Revisiting the Factors that Engender Trust of Global Systems Engineers

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Abstract— **Trust is generally considered a key element of effective and productive distributed team collaborations. In this paper, we report the results of our investigation into the factors that engender trust in Global Systems Engineering (GSE) teams in five multinational organizations. We extend our previous work by conducting a new field study focused solely on factors that engender trust and identify the implications of these factors. Our work provides significant contributions to practitioners, researchers and tool developers. Managers working in study field sites have confirmed that our findings will be used to inform future team management strategies. Our results can also be used to structure and guide future research in this field, as it identifies gaps in existing literature. Finally, our findings can be used to inform the development of future tools that aim to support collaborative work in general and GSE teams specifically.**

Keywords—trust; distributed teams; global systems development, global systems engineering, virtual teams.

I. INTRODUCTION

The research community is continually striving to gain a deeper understanding of Global Systems Engineering (GSE) teams to help overcome the challenges that are associated with collaborations across spatial and temporal distance, and the resulting breakdowns that arise. Trust is one of the key challenges and is often considered the primary element of knowledge sharing and collaboration around artifacts in both collocated and distributed development teams [1][2]. We sought to investigate the factors that engender the development of trust in such teams from the perspective of individual developers working within GSE Teams.

In our previous work, we conducted an empirical field study through a series of interviews involving practitioners who collaborate with others in remote locations to develop systems [3]. This previous work focused on investigating communication, distribution of tasks, and leadership in GSE teams. While we did not seek to investigate trust, we did find that many of our participants discussed this issue. Our further analysis of trust within these contexts led us to some initial hypotheses, which motivated us to pursue this issue further. To this end, we conducted a new and more in-depth empirical study of the diverse aspects of trust in GSE teams. We sought to validate our previous hypotheses and broaden our understanding of trust within the context of GSE teams. We use the term *system engineer* to refer anyone involved in the development of a *software system* and can thus refer to managers, human resources, software designers, requirements engineers, testers, etc.

In this paper, we revisit the factors that engender trust that were identified in our earlier study, namely team size, project type, diversity, and leadership [3]. We report the findings of our new study which focuses solely on trust in GSE teams. The previous study was based on sixteen participants, from a single Fortune 500 organization. Our current study covers seventy-one participants from five multinational organizations. These participants work with members distributed across anywhere between 2 to 11 sites.

Our new data set suggests that the previously reported factors of team size, diversity, and leadership do have a significant influence on the level of trust that develops among distributed team members, although the new data does not provide evidence that the type of project is influential. We also report new factors that were discussed with the participants, including media, face-to-face meetings, previous experience working together, and technical knowledge.

Our findings can be used by managers and team leaders to both form teams (assign team members to a project) and create team structure (e.g. reporting structure, hierarchy and distribution). We also anticipate that the findings reported in this paper will help structure and guide future work conducted in this field. Finally, the understanding gained of the factors which engender trust can be used to inform future development of software tools.

Our study background, approach, analysis and findings are presented in following sections. The paper concludes with a discussion of these findings and the potential contributions to various fields of study.

II. FACTORS THAT ENGENDER TRUST: AN OUTLINE

We define trust as a belief that the trustee (individual, team and/or organization) will meet the positive expectations of the trustor (individual, team and/or organization) [3]. From this starting point, we seek to gain a deeper understanding of the factors that influence these expectations in GSE teams. We use the term *team* to refer to two or more people involved in the development process of a single project in some role during the project life-cycle. We will also use the term *system engineering* to refer to all aspects associated with the development of software e.g.

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developing hardware, and negotiating contracts in addition to developing software components.

As noted in the introduction, in our initial study of GSE teams, we were primarily concerned with understanding communication, distribution of tasks, and leadership amongst team members, from an individual's perspective. Trust emerged as a primary concern to those involved in the study, all of whom were practitioners with several years' experience within distributed development teams. Further analyses of the initial data led us to four hypotheses repeated here from our previous work [3]:

H1. Trust is more likely to be an issue of concern to developers working in large distributed teams.

H2. Trust is more likely to be an issue when developers in a distributed team are to deliver an innovative or new product.

H3. Trust is more likely to be an issue, the greater the [cultural] diversity of the team's distribution.

H4. Trust is more readily granted to an authoritative team member characterized by leadership qualities within a distributed team.

Although we presented these as separate hypotheses, we recognized that these factors do not exist independent of one another or "in a vacuum" but can coexist in a single GSE team. For example, a team may be highly distributed with great cultural diversity, but high level of trust may exist because of the leadership skills exhibited by the team's leader. Other scenarios and combinations of these factors were discussed in the original paper [3]. These findings and hypotheses, however, were based on a relatively small sample gathered from a single organization.

We sought to expand our initial understanding of the factors which engender trust through others work. To this end, we conducted a survey of published work which reports various aspects of trust. We found that while many researchers reported the impact of team size on transactive memory [4] and effectiveness [5], for example, few investigated the influence of team size on the development of trust. Furthermore, we noted that these findings were often reports of virtual teams in general, e.g. people collaborating through a virtual game, and not GSE teams specifically. We could not find any direct discussion of the influence of team size on the development of trust in GSE teams (H1).

The same finding is also true with regards to the influence of working on innovative or new projects on the development of trust (H2). We found that the work exploring the relationship between innovation and trust in GSE teams is limited and more often derived from investigations of team in general rather than GSE teams specifically (e.g., [6]).

We did find a rich body of work which investigates various aspects of trust, primarily with respect to cultural diversity (e.g., [7] and [8]). In an experimental study of undergraduate students recruited from four universities in China and the USA, for example, researchers found that trust was higher in Chinese groups than in US groups. In the same study it was found that in the culturally heterogeneous groups, Chinese members perceived less interpersonal trust than US members when carrying out software engineering tasks [9]. These findings are often generalized to be indicative of the development of trust in collectivists (Chinese) and individualistic culture (US). A collectivist culture is typically one in which an individual is committed to the well-being of the community or the collective, whereas an individualistic culture is one in which the individual is more concerned about personal gains and achievements [7]. Such reports provide some context for our initial hypothesis (H3) but do not support or negate it.

Other researchers also investigated the relationship that leadership plays in the sense of trust (H4). One notable article describes an experiment that drew from 20 management teams from 3 company divisions, comprising 89 team members and 20 team leaders [10]. The researchers found that team members' trust in leaders increased if the team members' input was considered by the leader during decision-making. Here again, however, we find that study participants were not necessarily managing GSE teams and the researchers did not explore the influence the leader has on the development of trust within the team.

Seminal work by Jarvenpaa and Leidner [2] also led us to recognize that many other factors could influence individuals' sense of trust towards others in their team like their response to crisis, their ability to cope with technical and task uncertainty in addition to communication conveying enthusiasm.

Work by one of the present authors on design principles for software tools for supporting trust in distributed teams identified from a literature survey a list of factors that influence one's perceived trustworthiness of their team members [11]. In addition to the factors already mentioned, this work also cited expertise, role, reputation, availability, years' experience, shared information, among others.

In sum, we first conclude that there is insufficient work which investigates the influences of the specific factors that emerged in our earlier study, namely team size, project type, diversity, and leadership in GSE teams. Second, we found that there are few empirical studies which engage and involve practitioners, even fewer that involve practitioners working within GSE teams and their sense of trust toward remote team members.

III. Overview of Research Design

Our new study was conducted across five multinational organizations. We recruited a total of 71 subjects through a combination of e-mails sent to a cross section of the organizations' mailing list and word of mouth (snowball sampling). The subjects spanned five multi-national organizations with sites distributed across countries in four continents (i.e. North America, South America, Europe, and Asia). One organization is a telecommunication company, another is a large computer manufacturing, and the three others are medium-size software development companies. We interviewed 20 female and 51 male employees. An analysis of the 71 participants' demographics revealed that 50 of the interviewees had been working on projects they discussed for over 6 months. The average experience in their current team calculated to be 5.3 years. Overall, participants had an average of 16 years of work experience.

The one-on-one semi-structured interviews lasted for an average of one hour and consisted of two main sections. In the first section, we focused on gaining an understanding of the participant's background and thus it included questions about age, work experience, education, etc. One set of questions in this section focused on identifying a project

(either ongoing or completed within the last year) in which one or more team members were located remotely from the participant. Participants were asked to describe the project, the type of project, number of members, number of sites, the number of people they interact with from each site, the frequency of their interactions, and communication media used during their collaborations. This project was then used as a benchmark to ground subsequent questions about trust towards team members.

In the second section of the interview, we focused primarily on gaining an understanding of trust from the practitioners' perspective. Questions regarding the factors that engender trust were part of this section in addition to questions regarding the participants' sense of trust towards others in their team. The appendix presents a sample of the questions asked in our interviews.

Participants involved in the study were members of different team and involved in the development of diverse products. The teams use mainly the waterfall and iterative models to guide development. One of the team follows XP practices. We found that our participants had different skills sets and consequently different positions within the team: managers - 23 (e.g. project manager, portfolio manager), developers - 39 (e.g. tester, software designer, system architect, business analyst), and support staff - 9 (e.g. lawyer, quality assurance).

IV. Data Analysis and Research Findings

All interviews were transcribed, and transcriptions were prepared for analysis in the ATLAS.ti qualitative data analysis software. Our subsequent analysis was guided by grounded theory procedures [12]. We coded the interviews identifying factors until we have exhausted their understanding and reached a final set of factors. We also sought to investigate whether certain demographics tended to find certain factors more influential than other demographics. To this end, we conducted binomial correlation statistical analysis [13] in an attempt to find out if age, sex, work experience, current position, and education positively correlated with any the influence of team size, project type diversity, or leadership discussed by our study participants. We did not find any such correlation, which implies that our qualitative findings are applicable across these demographic boundaries and are not specific to a certain group. Our findings regarding each of the hypotheses are presented in the oncoming sections.

A. Team size

"Team size is a big deal."(P181)

Study participants often stated that the number of team members assigned to a project varied over the project life-cycle. The fluctuating team size led us to use the highest number, in the participant's estimation, of team members at any given stage of their collaboration.

We found that over 70%[1] of our participants felt that the size of the team influenced their sense of trust towards others in their team or would only be an influence under certain conditions. Those participants that stated that the size of the team did not influence their sense of trust, typically also stated that they had less expectation of trust around others in such teams. Others stated that they used the team size to their advantage, avoiding working with those that they did not trust. Participants also emphasized the role that the team leader plays in establishing trust in large teams. One strategic planner working in the US explains:

"*I think the bigger question that you need to ask yourself first is, regardless of the size of the team is the leader or group of leaders focused enough to make any team, regardless of its size, capable.*" *(P351)*

Participants were often reluctant to give "*one magic number*" for an ideal team size. What constituted as a large team varied from one participant to another, with one participant stating that "*somewhere around 20*" team members is reasonable. Others stated that a 400 member team is a reasonable number, if the personalities were well matched and another stating that going beyond 200 to 250 would be too many team members. We could not reach a meaningful consensus on what constituted a large GSE team from our analysis of such statements. We did conclude, however, that participants focused on the importance of team structure.

Many participants recognized the limitations imposed by their ability to maintain meaningful *trusting* relationships with a large number of people. This point is demonstrated below by the statement of a system's developer working in a team that has approximately 500 members allocated to it.

"You know, I think it does… I think there's - everybody's different, but there's probably some maximum number of people you can meaningfully know. Your brain's only so big. And who knows, maybe it's 100, 150, maybe it's a lot, but there's got to be some size beyond which you're simply just not going to remember the names and faces. It's sort of a running joke. We talk about how big is your village. I see some 800 or 1,000 person design teams and I think, there's folks on that team who've never met each other." (P241)

A significant conclusion from our analysis of our discussions with participants is that the number of team members that are collocated in a single site rather than the size of the team overall is the greatest influence on an individual's sense of trust towards others in remote locations. Our findings suggest that an imbalance in team dispersion has a significant impact on the development of trust. Many participants emphasized that 2-3 members located in a remote site will lead to their "*isolation"* or their being regarded as an "*outpost"*, as the contribution from that site will be insignificant in comparison with the productivity of other larger sub-teams collocated in other sites. Participants implied that this isolation and minimal dependency (because of comparatively low productivity) on team members in such small numbers would subsequently lead to a lower level of trust the study participant had towards the remote team member. For example, a male manager located in the US stated:

"I think people need to have a sense of - I think family's too strong of a word, but certainly having a sense of you're part of a team and your work is appreciated by a local peer group, I think, is - or understood, I think, is important. It's hard to do that with just a few folks, two or three people."(P181)

This participant's statement exemplifies many others who are of the opinion that the emergence of a team identity or a sense of belonging to a larger contingent is enabled by a

[1] All values are truncated integer values of our calculations.

significant number of peers collocated in the same site. Participants felt that having more than 2-3 peers collocated in the same site can help these team members develop a sense of "*family*" not only within the site but across sites to other members located in remote sites.

Participants also recognized that larger teams lead to more generic, less personal conversations and consequently a weaker sense of trust towards others. For example one participant observed she would be less likely to reveal problems and ask for help from others if the team was large (P251). Other participants, like a female support staff member located in the US, stated that she found that the fluctuating number of team members and structural landscape negatively influences her sense of trust towards others:

"I think a factor that we - our challenge… is a high rate of change…the whole team's kind of jumbled up and rearranged or you add a new team member or someone leaves. So that building trust amongst a high rate of change organization or team I think is an interesting factor." (P251)

In both of these representative examples, we find that participants generally reported that the need to interact with a larger number of members often makes it more difficult for trust to develop. Some participants described the challenges collaborating with a large team and its impact on trust. Other participants recognized that volatile membership forces them to interact with a large number of people without any guarantee of continuity. Thus, a team may still consist of a relatively small team membership, but its volatility can mean that a single team member needs to interact with a large number of people as they leave and others join the team. This can impact their motivation to invest in developing a sense of trust towards others.

Some participants emphasized that being a member of a large team does not imply that they need to collaborate with all the team members nor do they expect to directly interact with everyone involved in the project. Instead, many stated that they typically only need to interact with those whose work overlaps with their own. Other participants stated that being part of a large team can offer an opportunity to avoid interactions with difficult team members or team members they did not trust. An analysis of their statements also revealed that the influence of this factor is highly dependent on the team structure.

A group of participants also mentioned that when the team is too large, it is a good practice to use one or two members as bridges with the remote locations to facilitate communication. A Brazilian female quality assurance analyst working with colleagues located in Dallas, US and Bangalore, India argued:

"I think you have to trust more people than in a small team, especially if you have a small team and completely based in one place only. If you have a team separated or geographically divided, you have to trust at least one people outside because you have to deal with those guys every day and you depend on them. And if you don't trust in at least one, {laughter} I think the work doesn't progress– this person will be your point of contact." (P012)

The statements we presented in this section emphasize that team size can influence the development of trust (H1), with the majority of participants agreeing that smaller teams are more likely to engender trust. The majority of participants also agreed, however, that the influence of this factor can be more manageable if due consideration is given to team structure, team membership at each location, membership stability and leadership quality.

B. Project type

"getting the project done." (P191)

We also investigated whether participants' sense of trust towards others in their team was in some way dependent on the type of product they were working on or the goal the team were assigned to achieve.

The first section of our interview focused on gathering background data to contextualize subsequent discussions around trust. In this section, we asked study participants to describe the project, prompting them to identify the *type of project* in addition to describing the product being developed. A project was considered an *innovative* project, if the final product will be the first of its kind. In other words, nothing like this product exists or it is the first time a certain technology or process was being employed to develop a certain product. A project was considered *new*, if something similar to the product existed prior to their work on its development but the product is being developed by the organization for the first time. Finally, a product was considered an *extension* of an existing product if the team was assigned the task of improving or releasing a new version of an existing product. This coding scheme is identical to that used in our first paper on the topic [3].

We found no significant trend of trust levels based on the type of project, which we coded as being *innovative*, *new* or an *extension* based on our discussion about the chosen project with participants. We did find, however, that approximately 60% of projects were self-identified as being *innovative* or *new* by study participants. Our analysis of the trust levels our study participants reported sensed towards team members did not vary based on the type of project used as a benchmark. Consequently, we conclude that we do not have evidence to support our hypothesis (H2), as we analyzed trust levels described by our study participants.

C. Diversity

"*it's like telling a joke to a Japanese audience. Maybe you'll get a chuckle"(P031)*

In our previous study [3], we derived diversity from the demographic data we collected from our study participants. In the follow up study that we report in this paper, we intentionally used the word *diversity* throughout our discussions without following pre-defined conceptualization to allow for open discussion without biasing our participants. We are also aware that discussing diversity might considered challenging for participants of certain cultures e.g. speaking negatively of others because of their regional cultural may not be socially acceptable. We sought to ask the participants about the influence of trust indirectly in an attempt to draw them into an open discussion of any situation issue related to diversity and avoid possibly discomfort and distortion of how this factor influences their sense of trust others of different cultures. This approach to the topic helped minimized the sensitivity that typically accompanies discussions of this topic, in addition to minimizing the bias that can arise when explicitly introducing culture may cause. Interestingly, most

participants discussed diversity in terms of regional culture and rarely made a connection between trust and professional culture, for example.

We found that 65% of participants felt diversity and distribution influenced their sense of trust, while others denied that it did (H3). In our analysis of the statements made by those that did feel that diversity influenced their sense of trust, we determined that cultural diversity was discussed as a factor in itself and received a lot of emphasis from these participants. Our analysis of the overall level of trust towards others in remote locations, however, revealed that our participants tended to have lower levels of trust towards other members in the project we adopted as a benchmark, when these members were located in remote locations and characterized by a different regional culture.

This set of participants stressed that they would typically find a way to adapt or work around the cultural differences that had a negative impact. Some stated that they created "*checklists*" of tasks assigned to remote team members or maintained awareness that remote team members may "*sugarcoat*" results but also relied on the team leader to establish trust in remote team members of different local culture. Other differences were more challenging to overcome and forced to distance themselves from team members who had conflicting belief systems as highlighted by a male support staff member we interviewed, located in Taiwan:

"if there was a Marxist communist that was my group leader and I knew that, and I genuinely believed he was a Marxist communist, I would move to another group or I would leave the company. I wouldn't work for someone like that." (P141)

This statement demonstrates that while trust is often discussed in terms of expectations, these are not only limited to meeting job expectations but also ideological and moral expectation to establish a commonality between the trustor and trustee. Thus, while they expect to encounter cultural differences in terms of language and social behaviors, participants generally expect remote others to have the same work and moral as themselves.

Participants also highlighted differences in perceptions based on their local culture and emphasized how such discrepancies impact the expected work outcome as stated by the this female tester engineer from Brazil working with seven years' experience working in GSE teams:

"We have problems with Ireland, with the business guys. I think they have a different culture there. They do respect working hours rigidly. The clock ticks "time to go" and they are gone. They do not have this sense of urgency. We had once a deployment planned on a Saturday, and Saturday came and there was no one there to support the deployment despite the agreement they were going to be there. We had to call it off. This has happened more than once." (P181)

Others pointed out that culture preconceptions are not always right and should be avoided in order to facilitate collaboration with remote members. For example, a male senior manager who had spent five years living in the United Stated and exposed himself to mixed cultures in his daily life mentioned the following:

"So, it's just – I guess this working style, this culture that we have here—it helps a lot, building trust. And it's amazing me, because whenever you speak with – about Brazilians outside, and even there, it's just like, "Well we're not on time for meetings; we just" – there's the whole other side of culture that is much more discussed abroad. But whenever they [Americans] start working with us, they realize the preconceptions are demystified" (P142)

Others focused on differences in communication style and the challenges that people with different cultures have in communicating with each other. These participants did not have problems with the differences in social norm as much as differences in intended meaning, including different interpretations of social cues and body language e.g. (P301)

Surprisingly, language is not perceived as an issue to establish trust, more so after time has passed and one has got used to listen to the remote colleagues. A manager located in the US stated:

"A little bit, but to be honest, that hasn't been a problem. Language difficulties can slow things down, but I don't think it has diminished any kind of trust establishment." (P181)

The overwhelming majority of those who did not feel that diversity and distribution had an influence believed that the organizational culture dominated their collaboration with others and influenced their sense of trust e.g. (P331). Others pointed out that even collocated team members were highly diverse, which minimizes the impact of remote team members' diversity. They often considered diversity within the team as an opportunity to learn and for innovation. A female manager located in the US concludes:

"if I look at my US team, it's a culturally diverse team anyway." (P391)

There were also some who highlighted that over time they learned that it is important to recognize that individuals are different despite their culture and location like this Brazilian male project manager working for over ten years with GSE teams stated:

"I would say – I think the style is really important and I've seen – when I started working with different cultures, a lot of people used to say, "Oh, this is a cultural thing," especially in India. Yes, we do notice some common behavior but an individual is an individual and then now we started just getting to know the person better and not putting a general tag saying it's an Indian culture." (P041)

We also found that some participants attributed the challenges they encountered to remote team member's location rather than the culture of that location as argued by a female developer, located in Ireland who has 15 years of experience working with GSE teams:

"And I haven't really found that there's - I suppose there's culture differences, but I haven't really found it to be - you don't want to - you have difficulties working with somebody because they're in India and that's a problem. I haven't really found that, no." (P311)

To diminish the impact of the physical distance, many argued that traveling is still one of the most efficient ways to help establishing relationships with the remote members and, as a consequence, building trust with them e.g. (P022).

Here too, participants drew on their own experience of a team leader supporting the development of trust towards others of different cultures. Many felt that the team leader

can provide the necessary background knowledge needed to understand others.

D. Leadership

"involves herding cats" (P111)

We formally defined leadership as being the process through which one member of the group (its leader) influences other group members towards attainment of specific group goals in our initial study based on seminal work by others [15]. This led us to other deliberations with study participants on whether such a definition referred to the project manager or the team leader. In the study we sought to eliminate any confusion and freed the participant to choose which of these team members they considered as being a *leader*.

We found that over 90% of participants felt that managers played a role whereas over 93% felt team leaders (e.g., development leader, testing leader) played a role in the development of trust. Participants typically considered managers to have a higher level position within the project team structure whereas a team leader was generally involved in the daily activities of a working unit assigned a task. We will refer to both team leaders and managers, as leaders herein.

Overall, there is a general agreement that leaders within the organizations are trustworthy because of their position and their consequent access to information that empowers them. Their position and the knowledge they have engenders a sense of trust towards them from members of the team. One participant, a software engineer, shared his thoughts about trusting managers:

"I guess for me it's not so much about the position they have or - I may naturally give somebody the benefit of the doubt based on their position…I may give them the benefit of the doubt a little bit more based on that they may have some information and knowledge that I don't have." (P271)

The overwhelming majority believed that strong leadership is essential to establishing trust both within a single site and across sites. Generally the participants considered the leader as a role model on appropriate collaborative interactions as they can demonstrate a willingness to trust others by setting the "tone" of the collaboration. They also stated that they relied on the leader to enforce company policies that protect their rights within the organization. A manager located in Israel stated:

"If I know that my manager, for example, and the manager of the other site don't get along and they fight with each other, it immediately affects me. And if I know that they will tell me, "We're working very - in coordination and everything is working great," and then they tell me that they expect me to do the same, then it affects me as well." (P121)

Participants generally felt that the leader can help resolve problems and to provide the necessary resources and support to team members. They are also decision-makers, and trusting their decisions comes as a natural consequence of their role. The male Brazilian manager cited before shared his opinion as follows:

"(…) because there are – a lot of the actions that are needed for a decision to be made, you need to trust that these actions will be done [by the leaders] and get back and you can consolidate it with the whole group." (P042)

In trusting others and enabling transparency, leaders establish a sense of trust in the team. A team leader can also create a negative tone by behaving in an unprincipled manner. For example, a manager located in the US said:

"If you see the leader being very political and guarded and out to screw other people, as an underling you're going to say, "I saw that leader go and screw this person. That leader could come and do [it to] me at any time." (P091)

Participants also indicated that one symptom of a lack of trust in the team and the leader's trust in the team is the increase in the number of meetings. This support staff, human resources manager, located in the US stated:

"… We have a lot of meetings. And when you really try and understand why is this meeting on top of that meeting on top of that meeting, I think a lot of times it's because one level doesn't trust the next level down. So you end up having five of the same meeting when you could have stopped it somewhere along the line and said, "Hey, we've evaluated this enough. We trust this midlevel manager to make this decision." Stop with the craziness, right? And when there's a lack of trust it goes all the way up or several layers up; farther than I think it would need to if there was a strong level of trust." (P251)

In summary, we concluded that the majority of participants explicitly stated that the leader played a vital role in establishing trust in GSE teams (H4). Participants tended to turn to the team member they identified as being the leader of their team with an expectation that the leader will resolve conflicts and challenges encountered. They also reported that the leader set the tone and establishing an environment that engenders trust. Some participants provided us with examples of instances when the leader failed to meet their expectations eroding participants' sense of trust towards others and towards the leader.

E. Communication tools and other factors

"Probably has some interesting consequences"(P221)

Throughout our discussions of the factors that engender the development of trust, we found three primary factors that are considered by most to be essential: time, face-to-face (f2f) meetings, and previous experience working together. While we discussed the various communication tools available ranging from traditional teleconferencing tools, e-mail, and IM to other emerging tools like telepresence and Web 2.0 technologies, we found that most participants preferred the discussion with an emphasis on the importance of f2f meetings. Many participants also highlighted the importance of utilizing a combination of communication tools to allow different levels of interaction supported by visual and audio cues in addition to written communication.

We found that 58% of participants felt that the type of *communication medium* used will impact the nature of the interaction and their subsequent sense of trust towards others. This led us to discuss specific communication tools they preferred and the potential for emerging tools to simulate f2f meetings. We specifically introduced the use of *telepresence*, in the first set of interviews, when discussing communication tools with our participants.

Some participants in the first set of interviews had used telepresence tool (high-definition videoconference) or had heard of others experience when using this tool to support

meetings with remote team members. Participants generally agreed that the quality of the visual and audio transmissions afforded by telepresence technologies far surpasses any other technology that is available to them. They stated that the technology, in some instances, makes them feel as if the remote members were in the same room as them. The scale of the visual is also life size and allows them to make eye contact with remote members. Some have also stated that it is ideal for 1:1 interactions.

One study participant, located in the US, reported that she uses the technology despite the difficulties encountered in trying to book it for meetings. She stated that she often uses it when she has a meeting with people who are both geographically and temporally remote. This means that she might have to come into campus at midnight and leave early in the morning, escorted to her vehicle by a security guard. However, she feels that the quality of the meeting afforded by the technology justifies the effort needed to overcome the challenges. In contrast, a male senior manager located in the Brazilian site of a large multinational IT company where the infrastructure needs to be prepped by whoever has scheduled the meeting mentioned the following:

"…the logistics to set up a call is so effort-consuming that I prefer to remain using either traditional videoconference or regular phone calls" (P042).

Our analysis of participants' statements led us to observe that interactions seem to break down when more people and/or sites are involved. Most participants reported that many attending a meeting in a telepresence room were more interested in the technology than the meeting agenda. They stated that attendees would discuss the technology and the quality and speed of the transmission. Their experience was further impaired if more than one site was involved. Thus the experience was more likely to be negative when more people were involved and sites were involved.

Several participants made comments regarding distracting camera movement. The camera in each site tracks movement and sound and will move to focus to the source of such triggers. However, movements and sounds are often inadvertent and consequently the camera's repeated movement often serves no practical purpose and acts as a distraction.

Some of the more intriguing comments referred to the "flatness" of the interaction, that there was "something" missing". While participants typically acknowledged that telepresence technology allows the replication of real life meetings they stated that would still prefer to meet the remote collaborators f2f. For instance, a male portfolio manager working for nearly a decade with GSE teams mentioned the following:

"Whenever I met people face to face, it becomes easier to understand some of the positions because you have an expression that is in there. For sure f2f is my favorite way to work with remote colleagues." (P032)

Our own ethnographic study of meetings conducted during site visits using both telepresence and teleconference leads us to observe that remote team members missed what may be important preliminary discussions leading up to the meeting as collocated team members congregated to the meeting room and conclusions drawn from the meeting as they walked away from the meeting room. The opportunity afforded to collocated team members often means that remote members may not be privy to other team members' reflections, conclusions or resolutions. The technologies (both teleconference and telepresence) both issue non-ambient warnings when the allotted time is about to expire. Discussions which include remote team members are typically abruptly terminated whereas collocated team members can continue their discussions while they walk away or agree to meet elsewhere on the premises. A developer, specializing in user experience, from the company where telepresence technologies were being promoted shared the following:

"I have used telepresence. Telepresence - I'm not particularly impressed with telepresence especially if you have multiple teams. You can see their faces. Other than that, I don't - because when you have three teams-three groups-working on telepresence, when someone is talking, only that group is visible to the other two. But with the other two, only that group is - you can't see everyone at the same time. It keeps shifting, and you don't know who you are watching and who you are - who is watching you. It's a clumsy way of - I don't know." (P421)

The use of teleconferencing technologies remains prevelant in this organizations as the technology is available accross all sites and most participants stated that such a communication medium (audio alone) is sufficient for them to conduct their collaboration with others in remote locations and support the development of trust.

Time is another factor that many participants recognized as a significant influence on the development of trust. Many felt that over time, they can manage their expectations and develop realistic understanding of others in their team. Time will provide them with an opportunity to socialize and discover commonalities e.g. shared hobbies or interest in sports, among others. For example, a requirements engineer located in the US stated the following:

"Time is a huge one. I think the more you work with someone, the more trust you're going to have in them; the less time you work with someone, the least trust you're going to have with them." (P111)

A female business analyst shared her thought about the role of time in developing trust and stated the following:

"What happens is that we usually rely on people that they are on the project for a longer time, right? So, what happened is it's a project that's just growing a lot and we have a lot of new people. So, on these new people I usually ask myself twice: "Should I trust them? Is everything going okay, can I trust them now?" So, it is a big problem for me to establish trust with people that are just get new to the team. So, this is very difficult at first but things evolve as time goes." (P022)

Such statements demonstrate the need for time to allow trust to develop, and also supports our previous observations regarding the volatility of team membership and team size. Team members need some evidence that others can be trusted e.g. *"can I trust them now?*". The process of establishing trust within the terms of certain expectations requires time and must be repeated with every new addition to the team.

For others they stated that they would try to gain others trust by maintaining their "role and not stumble" and

recognize people's role in the organization's hierarchy. This factor was also true with regards to how many participants perceived leaders and explained their sense of trust towards leaders within their teams.

Another factor largely discussed by participants from three of the companies is previous *experience working together*. Being familiar with their remote colleagues preferences and working style (e.g., contact a colleague by e-mail or phone to get a faster response, understand what silence means, etc) was discussed as facilitating collaboration and positively affecting trust levels. An experienced male developer working with the same remote colleagues for over five years stated:

"Previous experience working together has impacted the project's results. The level of trust goes up and down for each colleague according to what they do in the current project, but the previous experience counts to define how much I trust them now." (P152)

A Brazilian female tester working also for about five years with the same remote colleagues mentioned that previous experience working together can help others decide what to say on one's behalf, leveraging trust among members of a GSE team.

"They know me from before, not only my work but the way I like to deal with things, they know me personally. They would be able to share my thoughts even without me telling them what I think about a certain thing, so I do trust them to go ahead on my behalf." (P272)

Other factors that were also mentioned to a certain extent are the level of *technical knowledge* a person has about the project and product being developed and honesty e.g. a female tester engineer (P192) located in Brazil.

An observable and tangibly honest *attitude* towards the project and colleagues was also considered influential of trust building among GSE teams. The male portfolio manager mentioned previously who has been working for nearly a decade with GSE teams described the following situation:

"Yes, exactly. We asked him to stay on a US holiday. It was more like a Spring break with his family, showed up with some requirements that we need to discuss in those meetings. And he said, "Okay. Yes, I…" – and he was very honest and I started to trust him even more. "It's not my preferred way to spend this training, but I understand that you guys need it. So, that's fine. We can figure out later how to do that. I will stay."(P032)

We conclude that other less dominant factors included basing trust on previous shared experiences, consistent behavior and others ability to meet their commitments. While these factors were mentioned by some participants, the factors were not clearly identified or discussed by the majority and will require further research to gain a deeper understanding of these and possibly other factors.

V. STUDY LIMITATIONS

We are sensitive to the reality that speaking about cultural diversity is unacceptable in some cultures. For instance, in countries that have experienced diversity for over five hundred years, discussing such differences is socially acceptable and is often welcome. Furthermore, a non-local accent may have inhibited some participants and prevented them from voicing their true feelings to the interviewer. Such factors may have biased some of our study participants in their discussions of certain sensitive and socially unacceptable topics, like diversity for example.

We are aware of such threats to the validity of our data set, and attempted to minimize its impact by relating our own encounters with people of different cultures. To this end, data was analyzed by researchers with diverse backgrounds and cultural experiences. We also utilized abstract scenarios of interaction of developers' interactions across remote sites. These were scenarios would be cited as examples and were presented in a way to motivate the participant to explore the diversity topic in a natural way.

Familiarity with the interviewer might also have helped participants to be open-minded about discussing diversity issues. For example, one of the interviewers has previously conducted research with two of the companies that joined the study. Access was granted by management based on knowledge that the employees would feel comfortable discussing such issues with someone that management trust.

VI. DISCUSSION

Our initial report of factors which engender trust in distributed teams was based on findings derived from an earlier investigation of communication, distribution of tasks, and leadership practices in GSE teams. While this initial investigation led us to some initial hypotheses, the small sample size (only 16 participants) and limited number of organizations (one organization) precluded us from capturing the nuances of trust and limited the generalizability of our findings.

Our study of trust over a three-year period led us to conclude that while trust is a theoretically rich field, the theories proposed typically stem from studying virtual teams in general rather than development teams specifically. Furthermore, we also found that study participants were typically students or subjects of experimental studies rather than practitioners from the field as some of the work discussed in this paper demonstrates. This new awareness motivated us to conduct our own empirical study of practitioners through a series of interviews.

Our initial study and preliminary conclusions helped us to structure our new and more focused study of individual developer's sense of trust within GSE teams in five multi-national organizations. We sought to investigate the preliminary factors we identified in our initial study and to provide our participants with an opportunity to identify other factors that they felt impacts their sense of trust towards others in their team. Thus, we discussed the impact of team size, project type, diversity, and leadership in addition to open discussions of trust in which participants discussed factors without prompting from the researcher conducting the interview. Our new data set (collected from larger, more comprehensive and more focused study) support hypotheses 1, 3 and 4, confirming our previous findings for these hypotheses, with insufficient evidence to either negate or support hypothesis 2.

Our results suggest that *team size* does indeed influence many developers' sense of trust towards remote team member, which supports H1. Furthermore, we found that the number of participants per site had a greater impact than the team size overall, as participants felt that have a limited

number of team members at a sight also means limited contribution to the overall effort and diminished trust towards those team members. This suggests that managers need to consider the number of people located in a single site as other researchers have found that this could influence project quality [14]. We also found that the impact of change on the team and structure of the team such that interdependencies form among a core group rather than with an unmanageable number also prohibit trust forming within a short time period.

We found that the *diversity* factor does have an impact on the level of trust. While many participants were aware of the impact diversity can have on their sense of trust; others explicitly stated that they did not. This finding is significant when considered in conjunction with our observation that our participants had a lower sense of trust towards their remote team members than those who were closer geographically and consequently culturally.

Our analysis of their trust levels towards remote others, of diverse cultural regional backgrounds, revealed that they typically had lower levels of trust. This finding led us to several conclusions. First, the discrepancy between the answers given by participants when asked directly and the reality of their sense of trust towards remote others can be traced to the study participants' sense of what is socially acceptable or what the politically correct answer to such a direct answer *should* be. We note that even those that did feel diversity influenced their sense of trust, emphasized that they would typically find a way to adapt or work around the cultural differences that negatively impacts their interactions with remote others [16]. This implies that while participant's trust is influenced by diversity to some degree, they are evolving to a point where this influence is minimal or can be minimized through interactions.

Second, it implies that trust breakdowns are more likely to occur when team members are separated by temporal distance. Thus, it suggests that participants do not attribute the breakdown in trust towards remote others to differences in culture but rather to personal characteristics of the person. This breakdown is also supported by our analyses of participants' opinion regarding communication media use and support. Here we found that interactions seem to break down when more people and/or sites are involved, which is more likely to occur the greater the geographical distance and the less dependable the regions' supporting infrastructure.

Third, it could imply that our study participants do not have a sense that a team member's location, and subsequently their culture, influences their sense of trust towards others. Many mentioned the various work-around they rely on to manage their understanding of behavioral norms (reported elsewhere [16]). This can suggest that participants are no longer aware of their adaptations but do have doubts about remote team members' trustworthiness.

Finally, our discussion of diversity and our anticipation of participants inhibition led us to investigate the internal and external processes they had developed to cope with *surprises* they had encountered during their collaborations with remote others. The results of this investigation were reported elsewhere [16].

Leadership is another of the factors that emerged in our initial study and grossed the largest level of explicit recognition of its influence on the development of trust in GSE teams. Our results suggest that leadership may have the most influence on the development of trust. Our calculations led us to observe that the *leadership* factor has the highest (in comparison to the other factors discussed) number of participants explicitly stating that the leader played a major role in engendering trust in their team. Furthermore, many participants also discussed the importance of leadership in minimizing the negative influence of other factors, like team size for example.

Our study participants generally expressed a high level of trust towards their leaders and managers, which we infer also reflects on their sense of trust in their organization's decision making process. There was a general consensus that leaders attained their position because they were trustworthy. Furthermore, study participants generally felt that their team leader had access to privileged information and will provide the appropriate guidance their team members need to succeed. Consequently, participants felt they could trust their leader's advice and support.

Participants also typically felt that *leaders* are responsible for establishing transparency, knowledge sharing and setting the general tone of the collaboration within the local site and across sites. We found that participants also generally agreed that the leader's lack of trust towards team members, or towards other leaders and sites had a significant impact on their sense of trust.

A myriad of other factors were also discussed by participants, with no clearly dominant factor emerging as a result of such discussions. We concluded that while these may have a significant influence on some participants, others did not identify them as such. Consequently, we use these additional factors as a starting point for future investigations of trust in GSE teams. Specifically, our results draw attention to the use of new communications tools that attempt to address the problems of collaborations across temporal and geographical distance. Our in-depth discussion of an existing tool, i.e. telepresence, led us to conclude that while some of its features enhance user experience and a sense of closeness, many features can be improved further.

VII. Concluding Remarks

In this paper, we sought to revisit and extend the findings of an earlier smaller study of GSE teams in which trust emerged as an issue of concern. We performed a follow-up, more focused and broader study of trust that we reported on in this paper. These findings can contribute to the field of GSE as follows:

- *GSE team formation, leadership and management:* Our findings provide guidelines effective team size, structure and distribution. Our data provides evidence, for example, that the number of team members in a single site should be such that they provide significant contribution to the overall project. For instance, the number should allow members to communicate in a regular basis with colleagues when necessary. It should also be possible to get everyone together for discussions if required. The importance of this consideration is magnified if the overall number of people assigned to project is large. There seemed to be a general consensus that the number of team members at a site should be significant relative to the overall team size.

One of the key aspects of establishing and supporting the development of trust is the tone set by GSE team leadership and management. The overwhelming majority of study participants emphasized the need for appropriate leadership and management skills by people within that role.

- *Research community:* We used our initial findings to guide the research we report in this paper. We anticipate that these findings will continue to help us and others to structure and guide future work conducted in this field. We also identified new factors that can be investigated further, such as dispersion and communication media used. It helps establish a baseline understanding by filling in the gaps in research literature regarding the influence of leadership, diversity and team size.
- *Tool development:* Our results have already been used by some members of our research team to guide the development of prototype software for supporting trust through visualizations that help collaborators set realistic expectations of one another [11]. It can also be used to guide the development of communication tools more generally, e.g. support for telepresence.

Our findings were also reported in presentation format to the organizations (field study sites) and their managers. In follow-up discussions managers informally confirmed the significance of these considerations and taking them into account in team formation in future work.

APPENDIX

Interview script. A sample of the questions asked in the interview is presented below.

Section 1. Project related questions

Please describe the most recent project that involved distributed collaboration:

(1) What kind of product were you involved in developing? (I.e. Innovative, new, upgrade)

(2) How many team members do you need to interact with regularly? What are their locations?

(3) Why do you interact with them? (E.g. location, worked with them before, they have technical knowledge, need to coordinate, interdependencies, etc.) How often?

(4) What is the nature of your collaboration?

(5) How do you interact with them? (E.g. phone, e-mail, telepresence, face-to-face, Twitter, Facebook, etc.)

Section 2. Trust related questions

(1) Ask participants what they mean when they say they trust someone. If they cannot develop one, give them a working definition and then ask if it resonate with them.

(2) What do you think helped develop trust during your collaborations?
[Note to the interviewer: To discuss each one of the factors below after the respondent has given her response]

Leadership/ Management
Company policies/ Expectations?
Distribution: Location? Diversity? Culture? Language? Team size?
Video conferencing? Telepresence?

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