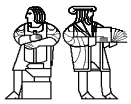

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MANAGING THE GLOBAL KNOWLEDGE-CREATION NETWORK: A SENSE-MAKING PERSPECTIVE

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We have entered the era of the knowledge economy, a period when knowledge has replaced natural resources and capital as the most important economic resource. Increasingly, corporations are reaching out globally to secure the best talent available at the most reasonable cost to serve world-wide markets. As a result, new organizational approaches are required to handle the increased complexity of simultaneously managing knowledge, products, geographies and customers (Galbraith, 2000). Traditional bureaucratic designs that are built around vertical control and lateral segmentation are being supplanted by organizational models that acknowledge that work occurs through cross-cutting processes that extend across the organization. In a multi-national firm, for example, dynamic configurations of teams carry out the development of products and processes, while lateral linkages coordinate and integrate diverse knowledge across dispersed knowledge centers (Dougherty, forthcoming; Mohrman, Mohrman & Cohen, 1995; Nonaka & Takeuchi, 1995). In other words, global new product development is a complex system, not simply the aggregation of multiple virtual and co-located teams.

In this chapter, we examine four areas of sense-making needed to foster virtual product development through an in-depth case analysis of one corporation's global knowledge system.[1] First we look at "strategic" objectives and practice, including approaches taken to connect knowledge activities to the strategic direction. Our second focus is on the integration of knowledge related to the ongoing technical task of generating new products. We then turn to the sense-making about customers and markets which is the basis for an organization's ability to

[1] These relate to the multiple "practices" that Dougherty has identified that go on simultaneously within the new product development organization (Dougherty, forthcoming). As we are focusing on innovation from the perspective of the technical community, we have grouped the activities somewhat differently than Dougherty.

optimize the use of technology to deliver value to the customer. Our final focus addresses "competency management practice" and explores the enhancement of the knowledge base of the organization, including individual development, process improvement, and the development of new organizational competencies. In all cases, we will see the use of both interactive collaboration and alignment frameworks used to make sense of the global knowledge-creation network.

Defining the Global Knowledge System

The complexity of a global knowledge system is illustrated in Figure 1. It depicts a global business with two product lines and the myriad of connections that are typically required to integrate the global knowledge system. Two main kinds of connections are depicted: vertical and lateral. Vertical connections link elements at different systems levels with one another. For example, product lines and geographies connect to the global businesses to which they belong. Teams connect to their product line(s) but also to the global business. A team, for example, may be creating a component for a specific product that has broad applicability to other product lines in their business unit, and perhaps to other business units. Individuals can also be connected to each of these more inclusive systems levels. A technical expert in a subsidiary may be carrying out a role in a project in a particular product line, but in the course of doing that may be conducting research that contributes to the corporate strategic technology direction and may serve on corporate-wide technology advisory boards.

[figure 1]

Lateral connections link different elements that are not embedded within one another. For example, individuals may link with peers doing related work in the same or other teams, product lines or geographies. A team may be connected to another team that is building a related component, or to another business unit that is supplying knowledge that can be reused, and so forth. It is also vital for individuals and teams to build connections, both electronic and personal, with sources of knowledge outside the organization to stimulate the generation of new ideas and

benchmark internal performance. It is important to note that all connections are depicted as two-way linkages, reflecting the reciprocal interdependence that requires mutual adjustment among the different elements and levels of the system.

The effectiveness of this complex knowledge generation network depends on how well it imports, shares, applies, and generates knowledge. Knowledge is the combination of information with experience, context, interpretation, and reflection (Davenport, Delong & Beers, 1998). It is socially constructed and emerges from social processes through which shared understandings are developed and become incorporated into beliefs and activities. Innovation, for example, is a collective process that entails making sense of new and diverse information and incorporating this knowledge into new methodologies, products and services (Nonaka and Takeuchi, 1995; Dougherty, forthcoming; Leonard-Barton, 1995). Product development organizations have been described as sense-making systems that are comprised of "social processes of developing a common or shared understanding… through which various information, insight and ideas coalesce into something useful." (Dougherty, Borelli, Munir & O'Sullivan, forthcoming, p. **XX**).

In the new product development process, many different individuals, teams, and business units act in loose or tight coordination with one another and with markets and customers. Accomplishing the strategic intent of the firm requires that these activities occur with an overall sense of purpose--that a common or shared meaning be established that can guide these many activities. But innovation generally occurs from the bottom up. Innovative ideas may stem from individuals, and they become organizational knowledge as they get interpreted by and embedded in the work of teams that interact and further diffuse the knowledge to affect work throughout the organization (Nonaka and Takeuchi; 1995). Sense-making occurs simultaneously at different levels of the organizational system -- corporate-wide, business units, product or process teams, and individuals. It also occurs laterally throughout the organization, by those who operate in different geographies, who carry out different processes, and who attend to different customers. To take maximum advantage of the innovation-creating capabilities of the global firm, the

different elements of the system must be aware of and connected to the larger system, and the larger system must be responsive to and able to incorporate the knowledge that is generated in its various sub-units. In other words, the organization must house the capacity to innovate in centers of excellence and diffuse it throughout the local units, and for local units to generate innovation and to diffuse it back to the center and to other local units (Bartlett & Ghoshal, 1998; Nohria and Ghoshal, 1997).

Although knowledge work is carried out and meaning is created in many differentiated elements and sub-systems, the overall effectiveness of the knowledge system depends on the creation of shared meaning through integrative, or sense-making, mechanisms. Such sense-making typically occurs through either "interactive collaboration" or "alignment frameworks."[2] Through interactive collaboration, individuals and groups interpret information, such as in jointly exploring novel approaches to solving technical problems or collectively defining solutions and applications. Organizations also use alignment frameworks to create contextually embedded shared understandings, e.g., roles, rules and routines, strategies, and product concepts, that do not require participation in an interactive interpretative process.

THE GLOBAL NEW PRODUCT DEVELOPMENT KNOWLEDGE SYSTEM: A CASE EXAMPLE

Techco, a global integrated electronics business based in Europe, has two major product lines. Each focuses on different types of electronic devices that are often used by the same customers for different purposes. Techco's products have evolved from mechanical to computerized devices, with the vast majority of value delivered embedded in software. In the past, these product line business units were able to operate independently of one another. Given

[2] Drawing on Weick(1995), Dougherty, Borelli, Munir & O'Sullivan (forthcoming) identified two kinds of sense-making: "intersubjective sense-making" and "generically subjective sense-making". For purposes of this paper we have renamed these two concepts as interactive collaboration and alignment mechanisms.

the capabilities of today's software tools and computer systems, eventual integration of these two systems appears inevitable and is part of the long-range strategy of the business. Currently each of the product line organizations designs and produces multiple products, modules, and sub-systems, which often vary by country. Because of the variety of industries making up the customer base, and the large differences in the user systems across industries and across geographies, there are many variations in the applications that are provided. New modules and products are being developed within an overarching architecture to enable integration. Additionally, the company is moving toward a new generation of devices, which represents a discontinuous development path. However, given the magnitude of the customer's investment in existing devices and the cost to change technologies, Techco feels that the new generation must be designed in a manner that enables gradual migration from the existing systems. Thus, the business is a global knowledge network with many different innovation and development activities that must unfold in an integrated manner.

Through a series of acquisitions, Techco has developed a global presence, including development capabilities on multiple continents. Thus, the company can take advantage of global technical capabilities, and have development occurring in closer proximity to customers around the world. The largest concentration of development activities resides in two European cities located relatively close to one another, i.e., within commuting distance, which allows for easy access to each other for face-to-face interactions. While each of the cities is considered the headquarters for a product line, software development teams include members from other locations that are viewed as global centers of excellence for specific technical competencies. Several recent global acquisitions provide both new and overlapping and, at times, redundant product capabilities. The business has gone through a process of rationalizing the product lines,

and determining what development work would be done in which locations and/or by teams that cut across the locations.[3]

Sense-making around Strategy

Business strategy is a major integrative element in the knowledge system: it relates the loose configuration of teams and projects to the larger system, provides direction and meaning to work, and also determines what knowledge needs to be acquired, generated, and leveraged (Nonaka & Takeuchi; 1995; Zack, 1999). Strategy is a core alignment framework. The sense-making for innovation entails linking strategic understanding across locations, and simultaneously focusing on established and emerging technology and market requirements (Jelinek & Schoonhoven, 1990). This is especially true at Techco since their strategy includes building transition capability from the current hard-wired devices generation to the emerging distributed, software-based technology that is being developed in large part in the subsidiaries.

In the headquarters location, all levels, including the individual engineers, expressed a clear sense of the strategy and understood the need for a dual strategy of extending the reach of the current product to new geographies while developing the solutions and technologies that will cannibalize the market.

> *We can't live from our current product family and technology forever. It's become a kind of commodity product and we have price erosion. We're giving a lot of consideration to how we go about maintaining our business while coming up with these new solutions… There's a paradigm shift. We're starting a new S-curve. Moving to component based architecture.* (Executive, Europe)

> *There is a clear strategy… We have a vision what is going to happen 10-20 years out.* (Engineer, Europe)

Core to building the innovative capabilities of Techco's global network is determining the role and activities of each of the dispersed units in the organization in contributing to

[3] The data reported in this chapter were collected as part of a larger study examining the conditions for technical excellence in large, geographically distributed firms. In Techco, we conducted 36 interviews with senior and middle level managers and individual contributors, and 6 focus groups of 3-4 technical employees. The interviews were conducted in two European and

corporate strategy, and how knowledge will be diffused and activities integrated across them. But within the North American subsidiary locations, there is mixed awareness of the strategy. Many of these sites are being relied on to take the lead in developing new technology and are thus faced with the challenge of managing a unit tasked with innovation while connecting to the larger system:

> *It is disruptive technology to our existing business. It would never see the light of day if done in Europe as it's too threatening to them. Yet ideas come from the current devices family. We've been set up as a separate group and are seeding our work with some key technical people from the existing product family to transfer their know how.* (Executive, North America)

One key tension is between direction from the corporate center and from within each of the geographic units, which are viewed as competency centers.[4] The North American locations are viewed not only as solutions developers for the local market, but also as the global competency center for the development of the new systems.

> *There are some principles that we have created in the last year and we've transported them to all locations. It's very important to give each global development center a known identity in terms of competence. If you try to use global development centers like many other companies using software engineers from India or test in Japan, it won't work… The U.S. is the country of software and personal computers so we decided [to build upon that expertise with a North American center of excellence]* (Senior manager, Europe)

This organizational strategy emerged in discussion and negotiation with the engineering directors in the subsidiaries. These discussions were the basis for creating shared understanding around the meaning of a competency center. One of the North American senior managers had resisted the tendency of the home unit to see the geographically distributed sites as places to "farm out work":

> *[European headquarters site] wanted us to take on project work for them. I refused and told them that the engineers here would leave… We had many discussions and came up with a memo of understanding [on how our work would be integrated].* (Senior manager, North America)

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three North American locations. Each interview and focus group was guided by a standard protocol, and lasted between one and two hours.

[4] The two product line headquarters were themselves competency centers. The competency centers for system testing, documentation, and solutions development were each located in European cities close to various customer sets.

Even so, managers who work within the North American sites do not have a clear idea of the overall picture and their role in it:

> *I'm in a microcosm. I don't attend the meetings that I used to attend. It seems like there is some vision coming from here and some vision coming from Europe. I really am not privy to them, but I don't think that they are always the same.* (Manager, North America)

> *I don't know how the top technical guys will fit in with the new charter. I don't know what the business strategy is so I don't know if we will need them.* (Manager, North America)

The North American line engineers in the other product line echoed this lack of awareness and a resulting cynicism about their role in the business:

> *The original intent [that we would be a center of excellence] brought excitement. The company was to be driven by technology and rapidly changing market needs. But I have seen very little change. We are just responding to requirements set by a massive organization in Europe that are defined slowly.* (Engineer, North America)

> *The power to make decisions is outside of our group and our managers don't even understand how the decisions are made.* (Engineer, North America)

In part, confusion about role reflects the dual identity common in today's global, matrixed organizational structures. Units are part of a global product line organization designed to leverage knowledge and take advantage of dispersed competencies to promote innovation. At the same time, they are located in a home country business unit held accountable for profit and loss at the local level. This leads to activities designed to "bring in revenue," such as taking on project work loosely related to the competency mission. At the same time, direction and funding to support the local innovation mission are often slow to materialize, since development strategy and funding is controlled from headquarters.

> *Senior managers in Europe care very little about whether we're making money or not. They care about market penetration and technological advancement. But unfortunately the US subsidiary tends to focus more on the business unit point of view. We can only spend as much on R&D as a percentage of the revenue you bring in.* (Executive, North America)

Adding to this ambiguity is the tendency of the European headquarters to farm out project work to some locations.

> *It's a very big strain on the R&D organization to meet all of these short-term requests from Europe.* (Senior manager, North America)

From the viewpoint of the Europeans, however, these requests enable the integration of the overall architecture of the system, including the ability to link different generations and components together as well as to link the hard-wired technology to the emergent pc and web-based technology so that customers can mix and match and determine their own migration path. Thus, individuals in the global subsidiaries often experience what the headquarters organization conceived as an elaborate and elegant network in a fragmented manner. This was particularly true for the lower level North American engineers, who are often enmeshed in a network of interdependent technical connections, often without the larger system perspective.

Sense-making around Technical Work

New product development entails defining product concepts that meet customer needs and market opportunities, and solving technical problems to design and deliver products and solutions. In the global corporation this requires linking knowledge about technology and markets across many dispersed units within the overall umbrella of the strategic intent of the corporation. "Product integrity" (Clark and Fujimoto, 1991) demands that various elements of the product fit with each other and with customer needs. Thus, both interactive collaboration and shared understandings derived from alignment frameworks are required to coordinate an ongoing juxtaposition of the emerging and existing technology, the interdependent work being done by many teams and units, and the multiple perspectives of numerous disciplines and functions (Dougherty, forthcoming; Iansiti, 1998).

Given that one of Techco's business strategies calls for integrating components into a compatible system and enabling customers to migrate between product generations and to discontinuous technologies, a great deal of integration is required. Although many of the projects have to fit together within an overall architecture, Techco differentiates units operationally by creating projects and sub-projects that develop whole products or systems.

> *Our North American locations handle our small systems and the software to program and configure the system. The European locations also have specific pieces. So although they have to be configured into the same overall system, their pieces are pretty self-contained except for the interfaces.* (Manager, Europe)

> *I try as much as possible to have work that isn't dependent on each other split between here and the other locations. Once you define the interface, it's easier to split work. Once you set goals and requirements clearly, then you can leave the team members to do what they need. Push ownership right down to the bottom.* (Manager, North America)

Despite efforts to partition the work, many projects include work done in multiple competency centers, and consequently entail virtual teams that cut across locations. One senior manager stressed the importance of being project driven, of having a manager for each project, and of projects being able to "*use the competency centers like a matrix organization*." Thus, a project may be fully contained within one of the competency centers, or may cut across locations, with direction coming to individuals from project managers in different business units.

High level integration of these many dispersed projects and teams is accomplished in part through alignment frameworks, such as the establishment of technical roadmaps, integrating architectures, and standard processes for change management and maintenance of the source code. These form the guiding context for the work being carried out in any particular team.

> *The managers of the technology group and marketing define the strategy for the Business's products and the roadmap. There is a roadmap on the intranet. There's a meeting every year where we get updates to the roadmap: markets and products.* (Manager, Europe)

But it is also recognized that the system architecture, although the "glue" that holds the system together, is dynamic and must respond to what is learned in the development activities. For this purpose, interactive collaboration is required.

> *Architecture is a living thing and doing implementation changes the architecture. Ideas on the white board may not be implementable, so we need to change it.* (Manager, Europe)

Thus, the use of formal integrative frameworks is supplemented by person-to-person interactions. This is because the information may be incomplete, dynamic, inaccessible, or ambiguous—or because it's easier to ask the person responsible than to search out information:

> *It all comes together in the source code—every engineer can look to the source code of all the projects. We have one system test group for our engineering tool and they make sure it fits. But it's easier to call them by phone than to look at the source code.* (Engineer, Europe)

> *The official database for specifications isn't sufficient. The description is never complete enough to get all the information. You need to find the source code or the person who developed it.* (Engineer, North America)

A great deal of person to person sense-making must also occur to enable various parts of the global network to contribute to the overall direction of the product line. The development of the architecture for each generation must be done through interactive collaboration.

> *There is only one central system architecture group. But the next generation architecture is worked out by a task force that we put together from several competence centers…The architecture is obligatory and we are sure it will be the basis of the different products based on the architecture because in these task forces are people who are now going back into the organization and using these features and developing on these. It is not an isolated group of technical architects doing architecture and nothing else.* (Executive, Europe)

But much of the ongoing interaction to make sense of how the product is unfolding and the frameworks are changing occurs in the European headquarters unit.

> *One team makes the systems architecture for the software and the hardware. If there are special problems or functions, normally there are meetings. Project leaders or coordinators get together.* (Project Leader, Europe)

> *Information is exchanged in meetings about the whole family. We have project leader meetings and project family meetings to exchange information. Architecture groups share as well in their meetings.* (Project Leader, Europe)

Although North American representatives may attend key events, in person or electronically, the subsidiary units may feel distant from this process, and that they are always on the receiving end of changes.

> *There is a group of systems engineers in Europe that maintain the specs for the interfaces We implement what they define. Sometimes we are involved in the definition and sometimes we are not. I got an e-mail this morning asking what impact a change would make. If we are lucky the specs are in English, but they are usually in [native language], so we have to get them translated. But there is also a communications problem in Europe across the sites. We have on-line specs and it gives us notification of changes. But the changes come at such a rate and they are in [native language] so it is hard to keep up with them.* (Engineer, North America)

Differences in the size, organization, and complexity of the subsidiary and home country units result in different operating styles, which, although fitting local requirements, result in subsidiary members being poorly connected to the product line sense-making. People in subsidiaries may not have access to the ongoing stream of sense-making activities in the home location.

> *The European group is very structured, because at any one time it could have up to 200 developers, project leads, sub leads, and team leads, each boxed into a particular domain. They have weekly meetings to communicate and exchange information. Most of the people there are very experienced developers. Know products and the code very well. Need structure to avoid chaos. We have a totally different situation here. Because we're so small, with 10-12 people and just 4 who are experienced, we can't afford a rigid structure.* (Senior Manager, North America)

> *They have a huge bureaucracy and it is hard to know who to talk with. They have many layers. It is difficult to just figure out how to get specifications… It's not a language issue – it's the distance and the large organization and not knowing who to talk to.* (Engineer, North America)

The requirements for interactive collaboration for sense-making increase for virtual projects in which dispersed team members need to work out ongoing task interdependencies. In Techco, this entails electronic coordination, translation, and frequent face-to-face meetings.

> *I'm working on a project that is being co-developed – they are doing the hardware in Europe and I'm doing the firmware. It is working well. I met the folks there when they were here for a meeting. My partner in Europe has the same design tools as I do and he has emulated my firmware to test it there. Language is the toughest part. He speaks good English but I still need to talk slowly and avoid slang. We share documents. He writes up the requirements documentation and then translates it and sends it to me. His English is good enough for translating the base requirements but I've had to have his comments translated. We both understand the function of the module so it works well. We communicate back and forth and work as a team. We exchange e-mails daily. He checks with me if he makes any little change to see if it is a problem. I was over there last month and will probably go again next month.* (Engineer, North America)

> *I did a project when I was in the North America and had to work closely together with Europe. We used Net meetings, and phone calls and uploading and downloading software and could use the 8-hour time differences so work kept on round the clock. We'd send problems to Europe by e-mail and they'd begin to solve the problem. One of my developers in North America came from that location. He knew all the people. Work is easier if you know people, especially if you have to communicate by phone and e-mail. We flew in a couple of times to meet as well.* (Engineer, Europe)

The information technology infrastructure is a key part of linking together geographically dispersed activities. European employees are quite positive about the electronic availability of information to link together the activities of all projects, and see these as "living documents" influenced by two-way interaction.

> *The most important thing is done—the infrastructure for the development guys is the same in all locations.* (Manager, Europe)

> *In order to drive world-wide development in a way we can manage, we have to use common tools and processes. We have a database that lets us see all the projects and their parameters, cost, schedule, and staffing. Everyone can look at it.* (Senior Manager, Europe)

North American employees, on the other hand, often experience obstacles due to system incompatibility, language, or limited access (partly due to document control) that cause delays and confusion. In addition, these employees perceived they were not allowed to feed information into the system.

> *On a project I was working on, I found out that people in Germany had fixed the problem but didn't tell me. We're not in the loop to get information. Even when we get the documents we will often be unable to read them because they will be in another language.* (Engineer, North America)

> *We can get parts list and drawings, and all the documentation of the product. It is read-only, however. It is not yet two-way. There's a technical incompatibility with them accessing our drawings. We don't even know if they care to see our stuff. We should be able to indicate changes when we see a problem. When we see problems in the code, there is no formal way to tell them.* (Engineer, North America)

Managers and engineers both acknowledge the issue of multiple languages and talk about efforts and difficulty in creating the conditions for people in all locations to participate more effectively in integrating the global development activities.

> *English is the language we've decided to use…From our development side we are a typical European department and everything is in our native language, and now we have global development and have to react. They cannot understand our language—and each specification has to be translated. A big challenge is to find a way to be efficient to get information back and forth. If English is not your native language it's hard to write specifications in English—you miss nuances within the language… You have to be in the North America and England and practice it for 2 or 3 weeks at a time. It's not possible to send all 500 European engineers to do this.* (Manager, Europe)

> *We have trouble getting information out of Europe. We keep asking the wrong question.*

> *They give us what we asked for but we do not necessarily know what we want*. (Engineer, North America)

While sophisticated communication and group work technologies are extensively applied in Techco, there is a general sense that this is insufficient to establish shared meaning.

> *Face to face meetings are essential. It takes such a long time to develop the same understanding of the issue. Then later you can do it by e-mail and phone.* (Engineer, Europe)

> *It starts with personal relationships—a lot of travel back and forth. You lose a lot of time traveling. We meet a couple of times a quarter at first—have to tune the roadmap and truly learn to understand each other—and have weekly videoconferences. For us in Europe, video conferencing is not so easy as we're not too familiar with it. On the North American side, they're used to it.* (Manager, Europe)

> *On my last project, I'd ask [my team members in Europe] for something and after about a week, I'd get something but it wasn't necessarily what I wanted. It may have been what I asked for but it wasn't what I wanted. I was over there for another meeting and sat down with the folks and told them what I needed and I got it.* (Engineer, North America)

In summary, Techco has common systems for communication and technical work; yet many of the individuals we interviewed in the subsidiaries experience frustration because of access limitations, language and translation issues, and inaccuracies and delays. These factors conspire to create a situation where geographically dispersed contributors are both vertically and laterally less well connected to and less able to impact the sense-making processes of the network.

Sense-making around Customers and Markets

Successful development of new products depends on merging technical knowledge with knowledge of the application contexts (Dougherty, 2000; Clark and Fujimoto, 1991; Iansiti, 1998). The core challenge in the global firm is to simultaneously leverage innovation while developing deep understanding of the needs of particular markets. In Techco, the tension concerns the attempt to develop a globally integrated approach that will have application in diverse local and industry markets, and across existing and disruptive technologies. The European business units understand the importance of being close to the customer, and in fact

have an elaborately defined set of processes for collecting customer information, involving marketing as a key player in the product definition process, establishing close co-development relationships with key customers, tracking field issues, and introducing new functionalities and components in response to customer experience. They also understand that their product represents substantial capital investment, that their customers are dependent on their devices for ongoing operation, and that the decisions to upgrade to new generations of technology, and even to discontinuous technology, will occur at different rates in different customers.

> *It is important for usability purposes to get information from customers. Then we can do a good job integrating these ideas. I went to the customers and asked questions as part of the usability team. In the past people from the product definition team would go do it and write the requirements paper. This was the first time development went outside to look at how they work with our system. We might return with information to refine product definition for parts of the system to get some separately operating components to work together better.* (Engineer, Europe)

The highly centralized and coordinated manner of making sense of and dealing with this market complexity provides guiding direction, but also creates tensions with the North American subsidiary. The North Americans are operating in a very different kind of marketplace, one that in comparison with the European marketplace is diverse in customers' current capabilities and systems and their expressed needs. Furthermore, the customers in Europe are in fact quite different—they employ highly trained technicians who can take advantage of complex products that require high sophistication from users. North American customers are looking for turnkey solutions that do not demand a great deal of local engineering.

> *The right thing for us is to pursue an integrated solution, but technology won't solve the market adoption problem… There is a big difference across different parts of the world. In North America, it's very heterogeneous out there. No norm. Whatever overriding concept you have will require lots of adaptation.* (Executive, North America)

> *In Europe, the product can be difficult to learn and doesn't need to be user-friendly because they have [highly skilled employees]. What they consider good, we consider unmarketable. They think their product is perfect and only customers need to learn how to use it. Nationalization of product is not just language, it is customizing the product to the user base. It is very difficult to learn customer needs outside of North America, that is our biggest challenge.* (Senior Manager, North America)

In addition, since the North American charter includes disruptive technology, a tension

arises from efforts to make sense of the disruptive technology with the same centralized sense-making approaches that are being used to evolve generations of the current technological approaches.

> *Europe has a very rigorous development process with input from sales and product marketing to make a product spec that fits in roadmap. It is a highly coordinated process. Because we are starting a new business with the North American products, we're still trying to figure out where to focus. We get a product marketing person who wants one thing, then the next day it changes. Very reactive to the market. Depends on which customer we met last and what they need.* (Senior Manager, North America)

The tension is accentuated in one acquired site where the technical workforce historically did both product development and direct customer interface. In this case, they view having to work through Europe as limiting customer input.

> *Things are being filtered. We've lost the original concept of what the customer wants by the time it gets to us.* (Engineer, North America)

Sense-making about the technical/market interface is particularly attenuated at the lower level of the subsidiaries. Higher level managers typically have the opportunity to attend roadmap meetings and other framework-building activities; however, the line engineers carrying out the development are generally on the receiving end, feeling disconnected from the logic that went into decisions and plans, and feeling that these plans are disconnected from their experience developing solutions for their local customers. These line engineers attribute this tension to "cultural" and "values" differences between the Europeans and North Americans.

> *It's a classical example of the difference between Europe and the North America. In Europe, they stand at the top, work through the thought process in advance and then let it trickle down. In North America, we just do it and see what happens. There is no culture for exchange [between Europe and North America about customer requirements]. We do have an electronic system for field problems and it has worked out well. But it is slow and there are language barriers.* (Engineer, North America)

> *For me, being excellent technically is total customer satisfaction. For the Europeans… it is achievement in the engineering world only. Excellence is designing a widget that is held in high esteem for engineering, not marketing.* (Manager, North America)

This gap in awareness and involvement creates a performance pattern that in many ways creates a self-fulfilling prophecy in some subsidiary locations—a belief that they have become

not active members of the innovating network, but passive recipients of work. The gap in sense-making about the customer is particularly impactful because practice and meaning in the product development network focus on using technology to bring value to the marketplace.

> *The biggest problem is that we need a vision to grow the business with a viable product. There is not a lot of entrepreneurial spirit here. Everything we do is from Europe. When you have an idea and it is taken to Europe, it gets squashed. It is "do what you are told to do." There is not a lot of interaction in our group with the customer. It is a very confined group.* (Engineer, North America)

Sense-making around Competency Development

A key task of the global network is to ensure the development and enhancement of the competencies required to enact the global strategy. This includes the knowledge that is embedded in individuals, in teams, in work processes, and in formal knowledge repositories. In Techco, the concept of centers of competence underlies an organizational strategy that clusters knowledge in units that become deep experts in particular technical and/or applied contexts. At the same time, there are emergent aspects of the organization's competencies. They entail development of new knowledge and include the application of knowledge from across the organization that provides the foundation for leveraging innovation and integrating the network's activities. Because of the integrated nature of new product development work at Techco, both emerging discipline knowledge and the broader product and customer knowledge need to be accessible throughout the organization.

Job design and staffing patterns impact the way in which knowledge is distributed in the organization, and the patterns of interaction required to connect knowledge. Patterns of specialized versus generalized knowledge reflect underlying assumptions about knowledge and how it is best created and applied. Differences in staffing patterns can make it difficult to identify where knowledge lies, and may reflect differences in world views (Dougherty, 1992) that present obstacles to the development of shared meaning. The European emphasis on deep specialty knowledge and the North American tendency toward more generalist knowledge bases and roles

create such a lack of symmetry. Likewise, national cultural differences in the notion of hierarchy and organizational cultural differences in units that were competitors prior to acquisition create potential barriers to openness and exchange.

> *In Europe, there is a lot more specialization. A person is in a job function and there is pride in doing that job well. In North America, we are more generalists and there is more innovation. Both work well within their context. If there is a problem in Europe, you know the person whose job it is to be an expert by the organization chart. The cultures tend to clash. There have been conflicting expectations in both directions. We expected innovation and they expected compartmentalized professionals.* (Engineer, North America)

> *North America seems to be very hierarchical--they only talk to next level. My experience in Europe is that if you're a technical specialist, you could be called by anyone. No one cares about skipping levels there. It just doesn't happen here. I'm not complaining, just curious about it.* (European Engineer in North America)

Work processes are a key element of an organization's competencies. In Techco, even the processes that guide development reflect the difference in cultures and complexity in various subsidiary units, and the differing approaches to work design. The Europeans stress uniformity of process that guides well-choreographed interactions between many different specialty groups and interdependent projects. In North America, the emphasis is on the ownership of process by the people doing the work. As a result, processes crafted for the North American sites have to be rationalized with the European processes to enable integration.

> *We have a formal process for the knowledge management side of things. We started with a team to document the process and that's what we're running to now. For me the management of technical product innovation and knowledge capture are crucial. We had a conscious set of conversations about how we do it. We have talked with Europe about how synchronize our process with what they are doing.* (Executive, North America)

The European discipline groups in the matrix organization take an active role in all aspects of competency development, including training and development, new process development and training, technology scanning and importing, and using job assignments and career rotation purposefully to support competency development. While development is also stressed in the North American locations, these units are smaller and do not have the infrastructure to support the extensive development activities and forums that are available in

Europe. Although development experiences that are offered interactively in Europe may be made available electronically for other locations, the North American sites are seemingly unaware of these offerings. Much development in the subsidiaries is through attendance at public seminars.. As a result, the carefully planned and integrated development offerings in Europe promote a shared understanding of the technical and business environment, while the experiences in North America appear to be somewhat more diffuse and individualized.

> *There are issues where it's necessary to have the same [skill] level for the people. They all need to know a particular tool. Then we do in-house courses right here in our location. Other issues when they have the need to learn something about our own products are when training in our headquarters training center works best. We try also to use external training companies so they get exchange with other people and get outside of this organization.* (Manager, Europe)

> *Developers go at least once a year to software developers conference. They can see that we're not just milking them, but investing in them… No one is left to struggle by himself. They can talk to peers and supervisors. If issue is simple, it's solved right away. If the issue is more general, lead engineer will organize an internal seminar and share the knowledge.* (Senior Manager, North America)

Within a geographic location, projects are co-located as much as possible in order to enable direct peer-to-peer learning and sense-making.

> *We try to concentrate people[with knowledge of a particular new technological approach] so it is easier to exchange information in real time and also people between projects. Mostly they sit together—in two rooms, so they can just talk to each other.* (Manager, Europe)

Person-to-person knowledge transfer is also used to carry knowledge and create a common understanding from team to team and location to location by moving people with relevant knowledge to locations that need to acquire that knowledge. Although long term expatriate assignments are more common from European to the North American locations than vice versa, a considerable number of North American engineers pay short visits to the European locations. In general, however, the ex-patriates from Europe are viewed as transporting knowledge of the European technology, work processes, and product lines that the North American locations need to gain. North Americans are viewed as coming to Europe to learn.

> *When we find that there is a gap in skills, then one expat will organize an internal class and try to bring people up to speed. We usually have an expat who has good knowledge and can get documentation and use the network back in Europe to find any missing information.* (Senior Manager, North America)

Regular meetings are also set up to share learning and create knowledge across the product lines. These forums are most prevalent in Europe, although one product line's intent is to have them occur in different locations. Again, we have an image of frequent and intense collective sensemaking interweaving the knowledge building activities in Europe, with North American contributors being only loosely connected, if at all.

> *We have regular meetings of the software discipline members. Team meetings of the heads of the groups are once a week for half a day; one focus is on exchanging information. Each head of the group tells the others what the situation is in the different projects. It is all part of systematic exchanging of information.* (Manager, Europe)

> *In Europe, there are meetings—events where people give reports about experiences, e.g., special tools or experience with a new technology. Sometimes any developers can come, sometimes it's a smaller team depending on what the issue is. For example, if there is something about using a new tool one or two people from each project may come.* (Engineer, Europe)

Techco often creates electronic access to the information from these gatherings so that individuals who are not in attendance can have access to the learning. Additionally there are a number of learning-oriented data bases that are regularly maintained and available to developers globally. Despite efforts to translate these databases, however, the inevitable delay and difficulty of intranet access cause them to be less useful to North American developers.

The frequent meetings and ongoing sharing in Europe enable cross-product line learning and facilitate the ultimate strategic intent to have a compatible multiple product line set of offerings for customers. They create a common understanding of the technology and its market effectiveness that allows the pull for cross-division learning and reuse to come from within, rather than to be dictated from the top.

> *We try to not reinvent from the bottom up but to learn from [another product's] experiences. And to reuse and elaborate. There are now teams coming from Product Line A's software architecture groups, working together with us [Product Line B] in the early stages of the new generation—to be sure we have the features in our new system we can learn from them.* (Senior Manager, Europe)

The North Americans are often not effectively linked into these exchanges, however, and various North American sites align almost exclusively with their product line units. As a result, they are relatively unable to drive technical integration across the European-based product lines.

> *There's not today firm cooperation between the different parts of our subsidiary We're trying to coordinate how we go to customer, but are not sure if we can drive core technical integration back in Europe. Each part of the subsidiary is relating back to its counterpart in Europe, rather than to each other.* (Executive, North America)

The North American developers are very dependent on building a network of contacts to link them into the highly interlinked activities and developing knowledge base of the European development community.

> *It would be definitely a problem for kind of work we're doing if didn't have expats here… Much of the important information isn't written. If don't have contacts back to mainstream development wouldn't be able to get work done. There are hundreds of developers back in Europe. You need to know the key people. Need to know who is the expert who is buried in the organization. It's not always those who are managers who you need to contact. Need to know who has the real knowledge. We use personal relationships. Those come from the projects you've worked on and friends you've made.* (Engineer, North America)

> *I guess I'm lucky because I've met the right developers in Europe. With the right permissions, you can get anything. I've scheduled meetings over there when I need software and explained to them what I need, and I get it. When they meet you and you have dinner with them, you develop a relationship. I get almost immediate response. I ask for something in the morning and have it in a couple of hours.* (Engineer, North America)

In summary, in the area of competency development, we heard many similar themes as in the other areas of the knowledge system. Competency development is an ongoing process entailing ongoing sense-making. In the home country, approaches to competency development were numerous, highly integrated and interactive—and served in a manner to create shared meaning across the organization. North American employees were not part of the face-to-face development activities and interactions, although the company applied dedicated resources to make sure that subsidiary employees had electronic access to course materials and learnings from

interactive forums. Employee development in North America was more disconnected from Techco, and more diffuse.

Knowledge was carried from headquarters to the subsidiaries by transferring people on assignments ranging from several weeks to several years. This center to periphery movement of people enhanced the ability to link the development activities in North America to the integrated product line, but it provided less ability for the North American development activities to influence how that product line unfolded and to incorporate its work into the overall framework. And although many of the North Americans traveled to Europe for meetings, there were fewer opportunities for North Americans to develop a network of informal contacts in Europe. The sites largely relied on the networks of the expatriates who came on temporary assignments. Lateral connections across the organization were also impeded by differences in staffing patterns that reflected fundamental differences in practice related to generalization or specialization of work.

> *Europe has developers conferences, but that is not how we get the information we need or identify experts. We rely on personal contacts and friends of friends. If I don't know someone, I'll ask another European colleague here to find out whom to call. It was a big advantage that we had ex-pats from different departments in Europe, and not all one location.* (Engineer, North America)

IMPLICATIONS

Designing knowledge-creation networks for highly integrated large systems is a complicated process. Aligning all aspects is difficult even when all parties involved in new product development are located on one site. Techco highlights how global dispersion increases the chances of misalignment and potentially magnifies its effects within and across the four sense-making areas.

One of the most interesting study findings is that none of the four areas of sense-making was done purely virtually, i.e., electronically mediated. New product development is dynamic work, and thus alignment frameworks, such as, architectures, specifications, and even interfaces,

can't stay static while each element carries out its part. Interactive collaboration enables these frameworks to be dynamic and responsive. This sense-making, however, occurs primarily through meetings or informal interactions. In other words, alignment frameworks are created through interactive collaboration and then those frameworks become the foundation for further interactive collaboration. As shown in Figure 2, there is a continuous iterative process between electronically mediated and person-to-person interaction in all four sense-making areas described in the Techco case.

- Figure 2 -

Geographically dispersed members of the network are disadvantaged with respect to participation in this sense-making. Lateral access to information about the dynamic unfolding of particular technical developments requires lateral connections and communication between contributors. With employees located across multiple sites around the globe, person-to-person interactions must move from ad hoc meetings and informal hallway discussions to a combination of synchronous and asynchronous electronically mediated communications. Synchronous interactions, both face-to-face and virtual, must be scheduled in advance and can lengthen the time required for interactive collaboration in all areas. Time delays and distance create discontinuities where misalignments can grow.

Due to all the time zone, language and cultural differences associated with global dispersion, some might hope that more time spent on the development and use of alignment frameworks will reduce the need for some of the informal sense-making. But as we have seen at Techco, the alignment frameworks are formulated and evolved through interactive collaboration in meetings or informal interactions. Thus, as shown in Figure 3, people who are physically located at headquarters or are within a short commute from headquarters have more access to those interactions, either because these interactions are done face-to-face or prior face-to-face interactions have led to the establishment of personal networks that promote interactive

collaboration. This is true for all new product development processes from strategy formation to competency development.

- Figure 3 -

Virtual teams exist at every level of an organization's hierarchy and each must develop it's own knowledge creation network. The global knowledge creation network, therefore, is the overarching framework within which teams can work through their own sense-making. As such, it plays a pivotal role in the development and maintenance of effective virtual teams by providing a basis for developing shared understanding within the teams relative to the teams' goals and objectives. Virtual team members within organizations that are effective global networks tend to have fewer struggles in understanding their role and how their team adds value to the business. Conflicts between local and global priorities will still exist (Klein and Barrett, 2000) but the context will be set for finding meaningful accommodation of local needs and global objectives since both team members and their local supervisors are part of a larger infrastructure that supports and nurtures global interaction.

Based on the Techco case, as well as the larger study to which it is a part, we believe that the establishment of formal and informal networks is a key in creating deeper understanding of alignment frameworks and more symmetrical interactive collaboration on a global basis. Table 1 summarizes the best practices that we have observed to enhance global sense-making across time, distance and language differences:

- Table 1 –

1. Ensure full connectivity and familiarity across site locations – It is critical that company, product, competitor and customer information is communicated to employees through the organization. General managers play an important role in linking the global network (Nohria and Ghoshal, 1997), but as the Techco case illustrates, they are essential but not necessarily sufficient. Building bridges upward and laterally is not enough. Translating global frameworks and integrating them with local norms and cultural assumptions can

be an even bigger task. For example, all the people we interviewed in Europe described a corporate strategy that included the North American subsidiaries playing a central role in the development of future products. Yet ironically, many employees within the North American sites question their role in the company's strategy.

2. Don't expect shared understanding across the global knowledge-creation network of alignment frameworks created primarily at headquarters– Managers of global knowledge-creation networks need to ensure that each location has full input into the processes and systems for defining products, architectures and strategies, and on-going feedback and influence as the product line evolves. Interactive collaboration brings together two sets of alignment frameworks – one for the global network, the other at the local site. Each local site has a set of cultural norms and processes that are built around the site's mission (e.g., development of discontinuous technologies), stage in the product life cycle, size and historical context. These local assumptions need to be considered in the development of global alignment mechanisms, and vice versa.
3. Devote time in meetings and during travel to network building – Communications occur between people who either know one another or are referred to each other by someone they know. As we have seen at Techco, language, cultural and time zone differences inhibit connections that would typically occur between engineers working side-by-side. Hence, building relationships is a critical part of creating a global knowledge-creation network. These relationships develop naturally when people are co-located but need to become part of meeting and travel agendas for people working on geographically dispersed projects.
4. Actively rotate people in and out of headquarter locations to develop a working network of contacts and an understanding of the bigger picture – Unfortunately, many companies only use expat assignments as a leadership development tool rather than a knowledge management and sense-making mechanism. Techco's expats played a pivotal role in

bridging European and North American locations by providing a conduit for interactive collaboration. They used their personal networks to link technical and business resources and build extended networks for individuals who have not had to opportunity to travel to or interact with other sites. In addition, they helped managers and engineers within newly acquired groups make sense of the new organizational norms and processes.

5. Use competency building, especially training, to further global networks – Techco's use of competency development across the European locations clearly shows the value of using training and development, as well as project assignments, to build networks across multiple locations. This often happens mostly by osmosis rather than consciously planning and leveraging the networks that are built during classroom or knowledge exchanges. By carefully selecting and building learning cohorts, organizations can create both formal and informal networks that can be used to extend and promote future knowledge transfer and sense-making throughout the global organization.
6. Move quickly to integrate alignment frameworks in newly acquired units and build integrative collaboration networks with the rest of the organization - When sites are acquired as intact product development units, their acceptance of an organization's generic processes is influenced by their experiences with prior corporate owners. Where the local workforce views the new owner as offering expanded opportunities or as a natural fit with their technology, they tend to be more willing to bridge the global and local issues. If the site views the acquisition to be a threat to their existing culture, norms, cultural and language differences are viewed as a barrier to both interactive collaboration and global alignment frameworks. For the units acquired by Techco, whether the employees welcomed or resisted the new owner had a powerful and lasting influence on the extent to which the members of these organizations actively sought to participate in the global knowledge-creation network.

7. Minimize cultural and language barriers to electronic connectivity – As the Techco case illustrates, it is all too easy to assume that a locally friendly information technology infrastructure will be accessible and accepted on a global basis. Information systems are an extreme case of where the local versus global cultural assumptions come into play. Each site has its own norms around technology use and information sharing. Furthermore, a hidden cost of many acquisitions is incompatibility of legacy systems. Hence, organizations need to develop and implement information technology to complement both local and global sense-making.

In summary, building the global knowledge creation network for new product development requires a focus on the overall global network. It is not sufficient to connect top managers to one another, or to concentrate on building each virtual team. The overall network of activities and interactions defines the capabilities of the system, and creates the context for each team and activity within. Failure to attend to the attributes of the global network has performance consequences in terms of time lost, redundancy, and rework. Perhaps more importantly, the characteristics of the global network determine the level of engagement that people have with the purposes of the firm.

Figure 1

Integrating the Global Knowledge System

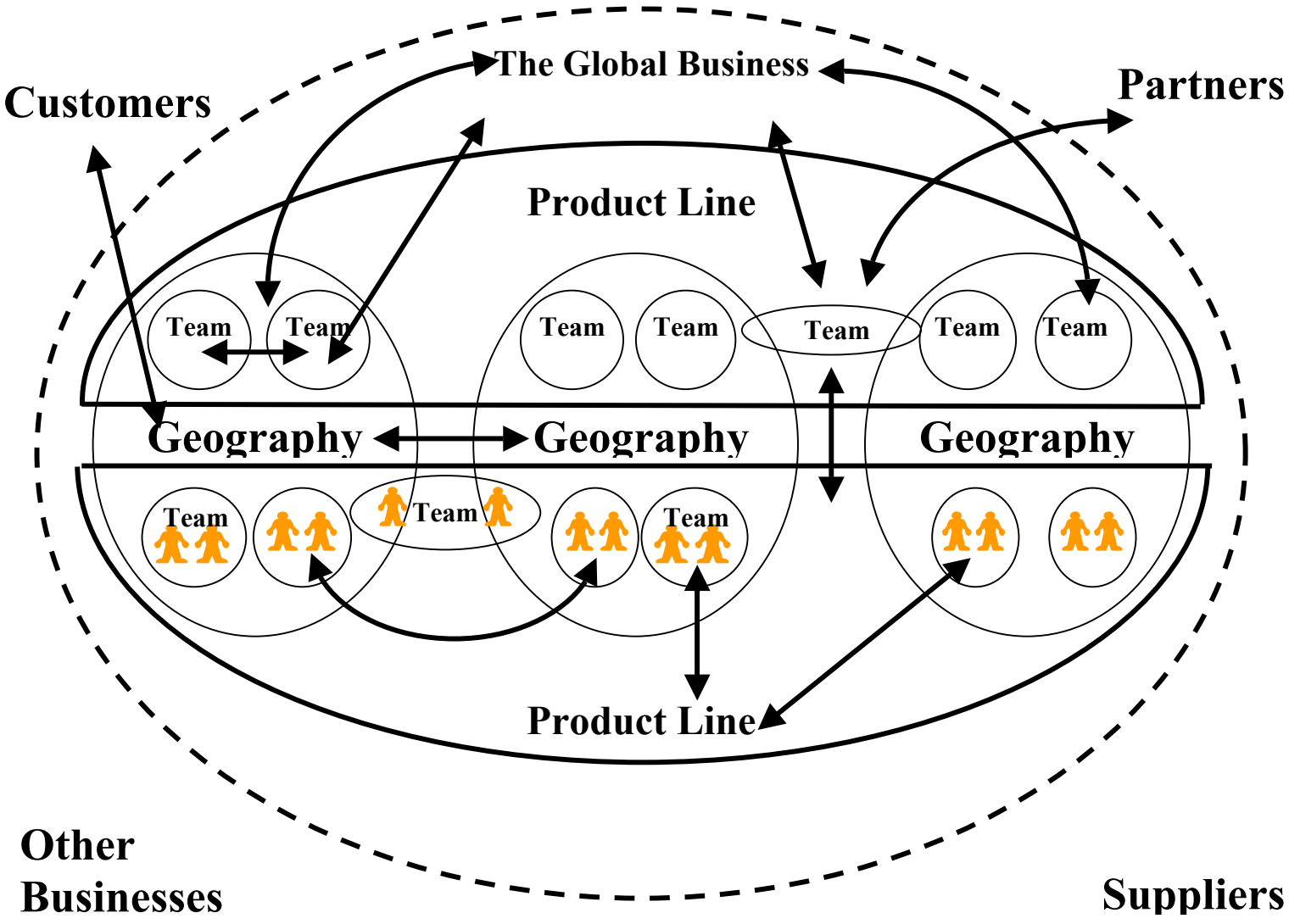

Figure 2

Iterative Sense-making

Figure 3

Interactive Collaboration

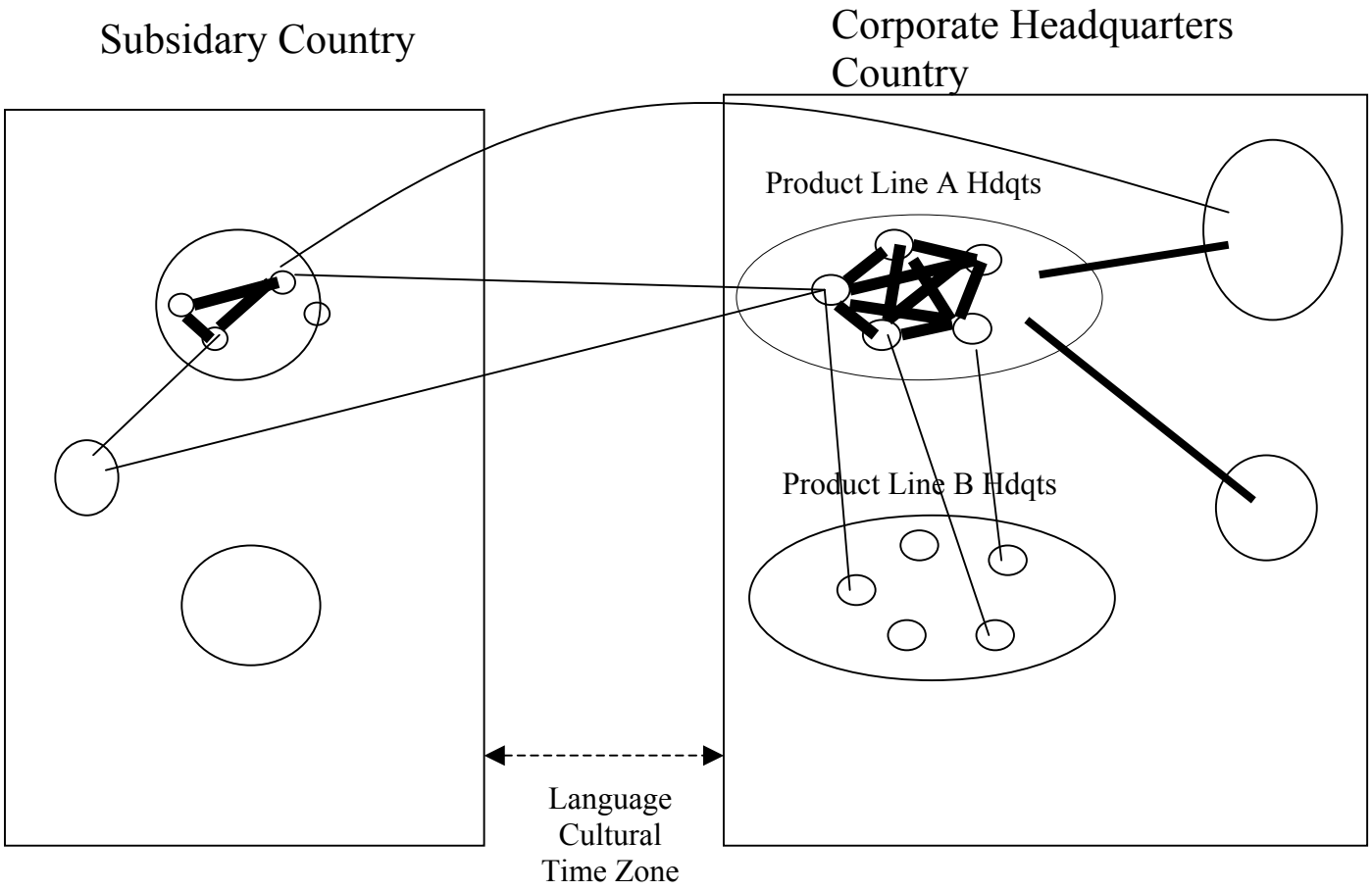

Table 1

Best Practices in Developing Global Knowledge Creation Networks

1. Ensure full connectivity and familiarity across site locations
2. Don't expect shared understanding of alignment frameworks created primarily at headquarters across the global knowledge-creation
3. Devote time in meetings and during travel to network building
4. Actively rotate people in and out of headquarter locations to develop a working network of contacts and an understanding of the bigger picture
5. Use competency building, especially training, to further global networks
6. Minimize cultural and language barriers to electronic connectivity
7. Move quickly to integrate alignment frameworks in newly acquired units and build integrative collaboration networks with the rest of the organization

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