Market, Technical, and Social Overlap in Technology Collaborations and Consortia

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Understanding technology collaborations and consortia should be an important issue for both firms and governments. The Triad countries, led by the European Union, have spent billions of dollars promoting technology collaborations and consortia. Even discounting government subsidies, firms have invested substantial assets and top management attention in technology partnerships, especially in high-technology industries. The first wave of scholarly activity in this area described the phenomenon. Until recently, scholars have focused on the second wave: the determinants of formation of technology collaborations. Lately, researchers have begun to explore the performance of these ventures in which a bilateral or multilateral exchange of knowledge or technology takes place. A contribution of this dissertation is a better understanding of the interplay between interpartner characteristics (market, technical, and social overlaps between partners) and interpartner processes (collaborative behavior) in influencing performance of technology collaborations and consortia.

The dissertation has three parts. The first part is a conceptual paper introducing the idea of interpartner overlaps in the market, technical, and social domains. The second part is a case study of two technology collaborations. In the second part, I seek to explore the effects of interpartner overlaps and whether other factors might influence performance. I conclude that collaborative behavior is a powerful influence on performance. The third part is an empirical test of the effect of overlaps and collaborative behavior on business unit strategic goal attainment. The contribution of the third paper is that it shows that the overlaps may be considered individually and their effects disentangled. Partner characteristics that lead to the most advantageous outcomes are associated with low market (client) overlap, high social overlap, and provision of similar products, admittedly a very small subset of potential partners. I conclude that factors beyond technical complementarities primarily determine the success of technology collaborations.

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This dissertation is dedicated to

my wife,
Carolyn Magnani Tucci

and

my parents,
Michael A. Tucci
Isabella A. D. G. Tucci
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Introduction

"Market, technical, and social overlap in technology collaborations and consortia"

Context

Understanding technology collaborations and consortia should be an important issue for both firms and governments. The Triad countries, led by the European Union, have spent billions of dollars promoting technology collaborations and consortia (Mytelka 1991). Even discounting government subsidies, firms have invested substantial assets and top management attention in technology partnerships, especially in high-technology industries (Gomes-Casseres 1996; Hagedoorn 1993). The first wave of scholarly activity in this area described the phenomenon (e.g., Hagedoorn 1993). Until recently, scholars have focused on the second wave: the determinants of formation of technology collaborations (e.g., Eisenhardt & Schoonhoven 1996). The time is ripe to explore the performance of these ventures in which a bilateral or multilateral exchange of knowledge or technology takes place. The contribution of this dissertation is a better understanding of the interplay between interpartner characteristics (market, technical, and social overlaps between partners) and interpartner processes (collaborative behavior) in influencing performance of technology collaborations and consortia.

Summary of dissertation

The dissertation has three parts. The first part is a conceptual one introducing the idea of interpartner overlaps in the market, technical, and social domain. The second part is a case study of two technology collaborations. In the second part, I seek to explore the effects of interpartner overlaps and whether other factors might influence performance. I conclude that collaborative behavior is a powerful influence on performance. The third part is an empirical test of the effect of overlaps and collaborative behavior on business unit strategic goal
attainment. The contribution of Part III is that it shows that the overlaps may be considered individually and their effects disentangled. Below are the individual summaries of the three parts.

**Part I. Market, technical, and social overlap in technology collaborations**

Most past research on alliances and interfirm collaboration has focused primarily on the formation of interorganizational relations. The few studies that look at performance of alliances and other interorganizational forms do not do so from the interorganizational level of analysis. Part I proposes a framework for thinking about performance based on “overlaps” between partners. In Part I, I note that a firm, under most circumstances, experiences a tension between finding partners that are more similar and finding those that are different or complementary. The benefits of similar partners stem from ease of communication and ability to work together; both of these are related to how similar the partners are socially. On the other hand, the benefits of different or complementary partners stem from potentially lower rivalry (how similar the partners are in their markets) and ability to generate more ideas or divide the work more efficiently (how similar the partners are in their technical specialties).

It may appear that these dimensions — which I call market, technical, and social overlaps — must necessarily be correlated, and in practice they usually are. However, in the first part of the dissertation, I propose that they are in theory separate dimensions whose individual effects on performance often work in different directions. The contribution of Part I is a set of propositions regarding when similarities and differences between partners may lead to better results. The proposed framework of market, technical, and social overlap thus provides a new lens through which we can view the structural characteristics of technology collaborations. The framework is the basis of a theory of how partner selection influences performance.
Part II. Case studies of software technology research collaboration

The second part of the dissertation explores whether the concepts of market, technical, and social overlap have relevance in analyzing real technology collaborations. The second part is a case study of one European and one American technology collaboration. In addition to providing some evidence of the effect of market, technical, and social overlap on performance, I found that the performance of the projects was influenced by the many ways the relationships were managed. Certain situations developed in which the opportunity for either "collaborative" or "non-collaborative" (opportunistic) behavior presented itself to one partner. If the partner chose the collaborative route, a cycle of positive interaction and performance characterized future dealings with the other partners. When the partner chose the non-collaborative route, the short-term gain was quickly eroded by a cycle of negative interaction and marginalization. Thus we see the potential for cycles of trust that end up leading to high performance and cycles of mistrust leading to low performance. These "tipping equilibria" can be initiated by one collaborative or non-collaborative act. Even though "trust-building" may seem like an obvious solution, the individual decisions involving acting non-collaboratively at any given moment are not so obviously misguided. The contribution of Part II is the development of a theory of trust-building and a better understanding of how initial structural factors and ongoing processes interact.

Part III. Performance of technology collaborations and consortia

The third part of the dissertation is a cross-sectional survey of European R&D managers. It tests a static, one-time model of the relation between interpartner overlaps, collaborative behavior, and performance. It also tests whether initial collaborative behavior is influenced by interpartner overlaps. The results are as follows: Market overlap can be thought of as both similarity of products and similarity of customers. These two forms of market overlap have different effects on performance (strategic goal attainment). Working with direct competitors (interpreted as similar customers) is negatively related to performance, while similarity of
products is positively related. Social overlap is also positively related. However, there appears to be no effect of technical overlap on performance. There is no discernible effect of interpartner overlaps on initial collaborative behavior. Initial collaborative behavior also positively influences performance and interacts with market overlap in a positive way. This is consistent with the key findings from Part II.

The contribution of Part III is that it shows that the overlaps may be considered individually and their effects disentangled. The surprising result is that, at best, technical overlap is irrelevant to goal attainment in collaborations specifically designed for technology development. As technical overlap is highly correlated with product similarity, an argument could be made that, rather than technical complementarities (differences) driving perceived alliance success, technical similarities manifesting themselves in similar products or services contribute to higher performance. Therefore, partner characteristics that lead to the most advantageous outcomes are associated with low market overlap, high social overlap, and provision of similar products, admittedly a very small subset of potential partners. While technical complementarities may be the primary reason for the formation of technology collaborations, it is the other factors that primarily determine their success.
Market, Technical, and Social Overlap

If all the participants [in an R&D collaboration] were virtually identical, they would have few resources to leverage and the information exchanged would be of little value. At the other extreme, if the critical mass of participants was completely diverse, there would be little basis for common discourse. So an important cause of synergy in a system is for it to composed of participants that are somewhat (but not too) different.

— Gibson & Rogers (1994, pp. 12–13)

1.1 Introduction

In business strategy circles and the academic literature, collaboration has become the watchword of the 1990s for firms involved in or affected by new technology. At the same time, the number of short-term, contractual technology alliances (also called by such names as “strategic partnerships,” “new style joint ventures,” and “cooperative R&D ventures”) has been increasing steadily for over 15 years (Mytelka 1991; European Union 1995) and a small number of studies has concentrated on them. (See, for example, Gibson & Rogers 1994; Mytelka 1991; Evan & Olk 1990; Roberts & Berry 1985.) While the conditions facilitating
alliance formation and choice of organizational form have become better understood in recent years (through the work of, for example, Eisenhardt & Schoonhoven 1996; Browning et al. 1995; Gulati 1995; Powell 1990; Harrigan 1985) there remains little consensus on the determinants of the outcomes of ventures\(^1\) in which bilateral or multilateral exchanges of knowledge or technology take place.

Understanding the phenomenon of “technology collaborations and consortia” is important for two reasons. The first is that the organizational form is important in its own right. The European Union has supported collaborations such as these for decades and spent billions of dollars subsidizing their formation and operation (Mytelka 1991). Japan has been funding and organizing technology collaborations for years (Cusumano 1991; Feigenbaum & McCorduck 1983). Finally, the U.S., while taking a less active role than Europe, has also been funding and encouraging technology collaborations especially since the passage of the National Cooperative Research Act of 1984 (Vonortas & Joshi 1997). As noted above, private enterprises have also dedicated both their own money and the time of top management on this form. Therefore, a better understanding of performance could have both business policy and public policy implications.

The second reason that the phenomenon is important is as an example of a broader class of interorganizational relations. While the duration of a technology collaboration is often shorter, the focus narrower, and the partners more numerous than a “typical” strategic alliance or joint venture, it also has the same fundamental property of involving independent yet interdependent parties (cf. Lessard 1995). These parties must often both collaborate and compete to achieve their goals (Hamel et al. 1989; Schelling 1980). Therefore, a better understanding of

\(^1\) This paper uses the words “technology collaboration” to refer to the kinds of partnerships or alliances in which bilateral or multilateral exchanges of knowledge take place specifically for the development of new technology, new products, or new processes. Thus a technology collaboration is a subset of a class of “strategic alliances.” The generalizability of the results to other kinds of interorganizational relations will be discussed in section 5 below.
technology collaboration performance may also shed some light on the management of alliances.

A research stream that has developed over the last ten years centers on the initial "structure," or initial "conditions," of alliances, and how these initial conditions affect alliance outcomes (for example, Hagedoorn & Schakenraad 1994; Powell et al. 1996). Hagedoorn & Schakenraad (1994) relate firm-level performance measures to several "structural" characteristics, including industrial sector, company structure, innovativeness of the firm, and number of external linkages. Powell et al. (1996), as part of a large and comprehensive study, relate such structural characteristics as collaborative R&D experience and centrality in a network of alliances to outcome measures of firm growth.

Past work in the area of technology collaboration performance has related organization-level measures to performance. I am interested in examining interorganization-level measures and their effect on performance (Figure 1–1). I propose that interorganizational overlaps in the market, technical, and social domains represent dimensions that are fundamentally important to the performance of technology collaborations. Market overlap represents the similarity of the partners’ products, customers, and areas of activity. Technical overlap represents the similarity of their technical specialties. Social overlap represents the similarity of their people. The overlap framework relating interpartner characteristics to performance is the contribution of this part of the dissertation to the literature.

The overlaps are interpartner level measures but are relative to each partner. For example, imagine a technology collaboration between three firms, two of which are intense rivals. From the point of view of either of the rivals, there is a fair amount of market overlap (as 50% of its partners are competitors). But from the point of view of the third firm, there is a low amount of market overlap. I propose that these two profiles have different performance implications.
As partner characteristics come in “bundles,” it may be difficult to disentangle the individual effects these overlaps have on technology collaboration performance. However, that is the precisely the goal of this literature review. In the next section, I describe the basic problem of examining the overlap effects. I then devote one section each to performance and the three overlaps. In these sections, I describe how other authors’ work in the area of interorganizational relations relates to the framework. I then briefly describe other potential explanations for performance. The final section contains the conclusions of Part I.

Figure 1–1. Interpartner overlaps and performance
1.2 Interpartner overlaps in the general population of partners

In this part of the dissertation, I propose that market, technical, and social overlaps are independent constructs with individual effects on performance. However, this story is complicated by the inability to actually examine each of the overlaps in a vacuum. In the general population of firms, one would expect that all forms of overlap are roughly correlated. For example, if one were to examine social overlap's effect on performance, it would be expected to look like an inverted-U shape. This is because low social overlap would likely be correlated with all other factors, making social overlap (or any other sort of overlap) more of a general test about how “similar” the partner was.

One could imagine that in the absence of economies of scale, partnerships between highly similar firms would produce poor results because there would not be enough complementarities or enough new ideas. There might also be too much downstream competition. This is precisely the scenario that Bleeke & Ernst (1995, p. 98) discuss as they warn that “alliances between competitors with similar core businesses, markets, and skills tend to fail.”

On the other hand, very different partners would also be less likely to produce good results due to their inability to work together or even understand each other. To understand the high performance middle ground outcomes shown in Figure 1–2, one needs to isolate the independent effect of each kind of overlap by examining combinations as they occur across collaborations. If we could isolate these independent effects, we would like to know the direction of their influence on performance.
1.3 Performance in the literature

Implicit theories of partner “compatibility” have existed for some time in the literature on joint ventures. Geringer (1988), for example, describes the partner selection process and how partner characteristics correlate with critical success factors relevant to joint venture performance. In a study of 90 joint ventures, Geringer demonstrates that firms actually employ nine firm-characteristic-related criteria to choose partners, including (1) knowledge of the local market, (2) local government influence, (3) “compatibility” (in this dissertation called “social overlap” as discussed below), (4) cost of production, (5) burden-sharing ability, (6) sales and service experience, (7) possession of strategic assets, (8) geographic proximity, and (9) access to inputs. These criteria can be interpreted as assessments of potential compatibility along several dimensions. In Geringer’s study, the criteria were examined for possible correlation with perceived critical success factors such as experienced technical personnel and strong market presence. Note that this study did not attempt to assess performance. In addition to Geringer, other case studies in the joint venture area suggest that partner selection may be an important ingredient in joint venture success (Beamish 1988; Berlew 1984; Porter & Fuller
1986; Lasserre 1984; Radway 1984; Simiar 1983; Killing 1982; Walmsley 1982; Berg & Friedman 1980; Janger 1980; Vepa 1980), thus implying that partner compatibility is worthy of further systematic empirical study, especially in the context of technology collaborations.

While the determinants and implementation of joint-venture collaboration have been popular topics over the last decade, the subject of performance of such ventures has been studied to a lesser degree, while performance of strategic alliances is an area that is yet to reach its prime. Baird, Lyles, & Reger (1993) provide a thorough review of the joint venture performance literature. Here I simply mention some of the major issues raised by that paper, which concludes that joint venture performance must be assessed from multiple perspectives, including those of employees, the joint venture itself, the parents (partners), and, in certain instances, the government. Baird et al. review how performance has been measured or proposed in 25 studies, including by profitability (Tomlinson 1970), growth (Artisien & Buckley 1983), survival (Killing 1983; Franko 1971), duration (Kogut 1988; Hergert & Morris 1987; Harrigan 1986), stability (Blodgett 1992; Gomes-Casseres 1987), organizational learning (Kogut 1988; Lyles 1988), and parental control (Lyles & Reger 1993; Geringer & Hebert 1989; Beamish 1985; Killing 1983).

While Baird et al. claim that joint venture performance metrics generalize well to all cooperative alliances, it is clear that most of the measures proposed above are inappropriate for contractual, non-equity technology collaborations. This is due to several facts: First, there is no central organization as a stand-alone company in less formal alliances, making most venture-level financial indicators meaningless. Second, most alliances are designed to occur over a limited duration, making stability, duration, and survival irrelevant. Third, partners often have different — and sometimes conflicting — goals, making venture-level non-financial measures useless and cross-partner firm-level measures difficult to assess. Yan & Gray (1994) propose the achievement of firm-level strategic goals as a measure of performance of joint ventures.
Attainment of technical goals have been usefully employed at the project level (e.g., Allen 1977; Tushman 1978). The attainment of firm-level technical goals is also related to learning or internalization (Hamel 1991). In essence, technology collaborations are projects, but they are projects involving more than one organization.

Another issue relevant to technology alliance performance is whether performance should be measured at the organization level, the venture level, or both. Again, measurement for joint ventures and other forms of strategic alliances diverge. Most of the literature, with the exception of Baird et al. (1993), concentrates on the venture level of performance. Baird et al., as mentioned above, also call for partner-level performance assessment, which seems natural for technology collaborations given the three key differences mentioned in the previous paragraph.

Recall from the first section that the overlaps are not necessarily symmetric among members if there are more than two partners. This is frequently the case in technology collaborations. For example, the median Eureka project in Europe had eight partners (Eureka 1993). As overlaps can differ significantly for different partners, partners are likely to receive differential benefits. This is actually a third good reason to study technology collaborations. The variance of overlaps is likely to be large when there are several ($n>2$) partners, meaning that one project can generate $n$ outcome observations.

Referring back to Figure 1–1, we see the overall framework of the study and structure of the rest of Part I. First, I discuss how market, technical, and social overlap are related to performance in the literature. Then I briefly examine the relation of performance to the other constructs, namely, alliance characteristics and task characteristics. I conclude with a discussion of a simple model of overlaps and performance.

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2The first two reasons are listed on p. 15.
1.4 Market overlap and performance

Market overlap is defined here as the degree to which two or more organizations overlap each other’s domains. Economic theory’s conventional wisdom on competition has to do with the market power of firms, or the ability of firms to set prices. The field of economics makes a distinction between firms in a competitive industry, where products are commodities, and firms in less competitive industries, where products can be differentiated and brand loyalties exist (Pindyck & Rubinfeld 1992).

Another view of competition, and that used most often in industrial organization, is the degree of market concentration (Tirole 1988). A third view is based on the idea of elasticity of substitution (or cross-price elasticity of demand) of products in a market segment. The elasticity of substitution is how sensitive demand for one product is to another product’s price. This is very similar to the first view, in that the elasticity of substitution is sensitive to the firms’ ability to set prices (since, if demand for firm 1’s product is highly sensitive to firm 2’s price, then firm 1 has little control over price and vice versa). However, this elasticity can be calculated on a pairwise basis, something that is not possible when examining price-setting ability.

Beyond economic theory, one framework that has been useful in understanding the competitive positioning of financial institutions (and that we may generalize to other sectors) is the "client-arena-product" (CAP) matrix proposed by Walter (1988). In this framework, business units that compete within the same "cell" of the matrix (i.e., those that have the same client base, are in the same geographical arena, and that market the same products) are thought to be in a similar overall "market." Generalizing from this, we may propose that the more similar businesses (or indeed, any service providers) are along the three dimensions, the more market
overlap (competition) exists between them. The client and arena dimensions seem fairly self-explanatory; below follows a discussion on overlap in product domains (Van de Ven 1976).

Meyer & Roberts (1986), based on Urban, Johnson, & Brudnick (1979), provide guidelines for recognizing product domains in their discussion of “market newness” of new products. In this approach, there is a “general market” for overall categories of products, such as the “printer market.” The general market is “segmented” into areas, or market segments, representing distinct classes of users. In the case of the printer market, the segments might be personal, business, and scientific. Each one of these segments has its own specific needs, and each individual offering for a need is called a market “niche.” For example, the personal printer segment may have drafts and graphics as its niche, while the scientific segment may have plotting and equations as niches. These niches are discovered only through extensive knowledge of the industry and interviews with industry experts and can be expected to change over time.

While the Meyer & Roberts article concentrates on firms evaluating how much “overlap” there is between current R&D projects and potential new ones, this same method can be used to determine how much overlap there is between two firms’ product domains. Roberts & Berry’s (1985) test of market familiarity can, in fact, be adapted to examine product domain overlap as shown in Figure 1–3.

Chen (1996) notes that competitor analysis must be conducted from the vantage point of each firm and that it is highly likely that asymmetries exist between pairs of firms. Using data from the airline industry as an example, Chen demonstrates that American is Delta’s main competitor (most similar in market overlap and resources), while United is American’s main competitor.
We now turn to the effect of market overlap on performance. There have been several studies of the effect of rivalry on research joint venture performance at both the firm and individual level, all of them pointing to difficulty with high levels of rivalry. In industrial organization economics, for example, the performance of cooperative ventures is critically dependent on competition levels, or market overlap, between partners, with performance measures such as expected profitability dropping with increased rivalry (Katz & Ordover 1990; Katz 1986). This is due to the firm-level effect of rents from innovations being "competed away" or "dissipated" in the subsequent stage of the product market: If research results in lower costs for firms, firms cut prices in the product market and consumers reap all the gains from the research. This can extend to potential future actions, too: future market entry into an overlapping domain creates an atmosphere of higher overlap than would ordinarily be the case.

Thus we see that firms lack incentives to collaborate with competitors. However, a more relevant question is: How is performance affected by market overlap for firms that proceed
with collaboration? Gomes-Casseres (1996) has an answer based on several case studies: performance is greatly affected — in a negative way. He claims that the only way for cooperation to succeed is for the partners to “suppress competition.” In the case of partners in highly overlapped markets working on technology development, this is a very difficult task to accomplish.

Hladik (1988) warns that the risk of sharing proprietary know-how with a competitor is a key problem hindering joint R&D success. At the individual level, Schrader (1991) and von Hippel (1987) show that competition between firms is sensed by researchers in firms, who withhold knowledge that might be considered detrimental to their own firm if disclosed. These same researchers, however, disclose knowledge that may be proprietary but not damaging with other researchers and expect to receive a “pay-back” in the future for their efforts.

The final consideration is why firms with little market overlap would ever form a partnership. In other words, what could the firms possibly learn from each other? First, it may be that similar technologies underlie both sets of products. Second, it is also possible that geographic barriers have completely segmented two identical product markets. Third, it could be that political barriers have effectively partitioned identical product markets. National telecommunications monopolies come to mind as examples of some of these effects, illustrating how firms may be in different arenas or have different clients while still providing similar products. It also illustrates what I believe is a "hierarchy" of overlap: product overlap is the least likely to remain segmented (i.e., easiest to enter), then client, and finally arena.

Thus, market overlap is concerned with the willingness, rather than the ability, to collaborate, and demonstrates the tradeoff between market knowledge and rent dissipation or unintended spillovers. These factors lead to the first proposition described below:

Proposition 1: Performance will decline as market overlap increases.
1.5 Technical overlap and performance

Technical overlap is the degree to which individuals or groups within two or more organizations are similar to each other on a technical level (Mowery, Oxley, & Silverman 1997). The most important and frequently cited issue surrounding technical overlap is complementarity of skills. When two or more firms provide each other with complementary strengths and weaknesses, there can be a fit that allows both firms to learn something, or, at least, exploit each other’s greater knowledge in that area for mutual gain (Axelrod 1984; Sinha & Cusumano 1991). Mariti & Smiley (1983), for example, found that the most common motivation to collaborate in the information technology sector related to “technical complementarities.” Likewise, Eureka (1993) found a staggering 74% of industrial respondents citing “complementary technical expertise” as an important motivation for collaboration. Hamel (1991) found that “internalization” or learning from partners with “scarce skills” can be one of the primary benefits of an international alliance.

There can be two ways in which technical areas of expertise are not complementary. The first is when the areas of expertise overlap completely. Unlike the market overlap effect discussed above, this does not necessarily pose a problem. Researchers sharing the same discipline often find themselves in positions to communicate effectively with each other (Allen 1977). In fact, Allen found that successful technical projects were associated with members who

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3In this dissertation, I use the word “overlap” instead of “complementarity,” where “complementary” means something like “not overlapped.” The reason for this is that “complementary” is less precise. It is a circular definition that refers to the outputs of the collaboration in defining its inputs. That is, when a collaboration is highly successful, one often reads that the partners were “complementary.” Complementarities can only actually be determined after the fact. What I am referring to is something more precise: how similar they are technically. This can be determined purely by looking at the technical specialties of the partners. One might guess that the “standard” definition of complementary is related to being “different, but not too different.” Almost nothing has been written on technical overlap; therefore, the major results reported here use the word “complementary.”
communicated more (than unsuccessful project members) with others outside of the project but within the same discipline.

The second way firms do not exhibit technical complementarity is when they are in completely unrelated fields, which is the converse of the overlap case. This subject has been formally studied only in the product development literature, where Kotabe & Swan (1995) found a positive relation between similarity of function between partners in an alliance and the innovativeness of new products. Likewise, Ancona & Caldwell (1992) found that functional diversity within the firm was negatively related to both innovation and team-based performance, implying that overall it is more difficult to produce results with team members in radically different areas. Figure 1–4 provides a framework for thinking about degrees of technical overlap between organizations.

The link between technical overlap (or lack thereof) and performance is established in the joint venture literature. Lynch’s (1989) list of success factors includes several that could be construed as technical dissimilarity: complementary technical skills and understanding of technical language; ambiguity / certainty requirements of the partners; and rate of change of partners’ own technological environments. Relative differences in these factors between partners leads to more effective and successful ventures. Doz (1988) likewise suggests technological complementarity as a basis for partnerships and as a factor that, if evident, can help minimize the difficulties associated with environmental uncertainty and cultural “distance” between partners.

Here again we must consider why completely unrelated organizations (technologically speaking) would care to form partnerships. One reason may be to learn and apply new

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4This does not provide direct evidence of technical overlap, as Ancona & Caldwell were referring to the functional diversity of marketing, R&D, manufacturing, etc. It is, however, suggestive of the problems of bringing together people with different areas of expertise.
technologies to specific business problems, perhaps in a similar market, in some form of a “technology swap.” Overall, however, one would expect that few partnerships of this nature exist.

1. same techniques as partner embodied in existing products / processes
2. same technical subfield as partner; technological capability used inside without being embodied in products
3. same technical discipline as partner; main features of partner's technology relate to existing inside skills
4. knowledge of partner's technology exists within the organization without being embodied in products / processes
5. monitors partner's technology systematically
6. relevant & reliable advice available from external consultants

Source: Adapted from Roberts & Berry (1985)

Figure 1–4. Decreasing overlap of scientific / technological domain

Technological overlap thus effects both the ability and the willingness to collaborate and demonstrates the tradeoff between the relevance of the partner's knowledge and the learning potential of the partnership (cf. the discussion on “technological newness” in Meyer & Roberts 1986). The logic of the above arguments leads to the next proposition, and the proposed inverse-U-shaped curve of performance (Meyer & Roberts 1986) shown in Figure 1–5:

Proposition 2: The highest performing technology alliances will exhibit partial technical overlap, followed by those within the same narrow specialty, followed by those in completely unrelated scientific / technical disciplines.
1.6 Social overlap and performance

Social overlap refers to how similar the individuals are within the partner organizations from a social perspective. One interpretation of social overlap is ease of communication, or the degree to which partners can decode oral, written, and non-verbal messages sent between them. If there are efficient mechanisms for transferring information between partners, then performance is likely to be higher. The basis for this springs from March & Simon (1958), who, along with Myers & Marquis (1969), proposed that oral communication is a highly effective and efficient method of transferring information. One implication of this is that effective research depends on information processing capability or information “flow” between researchers in labs (Allen & Cohen 1969). This line of inquiry would lead one to believe that more similar partners in terms of communication, such as partners who speak the same language or partners who are physically closer (Schmerhermorn 1975), the better the performance of the venture.
Aside from pure communications issues, there may be a link between institutional homogeneity and social overlap. Reduced linguistic and cultural homogeneity may make oral and written communication a far less efficient mechanisms to transfer information. Linguistic and cultural heterogeneity suggests that partners may be less socially similar across national borders (Parkhe 1991; Gray 1985). Within the same country, corporate cultural differences can also lead to “semantic noise” and inefficient communication (Allen 1977; Cherry 1957).

Social overlap has also been shown to be important to the performance of joint ventures. Lynch (1989), in an adaptation of Lawrence & Lorsch (1967), cites several social overlap factors critical to “joint venture and strategic alliance” success. The most important of these are similarities in organization structure; level of personal relationships between the partners, especially at the top; similarities in coordinative business culture; and language / social culture similarities. Lynch, citing case studies in several different industries, claims that when differences in these social overlap factors are high, performance of the joint venture suffers, and when overlap is high, performance is also high. Doz (1988) concurs for organization culture in a study of large-small partnerships.

Therefore, social overlap is concerned with the ability, rather than the willingness, to collaborate. This leads to the next proposition and proposed effect of social “overlap” on performance:

Proposition 3: The highest performing technology alliances will be associated with partners from highly similar national and corporate cultures.
1.7 Other factors

Interpartner-level differences between organizations, while important, are not the only factors affecting the performance of technology collaborations. As mentioned in the first section, there are at least two other groups of factors: alliance characteristics and task characteristics. Alliance characteristics are factors that are specific to the alliance itself, such as governance mechanisms, joint vs. separate facilities, and so on. The earlier discussion emphasized how different governance mechanisms influence both overlap and performance measures, underscoring the importance of controlling for these characteristics. In addition, factors such as whether to conduct research jointly or separately may influence the social interactions of partners and venture performance due to different communication patterns (Tucci & Lojo 1994).

The second set of factors revolves around task characteristics of the collaborative venture. Killing (1988) examined the complexity of the proposed project as an important factor along with the fit with organizational complexity (alliance structure) in the success of alliances. Killing’s task complexity involves the scope of alliance activities (broader means more complex), environmental uncertainty (higher is more complex) and relevance of partner skills (lower is more complex). While some of these I have categorized as alliance-level and interpartner-level structural factors, the basic idea of task complexity as an entity unto itself is a useful one. The Schrader, Riggs, and Smith (1993) categories of “ambiguity” (variables unknown) and “uncertainty” (values unknown) are closer to what I refer to as task characteristics, with high ambiguity-high uncertainty tasks — such as those involved in more fundamental research — being more complex.

Finally, any study of these interpartner overlaps should control for some factors correlated with general successful innovation. The purpose behind controlling for “innovativeness” is to
examine whether the success of the interfirm collaboration is due to factors that make all R&D successful or whether it is due to the unique overlap factors outlined above. To this end, Freeman (1982) provides a review of possible factors contributing to innovative success and tests those factors in the SAPPHO research project. He finds that (1) strong in-house professional R&D; (2) use of patents; (3) efforts to involve, educate, and assist users; (4) tight coordination of R&D, production, and marketing; and (5) good communication with the outside scientific world are most strongly correlated with innovation. Brown & Eisenhardt (1995), in a broad review of product development and innovation, conclude that use of cross-functional teams (as in Clark & Fujimoto 1991), the existence of a “gatekeeper” (as in Allen 1977), and moderate group tenure (of 1.5 to 5.0 years as in Katz 1982) are all related to high “process performance” or project goal achievement.

1.8 A model of overlaps and performance

After examining the directions of the effects outlined above, one can see why it is difficult to unravel the true effect of each form of overlap. If one assumes that each of the three overlaps has the partial effect specified above and the effect on performance is additive, then we may examine performance as one or more variables vary simultaneously.

A simple model such as the one above can also provide intuition about why the overall effect of increasing “diversity” of partners is roughly inversely U-shaped. If the three overlaps are highly correlated, then all three variables will move together. The true benefits of lower market overlap will be nullified by the true costs of lower social overlap, leaving nothing remaining except the effect of technical overlap. Furthermore, if the only model fitted to the data is a straight line, then the overall slope will not be statistically different from zero. Thus, any

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5 These are highly stylized with the sole purpose being to discuss the shape and direction of effects.
empirical study that does not attempt to control for levels of the other overlaps may come to the conclusion that any individual overlap has no effect. Furthermore, if the variables are not perfectly correlated, one can imagine that effects of one overlap could be spuriously attributed to another.

1.9 Conclusions
In this first part of the dissertation, I have proposed a framework for thinking about interpartner characteristics. I claim that market, technical, and social “overlaps” between partners could have an influence on performance of technology collaborations. Market overlap would tend to have a negative effect on performance due to rent dissipation, unintended spillovers, and the tendency to withhold proprietary information from the partners. Technical overlap would have an inverted U-shaped effect on performance as (1) it would be hard to apply vastly different knowledge bases to a common problem, and (2) identical knowledge bases would not provide adequate outside perspective. Social overlap would have a positive effect on performance based on efficiency of communication.

I also proposed a very simple model to illustrate the difficulty of testing for the individual effects of the overlaps. When the partner characteristics are bundled together, it may be difficult to locate partners with low market overlap, high social overlap, and moderate technical overlap.

The literature on motivations for technological collaboration seems to center almost exclusively on technical overlap (Eureka 1993; Mariti & Smiley 1983). One could argue that the high percentages of respondents claiming that “technical complementarities” drive formation seems like an almost fanatical and irrational propensity to collaborate without regard to other non-

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6Again, in the absence of economies of scale in R&D.
technical obstacles. However, a belief in the primacy of technical complementarities is consistent with the notion that managers act as if all of the overlaps move together. If that were the case, a rational manager would simply look for moderate levels of technical overlap (implying moderate levels of market and social overlap, too) as that would probably be most likely to produce the highest level of performance.

In conclusion, we may refer back to the quote at the beginning of this part of the dissertation. I have proposed that the best way to analyze the phenomenon of technology collaborations is from an interorganizational perspective. Furthermore, I have proposed that overlaps in three different dimensions drive the “synergies” referred to by Gibson & Rogers. The next two parts of the dissertation will be concerned with the further exploration of the usefulness of the concepts of market, technical, and social overlap.
Case Studies in Software Technology Research Collaboration

2.1 Introduction & theoretical background

The incidence of inter-firm collaboration — especially in relatively short-term, informal ventures — has been rising rapidly over the last twenty years (Hladik 1985; Mowery 1988; Mytelka 1991; Freeman 1991; Hagedoorn & Schakenraad 1992). In addition, bilateral or multilateral exchange of knowledge or technology has become an important source of capability acquisition by firms (Link & Bauer 1989; Fusfeld & Haklisch 1985; Häusler et al. 1993). However, it is difficult to draw conclusions about the conditions under which these "technology collaborations" and consortia are successful. Part I of this dissertation proposes that partner characteristics represented by market, technical, and social overlaps between partners may be important determinants of technology collaboration performance.

The purpose of Part II is to explore whether the theory proposed in Part I is consistent with reality. This part of the dissertation examines the question: Are market, technical, and social overlaps the primary determinants of technology collaboration performance, or are other factors more important? Qualitative field-based research is an appropriate vehicle to examine this research question, as it allows more freedom to explore alternative models of the
phenomenon, including the effects of history and processes (Parkhe 1993a). The insights gained from this study should contribute to the development of a model of collaborative success, to a better contextual understanding of constructs such as “competition,” “compatibility,” “culture,” and “performance,” and, ultimately, to better measurements in large-sample studies of the phenomenon.

The setting of the study is cooperative R&D and technology collaborations, in which partnerships may be vertical or horizontal and partners may bring a variety of skills and capabilities to the venture. To illuminate the research question posed above and explore the relationship between market, technical, and social overlap and performance in technology collaborations, I provide examples from case studies of two joint software research projects and from field interviews in the information technology sector.

The primary pattern that emerged from the field research is that interpartner market, technical, and social overlap do indeed have some face validity. In other words, there is some evidence that each of these factors contributes in some way to the outcomes of the collaborations. However, a major shortcoming of the framework proposed in Part I is the lack of a process construct. In the course of the study, there arose situations for certain partners in which they had to make a decision: to act “collaboratively” and possibly forgo some short-term gain or to act “non-collaboratively” in the interests of short-term gain.

These individual decisions had larger ramifications within the partnerships. Cycles of trust developed when partners acted collaboratively, leading to closer relations and better technical results. However, when a partner acted non-collaboratively, cycles of mistrust developed that eventually marginalized the non-collaborator. Taking these observations to an extreme, it seems plausible that critical decision points can lead to “tipping equilibria” in which partners starting off acting collaboratively achieve better performance. I therefore propose the concept of “collaborative behavior” as a moderator of the overlap effects.
Part I proposes that interpartner characteristics fall into three categories: market, technical, and social overlap. Market overlap is concerned with competition and rivalry between partners (Gomes-Casseres 1996). Competition and rivalry can have two different effects on performance: a rent effect and an incentive effect. First, given that the partners collaborate, high levels of rivalry may lead to lower returns from the collaboration (Katz 1986; Tirole 1988). Knowing this, firms may be unwilling to collaborate or share information with competitors (Hladik 1988; Schrader 1991; von Hippel 1987).

Technical overlap refers to the similarity of technical specialties of research groups within partner organizations. Technical complementarities, or the opposite of technical overlap, have been studied mainly in reference to the formation of collaborative ventures, but rarely in reference to performance. For example, Mariti & Smiley (1983) and Eureka (1993) find that technical complementarities are the most common reason to form an alliance. Hamel (1991) found that "internalization" or learning from partners with "scarce skills" can be one of the primary benefits of an international alliance.

Social overlap, or the similarity of the people involved in a collaboration, is about how well individuals within partner organizations can decode oral and written messages sent between them. Therefore, one view of social overlap is ease of communication. Effective research depends on information processing capability or information "flow" between scientists in labs (Allen & Cohen 1969). This line of inquiry would lead one to believe that more similar partners in terms of communication, such as partners in the same technical field (Hladik 1988), partners who speak the same language, or partners who are physically closer (Schermerhorn 1975) exhibit more overlap. In general, the higher the social overlap, the better.

The rest of Part II is organized as follows: Section 2.2 provides details on the research method used in this analysis. Sections 2.3 and 2.4 are descriptions of two collaborative software technology research projects: a system for integrating design and manufacturing

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1This is not quite true; see footnote 79 below.
workstations across a factory floor, and an environment for utilizing object-oriented databases in software engineering applications. Each of those sections starts out with a description of the project’s goals and participants, and then discusses the history of the projects from 1992 to 1995. Section 2.5 is an analysis and discussion of the most salient features and dynamics of the collaborations. Section 2.6 proposes some theoretical extensions based on the findings and discusses the conclusions of the study.

2.2 Method

As mentioned above, this study utilizes qualitative data analysis to explore the constructs outlined in section 1. In the process, I present evidence of relations between the constructs and discuss other factors that may also explain the outcomes. The qualitative data are primarily drawn from interviews with managers and scientists involved in two collaborations. Therefore the data is primarily based on two cases, one for each partnership.

2.2.1 Case selection

This analysis centers on two consortia (OBJECTDB and CIMP)\(^2\) in the software research area, based in Europe and the United States, respectively. Table 2–1 summarizes the main features of the ventures. Tables 2–2 and 2–3, listed below, summarize some pertinent information about the partners. The two projects were chosen with several criteria in mind to control as much as possible for differences between the projects and yet provide for some variance on the overlap variables. This variance is explained at the end of this section. The two most important control “variables” were organization and technology. The third salient feature is the size of the project and partners. I discuss each of these below.

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\(^2\)The names have been disguised to preserve confidentiality as a condition of access. Please contact the author for more information on participants.


<table>
<thead>
<tr>
<th>Feature</th>
<th>OBJECTDB</th>
<th>CIMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical area</td>
<td>object-oriented database management systems for software engineering applications</td>
<td>integration of computer-aided design and computer-aided manufacturing databases</td>
</tr>
<tr>
<td>Research conducted</td>
<td>at partner sites</td>
<td>at partner sites</td>
</tr>
<tr>
<td>Foundation</td>
<td>1992</td>
<td>1992</td>
</tr>
<tr>
<td>Planned duration</td>
<td>3+ years</td>
<td>5 years</td>
</tr>
<tr>
<td>Subsidized?</td>
<td>Yes — 50%</td>
<td>Yes — 50%</td>
</tr>
<tr>
<td>International partners?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Number of partners</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Researchers per partner</td>
<td>3 – 6</td>
<td>3 – 8</td>
</tr>
</tbody>
</table>

Table 2-1. Key features of the case studies.

Organization. In both cases, the project is made up of independent participants who conduct research at their own, separate sites and share results with one another. There is no central, official joint venture or other organizational form created for the purpose of the collaboration, although both projects do have a central administrative authority that oversees the progress of the project.

• Funding/subsidization. Both projects are partially subsidized. The OBJECTDB project is funded about 50% by the European Union, while the CIMP project is subsidized about 50% by the United States Department of Commerce. The numbers are approximate in both cases because there are some performance-based incentives imposed by the government agencies.

• Duration. The OBJECTDB project lasts three years, with the possibility of extension. CIMP lasts five years.

• Kinds of partners. The kinds of partners differ between the two projects. In OBJECTDB, there are several software companies teamed with universities and a large airline.
In CIMP, there are several software companies teamed mainly with the research arms of manufacturing concerns.

**Technology.** Both projects involve research into software technology. Software research collaboration was chosen for several reasons. First, software itself is now one of the most expensive, complex, and critical parts of most “systems” products, such as the telephone system, space shuttle, and even manufactured products such as the automobile (Levy 1987; Boehm 1981). Even if the lessons learned can be applied to software research only, then managers may still gain insight into managing one of the most expensive pieces of their products. If they can be generalized to other technology research projects, all the better.

The second reason software research was chosen was that software development is a complex undertaking requiring the coordination of many highly trained workers to produce a product to solve a very specific problem. Since software development involves interdependency between developers, software R&D, like other kinds of R&D, cannot be easily “partitioned.” The tasks involving the coordination between researchers to improve the development process are difficult to divide between organizations. Hence interorganizational collaboration becomes more challenging than, say, a collaboration between a supplier and a customer for distributing a product. Insights gained from studying software research may also apply to other complex, tightly-linked research projects.

**Size of the project.**

- **Number of partners.** The number of participants (which includes mostly firms, but also two university departments, one non-profit laboratory, and one government laboratory) in both cases is nine.

- **Budget.** The budget for CIMP is bigger than OBJECTDB. Total private and public spending on CIMP is about $40M to fund the research over five years. Total private and public spending on ObjectDB is about $20M over three years. The partnerships seem to employ
roughly the same number of managers and researchers, with the CIMP project occupying a slightly larger number of people.

- **Size of participants.** The average participant in CIMP is very much larger. However, at the business unit level, which is where all of the research occurs, CIMP has only slightly larger units. For example, even though Mantronix is a very large company, Mantronix’s Central Research Laboratory, which is participating in CIMP, is about the same size as the average OBJECTDB participant.

Market overlap differed between the two projects with an initial estimate (average number of partners within the same three- and four-digit SIC codes) shown in Figure 2–1. CIMP had more market overlap than ObjectDB. For example, several of the software companies involved in CIMP do not actually compete head to head in the CAD/CAM market. All of them, however, have products that target the CAD/CAM market. And a few of the firms, such as Cimco, have other divisions within their own firms (usually through merger or acquisition) that do have products that compete with Cimtools and CadCorp. Three-D could easily vertically integrate into the CAD/CAM software production market. Computation, as a final example, is using the OBJECTDB project to build up competence in object-oriented design with the long-term goal of selling customized products, possibly using NewDB, but possibly to the exclusion of NewDB.

Social overlap differed between the two projects with some initial estimates shown in Figure 2–2. *Ex ante,* we would expect there to be differences in social overlap due to the types of organizations involved, size of operating units involved, and the number of countries involved. CIMP exhibited higher levels of social overlap with all partners being based in the U.S. and with only two kinds of organizations.
Figure 2–1. Initial estimates of market overlap: average number of partners within the same three- and four-digit SIC categories

Figure 2–2(a). Initial estimates of social overlap based on number of countries represented

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3Source for SIC codes: Dun & Bradstreet, interviewee’s list of competitors, and the Amadeus database. The values were computed by comparing the three-and four-digit SIC codes for each partner. For each partner, I counted the number of SIC codes that were the same. I then averaged these numbers for the entire partnership.
In conclusion, I have studied projects that are somewhat similar in their organization and in their technologies. However, small-sample qualitative studies are always subject to the individual circumstances of the cases. To bolster the sense of representativeness of the cases, I conducted interviews with information technology organizations outside of the two collaborations and, as part of the interview series with the participants to ObjectDB and CIMP, asked participants to compare their particular collaboration with other past or ongoing collaborations. The results may be peculiar to software research, but most likely can be generalized to other technology-based research collaborations. In any case, the purpose of these case studies is to illuminate the constructs and variables outlined above to study further, thereby enhancing modeling efforts and providing input to future studies.
2.2.2 Data collection

The data collection discussed here consists of four rounds of field research in Europe and the US. The initial sample was based on the software technology projects summarized in the European Strategic Program for R&D in Information Technology (ESPRIT) Synopsis Book (Commission of the European Communities 1992). I visited 30 information technology, computer, software, and other research organizations\(^4\) and performed interviews with 45 researchers and managers. I also interviewed three project officers responsible for monitoring and evaluating information technology projects within the European Union.

At each site, I conducted a semi-structured interview with a prepared list of topics lasting from two to four hours. The prepared list of topics is shown in Appendix B. Site visits lasted from two hours to two days. Appendix C shows a list of people interviewed and their titles. The interviews focused on information on the organization’s past and present collaborations, the reasons for entering into them, and the successes and failures of the collaborations. Whenever possible and appropriate, I received demonstrations of software in progress or completed through the collaborations. Twenty of the interviews were taped. All interviews were transcribed as soon as possible, in most cases the same day as the interview.

I also received permission to attend two general meetings of the partners in which they made both managerial and technical decisions. These meetings lasted two days each. I took extensive notes at these meetings and observed such things as the interactions between the partners and the process of group decision making. Another source was written records. I obtained written internal documents and email messages on as many projects as were offered by the respondents. I also searched for and found publicly-available information on the participants, such as marketing bulletins, technical publications, and news reports.

Agreement between sources was found to be moderately high. I estimate the percentage of agreement between sources in excess of 80%. In most cases, one person per

\(^4\)Two were academic departments of computer science, one was a non-profit research center, and one was a government laboratory. The rest were firms.
firm was interviewed, although in others, I interviewed as many as four people. Between
interviewees and written records, agreement was also moderately high. Discrepancies were
resolved by telephone or email contact if possible. In the narrative that follows, I chronicle a
series of events based on the sources described above. My criteria for providing details of
events were as follows. For interactions and factual statements involving multiple parties, I
required at least one other source to agree and no source to deny that the event happened.5 For
statements of events involving one party, I required that no source deny the event happened.
Personal anecdotes or statements of feelings are reported as they were told if appropriate to the
narrative.

2.2.3 Data coding

Part of the data analysis involved content analysis techniques (Strauss 1987; Taylor &
Bogdan 1984; Diesing 1971). The contents of the interviews were coded into various
categories corresponding to the baseline model and how the constructs in the model have
changed over time. Certain categories were not found useful (i.e., no one mentioned them in
the interviews or written reports) and certain other categories were too broad. This led to a
reclassification to level of reference: personal (P), organizational (O), or consortium (A).
Within the last two, I used (1) competition and markets (CM); (2) technology (TO); (3) social,
cultural, and communication (SC); (4) goal statements (GO); (5) performance, goal attainment,
and outcomes (P); and (6) process issues, including collaborative behavior (PI-CB), dynamics
(PI-DY), and all other process issues (PI-PI). In addition, within the organizational level, I
also had a category for collaborative experience (E). Appendix D shows the categories, while
Appendix E gives examples of interview excerpts and their codes.

5 There is one exception to this in section 4.2.4. The “Demo Central” dispute was reported by four participants
at three companies. The actions of Prodoco were not denied but the intent attributed to Prodoco was denied by
the Prodoco participant. This is explained in the text.
Coding was performed by me and by a research assistant. I developed the coding scheme and worked with the assistant on one case. This was followed by alternating between coding and auditing. We performed spot audits on the coding and found a high degree of consistency between us, as detailed in Appendix E.

2.2.4 Case analysis method

This study uses the technique of analytic induction, also known as analytic research (Katz 1983; Glaser & Strauss 1967), to explore the context of technology collaborations and consortia. Analytic induction begins with a theory and compares the theory with qualitative data to either verify or modify the original theory. Of special importance are cases that conflict with the theory, since these tend to lead to a more robust or inclusive theory. Taylor & Bogdan (1984) provide the following steps as central to the method: (1) The development of a rough definition of the phenomenon. (2) The formulation of a hypothesis to explain the phenomenon based on data or insight. (3) The study of one case to examine the "fit" between the case and the hypothesis. (4) The reformulation of the hypothesis or redefinition of the phenomenon. (5) The active search for negative cases to disprove the hypothesis. (6) The reformulation after the negative cases have been found. (7) The formulation of a hypothesis that corresponds to all cases. This is also a form of the "comparative case method" (Yan & Gray 1994).

This procedure was used to refine the theoretical model and generate the theory discussed in section 2.5 below. The focus on the specific constructs was inspired by the preliminary round of field research with information technology managers. Then the constructs were examined by comparing them with the cases one at a time. Yan & Gray (1994) used this method in their examination of bargaining power, managerial control, and performance of US – China joint ventures. Parkhe (1993b) has argued that the comparative case method is particularly well suited for partnerships such as joint ventures due to the need for theory development.
2.3 CIMP

The project, the Computer Integration and Manufacturing Project (CIMP), is administered through the U.S. government, and is managed by the Management Science Institute (MSI). All participants are members of MSI. The participants include four manufacturing companies: Prodco, Mantronix, Risce, and Sprockets Corp; five software companies: SystemSW, Cimtools, CadCorp, Cimco, and Three-D Corporation; and DefensePower, which administers one of the US Department of Energy’s national laboratories.

This section chronicles the history of CIMP from its inception within MSI through the development of a demonstration and just beyond. In it, I attempt to convey some of the interactions between the partners and show how the partner characteristics influenced the outcomes. I also explore whether other factors may explain outcomes and how the partners managed the collaboration. I begin with a brief description of each partner, then describe the process of collaboration within the consortium. I do not present an analysis of the case until Section 5. In section 6, I interpret the results of the analysis and propose some theories that are consistent with the case data.

2.3.1 The partners

In this section, I provide a short description of each partner’s business and strategy, followed by a brief statement of the partner’s past collaborative experience at the time of the beginning of the project (1992). Table 2-2 summarizes some of the main features of the partners.

**CadCorp**

CadCorp was started in 1984 as a software company specializing in extending traditional CAD systems to include rule-based reasoning about design and manufacturing. It employs about 70 people. Its main product is called CADCORP System, which allows for the development of feature-based “libraries” used in design and manufacturing. CadCorp’s stated
goal is to increase their customer’s competitiveness through the automation of engineering applications and mainly targets the aerospace, automotive, and industrial equipment markets.

CadCorp has several projects in which it is collaborating externally. First, it has a series of collaborations to support direct CAD output from other software companies. CadCorp has also recently built an interface for a CAD program offered by a major aerospace and defense company, which now markets the joint product. Another large defense contractor teamed with CadCorp to extend its own CAD system for use in an Air Force program. The goals of the project are to handle three-dimensional data, “adjudicate” space usage when more than one part is in “competition” for it, and develop complete “data control flows.” Finally, CadCorp has joined with yet a third defense contractor to develop a system for a Navy program. The system will be used to develop automatically “macro-process” plans for small manufactured parts and printed wiring assemblies defined in the Product Definition and Exchange System (PDES) mentioned above.

<table>
<thead>
<tr>
<th>Name</th>
<th>Business</th>
<th>Revenues</th>
<th>Collaborative Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>CadCorp</td>
<td>software</td>
<td>$10 – 25M</td>
<td>several joint bidding projects in defense</td>
</tr>
<tr>
<td>Cimco</td>
<td>software</td>
<td>$1 – 10M</td>
<td>subcontractor relations</td>
</tr>
<tr>
<td>Cimtools</td>
<td>software</td>
<td>$1 – 10M</td>
<td>customize products for clients</td>
</tr>
<tr>
<td>DefensePower</td>
<td>national lab</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>Mantronix</td>
<td>manufacturing</td>
<td>&gt; $50B</td>
<td>informal academic collaborations</td>
</tr>
<tr>
<td>Prodcot</td>
<td>manufacturing</td>
<td>&gt; $50B</td>
<td>outsourcing for other companies</td>
</tr>
<tr>
<td>Riscy</td>
<td>manufacturing</td>
<td>$1 – 10B</td>
<td>alliances in both hardware and software</td>
</tr>
<tr>
<td>Sprockets</td>
<td>manufacturing</td>
<td>$10 – 25B</td>
<td>little</td>
</tr>
<tr>
<td>SystemSW</td>
<td>software</td>
<td>$25 – 50M</td>
<td>little</td>
</tr>
<tr>
<td>Three-D</td>
<td>software</td>
<td>$10 – 25M</td>
<td>alliances with potential adopters</td>
</tr>
</tbody>
</table>

Table 2-2. Overview of partners of CIMP
Cimco

Cimco provides advanced software and integrated systems for factory management, automation, and control. The company was founded in 1982 and is made up of three divisions: Factory Management and Control Systems; Automated Factories; and Artificial Intelligence (AI). Cimco employs about 150 people.

The AI Division, which is participating in CIMP, provides knowledge processing solutions that mainly utilize expert systems to apply human knowledge to solve problems. AI sells three main products, all software tools, for (1) building knowledge systems, (2) building intelligent diagnostic applications such as help desks and field engineering support systems, and (3) enabling companies to capture, analyze, and evaluate product requirements to decrease market lead times. In 1994, Cimco introduced a software program for use in computer-integrated manufacturing (CIM).

Cimco’s technology strategy is to combine expertise in factory automation with today’s industry standards to provide product-based, or off-the-shelf, solutions. These products take the form of software systems that are customized to a manufacturing process, yet based on standard products for repeated implementation and lower cost and risk. Formal collaborations outside of subcontractor relations had not been an important part of Cimco’s strategy, although CIMP gives Cimco a competitive edge in its relations with large potential customers with geographically dispersed design and manufacturing applications.6

Cimtools

Cimtools is a CAD/CAM integrator. It sells a software product that translates an engineer’s three-dimensional drawing into a data structure used to run tools to cut the part. The product also records information about the best tool to use for each part and the optimal

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6*Penton's Controls & Systems*. See Appendix A. In the following footnotes, incomplete references are used to protect the confidentiality of the people interviewed as a condition of access to the organizations. Contact the author for more information.
operating characteristics of each tool. Industrial software specialists started the company in 1984. However, five years (and $35M) later, in 1989, the company filed for bankruptcy. The technology was viable but workstations that controlled numerical machine tools were not powerful enough to take advantage of the product to justify its high cost. In late 1990, a large investment bank and a group of employees bought the technology and created a new company, with a former NASA engineer and Digital Equipment manager hired to run it. The company is still privately held with revenues of about $1–10M in 1993. Cimtools has focused on large companies with low production runs of a wide variety of high-value products, such as Boeing, Caterpillar, and Allen-Bradley.

The company has had several collaborations with potential customers to customize their product, but CIMP is the first partnership that Cimtools has entered into that is not oriented toward direct sales. The partnership has allowed them to interact with potential customers in a different setting:

In CIMP, you have a different relation with those companies than when you’re peddling products... But being out to talk, talking in a totally different fashion than if you were, and I’ll say it again, peddling products. There are more joint interests involved.8

DefensePower

DefensePower designs, manufactures, integrates, and operates large-scale systems and products for the aerospace, electronics, information technology, and energy fields, and produces materials for construction and industrial applications. The company’s technical areas of expertise are in electro-optics, microelectronics, ultra-high-speed signal processing, automatic target recognition, laser communications, neural networks and artificial intelligence, robotics, and materials. DefensePower’s customers include agencies of the US government and other nations, as well as major domestic and foreign industries. The company’s revenues

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7*Forbes.*
8Interview with Zeenath Srinivasan, Vice President, Cimtools, October, 1995.
are approximately $6 billion, with net profits of about $350 million. DefensePower employs approximately 56,000 people.

DefensePower, a wholly-owned subsidiary of the corporation, is the partner in CIMP. DefensePower manages one of the US Department of Energy’s science, technology, and production facilities: a national laboratory and various nuclear facilities. DefensePower’s recently enlarged mission now includes weapons disassembly, materials storage and transfer of technological expertise to private industry in such areas as precision manufacturing, measurement and certification methods, highly accurate joining, computer-controlled equipment, flexible production systems, quality control, and fabrication of advanced ceramics and composites. It is in these areas that the results of CIMP are most relevant to DefensePower. DefensePower is not an official member of CIMP (see below), but has participated in some of the sub-projects. It had virtually no collaborative experience before this undertaking.

**Mantronix / Central R&D Lab**

Mantronix is one of the largest manufacturers in the United States. Its 1993 sales were in the many dozens of billions of dollars. Mantronix has manufacturing, assembly, or sales operations in 30 countries worldwide, and employs several hundred thousand people. The Mantronix Central R&D Lab is the partner in CIMP. The Central R&D Lab employs about 625, including professionals and staff. In the Central R&D Lab, the researchers are not in the product development process *per se*, although they are an integral part of the larger organization that eventually ends up adopting some of the technologies and methods that they develop. The mission of the Lab is to get involved in advanced technology projects that attempt to fill a need inside the company:

I’d say that the whole thing is much more a push than a pull. Although it is a pull from the point of view that we are trying to solve the generic complaint from the engineers in the company who basically say that ‘we can’t do our job fast enough.’ So we say, well, here’s some software, here’s some
networking to do your job. So for the most part it is technology push although we are working from a perceived pull by the engineers.\textsuperscript{9}

Research on CIMP is pursued in the Department of Computer-Aided Engineering. Most of the work in the department involves numerical methods, but they also perform research on solid mechanics, shape optimization, topology, product performance analysis, and even artificial intelligence (AI). The AI research group specializes in using AI for developing computer-aided engineering (CAE). This relates to the overall problem of software projects developing CAE models and connecting models. These “integration strategies” have been pursued since 1992 and, commencing in 1993, have been focused specifically on developing CadCorp models.

Like many of the partners in CIMP, Mantronix Central R&D does not have many formal external collaborations, although they do participate in company-wide research projects such as the Artificial Intelligence Working Group that involves researchers from other divisions. External collaboration is still somewhat new for Mantronix’s researchers. They also participate in informal research contacts on an individual basis with university researchers involving limited funding and ongoing contact via email, meetings, and seminars.\textsuperscript{10}

\textbf{Prodco}

Prodco is one of the world’s largest manufacturers. It makes and sells its products around the world. Its 1993 sales for the entire company was in the many dozens of billions of dollars with profits of over one billion dollars.

One of Prodco’s divisions, Prodco Parts, is a supplier to Prodco’s manufacturing and final assembly facilities. Its charter had been changed in the early 1990s to allow it to supply any company, including competitors of Prodco. It is this division that is the primary partner within CIMP, although executives at higher levels within the company are also involved, as is

\textsuperscript{9}Interview with Kathleen Feerick, Mantronix, August, 1994.
\textsuperscript{10}Feerick interview.
the Prodco Information division, whose business is explained next. Prodco Parts had not entered into any partnerships before this project was undertaken.

Prodco Information applies information technology for its worldwide customers, including internal (Prodco) and external (non-Prodco). Its goal is to improve customers' business performance through increased product quality, faster time-to-market speed, and improved efficiency. Prodco Information employs over 50,000 people. Prodco Information emphasizes service in its stated strategy. They seek to provide high-quality service in information technology around the world. Prodco Information's formal external collaborations, aside from outsourcing other company's IT functions, had also been minimal.

**Riscy**

Riscy, Inc. is a high-technology company with worldwide sales and manufacturing. Riscy products and services include semiconductors, defense electronics systems, software productivity tools, computers and peripheral products, custom engineering and manufacturing services, electrical controls, metallurgical materials, and consumer electronics products. Its 1992 profits were in the hundreds of millions on revenues of around $1–10 billion. The company employs over 50,000 people.

Riscy has several strategic business areas, all of whose goals and objectives have been reconsidered and reshaped in the last five years. In the semiconductor area, the strategy has been to move to a broader variety of differentiated products, and to set up production facilities around the world. In the defense electronics area, the company has sought to adapt to a much smaller market. In the information technology area, the company has decided to focus on software products and services, especially in the area of helping companies respond more flexibly and quickly to changes in customers' requirements. During 1992, Riscy sold off their multi-user minicomputer systems and service operations to a major workstation manufacturer (Riscy 1992).
Regarding Riscy's alliance strategy, the organization has entered into a number of R&D alliances with other companies. They teamed with a leading workstation manufacturer to develop a next-generation RISC chip and a micro-size RISC chip. The next-generation RISC chip developed in this alliance was the most highly integrated microprocessor in the industry in 1992.

Riscy has also teamed with many hardware and software vendors to develop tools for open-architecture, industry-standard platforms that promote reuse of designs. They joined with a software chip design company to develop the industry's first open-architecture, "mixed signal" tool sets. Riscy also teamed with a different software chip design company to develop the next generation of Application Specific Integrated Circuit (ASIC) design environments.

Finally, Riscy has also formed alliances with suppliers and customers to perform R&D targeted toward penetrating new markets. They have teamed with major computer manufacturers to provide a multimedia system, which integrates multimedia capability into a single add-in computer card or onto a compact motherboard system. In an alliance with a major telecommunications company, Riscy has gained a stronger position in the world telecommunications market, while its partner has gained a competitive advantage in cellular telephones. With two large Japanese consumer and business manufacturers, Riscy has developed Semiconductor applications for the consumer electronics market, while with Prodoco, Riscy has adapted a mixed-signal process to automotive applications. Finally, in a separate alliance with Mantronix, Riscy has produced innovations in remote keyless entry systems, controllers, and instrument clusters.

**Sprockets / AirDiv**

Sprockets supplies high-technology products and services across a range of customers in the aerospace, building, and automotive industries worldwide. The corporation also supplies equipment and services for the U.S. government. The company's 1992 revenues totaled about $10–25 billion. Sprockets employs over 100,000 people.
AirDiv is the largest division of Sprockets in terms of revenues but the least profitable, with about $6 billion in revenues in 1993. Its main products and services are related to the aerospace industry. Its main customers, not surprisingly, are commercial aircraft manufacturing and leasing companies; the U.S. government; foreign governments; and airlines. The Sprockets Research Center, affiliated with AirDiv, is the Sprockets participant in CIMP. AirDiv has not pursued an extensive strategy of collaboration in the past.

SystemSW

SystemSW Corporation was a company that had developed some expertise in geometric modeling, which is one of the techniques used in computer-aided design. SystemSW’s main product was used primarily for plastic injection molding analysis, although it was also used for thermal, electromagnetic, kinematic and similar types of analyses. It was acquired in 1994 by FEA, which is one of the largest providers of finite element analysis products and solutions to the computer-aided engineering market. The acquisition hastened FEA’s entry into the broader CAD market.11

FEA employs 650 people and has earnings of approximately $2 million on $25-50 million in annual revenues. FEA’s products, which includes the products inherited from SystemSW, are marketed for their engineering expertise, technology leadership, and superior customer support. FEA attempts to work closely with customers, identify their requirements, tailor software products to those needs, and then follow up with strong user support.

The original representative from SystemSW, Audrey Waxenberg, was one of the founders of CIMP. She organized the members through the Management Science Institute, wrote the original proposal to the government, and organized the first Steering Group to decide on what tasks were to be accomplished. Despite this coordinating role, SystemSW had little prior experience in managing collaborative relations.

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11Business Wire.
Three-D

Three-D is a supplier of component technology. It was founded in 1986 to advance the level of 3D modeling available in computer-aided design (CAD), manufacturing (CAM), engineering (CAE) and related applications by broadly licensing state-of-the-art object-oriented 3D modeling technologies. Three-D employs 50 people and has annual revenues of about $10–25 million. It promoted the development and use of 3D products and related component technologies built on a common open architecture, which would free companies from the limitations and “lock-in” of proprietary CAD/CAM systems. Essentially, it pursued the “open architecture” strategy that companies like Sun Microsystems made famous and applied the concept to three-dimensional modeling, using a worldwide licensing strategy for broad dissemination of their architecture. The company’s two product lines include a next generation 3-D geometric modeler and a numerical control machining product.

Three-D’s alliance strategy prior to CIMP involved three technology alliances with software companies (none of them affiliated with CIMP), two of which were aborted immediately and one that was generally considered a failure and also closed down prematurely. These software companies were potential adopters of Three-D’s main product. The alliances “never got off the ground because you have to have a synergism that includes mutually consistent goals. If you don’t have that synergism you can’t consort,” according to Three-D’s VP of Business Development, Elmer Quinn.

2.3.2. History of the project

In this section, I provide details on CIMP relating to the history of the project between 1991 (one year before its official start) and 1995. Specifically, I discuss the origins of the project, the goals of the project, and background information on the technology involved. I

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\[12\] Akihiro Ikeda, product marketing director, Three-D. *Industrial Engineering*. 

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then describe how the partners worked together and what changes occurred during the course of the collaboration.

2.3.2.1 The origins of CIMP

The origins of CIMP can be traced to the Advanced Technology Program (ATP) proposed by U.S. President George Bush in 1988. ATP was established by law in section 4131 of the Omnibus Trade and Competitiveness Act of 1988 and was initially funded in FY1990. The impetus was clear: American industry was perceived to be falling further and further behind its “rival” countries and few manufacturing firms were funding applied technology development to the appropriate degree (Dertouzos et al. 1989, Ch. 4). Most federal money had been going into basic science and defense-oriented technology development (National Science Board 1987, Appendix). In addition, there had been a perception since the early 1980s, culminating in the National Cooperative Research Act of 1984, that Japan and Europe were encouraging collaboration in applied technology development to the detriment of American firms. Sentiment was shifting away from collaboration being harmful (collusive) toward being beneficial (Dertouzos et al. 1989, Ch. 7; Feigenbaum & McCorduck 1983). President Clinton increased ATP’s budget from $68 million in 1992 to $431 million in 1995 and made it a centerpiece of his administration’s initial years.

Around the same time, participants in the American machine tool industry banded together to improve their competitiveness. They were being affected by the same forces of global competition buffeting other manufacturing industries. They formed a non-profit consortium, the Management Science Institute (MSI), which was dedicated to advancing the manufacturing capability of firms in the U.S. It has since expanded from machine-tool companies to include the biggest companies in manufacturing while expanding its membership

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13 Much of the information about CIMP in this section except as noted in footnotes is from interviews with Audrey Waxenberg, formerly of MSI and now of FEA, 1995, 1997.
15 Los Angeles Times.
16 Industry Week.
to smaller manufacturing concerns and suppliers. In fact, 90% of its members are small companies. MSI acts as a “broker,” facilitating joint technology development projects among its members and between its members and affiliated universities, non-profits, and government labs.

MSI quickly became exceptionally good at pursuing and winning government grants,\textsuperscript{17} thanks to managers such as Audrey Waxenberg. Waxenberg had just won a large ATP grant involving computer manufacturing. She was connected with the ATP administration through this program and it seemed as if there might be more funding — perhaps a fairly large amount of it — available for another project. She was also involved with a small working group from Mantronix, Sprockets, Riscy, and a national laboratory. This group worked together on mutual problems in feature-oriented design (FOD). Waxenberg thought that there might be some “synergies” within the group and that they should apply for an ATP grant.

She scheduled a meeting with the four companies, but had a conflicting meeting at Prodoco, so she shuttled back and forth between the two. She mentioned the FOD meeting to Prodoco and it seemed they were interested, but when she got back to the FOD meeting, the representatives were all gone as they had voted not to create the partnership. While the companies believed that synergies between them existed, the representatives were not senior enough to commit their organizations to the partnership, nor did they have the time to build the commitment within their organizations.

Waxenberg persisted. She went to the president of MSI, who contacted senior executives at Mantronix, Riscy, and Sprockets. They scheduled a meeting at which the partners, with the national laboratory and Prodoco, agreed to go ahead with the project. The group created a proposal that broadened the scope beyond FOD. The new scope was more aligned with concurrent engineering concepts. The overall goal was to reduce the time to market for the manufacturing partners’ products by 50% through the use of computer technology:

\textsuperscript{17}Industry Week.
The common goal is to reduce the time it takes to get products to market by the application of next generation computer technology to the design and manufacturing cycles... Each company has an operating manufacturing component involved, such as a fan case.\textsuperscript{18}

The original five members mentioned above each used different CAD/CAM software packages purchased from outside vendors with the exception of Mantronix, which had developed its own in-house system. The vendors these partners used provided products in different segments of the CAD/CAM industry. For example, Cimtools made machine tools from CAD descriptions of parts. Three-D made a geometric modeler module that was intended to fit inside CAD/CAM packages. CadCorp worked on knowledge-based engineering extensions of CAD. FEA / SystemSW did pre- and post-processing of finite element analysis of CAD and CAE. Cimco makes expert system shells used to integrate diverse software systems. Unicorn and Beta CAD/CAM systems were also in use at some of the partner companies. Both Unicorn and Beta were larger CAD/CAM companies who had products competing with the other five. Unicorn had recently been acquired by Prodco. Unfortunately, all of these software companies developed and used incompatible product specifications. There was no standard at the time that was rich enough to convey both design and manufacturing information.

Two weeks before the deadline imposed by ATP, the partners had a final draft that they presented to the president of MSI. The president reacted with surprise that they had not included the software vendors mentioned above in the proposal. Part of the purpose of the grant was supposed to be building up supplier capabilities in manufacturing. So how could the partnership not include CAD/CAM software vendors? The president rejected the proposal and said that MSI could not submit it without new partners drawn from the supplier population.

Each partner submitted one or more names of CAD/CAM suppliers listed above. These companies were contacted and requested to come to MSI in four days for a meeting. If they could all come together, there might be a way to combine their expertise and truly integrate the functions of computer-aided design, manufacturing, and computer-aided engineering. This

\textsuperscript{18}Adam Gallegos, Program Manager for CIMP at the Management Science Institute.
had been an unrealized goal of manufacturers for years (Tucci et al. 1994). All of them came, agreed to participate, and the proposal went in to the government on schedule. Several months later, they were invited for “orals” and a few months after that were notified that they were the recipients of the largest ATP grant ($20M) up to that point.

2.3.2.2 Technology & Goals of CIMP

There are several goals of the project. The most important outcome of the project is the development of computer-based tools and processes to speed up development and production of manufactured goods. The second goal is the production of an “accurate” part based on the use of the tools and processes. The third goal is to help manufacturing enterprises evaluate manufacturing constraints earlier in the process, preferably during the design phase.

To accomplish this, the participants are attempting to create a database called the Integrated Data Model (IDM) that will contain information about each product. The information includes the part’s geometry, features, and how to manufacture it. All of the software systems from the design through manufacturing stages will then have access to the IDM. This will eliminate the need to re-enter or rewrite design and manufacturing data as the product moves from one stage to another (and possibly back again).

Another technical task of the project is therefore the capture of manufacturing information so that when a design engineer proposes a part with certain features, such as geometry, tolerances, or dimensions, the system will be able to produce automatically the manufacturing process know-how and constraints to actually make the part with those features. This will eliminate the need for lengthy turnaround time of manufacturing engineers deriving essentially the same information with their own separate systems in different locations (Tucci et al. 1994). A related task is to update the manufacturing plan as parts are designed and to keep an “inventory” of manufacturing and design knowledge.

A key task of CIMP is also the integration of many systems from design through to manufacturing. To accomplish this task, a kind of open software “architecture” that is legible
by all systems must be designed. Then computer-aided design and manufacturing tools can be built to take advantage of the architecture, implying that many suppliers will be able to produce computer systems for it. Another goal of the architecture is that it be extensible to provide flexibility to encompass future technological changes in manufacturing.

At the data level, the ability to read and write information must be standardized around a common form. In CIMP, this standardized form is called the Product Data Exchange Standard (recently renamed Product Data Exchange using STEP, or PDES), which is being developed by The National Institute of Standards and Technology (NIST). PDES is the North American effort in computer-integrated manufacturing in support of the international standard known as STEP (STandard for the Exchange of Product model data).\(^{19}\) CIMP is one of the first projects to use the new standard.

Initially, we were completely concerned with FOD and modeling... An example of a feature is the edge of a file cabinet. Is it rounded? [Looks at a portable stereo system.] There are many features here. Groove, hole, tab, fillet. Features are what designers recognize as basic elements, such as geometry, surface finish, etc. There are certain rules that features conform to. For example, sharp corners lead to high stress.

Designers have features in mind, but they don’t match the manufacturing guys’ features. An example is a plastic shoebox with a wobbly design. The designer puts another piece of cardboard inside, like a rib. This involves machined features. Manufacturing sees this new object as two pockets that need to be machined.

... This is tied into research on group technology. It gets into what size the fillets are. If you have a quarter-inch and half-inch fillet on the same piece, you need two tools. Can you use a half-inch on both? This would eliminate both the purchase of new equipment and also a tool change. This is the kind of question we wanted to pursue. Basically, the project involves how do you connect CAD to CAM?\(^{20}\)

Just before the award contracts were signed, one of the partners, Beta, dropped out of the project. Beta had been resistant in the negotiations regarding the sharing of technical information. As a market leader, they were afraid of losing proprietary information to a

\(^{19}\)ISO 10303 — Industrial automation systems and integration — Product data representation and exchange.

\(^{20}\)Interview with Yong Hwan Chae, Sprockets., July 1994.
partnership whose members competed with them in three different segments of the CAD/CAM value chain.²¹

2.3.2.3 Initial stages of working together, 1992

Most of the first year of the program was spent negotiating, both with the government and with each other. Government negotiations were protracted and focused on such issues as how the firms should change their accounting practices before they would qualify for government funding. In the end, the parties agreed that "the accounting practices that were adequate for Wall Street were okay for the government."²² There was also a long and protracted debate within the partnership about how the partners would work together. Collaboration was novel enough that most of the participants had to learn how to collaborate without past experience to guide them. As Yong Hwan Chae, a researcher for Sprockets put it, "the structure of this project was completely illegal a few years ago."²³

This lack of experience meant that the partners had to simultaneously negotiate both technical and managerial decisions. There was no central authority to adjudicate disputes for several reasons. Audrey Waxenberg, the only central figure in the initial contract negotiations, had moved to SystemSW / FEA. Waxenberg's replacement, Adam Gallegos, had not been on the job long enough to assume command. Also, while Gallegos was an excellent and well-liked administrator, his personality was not an authoritarian one. Finally, the structure of the collaboration called for the four manufacturing enterprises to all have an equal say in any decision. These factors led to some frustration with the initial process:

The minuses are it takes too long to do the politics. The biggest problem is that there is a lack of knowledge of how to collaborate. The result of this is that we are less than productive. We don't take into consideration geography, lousy group process, lousy management of collaboration. There's a 'collaboration burden' analogous to the 'labor burden' you were talking about

²¹Waxenberg interview, Srinivasan interview. Telephone interview with CFO of Three-D, December, 1996. This will be discussed further in section 2.7 below.
²²Waxenberg interview.
²³Interview with Yong Hwan Chae, Sprockets., June 1994.
earlier. We have a collaboration burden without the right technology or knowledge... We have lousy skills in collaborating.\textsuperscript{24}

I took on the entire infrastructure issue: infrastructure, basic architecture, engineering environment, etc. This was dysfunctional. So we had to step up to the role of how the groups relate to one another. The MSI contact is a statesman, not a get-in-there-wire-things-up kind of guy. But we had no experience whatsoever with external collaboration.\textsuperscript{25}

The question became, ‘how do we manage something like this?’ It’s an absolute mess. No one has had any experience with this. There was the lack of a technical architect, this never came to be. So it was left up to the member companies to step in and tell [each other] what to do. What we needed was a high-powered visionary.\textsuperscript{26}

Even though the National Cooperative Research Act of 1984 made it legal for the firms to collaborate in pre-competitive projects, the intellectual property ownership had to be negotiated separately. End-user applications always remain proprietary to members. The entire body of material would be available to MSI for three years following its release. After that, material would be released through NIST. In addition, the software partners could produce specialized software under the agreement, but further efforts to make commercial products, such as better user interfaces, could not be subsidized by the Department of Commerce. In other words, the research could be brought to a so-called “pre-competitive level.”

The primary managerial debate within the partnership centered on whether it should be a tightly-coupled large group working on one big project, or a loosely-coupled “confederation” whose members broke into smaller “projects” and then shared the results. The initial decision was to work together and make technical decisions by consensus, but it was left as an issue to be reopened.

We get impatient with the rate of progress sometimes. The large companies have their agendas and sometimes it is difficult to understand what they are. Now, the guys on the Steering Group are excellent: live, bright, dedicated, but it’s the nature of the organizations they come from. They are very large and slow and hard to move.\textsuperscript{27}

\textsuperscript{24}Feerick interview.
\textsuperscript{25}Chae interview, June 1994.
\textsuperscript{26}Jasper interview, June 1994.
\textsuperscript{27}Srinivasan interview.
During this time, the involvement of the national laboratory was still undecided as the government was unable to resolve the apparent contradiction of one of the U.S. Department of Energy’s national laboratories participation via DefensePower in a project funded by the Department of Commerce. It was decided that DefensePower’s participation required a separate Cooperative Research and Development Agreement between the two agencies. The negotiations on this agreement lasted for over two years. DefensePower was involved on an informal basis, though. They have even taken the lead on one part of the project: the integrated data model (IDM).

2.3.2.4 Working together, 1993

The technical collaboration began in earnest in 1993. The main task was to integrate the various software specifications used to store design and manufacturing information in the four manufacturing companies and the national lab. This was a very difficult task that would require fairly large changes to several of the software companies’ products as well as to the in-house systems of the manufacturers. Abdul Khalili, a senior researcher at Cimco, had been thinking about this problem since 1990. In the proposal to the government, he developed the concept of a “basic architecture.” The architecture would serve as a standard upon which an integrated software system could be based. During the initial technical collaboration, Khalili took the lead on the basic architecture. Researchers at Sprockets, however, felt that Cimco was not acting in a collaborative manner:

But Cimco was very proprietary about this. When they were talking about this, the slides they showed, they wouldn’t let us take notes! It turns out that they had already done all this for a proposal for someone else. They were recycling an old presentation. They came out with this report with a bill for $900K for a 100-page report! They asked me if we should pay it.

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29Much of the information for this section came from interviews with Yong Hwan Chae in 1994.
30Interview with Elmela Zlatanic, Cimco, October, 1995.
31CIMP document, “Basic Architecture.”
32Lane interview, August 1994.
In exchange for Khalili’s report on his basic architecture, Cimco requested that the other companies pay its share of the matching funds. This would have the effect of selling the report to the consortium for twice the price. All companies except Sprockets agreed to pay. As decisions were made by consensus, Sprockets eventually prevailed and Cimco was never paid for the report.

Sprockets rebelled. All others said, ‘we’ll just pay you,’ but Sprockets said ‘the best we’ll do is give you in-kind help, but we’re not paying Cimco to do work that is part of the proposal.’ So the question became: How can I shut them down? This was the first project I was involved in just to shut another partner down. I proposed, in six weeks, not paying Cimco to do this work. I said that huge amounts of money were already being spent by the Army and by ESPRIT, like hundreds of millions. How could we do it any better?

I was successful in shutting them down.33

Another event occurred around the same time that would have an impact on the collaborative process. It was decided early on that there should be a demonstration center to house the project and provide demonstrations to visiting government officials. This demonstration center could include testbeds, meeting rooms, and facilities for designing. Mantronix donated an entire building and the partners agreed that this “Demo Central,” as it was to be called, would be housed in the building. After some negotiation with the government, it was decided that the government would reimburse Mantronix up to $700,000 to construct the site.

When the news of this reimbursement broke, Prodco tried to scuttle the idea, at least according to participants from Mantronix, Sprockets, and Cimtools. Participants from Prodco denied that they wanted to scuttle the idea; rather, they thought the demonstrations would be more effective if they took place at a variety of partner locations, including a real factory floor.34 In any case, Prodco proposed six different types of organization structures, including a Demo Central that rotated from partner to partner every six months. Again, due to the

34Interview with Francine Nelson, October, 1995.
consensual nature of the decisionmaking process, a compromise was reached with the Demo Central being located at Mantronix but with an attenuated concentration of resources. The resources would be dispersed among the four manufacturing companies and there would be videoconferencing facilities set up at each of the satellite locations. The reimbursement funding would be divided up among the manufacturing companies. Although Mantronix would get a majority of the funds, it would not get all of them.

One final event of note in the early history of the collaboration took place shortly after the Demo Central decision. As mentioned above, one of the four areas of inquiry for the program as a whole was the knowledge engineering area, or KEA. KEA would support capturing design and manufacturing knowledge into a knowledge base so that designers and manufacturing engineers could reuse information that they or others had previously developed. Using a knowledge-based system, they could avoid starting from scratch when designing a new part. The specific goal of this area was the identification and formalization of knowledge required in design, manufacturing, and their integration.35 Prodco was to take the lead on this project.

The partners needed to know the knowledge-based applications (KBAs) in use at each others’ companies to assess the extent of what they each knew and as a base upon which to build the unified environment. Therefore, Prodco requested the list of KBAs in use at each company. At Sprockets, this required the coordination of many divisions. After spending some time gathering the information from the divisions, Sprockets produced the report. The report had to pass through the corporate legal department, however, where it was delayed. The delay was due to concerns about the proprietary nature of the report and how any intellectual property resulting from the report would be handled.

Finally, the report was approved by the legal department and sent back to the divisions for approval. All of the divisions approved the report except AirDiv, which was the primary

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35CIMP document, “Knowledge-engineering applications.”
Sprockets partner in the collaboration. Therefore, Sprockets was forced to reduce its commitment and attention to that area and notified its partners.

We sent them a letter saying, 'sorry, that request was too sensitive.' I actually got into trouble for saying that in the declination letter. I was told, 'hey, now they know what we consider sensitive.' ... That was really ugly... From an intellectual property standpoint, we had no idea how to collaborate.36

2.3.2.5 Settling in, 199437

Perhaps due to the issues mentioned in the previous section, the partners agreed to work in smaller teams, or projects, that would be funded by a majority vote. Each manufacturing company would have one vote, the software companies would have one vote among them, and MSI would have one vote.38 This would enable them to make decisions more quickly and allow them to explore different technical directions simultaneously in small teams. Any partner could “sponsor,” or propose a project. If desired, the partner could assemble potential partners from among any of the companies and submit a proposal to the Steering Group.

The proposals were supposed to follow a fixed format of sponsor, contact, objective, benefits, approach, deliverables, milestones, risks, metrics, and resources. The team members proposing the project specified how much money they proposed to spend. These expenditures were examined carefully, as they would be matched by the government as part of the grant. Therefore, by proposing a project, the team was committing every partner’s resources in foregone grant money for other projects. In return, all partners would have access to the results. This more formal system worked much better for the participants. Most of the decisions were unanimous anyway, but the threat of a veto by one partner was eliminated.39

37Much of the information for this section, except where noted otherwise, is from interviews with Kathleen Feerick, Mantronix, 1994, 1995.
38Interview with Adam Gallegos, MSI, October, 1994.
39Gallegos interview.
In a series of four projects, CadCorp worked with Mantronix to develop a connection between Three-D’s and CadCorp’s products. Each so-called “pilot” project produced a deliverable that was built upon in the next pilot. As mentioned above, Mantronix had developed its own in-house CAD system that was somewhat advanced technologically. The system, ManDraft, was primarily a drafting system in contrast with CadCorp’s rule-based system. The overall goal was to translate the drafting information into three-dimensional geometric models, which could then be used further downstream by a CAM system.

With a much smaller group involved in operating decisions, the coordination costs were lower. The complementary resources and skills necessary to work on the projects were also more readily apparent. In this case, Three-D and CadCorp furnished licenses for their software while Mantronix provided programming support. Three-D provided expertise in geometric modeling, CadCorp in rule-based CAD systems, and Mantronix in the inner workings of ManDraft. Each pilot project was relatively short, and the team had a working demo — with a “tolerable” loss of information — by the end of 1994. After that, other teams with different partners built upon the work of the original team, so Mantronix considered it to be both a technical and collaborative success. In addition, Three-D and CadCorp entered into negotiations around that time to commercialize the enhancement of CadCorp’s product involving the three-dimensional modeler.40

The demonstration reported above and most other ones like it were primarily for internal review purposes. In early 1994, however, the partners decided that an external demonstration to the government would be advantageous for public relations and motivation. The demonstration would also be taken “on the road” to professional conferences. As mentioned above, Prodcos Parts is actually a supplier to Mantronix even though Prodcos competes with Mantronix in many retail markets.

The group decided that the demonstration should start with the design of a part such as a gear. Prodcos Parts would design the part using their Unicorn system and transmit it

40Quinn interview.
electronically to Mantronix. Mantronix would alter the design using its ManDraft system and send it back. It would also conduct packaging design studies based on the information. Then the part description would be transmitted to Cimtools, where the tooling would be designed.\textsuperscript{41}

The interactions between Mantronix and Prodco went more smoothly in this project for several reasons. First, the relations between Mantronix and Prodco Parts were well-developed as they had a previous supplier relation. Second, by this point they had more experience in working with other companies. And finally, the demonstration deadline was fairly tight and required concerted effort. Any delay or political maneuvering would be seen as a threat to the viability of the collaboration.

In late 1994, under extreme time pressure, the demonstration was completed. However, the goal of completely electronic transfer could not be attained. Rather than cancel the demonstration after promising so much, it was decided to manually edit some design information that would have been lost upon transfer to ManDraft. The demonstration was described as a “limited success” by the only technology analyst to follow it.\textsuperscript{42} Considering the organizational coordination involved in bringing the project about, it may have been a limited success, but a success it was.

2.4 OBJECTDB

OBJECTDB is a collaborative venture sponsored by the European Union under the auspices of the European Strategic Program for R&D in Information Technology (ESPRIT). The partners include three software companies (Computation, DataBase, and Multisoft); an airline (Europe Air); a telecommunications / computer company (SoftIV); three universities (Uni-DB, Uni-SW, and Uni-Mount); and one national lab (Fractal). Below I provide a brief description of the partners, followed by a history of the project from 1991–1995.

\textsuperscript{41}Product Data International. CIMP document “Prodco Parts - Mantronix data Exchange Pilot.”
\textsuperscript{42}Product Data International.
2.4.1. The partners

In this section, as in Section 3.1, I provide a brief description of each organization, its main products, services, and strategy, and its collaborative experience. The time frame for these descriptions is generally around 1992. Some features of the partners are summarized in Table 2-3.

<table>
<thead>
<tr>
<th>Name</th>
<th>Business</th>
<th>Revenues</th>
<th>Collaborative Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation</td>
<td>software</td>
<td>$50 – 100M</td>
<td>some collab R&amp;D in SW technology</td>
</tr>
<tr>
<td>DataBase</td>
<td>software</td>
<td>$10 – 25M</td>
<td>new features via customer alliances</td>
</tr>
<tr>
<td>Europe Air</td>
<td>transportation</td>
<td>$10 – 25B</td>
<td>collab with SW suppliers</td>
</tr>
<tr>
<td>Fractal</td>
<td>national lab</td>
<td></td>
<td>huge number of collaborative projects</td>
</tr>
<tr>
<td>Multisoft</td>
<td>software</td>
<td>$500M – 1B</td>
<td>alliances in both hardware and software</td>
</tr>
<tr>
<td>SoftJV</td>
<td>consortium</td>
<td></td>
<td>several projects in SW and multimedia</td>
</tr>
<tr>
<td>Uni-Mount</td>
<td>education</td>
<td></td>
<td>small number of collab R&amp;D projects</td>
</tr>
<tr>
<td>Uni-DB</td>
<td>education</td>
<td></td>
<td>small number of collab R&amp;D projects</td>
</tr>
<tr>
<td>Uni-SW</td>
<td>education</td>
<td></td>
<td>joint R&amp;D w/ local companies</td>
</tr>
</tbody>
</table>

Table 2-3. Overview of partners of ObjectDB

Computation

Computation is one of the larger information technology consulting firms in Europe. The company specializes in custom software solutions and related services for their clients and employs 800 people. Its 1995 revenues were about $50–100 million from clients primarily in the finance and insurance industries. In 1990, a privately-owned French investment banking and financial services group acquired a minority stake in Computation. The R&D facility is the main coordinator of the OBJECTDB program.

Computation has had a small number of collaborative R&D ventures with European partners before OBJECTDB, always in the software technology development area. The alliance
strategy they have pursued has been to form partnerships to build up expertise in certain areas of computer science that correspond to possible business needs, for example, object-orientation and its application to CASE tools. In contrast with the other software companies discussed in this part of the dissertation, they have not been seeking out customers, but rather seeking expertise that was eventually used to develop business outside of the partnership.

**DataBase**

DataBase specializes in the development and sales of object-oriented database management systems (OODBMSS). In the OODBMS market,\(^43\) DataBase holds 18% of the world market and 37% of the European market with its main product, the NewDB System. NewDB System served as a reference for an international OODBMS standard called ODMG, and was the first object-oriented database system to conform to that standard. DataBase has built and sustained a reputation for heavy R&D investment and technological advancement in its product.\(^44\) In 1994, DataBase had over 50 employees. About half of those are engaged in R&D activities. As of 1994, over 1400 licenses had been installed in over 200 client sites in 20 countries. Its 1993 revenues were about $10–25 million.

DBCo’s overall strategy has been to create a market for object-oriented database management systems in competition with relational database management systems. Technical credibility and market presence are the most important aspects sought by the firm. The alliance strategy concentrates on performing R&D with potential customers to put new features into the product:

The strategy I work on is therefore the product of three to five years in the future. In my area, we pick part of the strategy and put it in a [collaborative] project and get users using our product in the project. We look to supply technology and at the same time enhance our product.\(^45\)

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\(^{43}\)Note that this market is much smaller than the general database market: $50M vs. approx. $3.5 billion in 1994. Source: Interview with Ethan Bahceci, Vice President of Research, DataBase, April 1994.

\(^{44}\)Software Magazine.

\(^{45}\)Bahceci interview.
Europe Air

Europe Air is one of the world’s largest international passenger airlines, and one of the most profitable airlines in the world. The airline has over 200 aircraft and flew 30 million passengers and 600,000 tons of cargo in 1994. Profits in 1993 were $750 million on revenues of approximately $10–25 billion. The company has about 50,000 employees. Europe Air is also one of the largest software developers in Europe. In 1991, they employed 3000 software developers in their home airport region alone.46

Europe Air is critically aware that the management and development of software will be a critical factor in the company’s success. Europe Air has 8000 internal users on workstations or personal computers supported by the Information Management Department, which is responsible for delivering and supporting the airline’s information technology systems.47 Europe Air has recognized that software development is a critical component in their information technology costs. They have therefore begun to survey potential cost-saving techniques they could use to organize and manage their development operations. Some of the techniques involve collaborative R&D projects with software suppliers, which, aside from typical airline code-sharing alliances, has been the hallmark of their collaborative strategy:

Europe Air has some object-oriented applications, or applications that lend themselves to object orientation. They have a library in C++ with many classes. They have problems in managing this library, which is resident on many PCs scattered throughout the development department. If they shift all of the environment to an OODBMS, they will have many benefits, such as access control to data. Everything will be easier than it is now.48

Fractal

Fractal is involved in research, training, transfer and exchange of information in computer science. Fractal has six laboratories / research facilities scattered around its home country, and conducts research in six different areas of information technology. It had a

46Management Today.
47Which Computer?
48Interview with Annie Nixdorf, Computation, April 1994.
budget of $84 million in 1992 and employs about 1300 people, about 1000 of which are scientists. The government estimates that by the year 2000, information technology will represent the most important economic sector in the world. However, with hardware prices declining and end-users becoming more sophisticated in software, the "applications sector" has become the most important driver of information technology. The increase in the complexity of systems has, however, negated cost advantages of those same systems. To comprehend this evolving situation, Fractal’s mission encompasses

...undertaking fundamental and applied research, designing and building experimental systems, organizing international scientific exchange, facilitating the circulation and transfer of knowledge and know-how, enhancing the value of research findings, contributing to cooperative development programs, conducting scientific evaluation, and contributing to the standardization of technologies.49

Fractal has a plethora of collaborative arrangements with industrial firms, universities, and other research institutes. They participate in, or have participated in, 55 ESPRIT projects, 31 Basic Research Actions, and six EUREKA projects. Fractal also participates in the ARIANE, HERMES, and COLUMBUS aerospace projects, in addition to the EUROSPACE and COMMETT satellite transmission projects. They have more than 90 partners in their country alone.

**Multisoft**

Multisoft is a large software systems and tools developer. It operates in 70 countries, with R&D facilities in five. Multisoft's software systems and tools are specialized in database management, applications development, and distributed computing services. The company employs about 4400 people worldwide and has revenues about $500–1000 million. Multisoft was founded in 1969 as a service and software provider to mainframe systems. The strategy has since been to provide service to customers who have made large investments in mainframes and database systems while trying to develop new customers requiring more technologically

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advanced solutions. To do this, the company has followed the trend to open systems, to portability from mainframes, and integration between incompatible systems.

Multisoft has been involved with several partnerships before joining OBJECTDB. They have joined two main kinds of alliances: those with hardware companies and those with other software companies. Alliances with hardware companies have traditionally taken the form of early specifications from the hardware vendor in exchange for having Multisoft’s products "ported" to the new hardware platform at a very early stage. In the software area, Multisoft generally provides manpower to convert other software companies’ products to run on more platforms or take advantage of client-server architectures in exchange for license fees when the product is used.

**SOFTJV**

SoftJV is a research joint venture of 12 multinational firms, two universities, and two public agencies. SoftJV was established to promote both research and education in the area of information technology, and has on-site visiting researchers from the companies, graduate student researchers, faculty with joint appointments to the universities, and in-house researchers. Research is conducted in digital signal processing, network systems, electronic design automation, transmission systems, factory automation, software engineering, advanced information systems applications, and advanced information systems technologies. External collaborative projects in addition to OBJECTDB are in the areas of multimedia workstation architecture definition, multimedia medical imaging processing, and network interconnections through the integrated services digital network (ISDN).

The role that SoftJV plays in the OBJECTDB project is based on its expertise in software process engineering. ItaJV’s mission is to consolidate the "language" used to describe the software engineering process and to link the NewDB DBMS with the software engineering tools that will be eventually developed.
Uni-DB

The Uni-DB Department of Informatics is primarily involved in computer science research in the database field. They are a major academic center in Europe for the study of database technology, and are involved in a number of collaborations. For example, a major Japanese electronics company has set up a European R&D Center near Uni-DB. The center is working on different European television standards and has close relationships with Uni-DB and research contracts with other academic institutions.

In addition, faculty in computer science at Uni-DB are active in their own startups involving interfirm collaboration. For example, Prof. Mark McQueen, the Technical Director of the OBJECTDB project, started a company in 1991. The startup was recently hired to represent the interests of an industry consortium of object-oriented technology firms in Europe. The company also has been organizing, managing and promoting international trade events, exhibitions and conferences aimed at acquainting European companies with object technology since 1991. Thus, although the partner itself is a university, there is some commercial interest in the outcome of the project.

Uni-SW

The Uni-SW is a relatively new university in Europe that has taken an active role in the reformation of its local area from mining and steel to a balance of heavy industry and high technology. Founded in 1962 to focus on engineering, natural sciences, economics, sociology, and planning, the school has grown into an incubator of high-technology startup companies, especially in the areas of automated production systems, robotics technology, artificial intelligence, expert systems, materials testing, and environmental technology.

The Department of Computer Science has played a key part in this incubation. It has founded the Information Technology Center, which is the focal point for the area in industry-university cooperation. The Center itself is also a partner with local companies (including multinationals with labs in the city) in joint research and development projects. In addition,
many alumni and faculty of the university have started companies nearby, some of which have now grown to considerable size. Prof. Alfred Hornung describes the transition to the high-technology environment in the city:

Uni-SW has been at the center of a new partnership to encourage the startup and growth of small high-tech firms around the university. There is some financial help and a lot of administrative help from the government. This used to be completely a steel and mining town... exactly, just like Pittsburgh. Anyway, now we are moving more toward the high-tech end. \(^{50}\)

2.4.2. History of the project

2.4.2.1 Origins of OBJECTDB\(^{51}\)

ObjectDB had its origins in academia. Before this project, computer scientists involved in databases and those involved in software engineering had little contact. Within these communities, some of the computer scientists had known each other for several years but there was little cross-fertilization of ideas. The database community revolved around Uni-DB and Fractal; the software engineering community around Uni-SW and Uni-Italy. The founder of DataBase, Lorraine Larke, was a research professor at Fractal and a professor at another French University. \(^{52}\)

In the late 1980s, however, more mobility had developed within the scientific community thanks in large part to the Community’s cooperative R&D programs such as ESPRIT. \(^{53}\) The social movement between European countries, shown in Figure 2–3, helped bring these researchers into contact with one another in late 1990.

Erhan Bahceci, the Vice President of Research for DataBase had been looking for ways to improve the NewDB product. As mentioned above, these enhancements had in the past often taken the form of collaborative R&D projects. The collaborations allowed DataBase to gain some leverage from its own limited resources. The founder of the company was

\(^{50}\)Interview with Alfred Hornung, Uni-SW, April 1994.
\(^{51}\)Much of the information for this section, except where noted, is from interviews with Erhan Bahceci.
\(^{52}\)Joint appointments such as this are fairly common in some European computer science communities.
\(^{53}\)Escoto interview, April 1994.
Bahceci’s former advisor, and they brainstormed about extending their product into the software engineering workstation environment.

Figure 2–3. Social networks and ObjectDB\textsuperscript{54}

It turned out that a recent employee and one of the earlier employees had academic contacts with the software engineering community through his Master’s program in Italy and it was through this that the two parties decided that there was potential for a collaborative project. They met originally with academic contacts at several other universities in France, Italy, and Germany and the group agreed to work together on a project.\textsuperscript{55}

Annie Nixdorf had been somewhat active in the software engineering community in Italy and was not unknown to the academics through her publications in journals such as *IEEE Software*. In addition, she was a senior manager and researcher at Computation and was the administrative director of another ESPRIT project. She was interested in obtaining more funding for Computation’s research laboratory through ESPRIT. She heard from Jonathan

\textsuperscript{54}Bahceci, Escoto, Dearden interviews.
\textsuperscript{55}McQueen interview.
Dearden about the efforts in developing tools for software engineering workstations based on object-oriented database technology. As her company had little expertise in OODBMSs, Nixdorf figured that a project such as that might be an ideal learning experience and chance to build up competencies in the area of OODBMSs. Nixdorf therefore committed Computation to the partnership and was made the administrative coordinator of the project.

Under ESPRIT, a Call for Proposals is issued for research in certain technical areas in information technology. Firms answer the Call by forming partnerships with at least one other firm from a different European country and submitting a proposal that is reviewed by project officers and scientific raters. Projects are then chosen and the teams possibly modified for reasons of technical complementarities or political considerations and a detailed “Technical Annex” is drawn up outlining all of the “work projects” that each participant will contribute. These work projects are specific sub-tasks of the main project and are assigned to one or more participant.

The European Union subsidizes the research costs of the project by about 50% if the participants continue to make progress toward the main tasks outlined in the Technical Annex. The consortium has a “coordinator” that is in charge of communicating with the European Union, and several “partners” whose names also appear on the official contract between the agency and the firms. Finally, each project has “associate partners” that can be quite involved with the project, but who have little legal connection with the European Union. Finally, on some projects (but not OBJECTDB), there are “subcontractors” to the partners and coordinator.

It was decided to apply for funding through ESPRIT. It was to be a somewhat academic effort between the various universities mentioned above plus two more academic colleagues in France and Germany, SoftJV, Computation, and DataBase.56 At the time, however, debates had been going on in Europe about the role of government in funding more applied technology development. These debates were similar to debates mentioned in section 2.4 above about the need for more applied research and development. The European Union decided to start

56McQueen interview.
requiring that all collaborations funded through ESPRIT have direct “relevance” to industry and that technology collaborations should move “closer to market.”\textsuperscript{57}

In anticipation of this, the team sought out another industrial partner. Europe Air’s potential need for software engineering development tools was also known to the software engineering community through contact at conferences and it was decided to see if they would like to try and use the tools built in managing some of their software libraries. Nick Bandouveris, the primary contact and a manager at Europe Air’s Research Center, agreed and the team was put together.

In the European Union’s review of the project proposal, it was decided that the project was too far from the market and too academic.\textsuperscript{58} The project reviewers offered the group a chance to alter the composition to include another industrial partner and fewer academic partners. It was also decided that a market feasibility study should be carried out as part of the project to assess the potential of the computer-aided software engineering market. The officials suggested that Multisoft might be an appropriate partner to undertake this study. According to Mark McQueen, technical director of the project, this sort of government influence on the composition of collaborations was typical:

These projects go through a series of screening procedures. There is the technical screening, which I respect. The people choosing the projects generally know what they see, and hire experts to help evaluate the projects. Then there is the political screening by Brussels, although no-one will tell you there is one, and no-one will admit that is what they do, but, in fact, that is what they do.\textsuperscript{59}

The final team was pared down to the list presented in section 2.4.1 above and Multisoft was contacted. They agreed to participate through one of their subsidiaries. It was approved in early 1992 and scheduled to begin in September 1992 with three years of funding at approximately $5.8M per year.

\textsuperscript{57}Interview with Shyaporn Theerakulstit, Informatique, July 1993.
\textsuperscript{58}McQueen interview.
\textsuperscript{59}McQueen interview.
2.4.2.2 Technology and goals of ObjectDB

The project involves using a new kind of database management system built on the concept of object-orientation. In computer science, information is grouped together in what are called data structures. In traditional computer programming environments, operations performed on a data structure are repeated throughout independent application programs, and a large number of general procedures are used to manipulate the data structures.

In an object-oriented system, data structures are stored along with the operations needed to manipulate them in what is called an object. This design approach is called "encapsulation." Objects can "inherit" or reuse properties from other objects if they are similar, but only similar objects use the same structures and specific procedures, called "methods." Inheritance is another key feature of object-oriented environments.

As an example, Fichman & Kemerer (1993) provide the case of a commercial payroll and accounting program that can handle both salaried and hourly employees. The system can be designed in two ways: the traditional way and the object-oriented way. In the traditional way, the system designers design a large data set with special operations and procedures to distinguish the two types of employees, or they design two separate data structures (one for each employee type) and have two highly redundant sets of procedures in place to handle the two types of employees.

In the object-oriented way, the designer encapsulates all of the common aspects of the data set into a "parent object class" that represents all employees. Two "subclasses" of employees are then created, one representing salaried, and the other representing hourly employees. The subclasses inherit all of the features of the parent, but special, unique procedures (for example, those having to do with compensation) can be resident in the object itself. This is both more efficient and natural and provides easier design and maintenance than the traditional approach.
Client-Server distributed systems. Computer networks have become bigger, better, and more widespread over the last three decades. At first, autonomous and independent computers were connected via networks solely for the purpose of sending messages back and forth. Eventually, file transfers across the network became popular, followed by a boom in remote-login applications, in which a user could log in to a remote computer across the building or even the world and run programs on that particular computer.

In the 1980s, however, with breakthroughs in hardware technology that allowed higher rates of communication ("bandwidth") across networks, computer scientists discovered that the programs themselves could be distributed across the network. For example, in a program to perform a series of complex calculations in parallel and add the final result together, specialized computers could be used to do the calculations, with the result being added on a different computer. Another example is a large storage device that simply rests on a network while remote users send and retrieve data from it.

This model eventually became known as a "client-server architecture." The server is usually a central repository or processor that provides access to a number of clients, who manipulate or display the information. A common example is a world-wide web server, which provides graphical images and hypertext capabilities directly to the client computer across the network.

OODBMSs. When the above principles are applied to database design, the result is called an "object-oriented database management system." Atkinson et al. (1992) describe the mandatory features of an OODBMS. These features are summarized in Appendix F. With these requirements in mind, the goal of the OBJECTDB project is to modify an existing OODBMS product to be used in software engineering environments. Software engineering environments are the environments used by software engineers to build other software systems. To be able to support software engineering applications, the database product called NewDB has to be modified so that tools can be built that call NewDB procedures:
The combined toolsets built on top of the enhanced NewDB system will be called the "OBJECTDB platform." The first step is to upgrade NewDB features, which requires relatively easy extensions of the NewDB technology. As the project progresses, software engineering tools will be built on top of the database and used to validate the enhancements to the database. To build tools more easily, the project also includes the development of tool generators that allow the automatic generation of graphical and textual tools from high-level specifications. The OBJECTDB platform also includes a system, called a software process toolset, that allows modeling, analysis, and "enactation" of software processes and is also built on top of the database. The tools will be used in specific areas, an airline application and a business application, as detailed below.

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60 OBJECTDB Team (1993)
2.4.2.3 Initial stages of working together, 1992-1993

In the initial stages, the participants were in frequent contact to define what they needed to do. This was heavily driven by DBCo’s product architecture, so there were many technical challenges to work out. In contrast with CIMP, however, the partners immediately set about to break the project into small teams revolving around their original areas of expertise and position in the network. The breakdown of tasks for ObjectDB is shown in Figure 2–5.

![Diagram of ObjectDB breakdown]

**Figure 2–5. Work Breakdown of OBJECTDB**

Figure 2–5 shows how the tasks were broken down among the participants. First, at the bottom of the figure, we see that several of them (Uni-DB, Fractal, Uni-Mount, and DataBase) are concerned with how the NewDB system can be modified to control and manage the object-oriented database. At the next level, SoftJV is concerned with software engineering processes, and how NewDB can be used to manage those. On top of those processes, tools are being built by two of the participants, Uni-SW and Computation. Finally, Computation and Europe Air will be end-users of the system for their own applications. Computation’s

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61 Much of the information from this section, except where noted otherwise, is from interviews with Annie Nixdorf, Computation, 1994, 1995.

application is an information system for a hospital. Europe Air’s is for creating and maintaining a library of C++ classes.\textsuperscript{63}

The primary problem in the initial stages of the collaboration were the constant misunderstandings stemming from the partners’ differing countries of origin. This was exacerbated by the partners’ not meeting face to face very frequently.\textsuperscript{64} As the teams met face to face only three or four times a year, it became imperative to establish regular communications. It was decided that email would be the medium of choice. All email messages between countries was conducted in English. However, email may not necessarily be the most efficient medium for capturing the nuances of cross-cultural communication. Content analysis of the interview data indicates that of the 13 people interviewed who participated in ObjectDB, nine reported “communication problems” and “cultural barriers” as one of their biggest problems with partners. Three did not mention either as a problem. One claimed that while cultural barriers were problematic, language was specifically not a problem, as all partners spoke English.\textsuperscript{65}

Examples of problems caused by linguistic and cultural barriers included misunderstandings due to different interpretations of email messages. One team member was planning a trip to DBCo starting in midweek for one week. Bahceci responding to an email message with “I’m free early that week,” which the researcher took to mean early in the one week s/he would be in there. Instead, Bahceci meant earlier in the week than the researcher would be there. When the researcher arrived at DataBase, Bahceci was not in town.\textsuperscript{66}

An example of a cultural problem was the initial mistrust between the academic and non-academic partners, perhaps in a misunderstanding about how each worked. Of the five

\textsuperscript{63}Escoto interview, April 1994.
\textsuperscript{64}Nixdorf interview.
\textsuperscript{65}The count does not add up to 13 because one of the partners (Bahceci) claimed that both were a problem in 1993 but in 1994 claimed only cultural barriers were a problem. Bahceci has therefore been counted twice in the above statistics.
\textsuperscript{66}Nixdorf interview. Note that anybody, whether a native speaker or not, could have made a similar typo. It seems plausible, however, that non-native speakers of English would have a more difficult time interpreting and resolving typos.
partners in industry, three claimed that the academic partners (in general) were not earning their money; likewise, of the six pure academics, three claimed that the industrial partners were not expending enough effort on the project.\textsuperscript{67} These feelings eventually subsided as the partners actually worked together on common tasks. A final example of national cultural barriers was trying to plan work around the varying vacation schedules of each partner’s country. This was especially true in the summer months.\textsuperscript{68}

In late 1993, one final event occurred regarding the collaborative process of the partnership. Multisoft, as a product-oriented company with wide distribution channels, joined the OBJECTDB project to exploit its expertise in and knowledge of the software market. The company’s task was to perform a study of the market potential for Computer-Aided Software Engineering (CASE) tools. As mentioned above, the presence of Multisoft was “encouraged” by the European Union reviewers. In essence, the government was subsidizing a marketing study done for the good of the entire consortium. This study was completed in early 1994. Multisoft had worked entirely on its own and did not have extensive contact with the other partners, nor did it try very hard to develop contact.

These factors have led to a certain amount of tension between Multisoft and other project members. Multisoft did not participate in any technical aspect of the project and rarely communicated with the other partners. For some inexplicable reason for a computer company, Multisoft did not have email access, the only one of the partners to be lacking in that regard.\textsuperscript{69} Since most of the communication on the project is by email, they miss out on most of the interfirm interaction. While Zoila Peña, a manager at Multisoft, believed that telephones and faxes were adequate to remain in contact, all other partners claimed that most of the day-to-day contact was maintained by email. Telephone and fax contact with each other were relatively

\textsuperscript{67} The other two interviews were with the quasi-academics at SofJV, neither of whom accused their partners of shirking.
\textsuperscript{68} Nixdorf interview.
\textsuperscript{69} Interview with Zoila Peña, Multisoft, April 1994.
rare and restricted to “official” documents, such as drafts of budget reports and contractual matters. By 1995, Multisoft had been eliminated from the partnership.

2.4.2.4 Working relations, 1994-1995

A routine eventually settled in to the participants. Uni-SW and Uni-DB implemented many of the features in a testbed, DataBase debugged the problems with their system, while SoftJV and Uni-SW worked on higher level routines. At Uni-SW, 12 graduate students, 4 of whom were being supported by the ObjectDB grant, wrote theses on extensions to NewDB. The extensions developed uncovered bugs in NewDB and holes in the documentation. The graduate students were in daily contact with NewDB developers, who welcomed the input. DataBase essentially had an additional 12 software developers working for them for free.

Eventually, the “end-users” became more involved. Europe Air began working closely with Uni-SW and DataBase in 1994. The library of C++ classes was intended for software reuse of modules. The modules were to be stored in the database so that older versions of the modules could be recalled in case of an error in a module or interaction between modules after one had been changed. The library changed the way that the software engineers within the company developed and reused software. The new library made the process more formal than it was previously and the team detected many constructs violating the Europe Air programming and documentation guidelines. During the development and testing of the library, the interaction between the three partners was similar to the interaction between Uni-SW and DataBase with regard to bug reporting and fixing. The partners settled into a focused routine of problem solving at Europe Air.

By the end of 1995, the software had been demonstrated successfully at several major conferences and applied to the software reuse libraries at Europe Air. The partners ran a

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70 Nixdorf interview.
71 ObjectDB document, “Final Report.”
72 Escoto interview, April 1994. See Appendix G for an example of a typical interaction.
74 Escoto interview.
controlled experiment and found that the tools ran slowly; they expected hardware
improvements to bring the speed to an acceptable level within a few years.\textsuperscript{75} Computation had
also begun to develop an information system for a hospital using the new features of NewDB
and some of the tools they and Uni-SW had developed. However, this was a much bigger
effort than the software reuse library.

DataBase was quite positive about the outcome of the project. They had enhanced their
existing product to handle software engineering environment objects, their database
specification was developing into a standard without as much effort in standards-making
bodies, and the enhancements had potential uses in markets other than software engineering:

OBJECTDB is a good example of our R&D strategy. What’s good for
software engineering can also be good for other markets. In order for CASE
tools to utilize our product, we need schema evolution, views, and versioning,
for example, technical & scientific data management, such as for CAD and
networking configuration. But these are all good for other markets, too. In
these projects, we do things we would do anyway, and the funding from the
European Community is good...\textsuperscript{76}

At the end of 1995, each partner each had something to show for the collaboration,
including Multisoft (money for its market study). Computation had built up some
competencies in OODBMSs, Europe Air had a more formal software development process in
place, and the academic partners had published 28 papers.

2.5 Analysis & Discussion

In this section, I find evidence that market, technical, and social overlap have some
effects on performance and perceived performance. After analyzing the interview data,
however, it became clear that the results were also being influenced by the way the partners
interacted and by their past history (cf. Gomes-Casseres 1996; Doz 1996). In section 2.5.2,
therefore, I present some examples of "collaborative behavior" and how that behavior
influenced the results. I propose a theory of collaborative behavior and how cycles of trust are

\textsuperscript{75}“Final Report,” pp. 20-21.
\textsuperscript{76}Bahcaci interview, April 1994.
developed. Finally, I end with three lessons learned about the management of technology collaborations.

2.5.1 Evidence of proposed effects

In this section, I cite examples from the cases to discuss how market, technical, and social overlap had some influence on the results. I also use content analysis of the interview data to show how frequently respondents mentioned or implied the effects of overlaps on performance. For example, I count how many times respondents claimed that competition among partners hurt results. I report these results for three groups: CIMP participants, ObjectDB participants, and all others. They are aggregated into positive effects, negative effects, no effect, and no mention. The total number of people interviewed was 16 CIMP participants, 13 ObjectDB participants, and 21 other managers who were involved with technology collaborations.

There is some evidence in the case that market overlap may have had some influence on the partners’ ability to accomplish all of their goals. In the case of CIMP, the initial strategic maneuvering between Prodoco and Manironix may have impeded initial progress. Likewise, competition between Beta and the other software companies may have led to Beta’s early retirement from the program as Beta was hesitant to share its knowledge with the group. In the case of ObjectDB, Multisoft’s marginalization and expulsion may have been related to its potential competition with both Database and Computation. I will discuss this further below.

The interview data also support the idea that managers related market overlap, in a broad sense, with lower performance.\textsuperscript{77} In Figure 2–6, we see that almost half (24) of all

\textsuperscript{77}There are some interesting cognitive issues related to agency and automatic adjustment of goals. We see here that managers and researchers perceive potential effects of interpartner overlaps. Since I have been studying perceptual factors related to performance of the collaborations, there is a question as to why or whether these perceived effects would change the expectations of the partnership. For example, it is fairly clear that participants perceive high levels of market overlap as harmful to performance and high levels of social overlap to be beneficial to performance. Therefore, one would expect highest performance to be associated with low market overlap and high social overlap as shown in Figure FN1.
participants interviewed mentioned lower performance in the same context as market overlap. Not one respondent claimed market overlap was beneficial and no-one claimed it had no effect. A majority (26), however, did not mention it at all. As an example, one participant claims that

Figure FN1. Performance based on market and social overlap.

The question remains, if managers know this, even intuitively, why would they not adjust their expectations downward in the other cells? Put another way, why wouldn't relative goal attainment be the same in all four cells? Three potential reasons spring to mind: (1) exaggeration of technical complementarities / bundling of attributes; (2) lack of experience; and (3) government interference. I discuss (1) and (3) briefly; (2) is discussed in further below in 5.4.

The first two reasons demonstrate endogeneity of strategic choice but rely on assumptions that managers are boundedly rational or worse. That is, even though they choose their own strategies (partner choice of technology collaboration), they do not adjust their expectations upward for the upper left cell in Figure FN1 nor do they adjust their expectations downward for the lower right cell.

There is some evidence for each of these reasons in the cases. The idea that managers exaggerate the benefits of technical complementarities while downplaying market and technical overlaps seems to have some merit. 100% of the partners — nine out of nine — in both cases cited technical complementarities as one of the most important reasons to enter into the collaboration. Of course, they were not necessarily trying to predict performance outcomes. However, they could have also mentioned reasons such as being similar in outlook or being in different markets. In this scenario, managers select partners based almost purely on technical complementarities and let the other variables fall where they may. Alternatively, we could have the case of “bundled” partner attributes, that is, it is difficult or impossible to choose the partner attributes individually. This is the argument made in Part I.

The third reason demonstrates exogeneity of strategic choice. That is, managers of collaborations are handed a strategy, which in this case is the partner decision. In the case of government interference, the partners may already have set their expectations prior to the government influence on their strategy. There is some evidence that this government interference effect was in play in the case of ObjectDB. Since the partners were changed after the initial review by ESPRIT, it could be that the new configuration was supposed to live up to the expectations set prior to the review.
the “academic orientation” of some of the OBJECTDB partners, including some of the firms, is a prime reason for the project’s success:

This project has gone exceptionally well, especially compared to other ESPRIT projects, about five or six of them, that we have done here in the Center. It may even be atypical in terms of the [technical] success for a case study. This is because of the domination of the project by academic partners... DataBase itself was a consortium run by Fractal, a French university, Informatique, and Rechner, I think. It still has an academic orientation, with most employees having a PhD from Fractal.  

![Figure 2–6. Perceived effects of market overlap on performance](image)

The cases seemed to support some benefits of technical complementarities. In CIMP, the collaboration between Mantronix, CadCorp, and Three-D seemed to be a success partly because each partner had an area of expertise that was different from and complementary to its partners. Likewise, the complementarities between Europe Air, Uni-SW, and DataBase enabled the partners to efficiently create the C++ library. Interview respondents also frequently

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78Escoto interview, April 1994.
mentioned complementarities as shown in Figure 2–7. In the figure, we see that about two-thirds of all respondents discussed some perceived benefit from technical complementarities (shown in the figure under TO- because lack of technical overlap was seen as a positive, hence technical overlap was seen as a negative). No-one claimed that complementarities were bad and no-one claimed that they were irrelevant. About one-third of the respondents did not mention them at all.

![Graph showing perceived effects of technical overlap on performance](image)

**Figure 2–7. Perceived effects of technical overlap on performance**

In the cases, there are examples in which social overlap has some benefits and lack of social overlap some disbenefits. In CIMP, small-large firm tensions caused some frustration early on (and ongoing in Cimtools) as the small software companies resented the time it took

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79 The label “TO-” is slightly misleading here as the respondents were talking specifically about complementarities which, as discussed in Part I, does not necessarily correspond one-to-one with lack of technical overlap.
the large companies to make decisions. In ObjectDB, some linguistic and cultural differences between partners had the initial effect of introducing inefficiency into the collaborative process. None of these problems were insurmountable, but one can imagine that if the partners were less patient or less committed, an initial bout of these social inefficiencies or misunderstandings may have led to the partnership’s early demise. Figure 2–8 is consistent with these examples. Half of the respondents mentioned either that social similarity was beneficial or that social dissimilarity was harmful. One respondent claimed that linguistic differences had no effect.\footnote{Again, Bahceci is counted twice.} And 25 other respondents did not mention performance in the context of social factors.

![Bar chart showing perceived effects of social overlap on performance.]

\textbf{Figure 2–8. Perceived effects of social overlap on performance}

\textit{2.5.2 Effects of overlaps contingent on process and history}

Many of the quotes collected under the category of market overlap seemed to go beyond competition and rivalry. In many cases, competition led to withholding of information, a
hesitancy to collaborate or to taking advantage of a partner’s vulnerability. These behaviors, while related to the structure of the ventures, are actually not structural. They reflect the chosen actions of the partners in the course of the collaboration.

There was evidence in the cases that a choice between collaborative and non-collaborative behavior may present itself at one point or another in the course of the collaboration. When the organization chooses to undertake the non-collaborative approach, it sends a signal to its partners about its intentions and does some damage to its reputation. The evidence from the case indicates that the perception of competition, that a rival may gain an advantage, may push an organization into this “non-collaborative moment.” As discussed above, in the case of Prodco, Cimco, and Multisoft, the results are usually detrimental to the rest of the partners and can lead to several consequences. The first is that relations with the other partners deteriorate. The second is that the partner may become marginalized by lack of inclusion into decisionmaking processes and communications. The third is that tasks may be repartitioned to minimize the contact between the rivals, leading to some inefficiencies but less friction.

In the case of Prodco, for example, the moment of truth came when Mantronix donated a building and proposed to build a Demo Central with a laboratory testbed. Prodco strongly resisted this idea and prevailed in diluting the concept of the Demo Central. However, after that, the other partners began to marginalize Prodco to the extent of withholding results and, at one point, forgetting to invite Prodco representatives to an important meeting.81 In the meeting missed by Prodco, the other partners made important decisions about process planning and some milestones for giving a demonstration to the government. So even though Prodco may have won the battle (to not have the Demo Central located at Mantronix), it may have lost the war as all of the other partners acted less collaboratively with it.

This would seem to indicate a negative spiral after an initial non-collaborative moment. Trust from the other partners deteriorates. In addition, as discussed in the case of Cimco’s

81This came to light at a Steering Group meeting I attended in February, 1995.
$900,000 proposal, once a non-collaborative move is taken, intermediate performance suffers, which leads to lower trust, which most likely leads to lower performance, and so on.

I analyzed CIMP milestone and program metrics documents to determine whether the impression I had of Cimco’s and Prodco’s marginalization was reflected in their actual participation in collaborative research. Cimco never took the leadership position in another project after the basic architecture incident in contrast with all of the other partners, who took the lead in at least one other project. In addition, content analysis of the project milestones and deliverables (Figure 2–9) showed that Cimco was the only software partner whose name was not mentioned in the sections on work scope, deliverables, and key milestones. While Prodco continued leading projects in roughly the same percentage as before the Demo Central incident, Figure 2–10 shows that, of the projects labeled “inactive” or “canceled,” Prodco is much more likely than the other manufacturers to be the leader of a failed project.

![Bar chart showing projects](chart.png)

**Figure 2–9. Projects involving software partners**

Multisoft had a complex relationship with the OBJECTDB project. First, Multisoft was a potential competitor with the other two software companies (DataBase and Computation). As mentioned above, the company was mostly a product company and did not compete directly with either of the two. However, Multisoft competed indirectly with both companies. It competed with DataBase in that it provided alternatives to OODBMSs, such as the ability to
maintain an old mainframe as a database across a network. It also competed with Computation, since Multisoft’s products could provide an alternative to Computation’s customized services in both software engineering and distributed systems.

![Bar Chart: Projects](chart)

**Figure 2-10. Failed projects led by manufacturers**

Multisoft was not an original member of the consortium. Initially, the participants were the current ones plus two more universities. Some reviewers thought that the consortium was too academically focused and that the group needed more of a market orientation. Thus Multisoft was brought into the group to perform the market analysis of CASE tools, which it did do independently and without consulting much with the other partners. It is my observation that since most of the interchange flows through Computation and DataBase, and since these two firms competed somewhat with Multisoft in their own countries, Multisoft was almost purposefully excluded from the interaction. They were eventually expelled from the project. Even before the expulsion, however, they were only mentioned in one official ObjectDB document (in contrast with the other companies whose names appear frequently). Of
the 58 documents referenced in the ObjectDB Final Report, none of them contain a reference to Multisoft, while there are at least five references to partners from each of the other companies.

2.5.3 Equilibrium outcomes based on cycles of trust

I discussed above how at a critical decision point, a partner may have to choose between acting collaborative or non-collaboratively. After a non-collaborative decision, the partner becomes increasingly marginal to the collaboration. This negative spiral is shown in Figure 2–11:

![Diagram](image)

**Figure 2–11 Negative cycle of mistrust**

This should be compared to the process models of Doz (1996) and Ring & Van de Ven (1994), who chronicle cycles of trust and mistrust based on initial expectations and feelings. This cycle is also consistent with game theoretic predictions of behavior under assumptions of
differing discount rates or reputation effects (Fudenberg & Tirole 1986). The contribution of this part of the dissertation is to propose causes for the initial collaborative decision based on both interpartner overlaps and collaborative predisposition. Analogous to the cycle of mistrust is the cycle of trust shown in Figure 2–12. In the figure, collaborative disposition combines with overlap factors to reaffirm the collaboration.

![Diagram of the positive cycle of trust]

**Figure 2–12. Positive cycle of trust**

This is not to say that the spiral must exist or that it cannot be reversed. For example, Prodco and Mantronix reversed the cycle of mistrust that was developing between Prodco and the rest of the partners. This reversal, however, took a concerted effort on the part of Prodco. The management of Prodco emphasized the complementarities and market relationship between Mantronix and Prodco Parts. They also distanced themselves from the operating decisions of Parts and delegated responsibility to the plant manager. In essence, they “suppressed competition” (Gomes-Casseres 1996) to accomplish the larger goal of the demonstration.

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82 These are discussed further in Part III.
83 Waxenberg interview.
2.5.4 Lessons learned about management of technological collaborations

(1) Break down tasks by overlaps

Anyone familiar with software engineering processes or task partitioning knows that breaking down large, complex tasks is important to reduce coordination costs and improve efficiency. In the cases, the CIMP partners’ performance improved after the group abandoned their large, consensus-based project and broke into a “loosely-coupled confederation.” The partners started working on many small projects, which had the effect of mitigating competitive tensions. For example, the project involving Mantronix, CadCorp, and Three-D is a consequence of the partitioning strategy. In ObjectDB, the partners already started out with tasks relatively efficiently partitioned. Multisoft, the primary force of market overlap in the consortium, never worked directly with any of the other partners.

The market, technical, and social overlap framework can be applied as a partitioning strategy. Instead of trying to “reduce coordination” or “reduce complexity,” the partners should strive to partition the tasks so that each team is characterized by low market overlap, technical complementarities, and high social overlap, if possible. Even though Mantronix and Prodco were competitors, a project involving the supplier Prodco Parts and Mantronix was a more natural partition. Gomes-Casseres (1996) counsels that firms should “suppress competition” to succeed in collaborations. Partitioning tasks along market, technical, and social overlaps is one way of suppressing competition.

(2) Jettison partners whose departure will lower market overlap the most

The cycles of mistrust leading to expulsion or marginalization are analogous to a body’s reaction to a transplanted organ. Under some circumstances, the body starts to reject the organ. If the organ is not removed, the body dies. In the cases, the partner with the highest likelihood of expulsion was the one with the most multimarket contact across the partners. In both cases, the partner expelled reduced market overlap the most, as shown in Figure 2–13. Beta, although it departed during the initial round of intellectual property negotiations, was the
only firm at that point in 1992 that competed directly with several of the partners. In the figure, the average number of same 3-digit SIC partners dropped from about four to about three, a large percentage given that the average is taken over 11 organizations. The post-Beta marginalization of Cimco and Prodoco are also consistent with this lesson.

Likewise, even though the average overlap is much lower, the percentage drop upon Multisoft’s expulsion is also quite notable. No other partner’s departure could have affected the averages as much, as Multisoft was the only firm in ObjectDB with the capabilities to compete with two other firms, Computation and DataBase.

![Bar chart showing reduction of market overlap through expulsion](image)

**Figure 2–13. Reduction of market overlap through expulsion**

*Note: scales are different*

(3) **There is no substitute for experience**

Managers who have not had much experience in collaborating do not know exactly how to evaluate potential partners and therefore choose partners almost randomly at first until they understand collaboration better. This is a particularly relevant lesson for CIMP. Ten out of the

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*More recently, consolidation in the CAD/CAM industry has meant that three of the five CIMP software partners now have sister divisions that compete with at least one partner.*
16 of the interviewees mentioned their lack of collaborative experience. The following chart also gives the average and median number of collaborations prior to 1992 for each of the two cases.

![Chart showing number of collaborations]

**Figure 2–14. Number of collaborations prior to 1992**

Not only is partner choice more difficult to evaluate, but the facts of how to interact closely with an independent party may also elude the inexperienced collaborator. In the cases, we saw that the initial interaction between CIMP participants was spoiled in some sense while they struggled to understand how to act collaboratively. In fact, the partners spent the first six months or so almost exclusively negotiating rather than working. It was only after about a year that they settled into the productive routine that eventually led to the demo. In contrast with this, we saw the sparser face-to-face contact and more efficient task partitioning of the ObjectDB team. Of course, ObjectDB’s relative efficiency was also due in part to the government’s collaborative experience: the European Union settled the intellectual property

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85This is at the operating unit level. Source: interviews and internal documents. See sections 2.4 and 2.5 above for more details.
contracting issues fifteen years ago, while the contracts NIST used were borrowed from past contracts with non-profits and government labs.

2.6 Conclusions, limitations, and further study

2.6.1 Conclusions

This study has several contributions to future empirical work on technology collaborations and consortia. The first has been the demonstration of perceived effects of market, technical, and social overlap. Interviewees generally regarded market similarities as contributing to poor performance, technical differences as contributing to higher performance, and social similarities as contributing to higher performance. In addition, the overlap concepts were found to be useful in analyzing the initial composition and strategic responses of the partners.

However, it was shown that market, technical, and social overlap alone do not account for all of the interactions among the partners. Another finding relates to the situations in which partners had to make a decision: to act “collaboratively” and possibly forgo some short-term gain or to act “non-collaboratively” in the interests of short-term gain. These individual decisions had larger ramifications within the partnerships. Cycles of trust developed when partners acted collaboratively, leading to closer relations and better technical results. However, when a partner acted non-collaboratively, cycles of mistrust developed that eventually marginalized the non-collaborator. Taking these observations to an extreme, it seems plausible that critical decision points can lead to “tipping equilibria” in which partners starting off acting collaboratively achieve better performance. I therefore propose the concept of “collaborative behavior” as a moderator of the overlap effects. Figure 2–15 summarizes the dynamics of the collaboration.86

86This figure was suggested by Don Lessard.
2.6.2 Limitations & further study

While the results of this study may be generalizable to many forms of technology collaborations in different industries, there are several limitations of this study that should be acknowledged. In this section, I discuss the potential limitations. The largest and most important limitation is the size of the sample. This was an exploratory study and, as such, only examined two collaborations. The intention was to see whether market, technical, and social overlap could be useful in analyzing technology collaboration performance. In this sense, I have found two examples where (I believe) the overlap concepts were useful. By talking with managers and researchers in the field, I developed an extension to the original theory. However, the challenge for future empirical work will be to move beyond this exploratory study to an examination of a much larger number of cases.  

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87Secondary threats to validity include lack of large amounts of variance in performance, the industrialized country bias of the sample, and the retrospective nature of the interviews. The first of these is the homogeneity along the performance dimension. In the case studies, the collaborations generally involved relatively strong performers, varying from moderate to high performance. The absence of low performers
Two issues relate to the level of analysis: how representative are the people I interviewed of their organization's culture? And how representative are they of their own national culture? Salk (1989) cautions against making generalizations based on members of the same group within an organization, as there may be subcultures defined by group boundaries. I cannot rule this out completely, even though I interviewed people at different levels of the organizations I studied. That is because the site visits were shorter than the ethnography that one would need to truly get a deep grasp of any organization’s culture. The same caution holds for the representativeness of the partner’s national culture. I have no reason to doubt my impressions of their representativeness, having extensive living experience in Europe before this study was undertaken, but I simply could not spend enough time within each firm to rule it out.88

This study has attempted to hold “policy” regimes constant by examining cases having similar levels of government intervention in subsidy levels and overall bureaucracy/reporting requirements. An interesting area for future research may be an examination of government policy options on firm performance. Such policy options may include, in addition to general

(except when comparing with other collaborations in interviews) may lead to inaccurate conclusions when examining the links between the constructs and performance, and may have led to other factors being ignored altogether.

The next secondary limitation is a sampling issue: only R&D collaborations in the software area were considered. It is not clear that other technologies applied to other industries would exhibit the same dynamics observed in the case studies and other interviews. For example, in industries with lower levels of rivalry, market overlap and collaborative behavior may be less important than pictured in this study.

Another limitation is that the cases and preliminary field research took place in Europe and the United States of America. With the exception of one company that was attempting to perform some in-house research in India, all collaborations took place between firms in highly industrialized countries. This should not be too problematic, since the vast majority of alliances take place within and between highly industrialized countries; however, when examining developing country alliances, the results may not hold.

The study is partially based on retrospective data. This has the effect of bringing biases present in the mind of respondents into play, for example, by inadvertently imputing strategic objectives different from the original ones for collaboration for projects eventually evaluated as failures. I tried to control for this as much as possible by searching for multiple sources of information from printed reports and other archival materials.

88Some might claim that no adult could ever spend enough time within a foreign culture to understand it completely.
subsidization and reporting, targeted R&D credits, vertical nature of technology collaborations, proximity to the market of the R&D, and intellectual property protection levels. Another area for future research will be true longitudinal studies that trace a number of technology collaborations from inception to dissolution. This study has examined a three-year window on the process, but following the strategic and technical goals from the proposal stage onward would be extremely illuminating. Finally, the theories put forth above should be tested on a larger sample of technology collaborations. As mentioned at the beginning of Part II, we have explored several important constructs; however, the results may be idiosyncratic to the small number of cases chosen. A larger sample quantitative study would inspire some confidence that the overlap variables and collaborative behavior are important influences on the performance of technology collaborations. This is precisely what I hope to accomplish in Part III of this dissertation.
Performance of Technology Collaborations

3.1 Introduction

Over the last twenty years, technology collaboration has become an important source for new capabilities within firms. While the conditions facilitating the formation and choice of organizational form have become better understood recently, there remains little consensus on the determinants of the outcomes (or performance) of ventures in which bilateral or multilateral exchanges of knowledge or technology take place.

As discussed in Part I, one research stream that has developed over the last ten years centers on the initial “structure,” or initial “conditions,” of alliances, and how these initial conditions affect alliance outcomes (for example, Hagedoorn & Schakenraad 1994; Powell et al. 1996). However, in Part II, I proposed that “collaborative behavior” also heavily influences performance. This is consistent with a research stream based on actions by firms that have entered into collaborative arrangements (see, e.g., Parkhe 1993c). In contrast with the “structural” approach, most work in this literature proposes methods of achieving joint gains through collaborative behavior. For example, Axelrod (1984) proposes that optimal strategies, such as tit-for-tat, exist for maintaining collaboration. In a similar vein, scholars have written several articles on “trust” and how organizational trust is developed (e.g., Mayer, Davis, &
Schoorman 1995). There is also related work in industrial organization economics on game theory and incentives to collaborate (e.g., Fudenberg & Tirole 1986). These works focus the attention on the primacy of the ongoing process of managing collaboration (referred to in this dissertation as “collaborative behavior”).

There has been little work bringing the two bodies of literature together and relating them to outcomes. Doz (1996), in the most comprehensive paper to directly address these two bodies of literature, examined how initial conditions constrain the process of collaboration, which directly influence the perceived success of the alliance. The initial conditions, such as the task definition, partners’ routines, interface design, and expectations, have an impact on whether the partners “adjust” to the requirements they learn about and how they act toward each other. In successful projects, the firms learn about the partner, how to collaborate successfully with it, and also internalize some important skills (cf. Hamel 1991). In unsuccessful projects, the firms learn about the partner and how to collaborate successfully with it, but are unwilling to “adjust” enough to do so due to lowered expectations, goal conflict, or mistrust.

Along similar lines, Part II of this dissertation proposes that the effect of interpartner overlaps is influenced by managerial action. Certain situations developed in which the opportunity for either “collaborative” or “non-collaborative” (opportunistic) behavior presented itself to one partner. If the partner chose the collaborative route, a cycle of positive interaction and performance characterized future dealings with the other partners. When the partner chose the non-collaborative route, the short-term gain was quickly eroded by a cycle of negative interaction and marginalization. Thus we see the potential for cycles of trust that end up leading to high performance and cycles of mistrust leading to low performance. These “tipping equilibria” can be initiated by one collaborative or non-collaborative act.
This part of the dissertation is a first attempt to explore the above arguments and constructs on a larger number of technology collaborations. As both Doz (1996) and Part II were case studies of small numbers of collaborations, a natural follow-on is whether collaborative behavior moderates between initial conditions and alliance performance in a large sample of alliances.

In this part of the dissertation, I examine firm characteristics and other more or less fixed, structural attributes and their effect on technology collaboration performance for a sample of 40 business units and 81 other organizations in the information technology sector. I also examine how initial collaborative behavior influences the effect the firm characteristics have on performance. The characteristics I concentrate on are market, technical, and social overlap, which correspond to Doz’s (1996) breakdown of organizational “contexts” (p.76). I find that performance, or the degree to which technical and strategic goals are met, is more closely associated with low rivalry between partners, high similarity of products, similar cultures, and high initial collaborative behavior. One notable lack here is the effect of technical overlap on performance, something that will be discussed later. The relationships between firm, alliance, and task characteristics, collaborative behavior, and performance are shown below in Figure 3-1 and elaborated further in Section 3.2 below.

The findings of Part III have managerial implications for firms desiring successful entry into short-term and relatively informal technology collaborations. Firms that enter into these ventures should consider the initial structure of the alliance and especially the characteristics of the partners, such as their specific products and services, their potential for market entry, and their corporate and national business cultures. The results reported in Part III come from a survey of alliance performance of 38 business units and 83 other organizations from 50 specific European technology alliances across several industrial sectors.

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1Other organizations include universities, non-profit enterprises, and government labs.
The rest of Part III is organized as follows: Section 3.2 reviews the literature relevant to overlaps, collaborative behavior, and alliance performance. In it, I present hypotheses that will be subsequently tested. Section 3.3 describes the context of European R&D collaboration and
gives further particulars on the dataset. Section 3.4 contains the specification, analysis, and results. Section 3.5 presents the conclusions of the study and plans for future research.

3.2 Literature Review & Framework

The basis of the analysis for this part of the dissertation springs from the notion that market, technical, and social "overlaps" can be isolated and that their effects can be examined independently. First, we briefly restate the propositions from Part I on how market, technical, and social overlap are related to performance in the literature. Then I examine the relation of performance to collaborative behavior. This section ends with a proposed econometric specification of a model designed to test the hypotheses.

Recall from Part I that the following hypotheses were proposed:

Hypothesis 1: Performance will decline as market overlap increases.

Hypothesis 2: The highest performing technology alliances will exhibit partial technical overlap, followed by those within the same narrow specialty, followed by those in completely unrelated scientific / technical disciplines.

Hypothesis 3: The highest performing technology alliances will be associated with partners from highly similar national and corporate cultures.

3.2.1 Collaborative behavior and performance

This general area of influence on performance proceeds from theories that collaboration can and should be managed on an ongoing basis, and that trust, reputation, and systematic attention to the relationship will net high results (Gulati 1995; Parkhe 1993; Killing 1988). In other
words, there is a right way and a wrong way to collaborate (Axelrod 1984), which relies on the
process, or method, of collaboration as opposed to (or in addition to) the structure of the
 collaboration. The important factors involved in collaborative behavior include not exploiting
opportunistic situations, forbearance of opportunistic behavior, frequent communication among
partners, and personal ties between managers. Gulati (1995) examines how past alliances lead
to lower usage of equity alliances, implying the existence of “trust” at an organization level.
Killing (1988) claims that the only way to handle highly complex “tasks” (as defined above) is
through previous collaborative experience with the same partners. Doz (1996) chronicles the
co-evolution of structural characteristics and collaborative behavior and how initial conditions
facilitate or hinder learning in a feedback cycle that amplifies the original structure.

Game theory can also be applied to the analysis of collaborative behavior’s effect. Consider
the repeated Prisoner’s Dilemma, where the payoffs are high if both parties collaborate (with
each other\(^2\)); are highest when the player defects (acts non-collaboratively) and the other
partner collaborates; are lowest when the player collaborates and the partner defects; and are
low if both partners defect (Axelrod 1984; Fudenberg & Tirole 1986; Kreps 1990; Schelling
1960). One equilibrium solution to the repeated game is to defect in the first round if the game
has a finite number of rounds, as one can assume that the partner will defect anyway in the last
round. Therefore, why not beat the partner to the punch and defect in the next-to-last round?
But the partner, realizing its vulnerability in the next-to-last round, should therefore defect on
the round before that. And so on, until both partners defect in the first round.

There are two factors that could prevent this from happening. The first is if the parties take into
consideration the future returns they are forgoing by not collaborating. That is, if they do not

\(^2\)The wording here is very tricky as some treatments of this subject use “collaborate,” to mean “collaborate with
the authorities” (defect) in the sense of a prisoner collaborating to get a lighter sentence. Here we will use the
terms “collaborate,” which means collaborate with each other (highest joint payoff) and “defect” or “act non-
collaboratively” which means seeking a short-term payoff at the expense of the partner. In this way, the
terminology is consistent with Part II of the dissertation.
discount the future too much, they may be willing to forgo a short-term gain for a gain over a longer period of time (Fudenberg & Tirole 1986). On the other hand, if the payoff from defecting is much bigger or they do not care about the future at all, then it is likely they will defect early on. Therefore, taking discount rates into consideration can lead to an equilibrium in which both parties collaborate for a longer period of time.\(^3\)

The second factor that could prevent the early defection of both parties is the building of a reputation for collaboration. This is precisely what Axelrod (1984) has shown and is the basis for some of the literature on “trust,” where trust in this sense is based on purely rational and self-interested gain (cf. Sabel 1992). That is, reputation is hard to build and easy to destroy. Once a partner has established a reputation for collaboration, it continues to reap the long-term benefits of the collaborative outcome as its own partners no longer become worried that it will defect early on. Another way to accomplish this where no reputation yet exists is through some sort of signaling or commitment mechanism, where the partner willingly makes the cost of defection higher than it might otherwise be to demonstrate that it will not defect (Kreps 1990).

Based on the above, we may conclude that efforts put into establishing and building trust, building a working relationship, or signaling a willingness to collaborate will lead to payoffs in later encounters as “vulnerabilities” may not be thoroughly exploited. These arguments lead to the following hypotheses:

Hypothesis 4a: Performance will decline with decreased levels of collaborative behavior.

\(^3\)If the game has an infinite number of periods, then an equilibrium exists where they continue to collaborate forever.
Hypothesis 4b: Collaborative behavior moderates interpartner overlap effects (i.e., there is an interaction between collaborative behavior and overlap effects).

3.2.2 The Model

The relationships outlined in Part I and above lead to a model of performance that can be tested econometrically. The specification of the model is as follows:

\[
\text{PERF} = f (\text{MO}, \text{TO}, \text{SO}, \text{ALL_CHAR}, \text{TASK_CHAR}, \text{COLLAB}, \text{FIRM}, \text{MO} \ast \text{COLLAB}, \\
\text{TO} \ast \text{COLLAB}, \text{SO} \ast \text{COLLAB}, \text{ALL_CHAR} \ast \text{COLLAB}, \text{TASK_CHAR} \ast \text{COLLAB}) + \epsilon
\]

where \( \text{PERF} \) is the degree to which technical or strategic goals of each firm are met, \( \text{MO}, \text{TO}, \text{SO} \) are the three kinds of overlap, \( \text{ALL_CHAR} \) represents other alliance characteristics, \( \text{TASK_CHAR} \) represents other task characteristics, and \( \text{COLLAB} \) is the degree of collaborative behavior employed. \( \text{ORG} \) represents control variables related to organizational characteristics, such as the innovativeness or size of the organization. The other terms are interaction effects designed to test the degree to which collaborative behavior moderates the effects. The error term, \( \epsilon \), represents random factors and explanatory variables unintentionally omitted from the model. These effects may be tested jointly or separately.

The hypotheses presented in the previous sections are testable as follows:

H1. \( \beta_{\text{MO}} < 0 \)
H2. Non-linear test of \( \beta_{\text{TO}} \) as shown in Figure 1–5, or \( \beta_{\text{TO}} < 0 \)
H3. \( \beta_{\text{SO}} > 0 \)
H4a. \( \beta_{\text{COLLAB}} \neq 0 \)
H4b. \( \beta_{\text{MO} \ast \text{COLLAB}} \neq 0 \) or \( \beta_{\text{TO} \ast \text{COLLAB}} \neq 0 \) or \( \beta_{\text{SO} \ast \text{COLLAB}} \neq 0 \)
3.3 Data and Method

3.3.1 European technology collaborations and data sources

The results reported in this part of the dissertation are based on a survey of firms engaged in technology collaborations in the information technology sector. The survey was a conducted in 1996 of representatives of 489 technology collaborations. The instrument attempted to ascertain exactly what goals were expected by the participants and what direct results came of the projects and is reported at the business unit (or operating unit) level.

The survey was conducted in the following manner. Information about the structure of the alliances was available from a census of over 12,600 government-sponsored "projects" (alliances) published over the Internet by the European Union. These projects comprise over 60,000 participants within approximately 35,000 organizations (business units, non-profits, universities, and government labs). For the collaborations in the sample, I have collected the information shown below in Tables 3–1 and 3–2. A sample record is found in Appendix H. For each partner, I have at least the organization and country, and sometimes all of the information in Table 3–2.

Of these, I eliminated all projects that had fewer than two or more than ten participants. The projects with one participant were obviously not alliances, and the ones with more than ten partners were usually large standards-setting committees whose goals and administration were sufficiently different from the nature of the bulk of the technology collaborations to warrant

4Note that this “sponsorship” does not necessarily imply subsidization. It could simply mean that the partners came together under the auspices of a government “matching” service or that they registered the alliance with the government.

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their exclusion. I then selected those projects that had the participation of at least one industrial partner. From these, I selected only those projects that had begun after December 31, 1979, and ended before January 1st, 1996. This left 902 projects with 4545 participants within 2574 organizations.

<table>
<thead>
<tr>
<th>LABEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCN</td>
<td>Record Control Number</td>
</tr>
<tr>
<td>QVD</td>
<td>Quality Validation Date</td>
</tr>
<tr>
<td>UPD</td>
<td>Update Date</td>
</tr>
<tr>
<td>PJA</td>
<td>Project Acronym</td>
</tr>
<tr>
<td>TTL</td>
<td>Title</td>
</tr>
<tr>
<td>SIC</td>
<td>Subject Index Classification Codes</td>
</tr>
<tr>
<td>SIP</td>
<td>Other Subject Indexes Provided</td>
</tr>
<tr>
<td>OBJ</td>
<td>Objectives</td>
</tr>
<tr>
<td>GEN</td>
<td>General Information</td>
</tr>
<tr>
<td>SDA</td>
<td>Start Date</td>
</tr>
<tr>
<td>EDA</td>
<td>End Date</td>
</tr>
<tr>
<td>DUR</td>
<td>Duration</td>
</tr>
<tr>
<td>PJS</td>
<td>Project Status</td>
</tr>
<tr>
<td>AED</td>
<td>Actual End Date</td>
</tr>
<tr>
<td>PGA</td>
<td>Program Acronym</td>
</tr>
<tr>
<td>SPA</td>
<td>Subprogram Area</td>
</tr>
<tr>
<td>RPG</td>
<td>Project Reference</td>
</tr>
<tr>
<td>POR</td>
<td>Prime Contractor Organization</td>
</tr>
<tr>
<td>POT</td>
<td>Prime Organization Type</td>
</tr>
<tr>
<td>PCD</td>
<td>Prime Contractor Department</td>
</tr>
<tr>
<td>PAD</td>
<td>Prime Contractor Address</td>
</tr>
<tr>
<td>PPC</td>
<td>Prime Contractor Postal Code</td>
</tr>
<tr>
<td>PTO</td>
<td>Prime Contractor Town</td>
</tr>
<tr>
<td>PRC</td>
<td>Prime Contractor Region Code</td>
</tr>
<tr>
<td>PRE</td>
<td>Prime Contractor Region</td>
</tr>
<tr>
<td>PCY</td>
<td>Prime Contractor Country</td>
</tr>
</tbody>
</table>

Table 3-1. Dataset fields

From these 902 projects, I selected the 489 projects where at least one participant had an electronic mail (email) address. The choice of email contact was made with the cost of administering the survey in mind. The representativeness of this sample is discussed further below in section 5.2. These 489 projects had 2345 participants within 1322 organizations. Of these 2345 participants, 1022 had email addresses. 100 of these people were contacted during the pilot test phase of the research project, leaving 922 potential participants to contact.
Table 3-2. Partner information

<table>
<thead>
<tr>
<th>CPJ</th>
<th>Contact Person of Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNM</td>
<td>Contact Name</td>
</tr>
<tr>
<td>POS</td>
<td>Position</td>
</tr>
<tr>
<td>DEP</td>
<td>Department</td>
</tr>
<tr>
<td>ORG</td>
<td>Organization</td>
</tr>
<tr>
<td>OTY</td>
<td>Organization Type</td>
</tr>
<tr>
<td>ADR</td>
<td>Address</td>
</tr>
<tr>
<td>CIT</td>
<td>City</td>
</tr>
<tr>
<td>POC</td>
<td>Postcode</td>
</tr>
<tr>
<td>REG</td>
<td>Region</td>
</tr>
<tr>
<td>CNY</td>
<td>Country</td>
</tr>
<tr>
<td>TEL</td>
<td>Telephone</td>
</tr>
<tr>
<td>FAX</td>
<td>Fax</td>
</tr>
<tr>
<td>TLX</td>
<td>Telex</td>
</tr>
<tr>
<td>MBX</td>
<td>Electronic Mailbox</td>
</tr>
</tbody>
</table>

At this point, I decided to compile an electronic mail list of people who would receive the survey. There were many reasons for this. First, there were mistakes in the original European Union database. The person listed as the contact person may have not been the executive or manager directly responsible for the project. Second, many organizations have policies against survey completion. Therefore, I wanted to ensure that the correct person within a "willing" organization received the survey to maximize the chances of reliable and accurate information about the organization and its participation in the alliance (cf. Loh 1993).

During the pilot test, it became obvious that many of the addresses — electronic and otherwise — were either outdated or incorrect. Therefore, before initial contact was made, I attempted to verify or otherwise track down every one of the 922 email addresses. This was done using a variety of Internet search tools. In the end, I was able to verify 758 of the 922 addresses.

An initial contact was attempted with all 922 participants. The statistics for the initial contact are listed below in Table 3-3. Of the 922, 183 (19.8%) were returned due to an incorrect email address. 389 (42.2%) were verified received, either because a "return receipt" was received, a "vacation message" was received, or because the participant replied to the letter. Finally, a substantial portion — 350 (38%) — may have been delivered, but there is no way to know as
no response was received and no "return receipt" was received. Therefore, the number of participants receiving the nomination letter was somewhere between 389 and 739.

<table>
<thead>
<tr>
<th>Table 3-3. Statistics on initial contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>758 verified vs. unverified 164</td>
</tr>
<tr>
<td>84 (11%) returned undelivered 99 (60%)</td>
</tr>
<tr>
<td>361 (48%) verified received 28 (17%)</td>
</tr>
<tr>
<td>313 (41%) possibly delivered 37 (23%)</td>
</tr>
</tbody>
</table>

A reply was returned by 263 participants, 209 (79.5%) of whom nominated themselves or someone else, while 54 (20.5%) refused to participate. In section 5.2, I provide some demographic information on the various categories of non-respondents to examine whether there is any non-response bias in the replies I did receive. The survey was available in four media: world-wide web, electronic mail, facsimile, and mailed hardcopy.

As of October, 1996, 193 surveys had been sent out, and 121 usable responses had been received. This corresponds to a 62.7% response rate on surveys sent, and a range of 16.4% to 31.1% on original participants contacted, depending on assumptions about how many non-respondents actually received the survey. This compares favorably to a domestic mail survey (Thach 1995).

The analysis presented in this part of the dissertation will concentrate primarily on the for-profit enterprises, although I will highlight some differences between the for-profit and non-profit organizations. The response statistics for the for-profits are very similar to the response statistics for the dataset as a whole: 610 contacts within companies in the sample, 254 of which

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5This includes 33 participants who nominated someone else and the people they nominated.
published email addresses, 228 of which I contacted after the pilot test. Of those 228, 94 responded and of those, 60 agreed to take the survey. 38 of the 60 completed the survey for a response rate of 63.3% on surveys sent and a minimum response rate of 16.7% on original participants contacted. Section 5.2 below discusses the representativeness of the subsample.

3.3.2 Operationalization of variables

Dependent variable. The performance measures are based on how well the project met each partner's goals. Strat & Tech are variables that measure goal attainment by asking the question whether none, some, most, or all of the firm's goals were met, or whether all goals were exceeded. The assumption is that low levels of goal achievement represent failure. The questionnaire asked the respondent to rate the attainment of both strategic and technical goals. In this part of the dissertation, I will concentrate on the achievement of strategic goals as the main dependent variable, but will also highlight differences between strategic and technical goal attainment.

In addition, the questionnaire asked for both subjective and objective data on the following outcomes: technical standing (with regard to competitors), technical understanding, new process creation, new product creation, new prototype creation, technical standard development, expansion into international markets, knowledge about management of collaboration, new feature development, startup or spinoff of companies, publications, patents, production throughput, product performance, licenses, royalties, decreased production costs, decreased production defects, increased market share, and increased sales volume. In the future, I expect to present results based on these outcomes, but they will not be presented here.

Independent variables. For each organization in the sample of 121 organizations, I construct measures of overlap based on market, technical, and social measures. Competitors is a
variable representing the percentage of partners labeled as “direct competitors.” I did not define what “direct competitors” meant in the context of the survey and left it to the individual respondents to interpret the question. Respondents were asked how many partners were competitors, how many were suppliers or customers, and how many had no market relation to the operating unit. Most likely, “direct competitors” was taken to mean “similar customers.” Products represents a subjective measure of the similarity of the partners’ products or services. These measures are averaged across all partners.

Tech Overlap is measured by responses to subjective questions about (1) how similar the technical specialties of the partners are to the respondent’s operating unit, and (2) to what extent the partners’ staff had the same professional training and skills as the respondent’s operating unit. I also collected data on the precise technical specialties of the partners and in a future study (see section 5.2 below) hope to incorporate independent raters’ assessment of technical overlap.

Social overlap is measured in several different ways, based primarily on Lawrence & Lorsch’s (1967) questionnaire on interdivisional differences and Schein’s (1985) work on organizational culture. Questions were developed about the similarity of the partners’ “way of conducting research,” time horizons, degree of hierarchy, and importance of formal rules as compared to the respondent’s unit. The scores were averaged across all partners.

Int’l Overlap attempts to capture some aspect of national cultural differences. A proxy was sought for the number of countries associated with the venture, as the variable was constrained to be less than the number of partners, thereby making it highly correlated (~0.8) with Partners. One measure of national cultural dispersion used frequently in international management research (e.g., Zaheer & Zaheer 1995; Shane 1995; Kogut & Singh 1988) has been Hofstede’s (1980) construct of uncertainty avoidance. This is a measure of tolerance for
uncertainty about the future and is known to differ across countries. Zaheer & Zaheer (1995) note that while some scholars have argued Hofstede’s work does not truly generalize to national cultural differences (e.g., Baligh 1994), the constructs may be useful in analyzing “national business cultures” across a large number of countries as that is the subset of the population sampled by Hofstede. Since this analysis is in fact interested in national culture as it manifests itself in firms undertaking international technology collaborations, I have chosen to use the variance of uncertainty avoidance as a proxy for international heterogeneity.

The concept of collaborative behavior is derived from several questions about how committed the unit was to the alliance and how “opportunistically” the unit acted toward its partners. Questions were developed about the quality of the employees working on the alliance’s project, the infrequency of withholding information from partners, the frequency of formal communication, and the frequency of formal communication. In all of these, the higher the value, the more collaborative behavior the unit exhibited. For example, I assume the more infrequent the withholding of information, the more “collaborative” the unit was in its dealings.

Control variables. The analysis controls for industry, Cost (total expenditures), innovativeness (total R&D Spending by the unit, prior technical position), stage or whether the project was undertaken for a marketable (Mkttable) product, the number of Partners, level of government subsidy, profitability of business units, task complexity, number of prior alliances, and size (in sales and number of employees).

I took several steps to ascertain the reliability and validity of the instrument and measures I used for the study. First, I telephoned ten randomly selected respondents to verify that the respondent himself or herself had actually received the original electronic mail message and that the respondent had completed the questionnaire. Of the ten, nine had completed the questionnaire themselves, while one respondent had a subordinate fill in the questionnaire and
then examined it himself and sent it back. I have no reason to believe this is any different from
typical responses to a mail survey. I also performed a test-retest of the instrument on a group
of 12 people. The test-retest correlation was 0.93 with one month elapsed between testing.

I also interviewed eight pilot test respondents after they had completed the questionnaire to
ensure that their interpretation of the questions corresponded to my intent on the questions.
Three questions out of 67 unique questions\(^6\) were reworded based on this feedback. Eighteen
questions were rescaled to maximize variance based on the results of the pilot test.

Table 3–4 summarizes the variables examined in this study with the notation from section 3.2.2
above, definition, operationalization, and notation in the regressions. Table 3–5 shows
summary statistics for the variables of interest.

3.4 Analysis and Results

3.4.1 Analysis

The univariate correlation between the performance measures and independent variables are
shown in Table 3–6. The full Pearson correlation matrix is listed in Appendix J. In Table 3–6,
Outlook is positively correlated with Strat, and Informal is negatively correlated.

Table 3–7 illustrates the results of several specifications of the models with different
combinations of the independent variables.\(^7\) In this section, I will present the evidence for the

\(^6\)In section B of the questionnaire, 14 questions were asked about each partner, so the minimum number of
questions on the questionnaire was 67.

\(^7\)Inspection of sample influence statistics indicated that there were two atypical cases in the dataset. One of
these was a potential outlier (studentized PRESS residual = –2.8, Cook’s D = 0.168) while the other was a
potential high-leverage datapoint (Hat statistic = 0.514, Cook’s D = 0.194). The sample average of Cook’s D
was 0.035 and the sample average Hat statistic was 0.265 by comparison. There is no reason to believe that
these two datapoints were mistakes or measurement failures. Furthermore, removal of the datapoints, singly and
together, did not measurably disturb the overall findings. In fact, removal of the high-leverage observation
strengthened the results for the Competitors variable. The results reported here, therefore, represent the full
sample of for-profit organizations.
 effect of the independent variables while leaving the interpretation of that evidence to the next section.

### Table 3–4. Constructs, their operationalizations, and variable notation

<table>
<thead>
<tr>
<th>Notation from §3.2.2</th>
<th>Definition</th>
<th>Operationalization</th>
<th>Notation in data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERF</td>
<td>Performance</td>
<td>How well the business (operating) unit met its strategic goals on a 5-point scale</td>
<td>Strat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How well the business (operating) unit met its technical goals on a 5-point scale</td>
<td>Tech</td>
</tr>
<tr>
<td>MO</td>
<td>Market overlap</td>
<td>Percentage of partners who were direct competitors with the firm.</td>
<td>Competitors(^8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarity of products &amp; services</td>
<td>Products</td>
</tr>
<tr>
<td>TO</td>
<td>Technical overlap</td>
<td>How related the technical specialty of the partner was (subjective)</td>
<td>Tech Overlap(^9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarity of staff's technical skills and training</td>
<td></td>
</tr>
</tbody>
</table>

\(^8\)Average of two questions: one at operating unit level and the other at parent level. Correlation = 0.67, Cronbach alpha = 0.80. Confirmatory factor analysis (CFA) for MO chi-square = 7.597*** but GFI > 0.90.

\(^9\)Average of the two questions. Correlation = 0.46, Cronbach alpha = 0.63.
<table>
<thead>
<tr>
<th>SO</th>
<th>Social overlap</th>
<th>Similarity of &quot;way of conducting research&quot;</th>
<th>Outlook&lt;sup&gt;10&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Similarity of time horizons</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Similarity of levels of hierarchy</td>
<td>Org Structure&lt;sup&gt;11&lt;/sup&gt;</td>
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<sup>10</sup>Average of the two questions. Correlation = 0.41, Cronbach alpha = 0.58. CFA chi-square = 10.85* for SO.
<sup>11</sup>Average of the two questions. Correlation = 0.66, Cronbach alpha = 0.79.
<sup>12</sup>CFA chi-square = 1.608 for COLLAB.
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Table 3–6. Univariate correlations of performance measures and independent variables for 38 business units (FP) and 83 other organizations (NFP) undertaking alliances in Europe

(*p<0.01, **p<0.05, *p<0.10).

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In the simplest of the models (I – III), we observe the limited effect of any individual overlap variable on the outcome. The one exception to this is the effect of Outlook (similarity of way of conducting research and time horizons), which appears to have a positive influence on goal attainment. Models IV and V demonstrate one effect of collaborative behavior: the negative effect of Informal communication frequency. Model V is the most parsimonious model involving collaborative behavior. Infrequency of Withholding information and frequency of Formal communication had very little predictive power in any of the models, either singly or as a contribution to any interaction; henceforth, they will be dropped from consideration. Model VI runs two controls,\textsuperscript{13} which, by themselves, have very little explanatory power. Unisize never exhibited any explanatory power in any models run; it, too, will be dropped from further consideration.

\textsuperscript{13}Other controls collected but not yet analyzed include innovativeness and financial health.
Table 3-7. Effect of independent variables on strategic goal attainment for 38 business units undertaking collaborative ventures in Europe

std. errors in parentheses, (**p<0.01, **p<0.05, *p<0.10).

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Table 3-7 (cont’d). Effect of independent variables on strategic goal attainment for 38 business units undertaking collaborative ventures in Europe
std. errors in parentheses, (**p<0.01, *p<0.05, *p<0.10).

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Table 3–7 (cont’d). Effect of independent variables on strategic goal attainment for 38 business units undertaking collaborative ventures in Europe

std. errors in parentheses, (**p<0.01, ***p<0.05, *p<0.10).

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<td>(7.65)</td>
<td>(6.04)</td>
<td>(5.42)</td>
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<td>-0.68**</td>
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<td>Int’l</td>
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<td>(1.47)</td>
<td>(1.04)</td>
<td>(2.15)</td>
<td>(0.77)</td>
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<td>Qual Staff</td>
<td>3.15***</td>
<td>3.12***</td>
<td>3.15***</td>
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<tr>
<td>Formal</td>
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<td>0.57**</td>
<td>-0.41**</td>
<td></td>
</tr>
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<td></td>
<td>(0.29)</td>
<td>(0.18)</td>
<td></td>
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<td>Informal</td>
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<td></td>
<td>-0.77***</td>
<td>0.45***</td>
<td></td>
</tr>
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<td></td>
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<td></td>
<td>(0.20)</td>
<td>(0.13)</td>
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<tr>
<td>Partners</td>
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<td>-0.39***</td>
<td>-0.34***</td>
<td>-0.37***</td>
<td>-0.59***</td>
<td>-0.13*</td>
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<tr>
<td></td>
<td>(0.10)</td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.08)</td>
<td>(0.17)</td>
<td>(0.07)</td>
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<td>Unitsize</td>
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<tr>
<td>Q.Staff * Comp</td>
<td>5.11**</td>
<td>4.65**</td>
<td>4.68**</td>
<td>4.14**</td>
<td>7.99**</td>
<td>6.51**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.37)</td>
<td>(2.30)</td>
<td>(2.30)</td>
<td>(1.87)</td>
<td>(3.61)</td>
<td>(3.10)</td>
<td></td>
</tr>
<tr>
<td>Q.Staff * Prod</td>
<td>-2.06***</td>
<td>-2.01***</td>
<td>-2.01***</td>
<td>-1.33***</td>
<td>-3.60***</td>
<td>-1.16</td>
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</tr>
<tr>
<td></td>
<td>(0.61)</td>
<td>(0.61)</td>
<td>(0.61)</td>
<td>(0.52)</td>
<td>(1.07)</td>
<td>(0.82)</td>
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<tr>
<td>Q.Staff * Out</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Q.Staff * Org Struct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.38*</td>
<td>0.55**</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>(0.81)</td>
<td>(0.27)</td>
<td></td>
</tr>
<tr>
<td>Q.Staff * Int</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R² (pseudo for probit)</td>
<td>0.551</td>
<td>0.538</td>
<td>0.556</td>
<td>0.708</td>
<td>0.653</td>
<td>0.469</td>
<td>0.276</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.408</td>
<td>0.414</td>
<td>0.414</td>
<td>0.614</td>
<td>0.269</td>
<td>0.179</td>
<td></td>
</tr>
</tbody>
</table>
Beginning with Model VII, we examine interaction effects with collaborative behavior variables. The only variable to exhibit significant interaction effects was Quality Staff; that is the only interaction variable shown in Table 3–7. In Model VII, both market overlap variables become statistically significant, although in different directions. Competitors shows a negative effect, while similarity of Products a positive one. Quality Staff and its interactions\textsuperscript{14} with the market overlap variables also become statistically significant in Models VII – IX, with the direction of the interaction effect the opposite of the main effect. With the addition of the number of Partners and frequency of Informal communication, Competitors fades from statistical significance, although its interaction with Quality Staff remains.

Models X and XI demonstrate no interaction effect for Tech Overlap, although Tech Overlap itself exhibits a positive effect on goal attainment. As usual, frequency of Informal communication and number of Partners are negatively related to goal attainment. In models XII and XIII, we see no individual or interaction effects based on social overlap.

Models XIV through XVII show some combinations of the overlap variables with controls and interactions. Competitors still exhibits a (weak) statistically significant negative relation, while similarity of Products a (strong) positive one, with the interactions in the opposite direction. Technical and social overlap measures are mainly absent with the exception of

\textsuperscript{14}Quality Staff was chosen initially as the closest approximation to initial collaborative behavior from a theoretical point of view and seemed to work better than any of the other variables as a moderator. To analyze the potential effects of multicollinearity, I ran a linear regression of the variables in the full model on the dependent variables, as recommended by Belsley et al. (1980). The interactions between the constant, Quality Staff, Intl, and Q.Staff * Intl exhibited some multicollinearity with the Belsley-Kuh-Welsch condition index in the highest factor of 435 for Strat and 473 for Tech and variance proportions higher than 0.73 each for those four variables. The effect of this multicollinearity is to inflate the variance estimates of those variables when all are present. It is unlikely to bias the coefficients.
similarity of Int’l cultures, which shows a positive relation with goal attainment. Quality Staff shows a consistent positive relation with perceived strategic goal attainment.

As Strat, or perceived strategic goal attainment, is measured on a five point scale, it may be argued that OLS regression is an inappropriate assessment technique for the effect of the independent variables despite its obvious benefits in assessing model fit and comparing models. To answer this potential criticism, I performed all of the above analyses using ordered probit regression and found that the results were strengthened significantly. That is, weaker statistical results in OLS ended up being stronger using ordered probit. Model XVIII gives an example of an ordered probit regression of Model XV.\textsuperscript{15} One can see that all of the effects of Model XV are mirrored in Model XVIII.

Model XIX is a model of the independent variables on perceived technical goal attainment. Competitors, once interaction terms are added, emerges as negatively related to both Strat and Tech, while the interaction with Staff is positively related to goal attainment. Outlook is positively related to technical goal achievement, while Org Structure has a negative relation with Tech. The frequency of Formal communication seems positively related to technical goal attainment, while the frequency of Informal communication seems negatively related to both Strat and Tech for the for-profit organizations.

Finally, Model XX shows a model of the independent variables on technical goal attainment for the 83 non-profits (universities, government labs, and other non-profits) in the sample. Both kinds of communication frequency exhibit the opposite relation between the sample of for-profit and non-profit organizations. In addition, Tech Overlap\textsuperscript{2} (i.e., extremely high and low values of technical overlap) seem to be negatively related to technical performance for the non profits. This, combined with a positive effect of Tech Overlap, would lead to a U-

\textsuperscript{15}This model had a likelihood ratio chi-squared of 64.3 and an Aldrich-Nelson pseudo-R\textsuperscript{2} of 0.653.
shaped effect of Tech Overlap on performance. Consistent with the previous models is Int1, which exhibits a positive relationship with technical goal attainment. Also consistent with the for-profits is Org Structure’s negative relation to Tech. Partners is also negatively related with Tech.

3.4.2 Discussion

The evidence from section 4.1 lends credence to some of the hypotheses of Section 2 while at the same time defying expectations in interesting ways. The basic idea of treating the overlaps as separate constructs with separate effects seems to be borne out by the results.

Hypothesis 1, or the effect of market overlap on performance, seems to be partially supported. Market overlap turned out to be more complex than originally envisioned and exhibited two components: rivalry and similarity of products. Rivalry is related to perceptions of partners’ market relations as a “competitor” rather than a supplier, customer, or unrelated. Rivalry’s effect, while being negligible by itself (Model I), is negative once an interaction term with Quality Staff is included. This is evident from Models VII–IX and XIV–XIX. The data support the difficulty of horizontal alliances between competitors. Similarity of Products, on the other hand, exhibits a strongly positive relation with the outcome once the interaction term is included. This is evident from the same models as those for Competitors.

From a theoretical perspective, the two effects described above make intuitive sense. Instead of “market overlap” being a monolithic construct, it is actually at least two separate constructs (cf. Chen 1996). It conforms with intuition that if we could control for the level of rivalry, similarity of products would actually be beneficial for producing high levels of performance. This is shown in Figure 3–2. In reality, as mentioned in Section 2, these two constructs are often correlated (r=0.41*** in this case) so it is difficult to find the full range of partners

130
representing the off-diagonal cells II and III. However, this analysis allows for some teasing out of the partial effects of each construct.

Figure 3–2. Combinations of rivalry and similarity of products and their effect on goal attainment

Technical overlap, at least the perceptual measure of it reported here, does not seem to have much effect either way on performance, except for an association in the non-profit sample. There are several potential explanations for this. First, it is likely that other measures, such as the similarity of products/services, outlook, and organization structure are capturing some of the explanatory power of technical overlap (highly correlated in the full and partitioned samples). This empirical fact has some merit from a theoretical perspective, as it is difficult to distinguish the resources of an organization from its structure and from its products or services (cf. Ulrich & Pearson’s [1994] “product archeology”). This is discussed further below. I ran other models with technical overlap substituted in for similarity of products; they exhibited much lower explanatory power.
Second, it could be that there are statistical problems with the measure having to do with testing the squared term and the interaction with staffing. I recentered the measure to zero to reduce correlation with the squared term, but the interaction term was correlated with technical overlap at 0.97, which could have a collinearity effect on the error variances. In any case, as the results stand, technical overlap appears to have little influence on goal attainment. For the non-profit organizations, the hypothesis seems to be weakly supported. Intermediate levels are associated with higher technical goal attainment, while low and high levels (entering through the squared term) are associated with lower goal attainment.

The evidence on social overlap is mixed. There seems to be broad support for the "national culture" measure. When the firms worked with firms from more similar countries (using the variance of Hofstede’s uncertainty avoidance scale and controlling for market overlap), the attainment of goals was generally higher. Similarity of outlook (way of conducting research and time horizons) between partners appears to have a positive influence on for-profit technical goal attainment as well.

Similarity of formality of organization structure (degree of hierarchy and importance of formal rules), however, provides very little explanatory power in the models run for this analysis. If anything, similarity of formality of organization structure has a negative effect. One potential explanation for this, again, is that similarity of organization structure is explaining some of the variance that would normally be attributed to technical overlap. Partners that are highly similar in formality of organization structure also tend to be highly overlapped in their technological portfolios (See Table 3–8 and its discussion below). The negative sign on the Org Structure variable (Models III, XIX, and XX) would therefore have more to do with the inability to exploit technical complementarities.
The above explanations hinge on the fact that the measurements taken in the survey are "impure" measures; they cannot precisely capture the nuances of the constructs we are most interested in. To test whether these issues of convergent and discriminant validity have any basis, I ran a factor analysis and examined the factor loadings of all of the overlap variables with a reduction to six factors (six being the number predicted in section 4 above with two market, one technical, and three social overlap variables) using varimax rotation. The results, shown in Table 3–8, confirm that technical overlap is intimately bound up with similarity of product, outlook, and, to a lesser extent, organization structure. The variables for rivalry and national cultural similarity do exhibit convergent and discriminant validity, while the others exhibit convergent but not discriminant validity due to the relation with technical overlap. Technical overlap exhibits neither convergent nor discriminant validity.

Table 3–8. Factor loadings for overlap variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
<th>Factor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitors 1</td>
<td>0.91</td>
<td>-0.03</td>
<td>-0.06</td>
<td>0.14</td>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td>Competitors 2</td>
<td>0.89</td>
<td>-0.01</td>
<td>0.23</td>
<td>-0.13</td>
<td>0.15</td>
<td>-0.17</td>
</tr>
<tr>
<td>Products</td>
<td>0.34</td>
<td>-0.01</td>
<td>-0.10</td>
<td>0.26</td>
<td>0.73</td>
<td>-0.28</td>
</tr>
<tr>
<td>Tech Overlap 1</td>
<td>0.14</td>
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<td>0.24</td>
<td>-0.15</td>
<td>0.82</td>
<td>0.09</td>
</tr>
<tr>
<td>Tech Overlap 2</td>
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<td>0.94</td>
<td>0.13</td>
<td>0.08</td>
<td>-0.02</td>
</tr>
<tr>
<td>Outlook 1</td>
<td>0.14</td>
<td>0.09</td>
<td>0.69</td>
<td>0.55</td>
<td>0.05</td>
<td>-0.25</td>
</tr>
<tr>
<td>Outlook 2</td>
<td>-0.01</td>
<td>0.17</td>
<td>0.22</td>
<td>0.91</td>
<td>0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>Org Structure 1</td>
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<td>0.14</td>
<td>0.18</td>
<td>0.04</td>
<td>-0.13</td>
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<tr>
<td>Org Structure 2</td>
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<td>0.05</td>
<td>0.04</td>
<td>0.18</td>
<td>-0.01</td>
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<tr>
<td>Int’l</td>
<td>-0.11</td>
<td>-0.11</td>
<td>-0.10</td>
<td>-0.06</td>
<td>-0.07</td>
<td>0.95</td>
</tr>
</tbody>
</table>

The data provide support for the influence of collaborative behavior on performance. Once interactions with the market overlap variables were introduced, the value of the quality staffing variable became positive and statistically significant (Models VII–IX and XIV–XVIII). My interpretation of this is that Qual Staff has both a direct and indirect effect. The direct
effect is simply the effect of sending the highest quality employees: it seems obvious that by sending higher quality employees, a firm would be more likely to attain its goals.

The indirect effect may be interpreted as a signaling effect consistent with the predictions of game theory and information economics discussed at the beginning of Part III. That is, by demonstrating a commitment to the relationship, positive benefits may accrue to mitigate the effect of rivalry and competition. These benefits are over and above any benefits gained by sending the highest quality employees. Figure 3–3 shows a depiction of this effect based on Model VII. When Quality Staff is at its lowest level (and all other variables taken at their means), the effect of Competitors is sharply negative; when Quality Staff is at its highest level, the effect is positive. This is based on linear regression results and shows one standard deviation around the mean of each variable; if taken to extremes, it could predict results out of bounds. A more obscure but accurate depiction of the effect is shown in Figure 3–4. At the lowest level of Quality Staff, changes in market overlap shift the response curve to the left (i.e., more likely to have lower performance). At the highest level, changes in market overlap shift the response curve to the right (more likely to have higher performance).

The evidence of the signaling effect is all the more compelling if we consider the theory from Part II. One would expect the process forms of collaborative behavior such as withholding of information and frequency of communication to have more of an interaction effect than the quality of staff, which is actually akin to an “initial collaborative behavior” effect. If as in Part II, however, performance is heavily dependent on the history of interactions between partners (Doz 1996; Ring & Van de Ven 1992), it makes sense that a partner’s first experience with collaborative behavior is also the most important. In the analysis run for this part of the dissertation, Quality Staff had far more predictive power as a moderator than any of the other collaborative behavior variables, underscoring the likelihood of signaling and path-dependency in technology collaboration outcomes.
Figure 3–3. Interaction effect between Quality Staff and Competitors depicted graphically
The frequency of informal communication was associated strongly with lower goal achievement in the for-profit sample (Models IV, V, IX, XI, XIII, and XVII). Furthermore, including this variable in any model increased the adjusted R-squared by more than twenty basis points, implying that it had fairly strong explanatory power. This puzzling result may be explained by the way employees within companies imagine that they accomplish work-related tasks. It seems plausible that, for example, the more applied development work associated with for-profit enterprises would not require extensive contact outside formal channels. Therefore, frequent informal communication may purely serve to distract from longer term goals.\textsuperscript{16}

There is some question whether collaborative behavior is exogenous to the models. In other words, do overlaps determine collaborative behavior, which then influences performance? If so, what is the net effect of the overlaps and collaborative behavior? To test this, I performed the following analyses: path analysis of a system in which collaborative behavior is endogenous (Figure 3–5); regression of overlaps on collaborative behavior (Table 3–9); and two-stage least squares regression of overlaps and fitted collaborative behavior on performance (Table 3–10).

None of these methods provided any evidence of the endogeneity of either of the two variables of interest, Quality Staff and Informal. Figure 3–5 shows that the unexplained variance of the collaborative behavior variables is 98%. Likewise, Table 3–9 shows that adjusted R-squared for the collaborative behavior variables is less than zero, a strong indicator that the overlap variables have no explanatory power. Finally, the two-stage least-squares

\textsuperscript{16}In all of these cases, the non-profit sample exhibited the inverse level of goal attainment. For example, frequency of informal communication was associated with higher levels of goal attainment, while frequency of formal communication seemed to negatively influence goal attainment for the non-profits. One explanation for this is that the culture of for-profit organizations' research may revolve around different methods of communicating information. It may be argued that within universities, much research-oriented technical work (compared to development-oriented work in firms) is executed outside of formal meetings; and that many formal meetings would only distract from the ability to get "real work" done (cf. Perlow 1995).
regressions of Table 3–10, while explaining some variance, are not nearly as good models as evidenced by comparing the R-squared and adjusted R-squared with those of Model XV. Therefore, I believe we can conclude that in this sample, collaborative behavior is determined by other factors than interpartner overlaps.

Figure 3–4. Interaction effect between Quality Staff and Competitors depicted graphically

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17There are some identification issues that require further exploration before trusting these two-stage least-squares results.
This fact has some interesting implications, not the least of which is that some firms choose to act collaboratively with their partners, while others do not. Interpartner characteristics are poor predictors of when this collaborative behavior will happen. Most likely, this would be
dependent on specific characteristics of the focal firms and of the personalities of the managers within them.

Table 3–9. Effect of interpartner overlaps on collaborative behavior for 38 business units undertaking collaborative ventures in Europe
std. errors in parentheses, (**p<0.01, *p<0.05, p<0.10).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Quality Staff</th>
<th>Informal</th>
</tr>
</thead>
<tbody>
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<td>Competitors</td>
<td>0.37</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>(1.40)</td>
<td>(1.18)</td>
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<tr>
<td>Products</td>
<td>-0.13</td>
<td>-0.20</td>
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<tr>
<td></td>
<td>(0.32)</td>
<td>(0.27)</td>
</tr>
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<tr>
<td></td>
<td>(0.35)</td>
<td>(0.29)</td>
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<tr>
<td>Outlook</td>
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<td>(0.33)</td>
<td>(0.28)</td>
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<tr>
<td>Org Structure</td>
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<td>0.40</td>
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<td></td>
<td>(0.36)</td>
<td>(0.31)</td>
</tr>
<tr>
<td>Int’l</td>
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<td></td>
<td>(0.90)</td>
<td>(0.76)</td>
</tr>
<tr>
<td>R²</td>
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<td>0.094</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>-0.087</td>
<td>-0.108</td>
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</tbody>
</table>

3.5 Conclusions

3.5.1 Summary

Table 3–11 summarizes the results of this study. The effect of competition and rivalry on performance of technology collaborations is strongly supported, leading to two main implications. The first is that it is very difficult to successfully manage horizontal technology alliances, even “upstream,” or so-called “precompetitive” alliances.¹⁸ The second is that, while it is tempting to search for partners with complementary technical expertise, more attention to

¹⁸Most of the alliances in this sample having firms as partners were classified by the European Union as “precompetitive.”
market positioning and potential entry is warranted. The relation between technical overlap and performance was shown to be quite weak.

Table 3-10. Two-stage least squares analysis of strategic goal attainment for 38 business units undertaking collaborative ventures in Europe

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Strat</th>
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<td>Competitors</td>
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<td>(16.79)</td>
<td>(15.82)</td>
</tr>
<tr>
<td>Products</td>
<td>10.94**</td>
<td>-0.56</td>
</tr>
<tr>
<td></td>
<td>(4.04)</td>
<td>(3.26)</td>
</tr>
<tr>
<td>Int’l</td>
<td>3.72**</td>
<td>2.92*</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(1.69)</td>
</tr>
<tr>
<td>Fitted Staff</td>
<td>5.73**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.17)</td>
<td></td>
</tr>
<tr>
<td>Fitted Informal</td>
<td></td>
<td>-1.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.60)</td>
</tr>
<tr>
<td>Partners</td>
<td>-0.40***</td>
<td>-0.29**</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Interaction w/ Competitors</td>
<td>0.72</td>
<td>-0.49</td>
</tr>
<tr>
<td></td>
<td>(5.36)</td>
<td>(7.53)</td>
</tr>
<tr>
<td>Interaction w/ Products</td>
<td>-3.55***</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>(1.33)</td>
<td>(1.71)</td>
</tr>
<tr>
<td>R²</td>
<td>0.439</td>
<td>0.306</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.288</td>
<td>0.119</td>
</tr>
</tbody>
</table>

(std. errors in parentheses, (**p<0.01, *p<0.05, *p<0.10).

The effect of social overlap on performance show mixed support in the dataset. There does appear to be a fairly strong “national cultural” effect of firms performing better with organizations from “similar” countries (or, at least, from countries whose business employees hold similar attitudes about work). The role of similarity of time horizons / way of conducting research was generally positive, while the role of similarity of “formality” had different effects on strategic and technical goal attainment.
Finally, the role of collaborative behavior, especially initial collaborative behavior in the form of quality staffing, is borne out as directly and indirectly influencing performance. Collaborative behavior generally has a positive relation with goal attainment, while also moderating the effects of the structural characteristics or initial conditions. In general, collaborative behavior is most valuable as a moderator when the structural characteristics are most unfavorable. Thus a successful firm pays attention to both market and social overlap characteristics as well as collaborative behavior techniques.

Table 3–11. Hypotheses and results based on the 1996 survey.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1. Market overlap</td>
<td>Competition and rivalry exhibits negative effect, while similarity of products exhibits positive effect.</td>
</tr>
<tr>
<td>H2. Technical overlap</td>
<td>Not supported. Variance explained by other constructs.</td>
</tr>
<tr>
<td>H3. Social overlap</td>
<td>Overlap of country “similarity” and “outlook” are positive.</td>
</tr>
<tr>
<td>H4a. Collaborative behavior direct effect</td>
<td>Initial collaborative behavior (quality staffing) exhibits positive effect</td>
</tr>
<tr>
<td>H4b. Collaborative behavior moderates effects</td>
<td>Interactions with market overlap variables in opposite direction from main effects.</td>
</tr>
</tbody>
</table>

3.5.2. Limitations and further study

This study has some important limitations. The findings discussed above are undoubtedly influenced by the context of European technology collaborations and about the specific method used to collect the data as described in section 3 above. Generalizing from the results of this study may be limited by the following issues: possible selection bias for email addresses, possible non-response bias(es), single-respondent bias, common method variance bias. I discuss each of these in turn.
The first potential limitation of the study is the sample selection discussed in section 3 in which only potential respondents with published email addresses were contacted. As I have a list of participants both with and without email addresses, the first analysis I undertook was to compare demographic characteristics of those two groups. The demographic characteristics I used were the number of partners, the geographic origin (country) of the organization, and the organizational form. Probit models of having email based on number of partners revealed a slight bias toward having fewer partners (with p<0.01), that is, the people in my database who had published email addresses were affiliated with projects employing a slightly lower mean number of partners. This is rather hard to interpret, but is given as an empirical observation. There was no geographic bias based on country dummies. It was, however, more likely for the universities (p<0.01) and non-profits (p<0.05) to have email addresses. In the future, I would like to contact a random sample of participants who did not publish email addresses to see how robust the results are across these two groups.

The second potential source of bias is the probability of responding to the “contact letter” given that the participant had a published email address. As one might expect, there is a slight bias toward fewer partners (with p<0.05). As the time estimate for completion of the survey was based on the number of partners, it appears that the time estimate had the effect of scaring off more of the respondents whose projects had relatively larger numbers of partners. There was no geographic bias based on country dummies.

The third area of potential bias is the probability of agreeing to take the survey given that the respondent actually replied to the contact letter. Here there were no discernible sources of bias based on number of partners, country of origin, or organizational form (dummies for universities, for-profits, and all others). The final sampling issue of (non-) respondent bias is the issue of the probability of completion of the survey given that the respondent agreed to take
it. Again, here there are no discernible sources of bias based on number of partners, country of origin, or organizational form.

There is the possibility of a single-respondent bias. Using the only practical way available to me of collecting the cross-sectional data relating to my specific research questions (cf. Huber & Power 1985), the data for each alliance were gleaned from a single source: the R&D manager, supervisor, or executive directly responsible for the alliance. The results reported in Part III are based primarily on the respondents’ perception of organization-, interfirm-, and alliance-level phenomena. In the future, I would like to corroborate a random sample of question responses via both primary (other participants within the same organization) and secondary (archives, press articles, and my own database) sources.

Another threat to validity of the study stems from common-method bias, that is, the bias that may occur when both dependent and independent variables are collected simultaneously using the same method, in this case, the questionnaire. There are three factors working to mitigate this effect, however. First, the questionnaire was rather long, taking about one hour to complete, and asked about additional aspects of the projects than those reported here. Second, in addition to perceptual data, the questionnaire contained questions on more “objective” data, such as patents, publications, license revenues, etc., as enumerated in section 3 above. Finally, the questions were arranged carefully in order of increasing sensitivity. Goals were ascertained before asking how well they were attained, which preceded questions relating to collaborative/opportunistic behavior (cf. Parkhe 1993). These factors may have made it more difficult to guess the purpose of the study.

In summary, the work presented here is a preliminary but important first step in the analysis of technology collaborations and consortia. The results of this study provide evidence that
interfirm characteristics — especially market overlap — and expected collaborative behavior are important to the achievement of technology collaboration goals.
References


Appendix A. Public sources consulted

The following public sources were also consulted or quoted in this analysis. Please contact the author for more information.

*AI Expert*

*American Machinist*

*Business Week*

*Business Wire*

CadCorp, Inc. “CADCORP Says Its Program Goes beyond Traditional CAD,” 1994


*Chicago Sun Times*


*Computer-Aided Engineering*

*Computer Reseller News*


DefensePower, Annual Reports, 1992, 1993

DefensePower, Fact Sheet, 1993

*Digital News & Review*

*Electronic Design News*


*European Report*

*Financial Times*

*Forbes*
Fractal, "Research in Computer Science and Control," 1993

*Industrial Engineering*

*Industry Week*

*Los Angeles Times*

*Management Matters*

*Management Today*

Mantronix, Annual Report, 1993

*Modern Machine Shop*

*New Technology Week*

New York Times

ObjectDB Team, "The ObjectDB Project," 1993


ObjectDB Technical Report, "Virtual Schemas [sic] and Bases," 1993


*Orlando Sentinel Tribune*

*Penton's Controls & Systems*

*Plastics Technology*

*PR Newswire*
Prodco, Annual Report, 1993
Product Data International

*Software Magazine*

Sprockets 1991 Placement Manual
Sprockets Annual Reports, 1992, 1993

*Tech Transfer Report*

Uni-SW. (1993). *Innovation zeigt Struktur*


*Which Computer?*
Appendix B. Interview topics

Here is the prepared list of topics for the interviews. In general, I tried to cover most if not all of the questions in part 2 below, but did not do so in any particular order, as I did not want to constrain the conversations too much.

1. overview of research and thesis direction
   technology collaborations
   plan: a case study of one European and one American project in software technology.

2. general questions and answers (open-ended)
   Q. How did you come into the job you have right now?
   Q. Tell me about your market.
   Q. Tell me about your partners.
   Q. What are the biggest areas of success of your alliance projects?
   Q. Can you think of one alliance project that was a big success? Which one? Describe.
   Q. What sort of projects are the most successful?
   Q. What are the biggest problems you have in general with your alliance projects?
   Q. Can you think of one project that was a big failure? Which one? Describe.
   Q. Is there any particular type of collaborative project that does not work well in general?
   Q. How do you know if a project is a success or not? Who determines that it is so?
Q. What are some factors you would like to use to evaluate projects?

Q. What non-ESPRIT [ATP] collaborations are you currently involved in? How do those compare with ESPRIT?

Q. Do you participate in French-only (or whatever country) efforts? How are those efforts different? [For Americans: Do you participate in any international efforts?]

Q. Who determines the direction of the research projects? How does an ESPRIT [ATP] collaboration work in terms of process of deciding what to do and how to do it?

Q. Do you think that ESPRIT [ATP] itself is a success? Why and/or why not?

3. specific questions and answers

list of successes and failures

most relevant for you? tell stories

most relevant for others? tell stories
Appendix C. Interviewees and their roles

<table>
<thead>
<tr>
<th>Partnership</th>
<th>Role of interviewee</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMP</td>
<td>(1) Project coordinator, Sprockets</td>
</tr>
<tr>
<td></td>
<td>(2) Researcher, Sprockets</td>
</tr>
<tr>
<td></td>
<td>(3) Chief technical coordinator of CIMP, project leader, Mantronix Research</td>
</tr>
<tr>
<td></td>
<td>(4) Project leader, CadCorp</td>
</tr>
<tr>
<td></td>
<td>(5) Investigator, CadCorp</td>
</tr>
<tr>
<td></td>
<td>(6) Senior manager, Prodoc Information</td>
</tr>
<tr>
<td></td>
<td>(7) Vice-President, R&amp;D, Cimtools</td>
</tr>
<tr>
<td></td>
<td>(8) President, Cimtools</td>
</tr>
<tr>
<td></td>
<td>(9) Project manager, Riscy</td>
</tr>
<tr>
<td></td>
<td>(10) Researcher, Riscy</td>
</tr>
<tr>
<td></td>
<td>(11) Vice-President, Business Development, Three-D</td>
</tr>
<tr>
<td></td>
<td>(12) Project leader, SystemSW</td>
</tr>
<tr>
<td></td>
<td>(13) Senior R&amp;D manager, Mantronix</td>
</tr>
<tr>
<td></td>
<td>(14) President, Cimco</td>
</tr>
<tr>
<td></td>
<td>(15) Vice President, R&amp;D, Cimco</td>
</tr>
<tr>
<td></td>
<td>(16) Director of External Projects, FEA</td>
</tr>
</tbody>
</table>
OBJECTDB

(1) Chief coordinator of project, senior manager at Computation

(2) Head of software engineering research of SoftJV

(3) Director of SoftJV

(4) Research manager, Multisoft

(5) Vice-President, R&D, DataBase

(6) Project coordinator, DataBase

(7) Technical director, OBJECTDB, and professor, Uni-DB

(8) Project investigator, Uni-DB

(9) Project investigator, professor, Uni-SW

(10) Project leader, Uni-SW

(11) Project manager, Europe Air

(12) Research director, Fractal

(13) Project leader, Uni-Mount
(1) President, Ricerca
(2) Director of External Cooperation, Informatique
(3) Project Officer, Commission of European Communities (CEC)
(4) Manager of External Cooperation, Informatique
(5) Director of Strategic Planning, TDF
(6) OBJECTDB Project Officer, CEC
(7) CIMP Project Coordinator, MSI
(8) Director of Software Research, U.S. Telecoms
(9) Telecommunications Policy Officer, CEC
(10) Director, Electronic Data Institute
(11) Academic Consultant to ESPRIT
(12) Director, R&D, Ricerca
(13) Project leader, Ricerca
(14) Assistant Director, ItalData
(15) Researcher, Informatique
(16) Director of Corporate Strategy, ItalSteel
(17) Manager of Scientific & Technical Development, Informatique
(18) Project leader, Design Subsid
(19) Researcher, Ricerca
(20) CEO, Mantronix Germany
(21) Director of International Development, ScanTel
Appendix D. Coding categories

- Personal (P)
  - competition & markets (O-CM)
  - technology (O-TO)
  - social, cultural, and communication (O-SC)
  - goal statements (O-GO)
  - performance, goal attainment, and outcomes (O-P)
  - process issues (O-PI)
    - collaborative behavior (O-PI-CB)
    - dynamics (O-PI-DY)
    - all other process issues (O-PI-PI)
  - experience (O-E)

- Organizational (O)
  - consortium (A)
    - competition & markets (A-CM)
    - technology (A-TO)
    - social, cultural, and communication (A-SC)
    - goal statements (A-GO)
    - performance, goal attainment, and outcomes (A-P)
    - process issues (A-PI)
      - collaborative behavior (A-PI-CB)
      - dynamics (A-PI-DY)
      - all other process issues (A-PI-PI)
Appendix E. Example of codes and inter-rater reliability

Excerpt from interview with Zeenath Srinivasan
Vice-President, Cimtools

<table>
<thead>
<tr>
<th>CT initial code(s)</th>
<th>SK initial code(s)</th>
<th>Final code(s)</th>
<th>Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-SC</td>
<td>A-SC</td>
<td>A-SC</td>
<td>_____ at Cimco would be a good person for you to talk to. He’s very nice and has also been a tenacious voice for the smaller companies given the huge manufacturing concerns we’re involved with on this project...</td>
</tr>
</tbody>
</table>

[How did you get involved in this company?]  

P  P  CL  It’s a long story. I was in the Indian Army and am now retired from the army. I was working with computers. When I retired, I joined ICL, which was the largest computer company outside the US. I found myself with ICL back in the military, installing computers for the Army, and ran quite a few large projects. But after a while, I and several others did not agree with the company’s policy on SW, so we sold ourselves as a bundle.

O-GO  P  CL  I had an old friend and colleague named _____ who at the time was the VP of CALMA, which was eventually taken over by GE. He took the company from $1M to $160M. _____ eventually fell out with Jack Welch. So we set up a company to do automation and technical projects. I joined the highest-funded SW startup in Silicon Valley. It was to do sold modeling, analysis, and mfg. There was no suitable systems architecture at that point, and we were targeting companies like IBM for customers. We had about 120 people. Finally, though, we ran out of money and closed.

O-PI-PI  O-SC  O-SC  Seven of us, though, stayed in touch with our customers. Morgan Stanley, who was one of the original funders, agreed to fund us with the support of our customers. We bought the rights to the technology we had developed under the bankruptcy court. This was in 1990.
This is what we wanted to do with the original company. It was a huge task! There was no language, so we had decided to develop our own. We were going to work on CAD, on analysis, and on CAM, develop our own proprietary DB system, and our own user interface and graphics. We were going to work on IBM systems, on MVS, VM, and UNIX and have ports for all of those operating systems.

In the new company, we decided to cut this rubbish. (Re-edits the diagram.)
Once we had cut all of that rubbish, we decided to go with C++ instead of our proprietary language, an OODBMS instead of our proprietary DB, and X-Windows instead of our own UI. We focused on our real strength, which was CAM on UNIX workstations. We have the most advanced mfg system in the world. We’re CAM, but not with a modeler.

So we constructed gateways to three major packages...

They don’t have a manufacturing package.

We were pulling the feature-oriented design out of them and put into CAM. Our strengths are in math and solid-feature recognition. We take what materials are needed, machines available, and tools, and generate the tool path.

The initial customer base was people who are on our Technical Advisory Council. There was Planeco, Sprockets, Mantronix, CTC. Some customers were horrified at our limited scope, but most were quite enthusiastic about it.

Our new product was launched about 2 to 3 yrs ago and we are selling to the mfg marketplace. Mfg people are the most cautious people you could ever come across. They have to be. They are the cost center. They’re not design engineers. They are kick-the-tires kind of guys.

But we built up a good customer base with the mfg people. We have 3 sites at Planeco, and 1 each at Defense1, Joe’s Milling Machines, Prodcot Motors, DefensePower (Charlie Smith’s group. He’s a nice guy.) Huckster Automotive, OldIT, and possibly Riscy.
I guess it reads a bit like the Fortune 100. They told us "you guys know what you're talking about." How can you ignore that? We went from version 5.0 to 5.2 to 6.0 to 6.1, which is out there now and is very good. We want it to be our version of Word Perfect 5.1.

I do everything at this company that no-one wants. I inherited everything that no-one wanted. Documentation, training, field support, consulting. I'm running the consulting business right now because we have to do both people and products. Did we over-focus on people in the old company? I think not. There's a trend toward selling services in the computer arena. Most mfg companies' staff are pared down on fat. Mfg is so lean that when someone is sick, your whole operation can get into trouble. These companies are willing to pay for service.

Not only for financial reasons. They could also be concerned with time-to-mkt and quality. It's the better soln for them. In fact, we refuse to sell just the product. Well, that's an exaggeration, but we do want the follow-on work.

Beta is the best success in the industry. And 40% of their revenue come from services despite the fact that they have the most fantastic product.

The companies that make the three products listed on the board there [Beta, CompuViz, Unicorn]. But, how many things can you be good at? We have a brilliant development team. I'm very fortunate to work with talented people. But, the whole thing is summed up by a customer talking about a CAD company. "They don't understand mfg. They have brilliant young guys who understand CAD and math maybe. But 10-20 yrs on the shop floor is the only way to learn about mfg."

We have no joint marketing arrangements with the other companies in the consortia [misunderstanding my question perhaps]. Beta was supposed to be a member but did not join at the contractual stage. Still, the software companies don't exhibit the same behavior that Mantronix & Prodco do!

The relations with end-user companies fall into three segments: (1) Integrated data model (IDM), (2) knowledge-engineered applications (KEAs), and (3) linked mfg (LM). There are projects in CIMP in all of these areas.
As far as results go, we’ve done some prototyping work with Riscy that was not very successful. [Why?] The amount of resources that either of us could devote to the project was severely limited. The nature of their work is too specialized. It might have been showy R&D, but it wasn’t applied enough for us. Particularly for vendors, we need to see something of commercial value. We need to see good results.

On the other hand, we had a very good prototype with DefensePower. It demonstrated the things that CIMP is about. It wasn’t just using our product. It was integrated with the IDM. Last October we did the demo. Mantronix started it with a part, put it into PDES, Prodcos Parts changed it, DefensePower did something with it, then finally Cimtools made the machine tool.

CIMP should be about integrating existing technology, not writing new ones. This demo led to a product with DefensePower.

[What were your strategic goals for CIMP as you entered into it?]

We’re a product-based company. We wanted to see better, to gain insight into the needs of end-user companies. In statements, they need to think about it [?].

Equally, it is nice to be associated with a program such as this one. It helps for recognition. If we can say, ‘hey, we’re in CIMP,’ that buys us a lot of credibility. It has helped for a few customers.

Equally, seed programs such as this teach us how to get productive capabilities and integrate with other vendors. The applications of other vendors have been more flashy. DefensePower is using ProE but Beta isn’t involved in the project, and besides, they don’t do as much mfg. Sprockets uses Unicorn but they’re not a member of the consortium. It’s still within the project objectives to interface with ancillary vendors.

[What were your technical goals?]

These are summed up by the IDM. There is a new emerging standard called PDES-STEP which is taking the place of an older one. That one did excellently for the years in which it was written. We wanted to get involved with the first work on the standard.

We also wanted to learn how our product should evolve in that area.
Technically, obviously, we wanted to learn of requests for our product in the automobile and the aerospace industries. To know people in the auto industry.

In CIMP, you have a different relation with those companies than when you’re peddling products. In the Steering Group that you attended this year, well, we’re constrained by size and by cash for what we can attend. It is not inexpensive to attend these meetings. Even if the govt is reimbursing us at 40% of expenses, we still have to fly out there, stay in a hotel, and all those other expenses.

But being out to talk, talking in a totally different fashion than if you were, and I’ll say it again, peddling products. There are more joint interests involved.

[Have any of your goals changed?] No, I don’t think so.

[How well have you met your strategic goals?]

(Long pause.) (Feeling uncomfortable.) We have met them reasonably well. Our frustration with the program really comes from the small company – big company problems. We are light, we can travel very fast and make decisions like that [snap]. We run a very flat organization, if someone needs help, or needs a decision, we can do it. Of course, Jan Uretski is still the president. But we can move and put some of our resources toward a pressing problem.

We get impatient with the rate of progress sometimes. The large companies have their agendas and sometimes it is difficult to understand what they are. Now, the guys on the Steering Group are excellent: live, bright, dedicated, but it’s the nature of the organizations they come from. They are very large and slow and hard to move.
Another great frustration is the funding aspect of the project. The govt refunds 40% of our costs of working on the project. They are extremely slow in response. It is run through several layers of govt. There is it is run through the Dept of Commerce, through the ATP and is administered by NIST through MSI. You see, I send in my costs to _____. She’s very good, and just the right person to run this project. But she then saves up the reimbursement to send in with other companies’ reimbursements, and she wants to get a pool of them together, which is understandable. But by the time she gets enough of them together, we’ve waited for a very long time, and it’s something that a small company simply can’t afford. The govt is also very slow in response.

[How well have you met your technical goals?]

Let me quantify that. Mfg follows design. They feed off data, or PDES IDM. We have our activities, which were so far prototyping activities. We see ourselves as playing, doing more in the later days of the program rather than in the earlier ones.

[What benefits have accrued to you because of the program?]

Some here, certainly.

Yes, stds very important, as well as linking developers and users of new technology. Access to new markets, certainly, but I mean that in a broader sense than just geographic or even products. Yes, I admit, subsidies and financial incentives are also important. I know what I said about the govt reimbursements, but the fact is that some of what we do can be used in other markets as well. Oh, I don’t know why I didn’t say capability building before. That’s also one. Risk sharing isn’t really relevant to our program.

[How about pitfalls?]
We don’t have conflicts between the venture and the parents, obviously. Communication problems and procedural conflicts are there, definitely, due to lack of resources. It’s because of our size. If someone has something that needs to go into production, we have to work on that. There’s a danger of being in a small company and having partnerships with large ones. If a small company, and I mean any company of say 20 people, not just ours, becomes enamored of a big one and starts to woo a large hardware vendor, well, the large company can just put 5-6 people on the project that completely swallows it [the small company]. If the partnership doesn’t work out, the small company can fail.

Notes on this initial round of coding. The assistant, not being as familiar with the projects and acronyms, assigns many more codes than I do, possibly in an attempt to avoid missing a code. We can calculate a couple initial measures of inter-rater reliability based on the first two columns (cf. Miles & Huberman 1984, p. 63). First, if we count how many times we agreed at least once on a paragraph against how many times we disagreed completely on a paragraph, we have 26 / (26+11) = 70.3%. If we count how many times my coding appeared within the assistant’s, we have 30 / 52 = 57.7%. Finally, if we count how many times we agree and disagree within each paragraph, we have 26 / (26+30) = 46.4%. These are acceptable for initial attempts at a new coding scheme (Miles & Huberman 1984). The next excerpt is from a later attempt at coding.
Excerpt from interview with Elmer Quinn
Director of Business Development, Three-D

CT code(s)      SK code(s)

[What do you do in your job?]

P P Director of business development, adjust to new products and new markets

[What is your background?]

P P Software development..

[You moved over to business development which is more of a long term, more strategic approach. You’ve been working at 3-D for a long time?]

P P Two years and two weeks.

[Can you tell me a little about the industry that you are in? One thing I don’t understand very well is how the various software companies in CIMP interact with each other in terms of the market. For example, the CAD Tools market, I guess. I’m not sure exactly where 3-D fits in the whole picture of CAD, CAM, integrating them.]


We’re what you call an enabling technology. What that means is that we enable other people to do things for that market. A GUI tool kit, and Internet are enabling technologies...allowing people to communicate better. A lot of toolkits go inside of CAD, CAM and CAE systems so that they build better products for their market places...

[So you are a supplier to CAD tool developers.]

O-CM O-CM O-GO

Yes, we sell OEM only, we sell to people, to package our products into theirs and sell it to the market.

[Who would you say are your biggest market competitors right now, if any?]

O-CM O-CM O-P

Well, there really aren’t any because _ is about 15 1/2 million dollar investment at this point and we are so far ahead of the game, by virtue of the number of companies that use our products. There are other tool kit technologies that do geometric modeling but you can count their customer list on one hand as opposed to our 270+ customers.

[You are the dominant player.]
We call ourselves the standard because we have literally hundreds of thousands of products with our products in it being used at the industry already.

[What are your market relations like with other CIMP partners?]

For the most part, through CIMP only. That’s one of the reasons why we, as a business development function, get involved in those kind of consortium because they provide you with avenues to meet people you wouldn’t normally otherwise meet. Risco, for example, is almost strictly a Beta Technology user. We are in CTT products we may never be...you never know. So, our products’ technical relationship is zippo with the others. We would like it to be otherwise but it will never be otherwise if we don’t know some of the people. So there are business needs.

One the other side of that spectrum, some of them use our products, some of them don’t, but all of them use products that have our products in it. But there are certainly other groups who have no idea, and no need and no use of products that have mine in it. But at the other end of the scale from CTT based Risco, is Mantronix, who has an internally developed CAD called ManDraft which uses my products. So they use it in a lot of places.

[Do you have previously established business relationships with the other software companies?]

For the most part, no. It’s not necessarily a requirement. In other words they are in somewhat different enough markets they don’t need a modeler in their products. The one that really did is CadCorp and in one of the CIMP products because they needed it, was to get CadCorp to have a version that has _ in it. And so largely why it was executed, and now CadCorp, SAGEL and my company are in formal business negotiations to commercialize that product for CadCorp. So CIMP specifically, I don’t know that we wouldn’t have gotten it without them, but certainly that led up together.

[Sounds like one your strategic goals is simply to establish some sort of relations with potential customers for projects like these in your collaboration.]

It’s nearly the exclusive goal. What else would we be in for?

[Are there any other strategic goals you have for this particular project?]
I think from a strategic technology development perspective, a gain that right up there with revenue (however, without the revenue side we wouldn’t be doing it), is to stay in tune with what large manufacturing companies demand in terms of technology today and tomorrow. So that clearly is a goal and that’s one of the reasons I’m involved because I have a technical background. For example, we had a workshop last week in interoperability. Very valuable for our company from a strategic playing perspective bc it tells where these people want to be going five years from now. Again, we wouldn’t get that information otherwise. We could hire any number of consultants and still never get that data.

[Can you tell me what are your technical goals for participating in CIMP?]

My job is new business, new products and new markets. Technology, what they call pre-competitive technology, is developed through the umbrella of CIMP projects. I have a specific and a general goal of commercializing those technologies as they become viable and fit my needs. So things will appear and things have appeared which have commercial viability in my market niche. I would like to have the option of getting down technologies and choosing to bundle them if I wish and selling them.

It’s a very well run program. It’s very hard to get companies who are competitors in the same room and consort. ____ and MSI does a very good job. Bottom line is, if they are sort of a mutual contribution type of program, they work very well.

[How many other consortia have you been involved in your positions.]

Well in my position, none because it’s only two months old. When I was doing marketing here, we were in involved, trying to get involved in three other programs, two of which died one of which still exists and is questionnable how long that will live but these programs come and go.

[Some of them are not suppose to last long time.]

No, they never got off the ground because you have to have a synergism that includes mutually consistent goals. If you don’t have that synergism you can’t consort.

[How have your relations with partners changed over time, if they have.]

It’s sort of the same answer to the same question you asked before. We take Riscy, for example, they’ve gone from zero to friendly, personal, regular interactions. Compared to ProdCo it’s similar. In the case of PRAD, better establishing a relationship. In the case of Mantronix it’s the same people, same type.
[So there seems to be this aspect of this being sort of linking developers and users of new technology. There’s also an aspect of plain social networks.]

A-PI-DY  A-GO
A-GO  A-PI-DY

Well, everything in business is networking, certainly it helps but bottom line is a prospect starts with a name and develops into a lead and then develops into a sale depending on relationships, need and product availability. It’s an allusion to need. CIMP exhibits some, has a few members who, all CIMP members fall somewhere on that spectrum but they all start with network and a contract.

[Do you feel that so far the program so far has met the technical goals that you had in mind when you started the project?]

A-P  A-P

Yes. We’ve had a lot of good feedback on our product and a lot of input on where I see the direction may go. Some of them were in discussion right now about picking it up under them and selling it.

[Can you tell me about technical synergies or compatibilities that you’ve seen, experienced with the project?]

A-CM  A-TO
A-PI-DY  A-P
A-TO  A-PI-DY

Mantronix, Prodco, Prodco Parts is separate unit within Prodco whose mission is to produce parts and sell them as separate and P&L to other [manufacturing] companies. And as such, they have a very strong requirement to share CAD information. Through the sharing of CAD information, they, Mantronix already had it, but Prodco recognized the value of using our products...it could have been a lot of different modellers and our product became a very important of the process of sharing a model between Mantronix and Prodco. Now, CIMP develops pre-competitive technology so it’s not to suggest it’s being used in production but it has opened the eyes of both groups how important our story is in large manufacturing companies to have lots of suppliers and opened the eyes of Prodco in terms of alternatives to forcing files to go through a particular format or an alternative to forcing a particular standard or an alternative to forcing suppliers to buy the same product.

[As you said, the fact that you are still part of it is a testimony, that there were some amount of synergies at least.]

A-SC  A-TO
A-GO  A-GO
A-SC

Well, if the thing wasn’t based on, wasn’t leveraging technology that I supplied, I would have no revenue potential and I wouldn’t be doing it. We’ve got everything down to what’s the value to my company. We have 50 people in this company, it’s not like we’re Prodco and if I can’t point specifically to revenue I either do it and get fired or don’t do it.

[First, let me ask you about these some of these pitfalls or incompatibilities. Which one of these do you think are relevant to CIMP and which ones are irrelevant?]
There are occasional conflicts between partners. Typically there aren’t any technical conflicts. We’ve rarely had a business conflict. Do we want to build something one way or another way? Not unlike engineers within one company. It has appeared and it is important.

Lack of trust is more obvious earlier in the game, when you are all getting to know each other, building relationships we talked about before definitely disappears pretty quickly and I haven’t seen it in a year, I suspect. Let’s not be fools. I suspect there is not a lot of “trust” about, the way I’ve dealt with it, by the way, people know better than to talk about proprietary things. There will be a discussion and the guy will stop and say, ‘I guess I’ll have to change my line of thinking here because I think that’s proprietary.’ So, you know, he can’t make the point without exposing anything.

Notes on later rounds of coding. This is a typical example of a spot check during later rounds of coding and demonstrates a substantial improvement in reliability over earlier attempts. Using the same three measures as above, we have:

1. percentage of agreement at least once per paragraph: \( \frac{23}{23 + 0} = 100.0\% \)
2. percentage of my codes appearing: \( \frac{34}{38} = 89.5\% \)
3. percentage of agreement and disagreement: \( \frac{23}{23 + 14} = 62.2\% \)
# Appendix F. Necessary features of an OODBMS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. the ability to handle complex objects</td>
<td>objects grouped together with various constructors</td>
</tr>
<tr>
<td>2. “identical” objects</td>
<td>where identical objects are actually represented in one data structure</td>
</tr>
<tr>
<td>3. encapsulation</td>
<td>as above</td>
</tr>
<tr>
<td>4. types or classes</td>
<td>types referring to certain kinds of predefined abstract data types as in programming language types of integer, real, character, etc.; classes refer to generic kinds of objects — such as the “parent object class” mentioned above — and can be generated or changed in real-time</td>
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<tr>
<td>5. hierarchies</td>
<td>as above</td>
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<tr>
<td>6. “late binding”</td>
<td>not assigning “names” or “types” of objects to certain procedures until they are needed</td>
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<tr>
<td>7. computational “completeness”</td>
<td>being able to express all computable expressions in the database language</td>
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<tr>
<td>8. extensibility</td>
<td>no distinction between user-defined and system-defined types</td>
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<tr>
<td>9. persistence</td>
<td>allowing all objects to “remember” their data</td>
</tr>
<tr>
<td>10. secondary storage</td>
<td>handling large databases transparently</td>
</tr>
<tr>
<td>11. concurrency</td>
<td>allow more than one simultaneous user</td>
</tr>
<tr>
<td>12. recovery</td>
<td>from hardware and software failures</td>
</tr>
<tr>
<td>13. the ability to answer ad hoc queries</td>
<td>allow interactive</td>
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</table>
Appendix G. Typical interaction between Uni-SW and DataBase

To: newdbline@dbco.com
Subject: Report on severe bug in NEWDB-C++ Interface V 4.4.b

I came along a severe bug in the above release which I would need to draw your attention on and which we need to have fixed.

The bug is in the export mechanism. Consider the following example:

<lots of C code>

The following compiler error occurs, if one tries to compile class B:

<error messages>

The reason for that is the last include directive in class A which includes class C. This causes the pre-processor to try to include class B in order to define it, but the macro B_HXX which has already been defined in the first round prevents B’s definition to be included again.

I actually cannot see a reason, why you include the forward referenced class definition in the header file and not in the code file. This would solve the problem from my point of view. It would moreover make the object code more dense.

Regards,
Anna

P.S. The makegen tool does not work at our site either. There seem to be a bug in the mechanism used to override pre-defined values. I tried for instance to customize the CC invocation command from /tools/bin/CC to CC in the $NEWDBHOME/lib/sparc_sunos_41.site.cf, but makegen ignored my definition.
The bug hotline replied,

To: escoto@Uni-SW
Cc: <big list>
Subject: Report on severe bug in NEWDB-C++ Interface V 4.4.b

Your bug description has been transmitted to the technical team. It will be fixed in a new release beginning of January.

For the makegen problem, I need more information, can you send me the content of the file $NEWDBHOME/lib/sparc_sunos_41.site.cf.

newdbline
(newdbline@dbco.com)
Appendix H

The following is a sample record from the dataset I have collected from European databases on the Internet. It describes a recently-concluded alliance to produce a prototype aircraft maintenance system.

PJA : ARAMIS
TTL : Airline Real Time Application for Maintenance Information Systems
SIC :
    ELM (Electronics, Microelectronics)
    IPS (Information Processing, Information Systems)
    TEL (Telecommunications)
OBJ : This project proposes to develop a maintenance information system for aircraft maintenance and to evaluate its usability. The objectives are:
    - To create and establish a new domain of applications: computer supported aircraft maintenance.
    - To provide faster, cheaper and more accurate ways to manage remote maintenance problems.
    - To incorporate emerging and available technologies in the domains of broadband communication, high speed and multimedia communication, multimedia databases, co-operative work and information technology.
    - To contribute to the introduction of advanced telecommunication infrastructure and high speed telecommunications services in Europe.
    - To provide inputs to standardization bodies in the areas of high speed data / multimedia communication and aircraft technical information.
    - To study the organizational impact of the introduction of advanced communication in aircraft maintenance.
SDA : 1992-01-01
EDA : 1994-12-31
PGA : RACE 2
RPG : R2046
SPA : Advanced communications application experiments;
     Project line 7 - Advanced communication experiments
POR : SCANDINAVIAN AIRLINES SYSTEM
PCY : DENMARK (DK)
CPJ : name: ANDERSEN, ERIK
tel: +45-32323251
fax: +45-32323602
email: 100140.1731@COMPUERVE.COM
PAR:

IBM-FRANCE S.A., LA GAUDE, FRANCE (FR)

COPENHAGEN TELEPHONE COMPANY, COPENHAGEN, DENMARK (DK)

COMPUTER RESOURCES INTERNATIONAL A/S, BIRKEROED, DENMARK (DK)

SIEMENS AG MUNICH, MUNICH 70, GERMANY (DE)

AEROPORTS DE PARIS, PARIS, FRANCE (FR)
Appendix J
PEARSON CORRELATION MATRIX FOR FULL SAMPLE

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(***p<0.01, **p<0.05, *p<0.10) for off-diagonals.