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**The Spatial, Temporal, and Configurational Characteristics
of Geographic Dispersion in Teams**

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ABSTRACT

Geographically dispersed teams are rarely 100% dispersed. However, by focusing on teams that are either fully dispersed or fully co-located, team research to date has lived on the ends of a spectrum at which relatively few teams may actually work. In this paper, we develop a more robust view of geographic dispersion in teams. Specifically, we focus on the spatial-temporal distances among team members and the configuration of team members across sites (independent of the spatial and temporal distances separating those sites). To better understand the nature of dispersion, we develop a series of five new measures and explore their relationships with communication frequency data from a sample of 182 teams (of varying degrees of dispersion) from a *Fortune 500* telecommunications firm. We conclude with recommendations regarding the use of different measures and important questions that they could help address.

I. INTRODUCTION

With only a few exceptions (e.g., Majchrzak *et al.*, 2000), research on geographically dispersed teams (GDTs) has taken a fairly narrow view of dispersion, considering all degrees of dispersion to be equal. Under this prevailing view, a team with half of its members at one site in Malaysia and half at a second site in Japan would be just as “dispersed” or “virtual” as a team with members spread across sites in the U.S., U.K., Brazil, and China. Furthermore, both of these teams would be compared with co-located teams in a simple dichotomous fashion.

However, these two teams clearly vary widely in terms of the number of sites represented, the miles separating members, and the degree to which members’ are in the same time zone. They also vary in the extent to which members are separated from their leader and isolated from each other. In this paper, we develop a series of new measures to capture these aspects of teams’ dispersion. Then, using a sample with the two teams mentioned above and 180 others from a global *Fortune 500* firm called “TeleCo” (Cummings, 2001), we explore the measures and their relationship to intra-team communications. The measures developed here help expand the dichotomous view of dispersed vs. co-located which has pervaded the literature.

Although research on computer-mediated communication, computer-supported collaborative work, and related topics is now several decades old, research on GDTs is relatively young and the domain is still being mapped (Jarvenpaa & Leidner, 1999; Maznevski & Chudoba, 2000). Much of the GDTs research has been done in laboratories or other settings that controlled teams’ degree of dispersion to focus on other important variables. Now, with field research and the prevalence of GDTs growing, it is especially important to expand our theoretical and methodological toolkits to include a definition, framework, and measures for characterizing the spatial, temporal, and configurational aspects of geographic dispersion in teams.

A Definition of Geographic Dispersion in Teams

Our approach to geographic dispersion includes both the spatial and temporal distances among team members and the configuration (or arrangement) of those team members across sites. Configuration has long received considerable attention at the organizational level (Miller, 1987), where researchers have used the “configurational approach” to study the relationships between organizational performance and various organizational characteristics (Ketchen *et al.*, 1997; Meyer *et al.*, 1993). Configuration has also been studied at the micro level, in regard to the arrangement of work spaces and physical aspects of work environments (for a review, see Oldham *et al.*, 1995). However, this interest in configuration at the organizational and individual levels has not carried over to the team level.

As we define it, a team’s configuration is the arrangement of members across sites, independent of the distances among them. Such configurations include: 1) a “fully dispersed” team with only one member at each of several sites, 2) a team with multiple members at multiple sites, or 3) a team split across only two sites. For example, there are 21 potential configurations for a dispersed team with eight-members, not counting variations in the arrangement of roles, resources, or the relative location of sites. As shown in Figure 1, an eight member dispersed team could have anywhere from two to eight sites.

**** INSERT FIGURE 1 ABOUT HERE ****

With two sites, the team could have four possible configurations – i.e., seven members co-located at one site and one at another (7-1); six members co-located at one site and two co-located at another (6-2); five members at one site and three co-located at another (5-3); or four members at one site and four at another (4-4). For a larger 12-member dispersed team, the

number of possible configurations jumps to 76. Configuration can also apply to more than the simple number and arrangement of members per site; it can refer to the arrangement of members with particular roles (e.g., members and leaders).

While no researchers studying GDTs have addressed configuration as such, several speak to its importance. For example, Grinter et al. (1999) touch on configuration in regard to the location of expertise and distribution of “project mass” for coordinating multi-site R&D work. Both Cramton (2001) and Armstrong & Cole (2002) describe how sub-group configurations can lead to conflict and how members who are isolated from the rest of the team tend to be left out of group communications. With this recent evidence highlighting the importance of configuration, we now turn to the more extensive evidence regarding the importance of dispersion.

The Importance of Dispersion in Organizations

Dispersed work is not new (Brytting, 1986; King & Frost, 2002; O’Leary *et al.*, 2002), and distance and proximity have been the subjects of research for decades (Maisonneuve *et al.*, 1952). However, they are becoming increasingly important as organizations themselves become more far-flung – nationally and internationally – and GDTs become more common. While consistent data regarding various types of dispersed work in the United States are not readily available (Brown & Duguid, 2000, p.68; Kiesler & Cummings, 2002), all indications are that the use of dispersed teams is extensive and likely to increase (McDonough *et al.*, 2001). For example, a recent survey found that 15% of employees’ time was spent working with others in different places at the same time and 30% was spent working with those in different places and times (Gartner Group, 2001). By 2010, those percentages are projected to rise to 25% and 40%, respectively. Since the tragic events of September 11th, there have been even more rapid increases in dispersed teamwork (Shillingford, 2001).

Since the hallmark studies in the 1970s by Allen (1977) and Short et al. (1976), researchers in a wide variety of fields (e.g., information systems, organization studies, CSCW, etc.) have been exploring the role of distance in work settings (Kraut *et al.*, 2002). Though research has focused on the dyadic level of analysis, we believe that dispersion at the team level is an important and distinct construct. We also know that distance has some strong general effects with important implications for collaborative work and the technologies to support it (Kiesler & Cummings, 2002; Olson & Olson, 2000). While we know that distance plays an important role, we have yet to unpack what it entails, especially at the team level.

Beyond Allen's (1977) communication-related findings, we have little understanding of how much (if any) dispersion is too much; little understanding of the relationships between degrees of dispersion and other important processes and outcomes. For example, some researchers have shown that relationships in co-located and dispersed teams may eventually reach the same level of development, but the dispersed teams get off to a slower start (Walther, 2002). If this is true outside of laboratory teams, is it equally true for all degrees of dispersion? Recent work by suggests that the effects of dispersion may be non-linear in regard to technology use (Sosa *et al.*, 2002). Might the speed of relationship development and other variables of interest behave in a similarly non-linear way with regard to degrees of dispersion? Research to date offers few answers to such questions. As Sessa et al. (1999, p.8) note:

Practice precedes science [in regard to GDTs]... In collecting and annotating the literature about GDTs, we have found that much of the current research looks only at the ends of the continuum, at teams that meet face-to-face or at teams that are completely dispersed.

In sum, research has focused on ends of a spectrum at which few teams may actually work.

Despite a broad range of dispersion, researchers have generally treated it as a static, domain-defining condition. In contrast, we believe it is better seen as a continuous variable with

important implications for outcome or process variables. We are aware of only a few studies (Burke *et al.*, 1999; Cummings, 2001; McDonough *et al.*, 2001) that specifically address varying degrees of dispersion in teams.¹ Each of them takes a different approach to characterizing dispersion in their teams.

McDonough *et al.* (2001) tried to account for different degrees of dispersion with their three categories of teams – i.e., “co-located, virtual, and global.” Unfortunately, these categories’ definitions conflate cultural diversity and location, and mix teams that are dispersed across different floors of the same building with teams dispersed across different countries. Burke *et al.*’s (1999) study of four-person student groups doing collaborative writing is noteworthy for articulating the need to study teams that fall between the extremes of co-location and complete dispersion, but “remote” in their study was operationalized by stationing three subjects in one room and the fourth in another room. Finally, Cummings (2001) uses clearer categories to describe degrees of dispersion in a large sample of project teams (e.g., hallway, floor, building, city, state, and country). This data and newly developed measures provide the basis for the empirical tests later in this paper.

II. MULTIPLE MEASURES OF GEOGRAPHIC DISPERSION

Informed by our research in both historic and modern firms, and by the literature on geographically dispersed teams, the measures proposed here operationalize teams’ geographic dispersion in a more robust way than the dichotomous approaches which have dominated previous research. The measures provide the means for usefully (but not unnecessarily) detailed characterizations of dispersion in GDTs. In all cases, we present only those measures for which there seems to be theoretical and/or empirical justification. While a single measure of dispersion would be analytically convenient, no single “index” is likely to capture teams’ dispersion

adequately. Rather than advocating one or two of the measures described below, we encourage researchers to choose (and explain their choices) carefully. Whenever possible, we also encourage researchers to conduct and report sensitivity analyses for their dispersion measures.

As summarized in Figure 2, the first two measures are of configuration, the subsequent ones are of spatial and temporal distance. The last one combines distance and configuration.

**** INSERT FIGURE 2 ABOUT HERE ****

In the following sub-sections, we define each measure, drawing inductively on Cummings' (2001) sample of 182 TeleCo project teams. The data were collected in June 2000, when the firm employed over 100,000 individuals (40% of whom were engineers). The teams worked on projects ranging from product development (e.g., design a handheld scanning device) to service improvement (e.g., convert a client platform for car phones from analog to digital) to process management (e.g., execute separation and sale of a business unit to another stakeholder) to manufacturing operations (e.g., modify existing an factory to support new production of pagers). The average project lasted 15 months and the average team had 8.1 members (SD = 1.94). Importantly for our purposes, 67 of the 182 teams were dispersed across at least two sites and members of the sample were from all around the world [U.S and Canada (63%); Europe (15%); India and East Asia (14%); the Middle East and Africa (5%); and Latin and South America (3%)]. For more on the sample, see Cummings (2001).

Site Index

Other things being equal, the more sites at which team members work, the more dispersed a team is. Inherent in this measure is a sense that as the number of sites increases, so does the technical and social complexity of coordination, interaction, and communication. The

definition of “site” is far from clear-cut (Olson & Olson, 2002), with some “co-located” teams spread across one floor of a building, while other “co-located” teams are spread across a corporate campus or even a city. For the purposes of this paper, we operationalize “site” at the building (as opposed to city or zip code) level, leaving room for site effects even at relatively close geographic proximity. In practice, the Site Index should be operationalized at whatever level is most meaningful for the context in which it is studied. TeleCo’s System Documentation Team represents one extreme on the Site Index, with eight sites across six states and seven cities. At the other extreme, there are 57 teams with members split between two sites (Site Indices = 2, as with the Customer Support Team, whose members are split between Israel and Illinois) and there are 67 single-site teams (i.e., Site Indices = 1).

Isolation Index

Measuring only the number of sites does not address the number of team members per site. For example, is dispersion of the TeleCo’s Mobile Phone Team with members distributed 2-2-2-1-1 the same as that of the Instructor Development Team, with members distributed 2-1-1-1-1? While the teams both have five sites, members of the Instructor Development Team are arguably more isolated. Absent travelling for face-to-face (FTF) meetings, collaborative work for them will require technology-enabled interaction, while the Mobile Phone Team could divide its work so that some highly interactive work is assigned to co-located pairs.

This suggests a second measure that we call the Isolation Index and define as the percent of team members who are at sites with no other teams members, with low values of the index indicating low levels of isolation. The range for this index is 0 (no percent of team members alone at their site) to 1.0 (all members alone at their sites). Many of the teams (including some of those with four or more sites) have few if any isolated members and, thus, have low Isolation

Indices. However, 15 teams have at least one third of their members isolated at a site. Some have more than two-thirds of their members isolated from each other.

Inherent in the Isolation Index is a sense that the more members per site, the greater the potential for in-person interaction without travel. While members who share a site with a cluster of teammates may not take advantage of such interaction, they at least have the option, whereas isolated members do not. The Isolation Index assumes that being isolated is problematic (see Cooper & Kurland, 2002, and studies reviewed by them, esp. p.512), but it is worth noting that sub-teams with clusters of members may result in inter-group relations problems (e.g., sub-teams may actually engender less trust and more conflict).

Although these indices help create a more complete picture of teams' dispersion, they do not account for spatial-temporal distances among sites – i.e., they are purely measures of configuration. For a picture of spatial-temporal distances, several other measures are helpful.

Separation Index

To account for spatial distances among sites, we suggest a Separation Index. Inherent in such a measure is the expectation that members of GDTs will occasionally want to meet FTF and that the ease and frequency with which those meetings happen depends on the distances separating members (as well as travel budgets and other factors).

The Separation Index is measured in terms of the “crow flies” or “Great Circle” distance between sites, weighted by the number of members at the sites, based on a matrix of all possible, non-redundant member-to-member connections.² The higher the Separation Index, the more dispersed the team. For example, TeleCo's Digital Audio Team had nine members dispersed across three sites in the U.S. (Austin, TX), Israel (Tel Aviv, IS), and Singapore (SI), the mileages separating sites are as follows: $Sep_{US-IS} = 7,143$ miles; $S_{US-SI} = 9,841$ miles, $S_{IL-SI} = 4,938$ miles.

With the number of members per site $n_{US} = 1$, $n_{IS} = 1$, and $n_{SI} = 7$, the Separation Index for this team would be calculated as follows:

$$\text{Separation Index} = [(Sep_{US-IS} * n_{US} * n_{IS}) + (Sep_{US-SI} * n_{US} * n_{SI}) + (Sep_{IS-SI} * n_{IS} * n_{SI})] / [(n^2 - n) / 2]$$

where n_i is the number of members per site and n is the total number of members on the team³

Thus, for TeleCo's three-site Digital Audio Team, the Separation Index would be equal to:

$$[(7,143 * 1 * 1) + (9,841 * 1 * 7) + (4,938 * 1 * 7)] / [(9^2 - 9) / 2] = 110,596 / 36 = 3,072$$

An expanded calculation would be used for teams with more sites, with distances and weights being added for each new member-to-member connection.

In the 182 team TeleCo sample, the average Separation Index is relatively low (279 miles), but there are teams like the Instructor Development Team which have members spread across four continents, with an average distance among members of 4,795 miles. The Handheld Device Team with members at eight sites in Georgia, Tennessee, Illinois, Arizona, and Israel has the next highest Separation Index at 3,691 miles. Although spatial distance is definitionally related to time zones, teams that are dispersed primarily east-west face greater temporal challenges than those dispersed north-south. Our next measure captures this distinction.

Overlap Index

As Kayworth & Leidner (2000) describe, the temporal aspect of distance can be a “major hurdle” for geographically dispersed teams. For some teams dispersed across time zones, the only alternative to working asynchronously is to extend the workday or travel for FTF meetings. Whether one uses miles or travel time to measure distance, the assumption is that team members will eventually or periodically want to meet FTF (as a team or in sub-teams) and there should be

measures to assess how difficult it is to hold such a meetings. To address this issue, we propose an Overlap Index, which gauges how difficult it is for a team to have synchronous communications at some time during a normal (or slightly extended) work day.

Inherent in a measure that accounts for time zones is the sense that spanning time zones adds complexity to the coordination and communication in a team, not to mention travel between sites. These temporal differences are likely to amplify spatial separations and make events like conference calls difficult to schedule. Conference calls that include members of a global team invariably require someone to dial in at times outside of their normal work day. For example, a team like Instructor Development with members in five widely divergent time zones across four continents would require some team members to dial in late in the evening (e.g., the leader in Illinois initiating a call at 9:00 a.m. in the central time zone would require his teammates in China to dial in at 11:00 p.m. their time).

Calculation of the Overlap Index parallels that of the Separation Index, in that it builds on a matrix of all possible member-to-member connections. With the Overlap Index, however, the matrix is populated by the number of overlapping work hours (OWH) between each member during a workday of fixed length (e.g., 8, 10, or 12 hours)⁴ and the Index divides OWH by the potential number of shared hours for a given workday and team size. Unlike the Separation Index, a higher Overlap Index indicates a *less* dispersed team.

The formula for the overlap between any two sites, allowing for any length workday is:

<p style="text-align: center;">If $TZ_A - TZ_B < 13$, $OWH_{X \text{ hour workday}AB} = WD - TZ_A - TZ_B$</p> <p style="text-align: center;">If $TZ_A - TZ_B \geq 13$, $OWH_{X \text{ hour workday}AB} = TZ_A - TZ_B - (24 - WD)$</p> <p style="text-align: center; font-size: small;">where A and B refer to the sites, TZ is the time zone, and WD is the length of the workday</p>
--

Time zones begin with 0 for Greenwich Mean Time and run east around the globe to 24.⁵

The potential number of shared work hours is simply $[(n^2-n)*WD]/2$, where “n” is the number of team members and “WD” is the length of the workday.

A longer workday would allow for a higher Overlap Index (e.g., .2 and .33 for 10 and 12 hour days, respectively) and any fully co-located team will have an index of 1, regardless of team size or work day length. For an eight-hour workday, teams that have three sites exactly eight hours apart will have the minimum overlap (e.g., teams spread across London, San Francisco, and Hong Kong; Tokyo, Denver, and Berlin; or Sydney, Chicago, and Tel Aviv). With a standard workday of less than 12 hours, the workdays for some pairs of time zones will neither touch nor overlap. For cities in such time zones, the Overlap Index is a negative number indicating how far apart they are from sharing any work hours (and, thus, how difficult scheduling any synchronous interaction is).

Because time zones are based on east-west geographic distance, the temporally-based Overlap Index is inherently tied (and correlated) to the spatially-based Separation Index. Nonetheless, the Overlap Index adds an important dimension to our understanding of certain dispersion patterns. Specifically, it captures an important difference between teams that are dispersed primarily in an east-west direction and teams that are dispersed in a north-south direction. For example, the Separation Index would describe a team split between New York and Lisbon as having almost the same level of dispersion as one split between New York and Lima – because the distance in kilometers between the three cities is similar. However, New York and Lima are in the same time zone and could have an extended conference call without adjusting their workdays at all. New York and Lisbon are five time zones apart and would have to extend their workdays considerably to have a similar conference call.

Of the 182 telecommunications company teams, there are few with high levels of north-south dispersion (and only one team with members in the Southern Hemisphere). However, the Communications Protocol Team, with its members within three time zones of each other in Western Europe and the Middle East, and the Product Distribution Team with its members split between Malaysia and Japan, are two examples of how teams with relatively high Separation Indices (1,374 and 1,755 miles, respectively) can still have high levels of temporal overlap (.83 and .93, respectively).

So far, all of the proposed measures have treated team members as interchangeable. An additional measure accounts for the fact that team members are rarely interchangeable, and that role differences add an important layer of complexity to teams' dispersion.

Role Index

The distribution of roles on a team can be characterized in a variety of ways. Most qualitatively, it can be described in narrative form, mentioning where key roles are located in the constellation of team members. Why is this important? Take, for example, TeleCo's Digital Audio Team, whose leader is in the company's Singapore office along with six other team members, and whose remaining two team members are in the U.S. and Israel. Given the leader's location at the same site with three-quarters of the team members, he might be less likely to call FTF meetings and lead by example when it comes to electronic communication (because he would be able to communicate FTF with the vast majority of the team). If he switched places with one of the isolated team members in the U.S. or Israel, the leader might be more likely to (1) support (and demonstrate) norms of effective electronic communications, or (2) call FTF meetings of the team. One can easily imagine how the difference between these two teams' "role maps" could have an important impact on their interactions and processes.

From one of their study's teams, Armstrong & Cole (2002) also describe how the position of a leader in relation to the team had a dramatic effect on conflict management. Team members in the leader's own office would regularly engage him in impromptu conversations and tell him "why [his plans] would be stupid." The leader would listen to their objections, clarify details, and explain his position. In contrast, employees from the site 15 km away would prepare formal objections to his plans and present them during the leader's weekly visits to the site. Although the remote site was a relatively short distance away, with no time zones or major social distances to cross, these objections still took much longer to resolve and were rarely resolved as completely as those raised by team member's in the leader's home office.

In this paper, we operationalize the Role Index as the average distance from each member to the team leader. It could also have been measured using the average number of overlapping work hours. Whether measured with miles or overlapping work hours, the Role Index always includes an element of configuration, since it is based on the location of the leader in relation to all other members. For teams with an isolated leader (like the Handheld Device Team, whose leader was alone at a site in Georgia with teams members split across three other U.S. sites and an Israeli site), the Role Index was quite high. Even when the leader was not isolated, the majority of members could be relatively far away from the leader (as with the Communications Protocol Team, whose leader was in Scotland with several other team members in Russia, Germany, and Israel).

For such an index, it is important to remember that roles change over time – in both emergent and planned ways – and that both have formal and informal manifestations. Any characterization of dispersion in terms of roles needs to be specific about the time when that characterization is made and whether formal or informal roles are being considered.

Having now defined the five new measures of dispersion, we present them together in Figure 3 for each of the TeleCo teams mentioned above. These teams are not intended as a representative sample; rather, we chose them for illustrative purposes.

**** INSERT FIGURE 3 ABOUT HERE ****

In the following section, we explore the measures as they relate to each other and team communications, using the TeleCo teams.

III. INVESTIGATING THE MEASURES

Having answered the question “How can we measure geographic dispersion more robustly?,” we now turn to an investigation of those measures with the TeleCo sample (n=182), which allows for more detailed examination of the measures in a real organizational context. TeleCo team leaders provided project descriptions as well as team members’ names, locations, and contact information. After gathering background information on the teams, an email survey was sent to each team member with a valid email address. The response rate was 73% (957/1315). Data were also collected on the city, state, and country of each member, which we used to obtain coordinates and time zones for each team member.⁶ There was an identified, formal leader for each team and the distance from each member to the team leader was measured on a 1 to 7 scale (1:immediately next to, 2:same hallway, 3:different hallway, 4:different floor, 5:different building, 6:different city/state, 7:different country), which we used to calculate the Role Index. For the communication frequency measure, each member indicated “How frequently did you communicate with X during the project?” on a 5-point scale (1:never, 2:monthly, 3:weekly, 4:daily, 5:hourly) where X represented the name of every other member ($\alpha = .77$; mean = 2.97; SD = 0.44). Members were asked to report their frequency of communication

during the planning phase (i.e., first half of group work; mean = 2.90; SD = .41) and the completion phase (i.e., second half of group work; mean = 3.11; SD = .50) of their projects.

As shown in Figure 4, teams ranged from one to eight sites, with the mean having 2.25 and the majority of teams having four or fewer sites. They also ranged from fully co-located to globally dispersed, with Separation Indices as low as .01⁷ and as high as 4,795 for the Instructor Development Team with members in the U.S., U.K., Brazil, and China. There were 115 multi-site teams, with higher Site, Separation, and Role Indices, as well as 26 multinational teams.

**** INSERT FIGURE 4 ABOUT HERE ****

Given the relatively low average Separation Index of 279 miles, the average Overlap is a high 0.97. By definition, teams with low spatial distances among members will have comparably high levels of temporal overlap. Most teams did not span many time zones, although some did have Overlap Indices below .50 (e.g., the Handheld Device Team with four members in Israel and six across three U.S. time zones, and the Instructor Development Team mentioned above).

As noted earlier, operationalization of the Role Index can vary depending on the nature of the sample and available data. Each of the 182 teams had a designated leader and the average distance from that leader to each member was available on Cummings' (2001) 1-7 scale. We used this average as our Role Index, given that the leader's site was a common meeting place for the teams and was where resource approval for the teams generally originated.⁸

Of the 182 teams, 156 had all members within one country, 18 had members spanning two countries, and 8 had members in three or four countries. There were 117 teams whose members were located within the same city, albeit not in the same building or area of a building. Thus, the sample includes a fairly wide range of dispersion and some "global" teams, but it includes a large majority of co-located and regionally or continentally dispersed teams. In

addition, only one of the 182 teams was dispersed across the Northern and Southern Hemispheres. As a result, spatial and temporal measures will be highly correlated.

Given this paper's interest in dispersed teams, the focus of our analyses is the teams that are spread across multiple sites (n=115), with occasional references to the sub-sample of teams that span multiple nations (n=26). These sub-samples differ most in terms of the Separation Index. The average Separation Index for multinational teams is more than three times that of the multi-site sub-sample (1,454 vs. 441 miles), and more than five times that of the full sample.

Relationships among Dispersion Measures and Communications

Figure 5 shows the correlations among measures for the full sample and two sub-samples. Ranging from .42 to .96, all are statistically significant ($p < .001$).⁹

**** INSERT FIGURE 5 ABOUT HERE ****

These correlations point to at least four key observations about the measures' behavior in this sample. First, with primarily east-west dispersed teams, the Separation and Overlap Indices are highly correlated. As noted earlier, the Overlap Index adds to the Separation Index when there are teams dispersed north to south. Such teams can have high degrees of separation in terms of mileage, but still have sites with mostly or completely overlapping work days. Second, a natural connection between the Site and Isolation Indices is borne out. As the number of sites on a team increases, the isolation of individual members is likely to increase unless team size also increases. Third, the Role Index is least related to the other measures, in part because it combines elements of spatial dispersion and configuration. Fourth, a factor analysis of the five indices points to two distinct factors, with the first one combining Site and Isolation accounting for the vast majority (86%) of the variance. The second factor loads on the Separation and Overlap

Indices, which, as noted earlier, are nearly indistinguishable in this sample. The Role Index, on the other hand, did not load on either factor. Thus, if one had to choose only one or two measures from among these five, and one's focus was configuration, the correlations and factor analysis point to the Site Index. Alternatively, if your focus was distance and your sample did not include many teams dispersed north to south, the Separation Index would be the preferred choice. In addition to these four observations, correlations between the measures and intra-team communications frequency suggest a number of additional observations discussed below.

Although most of the 115 multi-site teams have fairly low levels of dispersion, there is still a relatively strong and highly statistically significant negative correlation between all measures of dispersion and communication frequency during the planning and completion phases of teams' work (Figure 6).

**** INSERT FIGURE 6 ABOUT HERE ****

Dispersion is clearly related to less frequent communications within the teams, and this is particularly true early in their projects. Furthermore, the negative relationships between communications, Site, and Isolation decrease somewhat over time (as indicated by lower correlations for completion phase communications). While a variety of explanations are possible, and post-hoc analyses of these data cannot adjudicate among them, these decreasingly negative correlations suggest that team members may learn to cope with the effects of dispersion. Overall, for the full sample and sub-samples, the complexity of coordinating across multiple sites appears more challenging than the miles among them or any of the other measures.

Comparing the 115 dispersed teams to all 182 teams and the sub-sample of 26 multinational teams, also highlights some interesting differences (see above, Figure 6). For example, the relationships between dispersion and communications are much stronger among

multinational teams than they are for the 182 team sample. The high correlations and significance levels for the relatively small sub-sample of multinational teams is noteworthy and suggests that the international aspects of teams may be an important factor in their communications that is not captured by the dispersion measures. The correlations also suggest that proximity to the team leader is associated with less frequent communications early on, but that this association diminishes by the completion phase of teams' work. Interestingly, however, for the 26 multinational teams the negative effect of dispersion for all measures actually *increases* over time, suggesting that international and cross-cultural factors may hinder learning and limit communications.

IV. CONCLUSIONS AND IMPLICATIONS

As noted in our introduction, research on dispersed teams is still in its relatively early stages and we are only now beginning to have useful frameworks and taxonomies with which to characterize the domain. However, the volume of research is growing quickly and we argue that the need for tools and terms to characterize teams' geographic dispersion is also growing. As others have called for richer descriptions of teams' actual tasks and contexts (e.g., Hackman, 1990), we encourage fellow researchers to characterize their subject teams' dispersion more completely. For small sample studies, narrative descriptions like the one in Majchrzak et al. (2000) may be sufficient:

Two members were located in different ends of the same building, three other members were each one mile away in different buildings; one member of a second organization was located 100 miles away; and two members of the third organization were located 1,000 miles away in different buildings. [Team] members limited their travel since they were involved with many different teams within their company. As a result, all members were together only once – at the end – although there were three other formal meetings held in which some members attended.

However, we still hope that the measures proposed here spur researchers using small samples to consider both spatial-temporal distance and configuration more carefully. For large sample studies, we hope that the measures offer a means for characterizing dispersion – be it an independent, dependent, or control variable – in a robust way.

The measures capture dispersion's spatial, temporal, and configurational dimensions in ways that complement existing non-linear measures of spatial distance¹⁰ and the well-tested measures of social distance. Although we believe our analyses are useful steps toward understanding teams' geographic dispersion better, and include some creative approaches, they are also post-hoc and exploratory. The measures remain to be tested in a wider variety of contexts (both naturally occurring and controlled) with a wider range of dependent variables. Regarding the measures themselves, despite the relatively high correlations among some of them, analyses of the sub-samples suggest that they will be more distinctive in samples with higher levels of dispersion.

Limitations and Suggestions for Future Research

Although it draws on a large sample of real, organizational project teams, this paper's focus has been the development of a framework and measures for characterizing teams' dispersion, not testing dispersion's role as an independent, dependent, or control variable. While we were able to conduct a post-hoc examination of the relationship between one variable (communications frequency) and dispersion, future work remains to be done testing this relationship further, and testing the relationship between dispersion and other variables of interest to those studying "virtual teams" (e.g., identity, conflict, trust, performance, learning).

Future research might also address the relationship between geographic dispersion and social distance (i.e., diversity in demographics, functions, educational background, etc.). In their

argument that “technologies for the management of distance have been built largely around the need to handle ambiguity across temporal, geographic, and social distance,” King & Frost (2002) note the importance of this relationship. Social distance (or, as it is more commonly known, demographic diversity) is the subject of considerable research in the organizational demography and team literatures (e.g., see Williams & O’Reilly, 1998, for a comprehensive review). A comparison of teams that are, for example, low in social distance but high in spatial-temporal distance would disentangle concepts that are commonly conflated. Such teams may help us articulate what (if anything) is attributable solely to spatial-temporal distance, and what is attributable to the diversity that often comes with dispersed teams.

In addition, we know little about how geographic and social dispersion combine to affect *perceived* dispersion for individual team members. Since, as the old adage has it, perception is 9/10ths of reality, future research would benefit greatly from an enhanced understanding of how team members perceive and respond to dispersion. The preceding sections have focused on the objective aspects of dispersion (in much the same way that demography research has focused on ascriptive personal characteristics), but individuals’ perceptions of their dispersion are important too. Under the rubric of “cognitive distance,” perceptions of distance and other geographic characteristics have received considerable attention in psychology, geography, planning, and other fields (Golledge & Stimson, 1997). The measures proposed here provide a baseline for comparison between geographic dispersion and perceptions of it.

While we have not addressed it in this paper, we believe there is considerable work to be done with an additional aspect of team’s configuration – i.e., the balance or clustering of members at sites. Decades of research on intergroup effects suggest that imbalanced sub-groups are likely to be important for other dependent variables not tested here – e.g., conflict,

competition, and cohesion. Future research could develop and test an “Imbalance Index” as well. The standard deviation of members per site divided by the team size might be one way to operationalize the concept of balance.

The analyses presented here have only scratched the surface with the Role Index. For example, the current Role Index is focused on the formal team leader. Other team roles warrant consideration, as do other approaches to team leadership. As we know from the work of Ancona and colleagues (e.g., Ancona & Caldwell, 1992), *external* relations and externally oriented roles are also critical to most teams. Thus, future research might also test an External Index, which could characterize the distances between team members and key *external* constituencies or resources (e.g., customers, headquarters, production facilities) in a way analogous to the Role Index’s characterization of the team in relation to its leader.

Our results include some sense of change over time in the planning and completion phase communication variables (see above, Figure 6), but the conception of dispersion is primarily static. As with most constructs, dispersion can change over time as team composition changes, team members travel or relocate, and organizations combine or separate. The measures proposed here lend themselves perfectly well to longitudinal or cross-sectional analyses of geographic dispersion. Their relationship to the percent of time team members spend different places [cf. Monge et al., 1985] would also be a useful check on the measures and provide interesting insights into the mobility or immobility of teams and team members. Additional work should also address the specific timing of certain interactions within teams (e.g., whether face-to-face interactions happen early in a team’s work together).

In a dispersed team context, attention to timing may also entail attention to communication media and their component features (Griffith & Northcraft, 1994), since only

some media enable synchronous interactions and only some provide visual cues. As dispersion increases beyond certain key levels, use of media may shift. For example, as dispersion increases to beyond the point at which team members can travel roundtrip to/from each others' site within a work day, they may shift away from FTF communication in favor of e-mail or phone. As dispersion increases to the level at which there are few shared work hours among team members, communication may shift more heavily toward asynchronous media. Furthermore, as levels of isolation increase, teams may need to be especially conscious that their choice and use of media does not exclude those members who are "out of sight."

In general, the teams literature has not considered the location of team members from a design standpoint. A team's configuration (like all aspects of its dispersion) can be the result of explicit decisions about team design, or it can be the indirect result of other factors like the location of a company's plants, offices, facilities, or customers. Given the known general effects of distance in other settings, it may behoove team leaders and sponsors to consider the location of team members carefully as they compose teams. It may also be especially important to consider team leaders' locations in relation to the rest of the team.

Despite this study's limitations, we believe that the measures and analyses presented here are an important contribution to the study of GDTs. We also hope that this work encourages us all to proceed with greater sensitivity to the degrees and multiple dimensions of dispersion in teams. Communication is the channel by which much of dispersed work occurs and varying degrees of dispersion appears to have important effects on communication. In addition, alternative measures capture conceptually different aspects of that dispersion, including spatial and temporal distance and configuration.

Figure 1: The 21 Possible Configurations for An Eight-Member Dispersed Team

Number of Sites	Configurations	For example:
2	7-1, 6-2, 5-3, 4-4	A 3-3-2 configuration represents a team with 3 members at Site A, 3 at Site B, and 2 at Site C
3	6-1-1, 5-2-1, 4-3-1, 4-2-2, 3-3-2	
4	5-1-1-1, 4-2-1-1, 3-3-1-1, 3-2-2-1, 2-2-2-2	
5	4-1-1-1-1, 3-2-1-1-1, 2-2-2-1-1	
6	3-1-1-1-1-1, 2-2-1-1-1-1	
7	2-1-1-1-1-1-1	
8	1-1-1-1-1-1-1-1	

Figure 2: Summary of Characteristics Captured by Each Dispersion Measure

Measures	Summary	Spatial	Temporal	Configurational
Site Index	Number of sites per team			*
Isolation Index	Percent of members alone with no other team members at their site			*
Separation Index	Average distance from one member to the “average other” member	*		
Overlap Index	Actual shared work hours among members divided by the potential shared hours if team were co-located		*	
Role Index	Average distance to the team leader	*	*	*

Figure 3: Summary of Dispersion Indices for Selected TeleCo Teams

Team	Countries or States	Dispersion Indices				
		Site	Isolation	Separation	Overlap	Role
System Documentation	IL,FL,CA,MD,WA,CO	8	.70	1,280	.83	6.00
Customer Support	IL and Israel	2	.17	2,048	.67	2.20
Instructor Development	Brazil, China, UK, US	5	.67	4,795	.48	5.60
Mobile Phone	IL and Germany	5	.25	2,459	.75	5.00
Product Distribution	Japan and Malaysia	4	.10	1,755	.93	6.11
Educational Tools	CA, IL, WA, TX, IL	7	.75	1,239	.83	5.43
Digital Audio	Singapore, Israel, US	3	.22	3,065	.68	3.63
Handheld Device	US and Israel	8	.60	3,691	.46	6.44
Communication Protocol	Scotland, Russia, Germany, and Israel	4	.00	1,374	.83	5.67

Figure 4: Descriptive Statistics of Dispersion Measures

Indices	All Teams (n=182)			Multi-Site Teams (n=115)			Multinational Teams (n=26)		
	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev	Range
Site	2.25	1.5	1-8	2.98	1.47	2-8	3.77	1.75	2-8
Isolation	.36	.30	.08-1.00	.29	.27	0-1	.39	.30	0-1
Separation	279	741	0.01-4,795	441	893	0.01-4,795	1,454	1,366	62-4,795
Overlap	.97	.09	.46-1.00	.95	.11	.46-1.00	.83	.17	.46-1.00
Role	3.27	1.16	1-6.44	3.77	1.13	1.5-6.4	4.28	1.16	2.2-6.4

Figure 5: Correlations among Dispersion Measures for Sub-Samples of Teams

Indices	All Teams (n=182)				Multi-Site Teams (n=115)				Multinational Teams (n=26)			
	1	2	3	4	1	2	3	4	1	2	3	4
1. Site												
2. Isolation	.88				.86				.82			
3. Separation	.64	.61			.62	.56			.64	.42*		
4. Overlap	-.66	-.63	-.96		-.66	-.60	-.96		-.71	-.78	-.94	
5. Role	.73	.58	.49	-.49	.63	.46	.45	-.45	.65	.42*	.47*	-.45*

Note: All correlations are significant at the $p < .001$ level except those marked with an *, which are $p < .05$

Figure 6: Correlations between Planning and Completion Phase Communication and Dispersion for All Teams, Multi-Site Teams, and Multinational Teams

Measures	All Teams, n=182		Multi-Site Teams, n=115		Multinational Teams, n=26	
	r_{planning}	$r_{\text{completion}}$	r_{planning}	$r_{\text{completion}}$	r_{planning}	$r_{\text{completion}}$
Site Index	-.41	-.29	-.46	-.37	-.61	-.67
Isolation Index	-.34	-.21**	-.34	-.23**	-.49**	-.59**
Separation Index	-.32	-.28	-.35	-.34	-.57**	-.60
Overlap Index	.31	.28	.35	.34	.57**	.61
Role Index	-.41	-.24	-.43	-.26**	-.54**	-.42**

Note: All correlations are significant at the $p < .001$ level except those marked with an **, which are $p < .01$

V. REFERENCES

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VI. ENDNOTES

¹ At the *individual* level of analysis, Scott & Timmerman (1999:245) control for “degree of virtuality,” which they define as the percent of one’s work week spent away from the main office, but do so in the context of “teleworkers.” Kurland & Bailey (1999) also describe a variety of virtual work arrangements, but again do so primarily in the context of individual teleworkers. Wiesenfeld et al. (1998) used a measure that they called “virtual status,” defined as the number of days spent in the office, at home, or in “mobile mode.” They argued that “working in any of [the other two] virtual states implies lack of face-to-face meetings and other organizational cues that may be available in the office.” Higher scores indicated more days in the office and lower “virtual status.” This misses the critical shared time element of shared work hours, but it may capture some important elements of contact with people outside the team.

² The average travel time between sites could be used instead of or in addition to distance in miles. Such an index would combine a sense of space, transportation technology, and time.

³ Note that redundant connections are not included in the calculation (e.g., three hours is included only once for the potential connection of team members K_1 and L_1 ; not also for the L_1K_1 connection in the matrix). However, same-site connections are included because the denominator accounts for all non-redundant connections by including the seven co-located connections.

⁴ While using a workday of common length across sites is necessary for calculating the SWH, it does mask international variations in the duration and start/end time of work days. For small samples of teams, a different length work day could be set for each site.

⁵ Note that many renditions of the Universal Time Code system use + and - values of 0 to 12, where UTCs of -1, -2, -3, etc. correspond to UTCs of 24, 23, 22, etc. in the 0-24 scheme that we employ. For example, in our use of the UTCs, New York has a UTC of 19; in the +/- 0-12 UTC scheme, New York has a UTC of -5 (indicating that it is 5 hours behind Greenwich Mean Time).

⁶ Team members’ coordinates were derived using ZipFind, government publications, and various other resources. Time zones were obtained manually from official time zone maps.

⁷ Note that all individuals in the same site were initially coded as having zero miles between them for the Separation Index. Because there is actually some distance between them, and because transformations with a Separation Index of zero are problematic, we re-coded all individuals in the same site as having .01 miles between them. For more careful assessments of distances within sites, the seven-item measure used by Cummings (2001) is more appropriate, but the .01 distance is adequate for comparisons with individuals separated by large distances.

⁸ The Role Index could also be calculated using distance in miles, but the seven-item measure seemed more appropriate for these exploratory tests because relatively small distances to the team leader (e.g., same floor or same hallway) may make an important difference.

⁹ Although not shown here, team size is significantly correlated with Isolation, but not with any of the other indices.

¹⁰ There is an extensive literature on spatial statistics. See, for example, Fischer & Getis (1997).