the ability to arrange, move, operate, and control data from remote sites. This is a significant challenge when formats vary from partner to partner. A product data registry (PDR) is a temporary collection of changing information about a product development project. Product data management (PDM) acts as a documentation vault and provides security, accessibility, and revision control to project documentation. Movement from a PDR to a PDM requires approval by designated resources depending upon their role on the project.

The infrastructure defines the factors that bind the collaboration and control layers together. The interview data found the most influential factors are: process, culture, web tools, security, suppliers, metrics, and communication. - Each factor has a domain and a

sphere of influence. For example, one partner has a specific security policy about data exchange. This set of domain rules influences the web tools utilized for communication. The factors permeate the boundaries of all partners. A nexus forms at the interface between partners where factors integrate with one another, e.g., each partner's project management process meets at an interface affecting its content and protocol to ease coordination. In some cases, a unique project management process is established for the partnership for the duration of the RCPD project. The infrastructure is established first among partners. Upon this foundation, the collaboration and control layers are constructed.

The theoretical RCPD model is an aggregate concept derived from participant data. There was not any one participant who possessed the model in its entirety. The factors were added to the model based upon their affect on performance in the environment. For example, metrics were not predominant among participants. However, the demonstrated impact of metrics on collaboration results at participants that utilized them versus those that did not, dictated their value. The model is by no means complete. It is an evolving concept. The current state captures the essential ingredients, which represent the characteristics that distinguish RCPD as a unique form of product development, where new rules and methods enable success among remote partners.

### **RCPD Methodology and Supplier Selection Model**

The benchmark study revealed that the practice of remote collaborative product development is in an embryonic stage. Missteps occurred as firms worked to leverage their partner's competencies and experiences. Active learning modified processes in real-time as developers and managers fought to eliminate problems stemming from the lack of face-to-face interaction or the lack of authority across an interface. The traditional phase-gate process was in transition at a majority of companies as they met head on the variability of product development across several suppliers. The industry, size, and type of collaboration affected which parts of the product development process were the most sensitive to modification. While a single best method was not evident at any individual participant, an aggregate method was discerned from examples that directly affected the quality of the result or improved performance en route. The method has eleven steps: Idea, Project Formation, Kick-off, Process Models, Create Shared Workspace, Upfront Project Planning, Project Execution, Integration and Test, Project to Commercialization, Release to Production, and Project Assessment. This aggregate method is shown in Figure 5 and represents the combined learning across all participants. Figure 6 provides a description of each step.

The RCPD methodology is the combination of the methods that existed among a set of partners. It is the beginning of sharing and knowledge transfer before the formal project begins. A senior manager described it as: "We kept several major company participants and each one of them had different processes...we actually created process models and did training on how to create process models by the company who had been the most senior in that activity. It was part of sharing our intellectual property."

Although the aggregate process is described using discrete steps, the actual process is more continuous and the boundaries between steps blurred. There are several reasons for this. The activities in an RCPD environment occur in parallel, simultaneously across

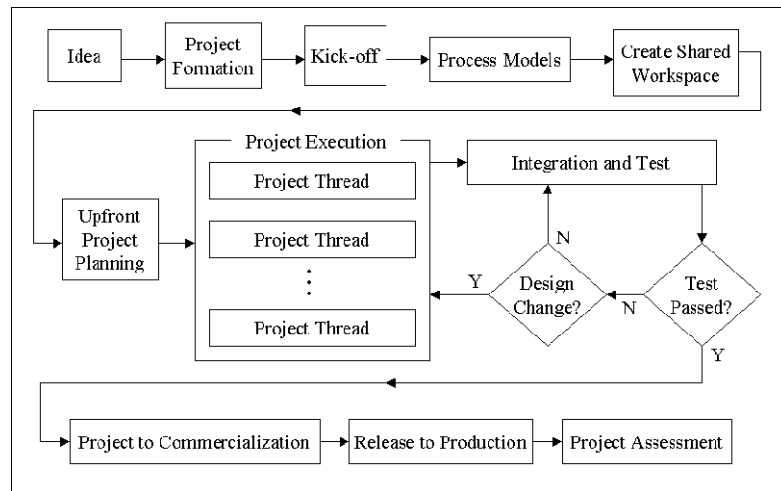


Figure 5 – RCPD Methodology (Aggregate)

several partners. Many actions overlap, starting before the predecessor finishes providing feedback as early as possible if feasibility is in question or the risk associated with not achieving the outcome too high. Ease of project coordination and containment of adverse impacts to a small portion of the project is desirable. Otherwise, money and time are wasted and disaster may quickly result. The purpose of exhibiting the RCPD method as a series of steps is for ease of explanation and for comparison to the traditional process.

Step	Description	Responsible	Deliverable
Idea	Ideas gathered worldwide	Portfolio team	Project recommendations
Project formation	Funding, interfaces, collaborators are identified	Steering team	Collaborators, team assignments, infrastructure assessment, funding, milestones, reward
Kick-off	Design team training	Steering team	Face-to-face training
Process models	Assessment of processes from each collaborator	Project team and Steering team	Adoption of best processes from each collaborator
Create shared workspace	Identify knowledge database, access, and administration	Steering team and project team	A shared or seamless integration of local web sites
Upfront project planning	Thinking and planning for the project	Project team	Project plan with interfaces, meetings, tasks and deliverables
Project execution	Design, develop, monitor, and prototype	Project team	Completed prototype
Integration and test	Tasks to reach reliability, quality, and robustness goal	Project team	Completed project
Project to commercialization	Extended enterprise involved to launch product	Steering team	Seamless transition
Release to production	The project team is disbanded	Steering team	Final approval
Project assessment	Face-to-face project history	Steering team	Celebration and improvement recommendations

Figure 6 – RCPD Process Description (Aggregate)

There are five significant differences between RCPD and a traditional collocated process after the shared project goals and objectives are agreed upon. First, after project kick-off, team members from all partners participate to determine the overall process model to be utilized for the duration of the project. This is all encompassing; a sampling of issues to be considered includes project management, engineering change order, procurement and supply chain, quality systems, resource allocation, oversight, and acceptance testing. Once best practices and specific processes are adopted into a combined method, all partners impacted by the changes are expected to make accommodations to interface to it. The collaborative method is documented and distributed via the shared workspace.

Second, a shared workspace is created with access limited to team members and key managers. Most participants responded that team members contributed more freely and frequently when they knew that senior management would have limited access to the data. This helped project managers learn of potential issues or delays sooner. The shared workspace is the focal point of the project and acts as a component for synchronization.

Third, after upfront planning, project execution rolls out as a set of individual projects threads. The threads are sub-projects consisting of product modules or specific deliverables. This approach facilitates overall coordination toward designated milestones, but allows each thread to operate in parallel and with relative independence. An adverse impact to a deliverable or an interaction with another thread initiates a posting to the shared database.

Fourth, the integration and test of deliverables is performed at each partner and the results are compared. Integration is the most problematic step in the RCPD methodology. Distance and time zones impose the most delays while remote teams search for solutions to debug problems. Most integration problems are resolved using structured discussions among team members at remote sites. Face-to-face meetings are a last resort. “We’re going to be testing the product as soon as we possibly can,” said one participant addressing the potential problems of integration, “Testing early and often. We’re going to be testing against our final specification. Is the product meeting the requirements?”

The last difference is the role of the steering team. A steering team is a cross-functional set of senior executives with product development responsibilities. The composition of the steering team—representation from each partner in the collaboration—is dependent upon the relationship among the partners. They are involved with the project team during the early stages to help construct the environment. Since the RCPD method is adapted from the product development processes of all partners, there is impact to cross-functional departments within the partner firms. The steering team enables seamless interfaces within the firm and with partners, while the project team plans the project. Nearly a quarter of the survey participants indicated a direct involvement by senior management to transform the firm to support a collaborative project. For example, the creation of a shared workspace raised concerns about access beyond firewalls of computer systems, intellectual property transfer, and financial investment approval. The steering team involvement wanes during execution as shared databases reduce the need

for direct oversight. The intensity of the steering team's interaction with the project team returns as proximity to commercial launch draws near.

The project formulation step requires the most attention by the steering team, for it involves the selection of suppliers to the development project. A traditional supplier certification process tends to be centered on purchasing and production. This can be an obstacle in an RCPD environment. Adding representatives from several other functional groups broadens the scope, but is not the complete answer. Most participants effectively evaluated the technical details in each discipline, but struggled to assess trust, track record, the potential to develop a long-term relationship, interaction with competitors, and the impact of information exchange and sharing on their business. Industries subject to government regulation and oversight were better at assessing the impact of the information exchange and sharing, since the process of discrete record keeping and mandatory disclosure is an intimate part of their business.

Just over ten percent of the survey participants had a formal supplier certification procedure. Twenty-five percent had components, but these were modified as they learned what worked and what did not. Nearly seventy-five percent used some consistent approach to bringing a collaborative supplier on board.

An aggregate supplier selection process is presented in Figure 7. Figure 8 lists the variability in selection criteria. The survey revealed that companies that evaluate a set of candidates by having them perform short-term projects before embarking on a full-scale collaboration have more successful partnerships. Further, companies that share the selection criteria and the list of potential candidates take a gigantic step toward developing trust throughout the engagement and beyond. Potential suppliers that complete the process are selected for more intense collaboration efforts. The relationship builds upon the candidate selection process formalize a strong working partnership. A participant summarized the approach as "Mutual acceptance criteria established early on, [then a] goal to deliver. [It] depends on the level of interdependency between organizations with more concrete definitions made [based upon] capability. [The deliverables defined, it is essential to be] clear on costs. [Mutual decision-making is required as] goals are refined as we move through development."

Nearly all of the large companies in the study suffered at one time or another from the “promotion” paradox as they developed a long-term relationship with a partner. This paradox occurs when a company promotes their systems and processes, rather than learning about the methods used by their supplier. The latter action is the motivation for collaborating with the partner in the first place. Consider two examples: a firm insists that its partner acquire workstations and software applications identical to its own to obtain compatibility, despite its original motivation to utilize and learn partner’s rapid prototyping technology and software; another large firm requires a partner to adopt their

Technical expertise –world class or investment (money, learning) for technology/function to achieve success: design skills and systems, knowledge, or core technology	Priority of our business – “We get time, because it is important to them that we both succeed” – closely related to percentage of their business that is with us
Electronic capability and IT alignment – seamless system integration. Web-enabled, project oriented system, expertise in tool sets (especially CAD/CAE tools)	Best value pricing for deliverable – beyond the unit and development costs, reliability and other service factors: the total cost of doing business
Cultural alignment – how business is conducted, treatment of employees, remote collaborative methods, accessibility to resources for the duration, evidence of follow-through when decision is made	Commitment and desire to establish unique relationship – “We need to feel there is no reason to go to look for any other supplier in that area or for those components, subsystems, or area of expertise”
Do they compete with us? or Could they compete with us? Financing the competition	Leadership/management intangibles: it is the confidence in their abilities from first impression
Proven track record of performance to schedule and quality of work	Proven track record in following a documented process/methodology and achieving results using it
Objective financial evaluation of the partner: business, operating model, reliability, and stability over the long-term	Ability and willingness to share: intellectual property (IP) or IP roadmap, openness and honesty, identify problems early on, and work to resolve them
Proven track record of innovation – the ability to deliver a desired feature, even if it does not exist yet	Ability to connect and integrate to our internal processes
Understanding our business and how we measure success	Accessibility to desired markets
Ability to gain regulatory approvals	

Figure 8 – Supplier Selection Criteria (Aggregate)

chemical process, even though their own process was flawed and causing significant yield problems. Active management by the steering team was necessary in both situations to reverse the tendency.

## Managerial Implications

The most successful remote collaborative environments overwhelmingly demonstrated the ability to share and synchronize information and to utilize it to increase their collective performance per unit of time. The managerial implications that follow all derive from these two unifying perspectives of the participants. The published reports of investigations by other researchers in related, but narrower studies reinforced the best practice considerations discerned from participant data. The related studies in the literature assisted in connecting the root causes to the outcomes, simplifying the complex interconnections, and serving as a catalyst to separate the best practices from everyday practices in use at the participant companies. The implications presented here are by no means definitive, but reflect strong themes recurring in several different contexts across a majority of companies in this study.

## Sharing and Mutual Identity

A mutual identity is a mechanism to smooth the progress of collaboration and to enhance sharing. It is an entity unto itself having self-governance. It is more than a remote team structure, for its purpose is to achieve the shared objective, bridge the gaps that exists between partners, and construct interfaces to limit the obstacles blocking the path forward. It does not report to a single management chain, for it operates in a workspace accountable to all. It is an extension of a firm's environment of sharing and mutual dependence, providing flexibility to combine technology, process, information, and people to construct a development path [Amaldoss00]. Each mutual identity is unique, for it integrates the partners and defines their interfaces. Open and frank information exchange is essential to fashion unspoken rules and behaviors leading to the establishment of strong bonds among team members. These bonds create a culture for the mutual identity unique and distinct from each of their parent companies. This creates a level of intimacy and trust to close the organizational and distance gaps. As one executive stated: "Common project plan, common notes, common whatever, that's the key thing and a key thing as well is you've got to get people working together upfront, and almost need a person to person relationship established from early on."

A mutual identity is initiated at the conclusion of the Process Models step of the RCPD development process. The structure of the mutual identity will impact the design of the shared workspace, i.e., the development tools, communication methods, databases, and documentation formats. It comes into the forefront as the steering team transitions responsibility to the project team. The steering and project teams have a joint role in the formation of the mutual identity. There is a creative tension between the desire for freedom by the project team and the need for business responsibility by the steering team as the charter of the mutual identity is established. The mutual identity must be complete before the Upfront Project Planning step begins. The various threads of Project Execution are governed within the mutual identity. The mutual identity begins to dissolve as Integration and Test conclude and the Project to Commercialization step begins. The lifespan of the mutual identity and its intersection with the RCPD development process is elastic as long as it aids collaboration among partner firms.

The benefit of forming a mutual identity is that it provides the necessary structure to define the management responsibility of each partner [Kamath94]. When one partner dominates, or when the financial stake and risk is shared by a small subset of partners, it is even more critical to form a mutual identify, for only a mutual identity can provide the checks and balances needed to level the playing field and to foster cooperation and productive contribution. The mutual identity shares the accountability in decision-making when adverse conditions occur by defining an arbitration process. For example, an escalation system with weighted authority makes available an approach to resolve issues. When all partners agree upon the escalation system a priori, it becomes part of the governance model of the mutual identity.



## Product Architecture and Organization

The outcome of the Project Formation step is the selection of the partners to develop the product for the marketplace. The survey data revealed that a majority of participants worked with partners to architect the functionality and modules of the final product and to craft the organizational structure that will deliver it. A mutual identity strengthens this aspect of collaboration when it mirrors the product architecture into its organizational structure. RCPD is further enhanced when partners modify their internal organizations to reflect the product architecture well [Kamath94, Sanchez96, Ward95].

This alignment reduces process complexity and enhances project coordination. Project workflow is more seamless. Modules and organizational priorities are identical. It simplifies interfaces among partners by casting organizational roles and responsibilities to match the functions and modules of the product architecture. This narrows information exchange to protect intellectual property and reduces the cost of knowledge management systems. Resource allocation requires matching skills and investments to module deliverables. The lack of alignment can be problematic. As one vice president said, “One big one is just lack of alignment. As you exchange information back and forth, it becomes fairly clear, are you aligned or not in your thinking in terms of specifications and so forth. So how well are you gaining alignment, and a measure there might be time to resolve issues. How long does it take to get the specification resolved? Whether or not we’ve had to add or delete functional requirements or features along the way because we thought we had resolution and didn’t.” A lack in alignment in the organization and the product architecture may impact cycle time, cost, and time-to-profit.

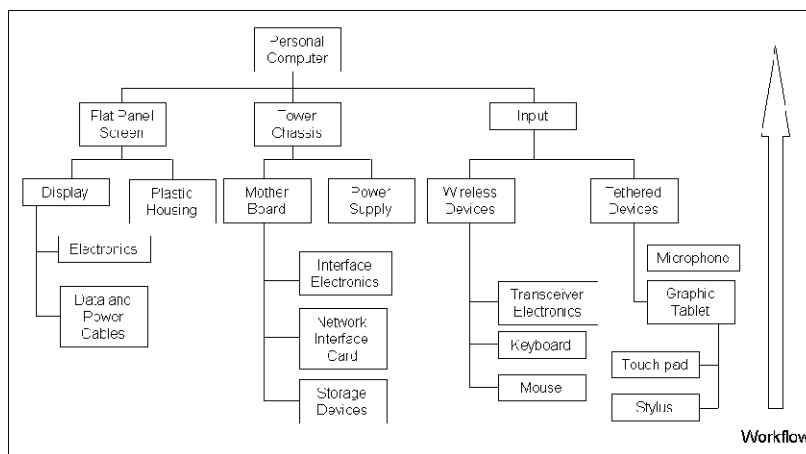


Figure 9 – Product Architecture and Organizational Structure as Tree Structure with Node and Root Showing Direction of Workflow

The hierarchy of the product architecture drives the RCPD project activities. This is a critical shift from collocated product development, where a product development process provides the underlying structure. In an RCPD environment, the partners have their own versions and variations of the product development process that work best for them. Combining all these processes into one large process would create mass confusion, and

would add unnecessary complexity. Product architecture is invariant across all partners. Workflow becomes synonymous with the product architecture. All integration activities flow from simple parts toward the complete system (or from the nodes of the tree structure to the root). See Figure 9.

The number of handoffs (or transfers) is defined by workflow. As the number of handoffs is decreased, the time and cost to transport parts is reduced as well. This is especially helpful when the physical distance between partners is great. Communication among partners is focused—both in content and in time—around their shared activity. Defining predictive metrics to characterize completeness for each module minimizes the need for rework loops that impose unplanned costs and delays. Results are more predictable when product modules are brought together for integration and test at each level of the system design. Project activities are parallel and overlapping, decreasing cycle time and development costs.

### **Project Management**

Project management in RCPD is a challenge. Partners work at their own rhythms to complete deliverables and the related activities leading to them. In multiple partner settings neither peak periods nor lulls in activities necessarily overlap or align. The boundaries of the firm and the interfaces with each partner limit a project manager's visibility of the development activities and the degree of control over them. Furthermore, the activities of each partner's own remote suppliers might be totally invisible, or worse, their existence unknown, to other partners. This exacerbates the need for coordination of information exchange, status updates, and decision-making in a timely manner to prevent adverse impacts.

“What you evolve to eventually,” says on senior project manager, “will be a mode of continuous monitoring of the project because you're driving towards a common information environment repository in a sense that is accessible by team members and beyond, and the content of that information is available to everybody: the requirements for the project, the schedule for the project, the history of information as it grows associated with various milestones of the project such that you're monitoring...the progress of the various elements of the project based upon design schedule and scope.” The environment is then defined by “more formalized...development of work breakdown structures...[for] specific milestones and deliverables.”

Project management is effective when limited to managing the interactions at the interfaces of each partner. “Keep the project boundary conditions and interfaces as crisp as possible,” recommends one participant. When an interface is defined as described in the last section – organizational structure reflects product architecture – it becomes the managerial checkpoint. All transfers of deliverables and information must traverse it. The objective is to make the transfers at a checkpoint more routine with a well-defined protocol and at a known frequency. This improves project communication, monitoring, and management.

A transaction is a two-part structured action—a request and a deliverable. It requires agreement and exchange. By contrast, a task is undertaken as part of a work assignment. Transactions facilitate identifying the intermediate targets leading to each deliverable. Predictive metrics for each target make available a means to measure progress toward the deliverable and take corrective action earlier, rather than later, to minimize adverse impacts and get the transaction back on track. This broadens the scope and depth of a project manager’s visibility. When a problem does occur, partners can shift resources to collaborate on the appropriate activities needed to bring the metrics back into an acceptable range. Transactions assist in establishing routine communication by establishing protocols to track metrics in addition to the desired result [Ahuja98].

Information crosses an interface in many formats. One of the best formats is a threaded discussion. This format widens the scope of knowledge sharing. It documents activities so when problems occur a project history exists. This reduces ramp up time of newly applied resources. More significantly, a threaded discussion can be utilized to report the status of a project. The posting frequency, content of the information, and its relative importance is matched to each partner’s rhythm. One survey participant, a remote software developer, used threaded discussions to explain software functionality, describe accomplishments, and report problems. Status was reported daily to assess the percent completeness of the project. Another participant, an equipment manufacturer, used threaded discussions to perform resource leveling and to leverage the competencies of a partner at problem foci. When problems occurred, resources were reassigned to provide the additional effort needed to recover from delays. Other participants made use of threaded discussions to manage projects proactively in combination with metrics. The survey showed that priorities and threaded discussions are more effective for managing projects in RCPD environments than tasks and schedules.

### **Evolution of Phase Gate Processes**

A phase gate process is the traditional cross-functional product development process. The process is a series of steps (phases) taking a product from early concept, through design, and into manufacturing. Phases consist of activities and design decisions generating solutions to meet the customer’s needs. A phase is a set of similar activities occurring during an interval of the product development, e.g., generation of a product concept. The output of a phase is a set of deliverables such as requirements, specifications, plans and schedules, prototypes, product documentation, and reports. A gate is a cross-functional management review held to evaluate the completeness of the development team’s work during a phase. A project team prepares a review package for a cross-functional management oversight team to assess the completeness of its work. The evaluation has one of three outcomes: moving forward to the next phase, remaining in the existing phase to complete specific deliverables, or cancellation of the project.

An early version of the phase gate approach was originated at NASA to provide structure, discipline, and oversight to the planning and development process [Smith92]. At present, there are several models of the phase gate product development process in use in industrial companies [Cooper90, Ulrich95]. The name, number, and purpose of the

phases, including the detailed activities within each phase, vary from company to company and even within the same company. The unifying theme is the completeness of activities and deliverables at the closure of a phase. This has much appeal, since it imposes discipline on customer requirements, design practices, risk management, financial and resource allocation, and cross-functional project teams. The phase gate approach has achieved good results in improving cycle time performance and in reaching cost and quality targets in sequential, dedicated, collocated, and stable environments having a high level of certainty for product information.

Recent studies have called into question the application of the phase gate model in highly dynamic and uncertain environments [Bhattacharya98, MacCormack01]. The structured system of sequential steps limits flexibility, speed, and adaptability under turbulent conditions. It curtails performance by preventing parallel, overlapped, or coupled design activities to minimize cycle time and design iterations [Krishnan97, Smith92]. Idle time occurs when teams wait for deliverables to finish before they can complete the gate review package. This requirement for completeness of information at a gate review is where this model struggles the most. Partial or continuous interaction with customers throughout the process, changing market conditions, and/or the discovery of new information is difficult to structure into a phase when its format and the time it will arrive is unknown. The bureaucratic structure restrains the performance of project teams even when things are going well, for time must be devoted to preparing for and presenting at gate reviews. When gate reviews are delayed – management has a more pressing priority – time is lost and information becomes obsolete. In a dynamic situation, the damage from a delay might be irreversible.

RCPD is a dynamic environment with a variety of interfaces, relationships, and individual collaborative resources. A different product development process at each partner adds to the complexity, as do the independent methods for project management, resource allocation, and management oversight. A project in this shared workspace has multiple and intertwined development paths, modules, and activities. They are overlapped and parallel, indistinct and well defined, and independent and interdependent all at the same time. As noted earlier, project workflow follows the product architecture rather than the process. Clear boundaries when or where one phase ends and another begins do not exist.

A gate review in an RCPD environment is problematic as well. Oversight is dispersed and spread over numerous partners, as is authority, decision-making, and control of financial, capital, and human resources. When partners are not major stakeholders or do not possess absolute authority, this structure becomes more fluid and tenuous. Deliverables are tied to transactions at the interfaces between partners. Transactions do not necessarily occur when each partner completes a phase, or when partners complete the same phase. Force-fitting the phase gate model to RCPD injects inefficiencies and confusion.

The *adaptive milestone model* is derived from how RCPD participants accomplish their objectives. This original model evolves the phase gate model to meet the new paradigm

of RCPD. A milestone is defined as an event on the path towards the completion of the shared objective. Milestones are composed of a transaction, an audit, and an outcome. A transaction was defined earlier as a request and a deliverable. An audit is an objective acceptance criteria and an owner who has authority to accept it. The acceptance criteria and owner/authority is defined *a priori* with the transaction. The acceptance criteria are derived from predictive and result metrics against which the completion of the transaction is measured. Predictive metrics are used to identify out-of-bounds conditions leading to the deliverable and result metrics are used to evaluate the final deliverable. The role of

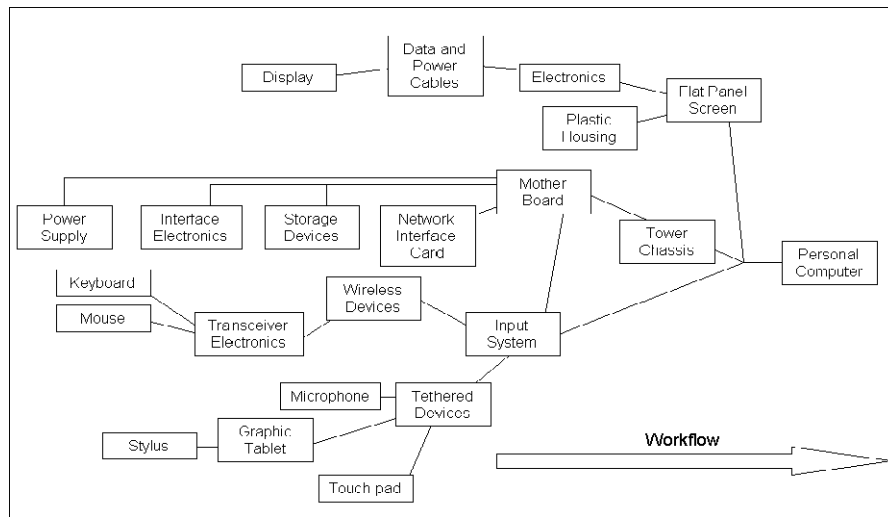


Figure 10 – Milestones and workflow

the owner/authority is to accept, reject, or request rework on the deliverable. This is the outcome of the milestone. Outcomes may have conditions attached to them, e.g., upon completion funds may be released, business agreements signed, or design work commenced. A milestone occurs at the project level and is visible across the extended enterprise.

Milestones are designed to be suitable to or fit for a specific use or situation. They are adaptive to the uniqueness of the RCPD environment. They can be scaled from a low level between two partners to a high level steering team composed of all partners. The acceptance criteria, owning authority, and outcomes can be scaled as well. The acceptance criteria and owner may be local management in one circumstance, and a remote management team in another. Ideally, milestones are drawn from and reflect the modules of the product architecture. When the product architecture is aligned to the organizational structure, milestones connect partners, projects, and deliverables. Figure 10 shows a simplified set of milestones to develop the shared objective of a personal computer. Realistically, any project transaction, e.g., a module, a prototype, a specification, or the exchange of information, qualifies as a milestone if it meets the definition.

The mechanism of the milestone adapts the project to the RCPD environment by rigor to discipline, not to structure. Upfront identification of the desired deliverable, recipient, and approval criteria, not a shared bureaucracy, reinforces the shared objective. The path to completing the transaction is left entirely up to the individuals responsible for

completing it. While this might seem ambiguous and amorphous, decision-making and project responsibility meet at a milestone [Ward95]. Each milestone has a priority assigned to it and is linked to other milestones via their position in the priority hierarchy. When a milestone is in jeopardy, resource allocation is shifted from lower priority milestones to take the appropriate corrective action. Since the priority of a milestone, like the milestone itself, transcends all partner interfaces, this aids the efforts of project managers to supervise a project in the RCPD environment as it converges on the shared objective.

## **Suggestions for Further Work**

The survey presented in the paper is the result of a small set of companies sharing their thoughts and perspectives at a particular moment in time along the learning curve of RCPD. The maturity of their methods and organizational effectiveness varies on a spectrum on which the endpoint is still being defined. Each is a pioneer, and all are in transition. Starting at the top and working down reveals a broad, but not a deep, picture. This view was by design. It was important to understand the drivers and the context, i.e., to connect the strategic objectives to the tactical implementation.

A suggested next step is to follow the efforts of several remote project teams from start to finish in order to compare and contrast their efforts and outcomes. Initially, the investigation would focus on one industry and then expand to cover others. Everyday aspects of project management—monitoring progress, celebrating success, and coordination in times of crisis—require in-depth observation and analysis. The characteristics for communication, awareness, and the work replacing face-to-face interaction require identification if the Internet is to be harnessed and the distance and interpersonal gaps overcome. Tools cannot merely extrapolate face-to-face methods to computer networks. Discovery of the nature of working together apart, via a telecommunications network, will link the next generation of RCPD participants more intimately in their daily work increasing productivity. The nature of teams requires attention; especially the steering team /project team relationship when defining authority, autonomy, and governance.

The “24/7” connection is another aspect for investigation. Remote collaboration does not imply working around the clock or around the world. RCPD stripped down to the essentials comprises geographically dispersed team members sharing their expertise and synchronizing their efforts to achieve an objective more quickly than they could individually. What are the consequences to RCPD with the addition of harnessing time from the “24/7” dimension? What new demands will be placed upon product development when this produces a competitive advantage?

## **Conclusion**

Remote collaborative product development is a new paradigm for conducting business. The challenges of harnessing time play a significant role from the selection of partners to the methods used to execute product development projects. Competitive markets, the rate of technological change, and the ever-faster pace at which customers demand solutions to problems, all conspire against companies that maintain the status quo. RCPD provides a method for companies to combine their talents to achieve greater success than they could achieve alone.

## References

- [Ahuja98] Ahuja, M.K., Carley, K.M., *Network Structure in Virtual Organizations*, Journal of Computer-Mediated Communication, 3, 4, 1998.
- [Amaldoss00] Amaldoss, W., Meyer, R.J., Raju, J.S., Rapoport, A., *Collaborating to Compete*, Marketing Science, 19, 2000, pp. 105-126.
- [Bhattacharya98] Bhattacharya, S., Krishnan, V., Mahajan, V., *Managing New Product Definition in Highly Dynamic Environments*, Management Science, 44, (1998), 11 Part 2, pp S50-S64.
- [Cooper90] Cooper, R.G., *Stage-gate systems: A new tool for managing new products*, Business Horizons (1990) 33, 3, pp. 44-54.
- [Dahan00] Dahan, E., Hauser, J.R., *Managing a Disperse Product Development Process*, for the Handbook of Marketing, B. Weitz and R. Wensley, Eds., October 2000, Working Paper.
- [Daft93] Daft, R.L., Lewin, A.Y., *Where Are the Theories for the "New" Organizational Forms? An Editorial Essay*, Organizational Science, 4, 4, (1993), pp. i-vi.
- [Fritsch01] Fritsch, M., Lukas, R., *Who cooperates on R&D?*, Research Policy 30, 2001, pp 297-312.
- [HandelWP] Handel, H., Wills, G., *Team Portal: Providing Team Awareness On the Web*, Working Paper.
- [Herbslab99] Herbslab, J.D., Grinter, R., *Architectures, Coordination, and Distance: Conway's Law and Beyond*, IEEE Software, September/October 1999, pp 63-70.
- [HerbslabWP] Herbslab, J.D., Mockus, A., Finholt, T.A., Grinter, R.E., *Distance, Dependencies, and Delay in Global Collaboration*, Working Paper, Bell Labs, Lucent Technologies, Naperville, IL, School of Information, University of Michigan, Ann Arbor, MI, Xerox PARC, Palo Alto, CA.
- [Hendricks77] Hendricks, K.B., Singhal, V.R., *Delays in New Product Introductions and the Market Value of the Firm: The Consequences of Being Late to the Market*, Management Science 43, 4, 1977, pp. 422-436.
- [Hlavacek77] Hlavacek, J.D., Dovey, B.H., Biondo, J.J., *Tie Small Business Technology to Marketing Power*, Harvard Business Review, January-February, 1977, pp. 106-166.
- [Kanter94] Kanter, R.M., *Collaborative Advantage: The Art of Alliances*, Harvard Business Review, July-August, 1994, pp. 96-108.



- [Kamath94] Kamath, R.R., Liker, J.K., *A Second Look at Japanese Product Development*, Harvard Business Review, November-December 1994, pp. 154-170.
- [Kleinknecht92] Kleinknecht, A., Reijnen, J.O.N., *Why do firms cooperate on R&D? An empirical study*, Research Policy 21, 1992, pp 347-360.
- [Krishnan01] Krishnan, V., and Ulrich, K., *Product development decisions: A review of the literature*, Management Science, 47, 1, 2001, pp. 1-21
- [Krishnan97] Krishnan, V. Eppinger, S.D., Whitney, D.E., *A Model-Based Framework to Overlap Product Development Activities*, Management Science, 43, 1997, 4, pp. 437-451.
- [Lambe97] Lambe, C.J. and Spekman, R.E., *Alliances External Technology, Acquisition, and Discontinuous Technological Change*, Journal of Product Innovation Management, 14, 1997, p.102-116.
- [MacCormack01] MacCormack, A., Verganti, R., Iansiti, M., *Developing Products on "Internet Time": The Anatomy of a Flexible Development Process*, Management Science, 47, (2001), 1, pp. 133-150.
- [MockusWP] Mockus, A., Fielding, R.T., Herbslab, J., *A Case Study of Open Source Software Development: The Apache Server*, Working Paper, Bell Labs, Naperville, IL and University of California, Irvine.
- [Mockus00] Mockus, A., Weiss, D.M., *Globalization by Chunking: a Quantitative Approach*, Working Paper, July, 2000.
- [Ohmae89] Ohmae, K., *The Global Logic of Strategic Alliances*, Harvard Business Review, March-April, 1989, pp.143-153.
- [Parkhe93] Parkhe, A., *Strategic Alliance Structuring: A Game Theoretical and Transaction Cost Examination of Interfirm Cooperation*, The Academy of Management Journal, 36, 4, (1993), pp. 794-829.
- [Powell96] Powell, W.W., Koput, K.W., Smith-Doerr, L.S., *Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology*, Administrative Science Quarterly, 41 (1996), pp. 116-145.
- [Reinertsen91] Reinertsen, D.G., Smith, P.G., *The Strategist's Role in Shortening Product Development*, The Journal of Business Strategy, July/August 1991, pp. 18-22.
- [Robertson98] Robertson, T.S., Gatignon, H., *Technology Development Mode: A Transaction Cost Conceptualization*, Strategic Management Journal, 1998, 19, pp. 515-531.

[Rouse98] Rouse, W.B. Thomas, B.S., Boff, K.R., *Knowledge Maps for Knowledge Mining: Application to R&D/Technology Management*, IEEE Transactions on Systems, Man, and Cybernetics, 1998, 20, pp.309-317.

[Sanchez96] Sanchez, R. Maloney, J.T., *Modularity, Flexibility, and Knowledge Management in Product and Organizational Design*, Strategic Management Journal, 17, Special Issue, Winter 1996, pp. 63-76.

[Shiba93] Shiba, S., Graham, A., Walden, D., *A New American TQM: Four Practical Revolutions In Management*. Productivity Press Portland, OR, 1993, Chap. 7, pp 141-188.

[Smith92] Smith, P.G. Reinertsen, D.G., *Shortening The Product Development Cycle*, Research-Technology Management, May-June 1992, pp. 44-49.

[Tushman86] Tushman, M. L., Anderson, P., *Technological Discontinuities and Organizational Environments*, Administrative Science Quarterly, 31, (1986), pp. 439-465.

[SubramanianWP] Subramanian, M., Venkatraman, N., *Routines Leveraging Knowledge Across Borders For Global New Product Development Capability: An Empirical Examination*, Working Paper for the Carnegie Bosch Institute.

[Ulrich95] Ulrich, E.T., and Eppinger, S.D., *Product Design and Development*, McGraw-Hill, New York, 1995.

[Upton94] Upton, D.M., *The Management of Manufacturing Flexibility*, California Management Review, 36, 2, 1994, pp.72-89.

[Ward95] Ward, A., Liker, J.K, Cristiano, J.J., Sobek II, D.K., *The Second Toyota Paradox: How Delaying Decisions Can make Better Cars Faster*, Sloan Management Review, Spring 1995, pp. 43-61.

## Appendix

A sample of the interview guide questions for this benchmark study is listed below. The questions focus three areas: strategy, measures for success, and results. The purpose of the guide is to initiate a dialogue during the interview. The interview technique relies upon the gaining specific examples in answer to the questions.

*Strategy* is the gathering and evaluation of information (or intelligence) about a particular objective to understand the obstacles that must be eliminated to reach the desired result. Describe how you do remote collaborative product development and share what works and doesn't work well (or what you like and dislike about it)?  
What do you see as the top 5 benefits and what problem does each benefit solve for you?  
What is an example of each of problem?  
What are the top 5 obstacles to achieving these benefits?  
Describe what aspects of your business strategy require (or would benefit from) remote collaborative product development?  
Describe your approach to implementing remote collaborative product development including what you have done already and what you plan for the future. What problems have you have had? Provide an example of what you have done so far? Give an example of what problem you hope to avoid by implementing your plan for the future?  
How has the down turn in business affected you approach to remote collaborative product development?

*Measures for Success* are the methods and metrics utilized to achieve a desired level of performance for a set of critical functions or objectives:  
What did you (should you) use as the 5 key predictive measures of collaborative design success?  
What were (should be) the 5 early indicators used to predict and fix problems early in the collaboration?  
How did you (should you) measure results at partner (outside) companies?  
What criteria did you (should you) use to select partners for collaborative development?  
How often and how did you (should you) monitor remote collaboration?  
Who has the best practices you know of in collaborative design?

*Results* focuses on the path taken and the outcome of the RCPD project:  
Please describe a typical remote collaborative project.  
Discuss and provide examples for the following questions:  
What type and how much training and preparation were conducted for your remote collaborative project teams before beginning the project?  
What happened that you did not expect?  
What were the differences in the project plan versus a collocated project?  
How much more or less time was needed to plan and then execute?  
How did you monitor the deliverables differently?  
How did you manage the tasks and activities at the remote site?  
How was project authority delegated?

How much knowledge was transferred and shared with the remote teams?  
What were the rewards and recognition do you use for remote collaborative product development teams?  
How did you manage security on this project?  
What were the cultural differences that stood out?  
From the result you have achieved, what items require effective integration to realize the benefits of remote collaborative product development in the aggregate?

## **Acknowledgements**

The author would like to thank the following individuals for their efforts in conducting the benchmark study, processing the data, analyzing and discussing the data, and continuing efforts during the preparation of this paper: Sheila Mello – Managing Director, Wayne Mackey – Principal, and Lyse Fontaine – Consultant, all of Product Development Consulting, Inc.