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A Process Framework for Global Software Engineering Teams

Ita Richardson, Valentine Casey, Fergal McCaffery, John Burton, Sarah Beecham

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Abstract

Context: Global Software Engineering (GSE) continues to experience substantial growth and is fundamentally different to collocated development. As a result, software managers have a pressing need for support in how to successfully manage teams in a global environment. Unfortunately, de facto process frameworks such as the Capability Maturity Model Integration (CMMI®) do not explicitly cater for the complex and changing needs of global software management.

Objective: To develop a Global Teaming (GT) process area to address specific problems relating to temporal, cultural, geographic and linguistic distance which will meet the complex and changing needs of global software management.

Method: We carried out three in-depth case studies of GSE within industry from 1999 to 2007. To supplement these studies we conducted three literature reviews. This allowed us to identify factors which are important to GSE. Based on a gap analysis between these GSE factors and the CMMI®, we developed the GT process area. Finally, the literature and our empirical data were used to identify threats to software projects if these processes are not implemented.

Results: Our new GT process area brings together practices drawn from the GSE literature and our previous empirical work, including many socio-technical factors important to global software development. The GT process area presented in this paper encompasses recommended practices that can be used independently or with existing models. We found that if managers are not proactive in implementing new GT practices they are putting their projects under threat of failure. We therefore include a list of threats that if ignored could have an adverse effect on an organization’s competitive advantage, employee satisfaction, timescales, and software quality.

Conclusion: The GT process area and associated threats presented in this paper provides both a guide and motivation for software managers to better understand how to manage technical talent across the globe.

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1. Introduction

In today’s global economy, increasing numbers of software engineers are expected to operate in a distributed environment [1]. In this environment, geographical distance introduces physical separation between team members and management [2], temporal distance hinders and limits opportunities for direct contact and cooperation [3], and cultural distance negatively impacts on the level of understanding and appreciation of the activities and efforts of remote colleagues and teams [4,5]. The lack of a common native language, or linguistic distance, creates further barriers to communication [1,6,7]. These distances culminate in global distance, which is commonly experienced in Global Software Engineering (GSE) environments. This results in GSE having complexities over and above those experienced in local, collocated, software development [1,8–10]. Our previous research recognized the importance of explicitly defined processes for GSE [11], and we argue that, given the substantial growth and associated complexities of GSE, it is important that process models are developed to support GSE. Therefore, we have developed a specific process area, Global Teaming (GT). GT establishes goals and sub-practices specific to GSE. To develop a Global Teaming (GT) process area to address specific problems relating to temporal, cultural, geographic and linguistic distance which will meet the complex and changing needs of global software management.

E-mail addresses: Ita.Richardson@lero.ie (I. Richardson), Val.Casey@dkit.ie (V. Casey), Fergal.McCaffery@dkit.ie (F. McCaffery), John.Burton@vitalograph.ie (J. Burton), Sarah.Beecham@lero.ie (S. Beecham).

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When carrying out our study, we also identified threats to the software project if GT processes are not implemented. We view threats broadly in terms of known and unforeseen factors that are likely to lead to project failure. In the same way as Bannerman [15], we portray threats in a broader context of vulnerability than is currently associated with risk management. Threats can be viewed as factors that prevent an organization from capitalising on the opportunities offered by successful GSE. Risk is closely associated to threat, as risk is basically the cost (or impact) of a threat and the probability of this threat happening [16].

We extend our previous work [17] by highlighting threats to successful GSD if organizations ignore the need to adapt their current processes to fit their new circumstances. The GT model detailed in this paper builds on Richardson et al. [17] to present a holistic view of the problems, solutions and threats to GSE. The underlying premise of the original GT model provided a springboard for our other related work such as barriers and solutions to GSD (which we worked on in parallel to this publication) [18], and has been adapted to reflect GSE practices specific to architectural knowledge management [19]. The previous presentation of the model was in the form of written lists or practices. In this study we explain how the practices were developed, and pull all practices together in one graphical model that should be easier to follow. We are also in the process of developing a decision support system based on practices detailed in the GT Model [20].

This paper is organized as follows: In Section 2 we provide a brief background to Global Software Engineering (GSE), Global Teams and process support. In Section 3 we report how we collected data on GSE factors through empirical studies and literature reviews; Potential threats faced if the GT processes are not implemented in practice are covered in Section 4. Section 5 presents our gap analysis that underpins the development of the Global Teaming (GT) Process area presented in Section 6. Section 7 concludes the paper. Fig. 1 shows the relationship between Sections 3-6.

2. Global Software Engineering

The growth of GSE in recent years means that many software engineers are required to collaborate over geographical, temporal, cultural and linguistic distance, collectively termed ‘global distance’ [1,2,7,21,22]. The tremendous take-up of GSE has gone hand-in-hand with technical communication advances such as the Internet, increased use of e-mail and instant messaging, and inexpensive international telecommunication [23]. In addition, the availability of highly skilled software engineers in low cost locations such as Eastern Europe, Latin America and the Far East [24], coupled with the desire to cut costs and take advantage of establishing operations close to emerging markets, have all contributed to more and more organizations selecting this strategy. In some cases, application development and maintenance have been outsourced to remote third party organizations. In others, organizations have set up subsidiaries in low cost economies and off-shored part or all of their software development to these locations [6,25].

2.1. Global Teams

The global team is described as the core building block of the global organization [26–28]. A traditional team is defined as a social group of individuals who are collocated and interdependent in their tasks. The group undertakes and coordinates their activities to achieve common goals and share responsibility for outcomes [29]. Global teams have the same goals and objectives as traditional teams and interact through interdependent tasks, but operate across time, geographical location and organizational boundaries linked by communication technologies [30]. They often operate in a multicultural and multilingual environment which may cross organizational boundaries [31]. Communication between global team members is normally electronic and asynchronous with limited opportunities for synchronous contact [30]. The team may function on a permanent or temporary basis contingent on the demands of the business environment in which it is operating. The team’s overall objective is to function as a single team, with the same goals as if they were collocated.

The implementation of a global team strategy can simply be a cost-based decision. For example costs can be reduced by combining technical skills and experience of staff located in a high-cost centre with engineers in a low-cost location. If the goal is a
of process improvement was later adopted by Deming who applied his 'Plan Do Check Act' cycle and statistical controls in both Japan and the USA in the 1980s [36]. Humphrey [37] adapted these ideas to software development and defines software process improvement as ‘the set of tools, methods and practices that we use to produce a software product’. Paulk et al. [38] expand this definition to ‘a set of activities, methods, practices and transformations that people use to develop and maintain software and the associated products’. Organizations improve their software processes to improve the quality of their product. While some argue that implementing planned processes decrease the efficiency of the software development process [39–41] there is no counter evidence that implementing planned processes increase productivity and efficiency [42–46]. Although there are valid reasons for not implementing planned process models, we argue that there are efficiencies to be gained in doing so, and, in particular, there are markets which require planned processes to be in place. For example, a recommended practice in Rottman and Lacity [47] is that when off-shoring work, the GSE organization should become CMMI certified as ‘the best way to extract value from the suppliers CMMI/CMMI processes’. Furthermore, domains such as the medical device industry must comply with the guidelines and standards of the medical device regulatory bodies (e.g. Food and Drugs Administration in USA) and require evidence that defined processes have been adopted.

While the CMMI® for Development (CMMI-DEV) [12] process model can operate successfully in local environments, it does not explicitly address the impact of GSE factors [48], especially relating to the socio-technical complexities [1,9,10]. This is supported by Prikладници et al. [49] who state that many GSE studies mention the need for Distributed Software Development (DSD) process models with specific DSD practices. The work of Ramasubbu et al. [50] also established that key processes for GSE are not specifically addressed in existing process models.

Although there is an increasing trend towards adapting and customising the CMMI® to different domains [51], there is a lack of guidance as to how to conduct such specializations in a systematic way [51]. We therefore need to explore whether the CMMI® structure would support the specialization of processes important to GSD.

These findings lead us to ask two linked research questions:

**Research Question 1:** “What are the threats faced by global software project teams if they do not implement GSE processes correctly?” and

**Research Question 2:** “Can our Global Teaming research be integrated in the CMMI® model?”

These questions build directly on our previous work. In 1999, we were asked by industry to help identify why their GSE teams were not working as effectively and efficiently as they expected. In our initial interviews with those managing GSE teams (see Table 1), we established that GSE was being mainly implemented due to short-term strategy, then GSE may be used simply as a knowledge transfer exercise. If, on the other hand, making use of GSE benefits is a long-term objective, sustained support will be required for team members at all locations. The reason for choosing a particular country to offshore to can also be based on their local knowledge or proximity to the customer base [32].

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<td>Irish division of US Multinational operating in Ireland &gt;20 years</td>
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<td>Offshore/near-shore</td>
<td>Software testing</td>
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**Table 1**

Studies used to investigate important factors in GSE.

2.2. Process support in GSE

The idea of increasing productivity and quality through improved individual processes originated in manufacturing and the work of Shewhart [35] in the 1930s. Shewhart’s continuous view of process improvement was later adopted by Deming who applied his ‘Plan Do Check Act’ cycle and statistical controls in both Japan and the USA in the 1980s [36]. Humphrey [37] adapted these ideas to software development and defines software process as ‘the set of tools, methods and practices we use to produce a software product’. Paulk et al. [38] expand this definition to ‘a set of activities, methods, practices and transformations that people use to develop and maintain software and the associated products’. Organizations improve their software processes to improve the quality of their product. While some argue that implementing planned processes decrease the efficiency of the software development process [39–41] there is counter evidence that implementing planned processes can increase productivity and efficiency [42–46]. Although there are valid reasons for not implementing planned process models, we argue that there are efficiencies to be gained in doing so, and, in particular, there are markets which require planned processes to be in place. For example, a recommended practice in Rottman and Lacity [47] is that when off-shoring work, the GSE organization should become CMMI® certified as ‘the best way to extract value from the supplier’s CMMI/CMMI processes’. Furthermore, domains such as the medical device industry must comply with the guidelines and standards of the medical device regulatory bodies (e.g. Food and Drugs Administration in USA) and require evidence that defined processes have been adopted.

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Studies used to investigate important factors in GSE.
3.1. Empirical studies

We conducted three contrasting empirical studies from 1999 to 2007 (summarized in Table 1). The first case involved local global teams, i.e. geographically distributed within the same country and organization [35]. In the second study, the organization employed offshore/near-shore global teams (involving geographical and temporal distance across continents) [56,57]. The third study examined off-shore global teams (involving geographical, linguistic, cultural and temporal distance where global team work for the same organization) [48,54,55].

We used an action research approach [58] and a grounded theory approach [59] for data gathering and data analysis. Action research was carried out through the direct intervention of a researcher who in this case was operating as part of the team in a management position. These structured approaches allowed us to leverage research opportunities and maintain a level of objectivity, resulting in the identification of factors and threats for GSE. The team involved in this research is composed of people with prior relevant industrial experience including one certified CMM assessor. All authors have been involved in GSE research for many years.

A key outcome from our three independent empirical studies was the commonality of our findings. These were reinforced by the use of an inductive research methodology where efforts were taken to ensure our previous findings did not influence our subsequent studies. When common factors were identified these were extensively explored for alternative explanations and to gain a greater insight into the problems encountered. In this way our GSE factors were identified and analysed. (Section 3.3 explains these factors in detail).

3.2. GSE Literature Review

An extensive literature review was undertaken for each of the three independent studies. The first study was undertaken in 1999 and extensive use was made of the University of Limerick's library and catalogue. The initial focus was on identifying books, journals and conference proceedings which dealt with the topics of managing software projects, information systems development, distributed software development, global software development, global software teams and computer supported cooperative work. These topics were also utilized as keywords to search manual and online database systems such as the IEEE’s digital library and the ACM digital library.

When relevant publications were identified they were reviewed and sorted into themes and chronological order. In this way key themes and their development were identified. The analysis of the literature also allowed potential gaps in research to be recognized and explored. The references in each publication were also used as a source of discovering additional material. Relevant journals identified included Communications of the ACM, IEEE Software, the Information Systems Journal, and IEEE Transactions on Engineering Management. Relevant conferences which emerged included the Hawaii International Conference on System Sciences, the International Conference on Information Systems, and the European Conference on Computer Supported Cooperative Work, and the International Conference on Software Engineering.

The second independent study took place in 2001 and a similar structured approach was implemented. The literature review from the first study was extended and updated to meet the specific requirements of this study. In particular, the search topics and keywords were extended to include specific aspects of project management, communication, cooperation, motivation, culture, fear, team work, management and organizational theory.

The third independent study took place over a 5 year period from 2002 to 2007. A further literature review was undertaken, building on the previous two literature reviews. These were consolidated and extensively expanded with 1500 additional publications identified and evaluated. Of these 300 were considered of particular relevance. This literature allowed the identification and augmentation of specific themes and they were then sorted in chronological order. To identify these publications extensive use was made of manual and online database systems. These included the IEEE’s digital library, the ACM digital library, Science Direct, Springer online, CiteSeer, Emerald and Wiley InterScience. The keywords outlined in the first and second studies were re-evaluated and expanded and these were utilized to search these systems. Numerous conferences and workshop proceedings were also reviewed. As well as those already mentioned, these included the IEEE International Conference on Global Software Engineering, the International Workshop on Global Software Development, the European Software Process Improvement Conference and the International Workshop on Distributed Software Development. What emerged from this analysis was a comprehensive and relevant literature review which was used extensively to support the third case study.

Our literature review identified many GSE related factors, which helped to identify practices included in our GT Model. However, while many of the practices in the GT Model will remain relevant and useful to organizations engaged in GSE over time, as GSE is a growth area, and the corresponding published research is also expanding, it could be that some of our recommendations will change in the future.

3.3. GSE Factors Identified

Findings from our empirical case study research and literature reviews led to the identification of several GSE factors. In this section we list some of these key factors.

Effective software project management in a single location is a complex endeavour [60]. There is the need to be an arbitrator between diverse stakeholders with different expectations and agendas, to manage the operation of the team effectively within the constraints of available resources, both financial and technological, and to manage the available personnel and technical capabilities. Therefore, successful software project management is a difficult undertaking which can only be achieved through the effective planning, organizing, staffing, leading, controlling, coordinating and day-to-day management of the project.

Software project management becomes even more complex in a globally distributed environment [61,62]. In addition to the effective organization and management of collocated teams and projects, there are additional factors which emanate directly from the operation of geographically distributed global teams and their related projects. As stated by Paré and Dubé, “The complex, usually uncertain, and highly interdependent nature of project tasks, together with geographical, temporal, structural and cultural gaps fundamental to distributed teams, make management of virtual projects a relatively complex undertaking” [62].

As shown in Fig. 2, global distance, which includes geographical, temporal, cultural and linguistic distance, introduces barriers and complexity into the GSE team environment. Effective coordination, visibility, communication and cooperation between locations are essential in a GSE team [2,63], but these are negatively impacted by global distance. Improving coordination, visibility, communication and cooperation can help to reduce the barriers and complexities. Such improvements must be accomplished under the financial and technical constraints of the project and with team
members from geographically dispersed groups. Ultimately, this is not an easy task, and our research has demonstrated that many other factors come into play during the implementation of global projects [9,48,54,55,57,64]. The full list of 25 factors identified in our case studies and literature reviews are listed in Table 2. We expand on some of these factors in this section, and provide full descriptions of all 25 factors in the Appendix.

While some of the non-technical factors noted in Table 2 have been recognized previously (e.g. communication, risk management), additional social factors, such as fear and its negative impact on trust emerged from our research [9,54], and are now more widely recognized as important to GSE [53].

Project Management challenges include promoting socializing processes to support globally distributed collaboration [33]. Research by Smite and Borzovs [65,66] shows that, in practice, the variety of collaboration models can be substantial – they identified 19 different models looking only at four life cycle processes. For example, development may be undertaken in one country’s group, with systems analysis, design and testing undertaken in another country. Alternatively some processes may be ‘shared’ – for example design and coding could be performed at both locations. Therefore, in practice, organizations are shown to distribute responsibilities across remote sites. Smite and Borzovs [66] define these as either ‘joint collaboration’, requiring investments in team building, or ‘independent collaboration’, requiring investments in knowledge management and transfer. Each model requires a level of socialization to succeed, and recommendations include face-to-face meetings to enable teams to share norms, attitudes and behaviours [33].

GSE is not without its inherent business related risks [61,67]. This has particular relevance when organizational boundaries are crossed. For example, aspects of a software application may provide competitive advantage to the organization that is having it developed [61]. In this case, they may not wish to grant an outside organization access to such information, even when temporarily partnered with them. To prevent this, a global team strategy can be employed to allow the partitioning of development across sites. The activities that need to remain confidential are undertaken by the organization’s own global team members, whereas related activities are undertaken by external remote team colleagues. There are many effective ways to partition tasks, where most would fit into three main classes: modularization, phase-based and integrated. Component based distribution of tasks offers flexibility in terms of task ownership, inter-site communication, collaboration and knowledge sharing [68].

An important outcome to emerge from our studies was the compounding impact of the GSE factors listed in Table 2. For example, fear emerged as a serious problem in each of the studies. In case study one, the direct impact of fear was a breakdown in communication, cooperation, knowledge transfer, motivation and trust. In addition, each of these factors compounded each other. The lack of communication was a barrier to the development of cooperation and therefore inhibited knowledge transfer. This had a negative impact on the motivation of the offsite team members and resulted in the lack of trust between locations, fostering the development of a “them and us culture” and adding to the level of fear, which further hindered communication and cooperation. The ultimate outcome was the total failure of the project and the dropping of the offsite strategy.

In case study two, as a result of their fear of losing jobs, email was used as a weapon by local team members to attack their remote colleagues. Any problems that were caused by the remote team members were highlighted to senior management. Once this practice had been established the remote team members reciprocated in a similar manner. Cultural differences came to the fore and team relationships and trust broke down. Rather than cooperating, team members actively sought to undermine and obstruct each other. This further inhibited communication and cooperation. It also polarized cultural differences which added to the level of fear and mistrust experienced by team members in both locations. This outcome was all the more surprising given that the team members had successfully worked together when they were collocated in the US for over a year.

In the third case study, many negative issues associated with GSE came into play. Fear inhibited communication between the off shoring location and the remote site. Extensive communication tools were provided, but they were not utilized and contact was limited to email. Cultural differences were misunderstood and helped to reinforce mistrust and fear. Remote colleagues were slow to communicate, using distance strategically to minimize information flow, which further hindered the development of cooperation. Very little knowledge transfer took place. Limited face-to-face contact led to cultural misunderstandings also resulting in additional fear and mistrust. The result was that the projects failed.

While fear was an important factor to emerge from our studies; it is only one of the 25 GSE factors identified. We observed in case study two, that once these factors were recognized, they can be successfully addressed. For example, fear was tackled along with the additional contributing factors through the provision of team building, communication and cultural training, which resulted in a successful project.

It is also important to highlight the compounding impact of the GSE factors we identified were experienced at different levels within the organizations researched. In each case study senior management had unrealistic expectations of what could be achieved, as the true cost of implementing their respective GSE strategies were not determined or the implications understood. This resulted in unrealistic expectations, which placed undue pressure on the project.
managers to deliver unachievable financial and productivity results. This pressure was passed down to team leaders and team members. This was exemplified in the third case study where the remote team members due to their cultural background agreed to undertake large amounts of additional work. This resulted initially in remote team members working extensive levels of unpaid overtime. When that level of work was no longer sustainable they left the organization. It was only after a prolonged period of time, when the sustained high attrition rate was investigated that this emerged as a key reason for the extent of the problem. Given their cultural background, the overworked remote team members would rather leave the company then communicate their inability to meet unrealistic expectations. The loss of these experienced engineers had a direct negative impact on productivity, knowledge transfer and the motivation of the team members at the remote location. As a result projects which were already behind were hindered further and revised deadlines were missed and further cost overruns incurred.

Each of the 25 GSE factors identified had a negative and compounding impact on the projects researched. Without the ability to effectively communicate and the correct use of tools to facilitate it, teams could not be successfully established, limited knowledge transfer took place and without corrective action projects could not be productively undertaken and managed. Temporal issues negatively impacted on communication, coordination, control and visibility. It also inhibited the development of relationships, trust, cooperation and teamness along with other factors. The lack of understanding of cultural difference compounded all of these factors and each factor had its own compounding impact. As case study 2 highlighted it was only when the negative GSE factors and their compounding impact were recognized and addressed that effective project management could be undertaken. In this case it resulted in a multimillion dollar project, which was failing being successfully turned around and delivered. As each of our studies showed, without effective technical support, team selection, clear definition of roles and responsibilities, skills management, process management, risk management, reporting and information management the success of GSE projects can be seriously impaired. Specific knowledge of each of these factors in the GSE setting is essential and their compounding impact needs to be understood and addressed.

In summary, implementing GSE is not an easy task, and many software teams continue to experience difficulties when they are required to work as a global rather than a local team. Having identified a comprehensive list of relevant factors from both direct experience with industry and the literature we are in a position to develop the GT process area (in Section 6) but first we present a rationale for developing the GT process area through a discussion of the threats which exist if GSE is not implemented correctly (Section 4).

4. Establishing Potential Threats

This section on potential threats relates to risks associated with GSE and answers our first research question, "What are the threats faced by global software project teams if they do not implement GSE processes correctly?" This provides a rationale for the development of the GT model presented in Section 6. The threats identified draw on the analysis of our empirical work and the literature reviews (Section 3).

While we cannot guarantee that implementing GT processes will reduce or eliminate the increased risks associated with GSE, we point out that if nothing is done to address problem areas (identified as such in the literature and in the empirical evidence), the project remains under threat of failure. It is important that global project managers understand that ignoring GSE issues could threaten the success of GSE projects.

4.1. Identification of Threats

As illustrated in Fig. 1, potential threats were identified through an analysis of the literature and our empirical work [9,48,69], where we looked at the problems organizations were facing in GSE (e.g. [17]) prior to looking for solutions. The new practices in the Global Teaming model therefore grew from recognizing the problems that organizations face. By including the threats, organizations are in a better position to assess the associated risk and may be more motivated to implement the new practice.

4.2. Potential Threats

For consistency, we discuss potential threats to GSE under the headings that directly relate to the GT process area specific practices (presented in Section 6).

4.2.1. Threats to Successful Global Task Management

In the software industry, a team structure should facilitate the successful management, coordination and operation of team members so that they produce the required software artefacts [61]. Managers need to consider the size of their global team as team size can directly impact the operation [70], as can the number of members situated at specific geographical locations. Team members may feel that if larger groups of developers are located in one or more remote geographical sites all the work may be centralized in these locations. This can threaten productivity due to feelings of alienation and fear for the future of their jobs, particularly for team members based at the location from which the work has been outsourced [71]. Additionally, management at one location may have responsibility for both their local and remote locations [71]. A structure shown to reduce this problem is the dual reporting to management where each location can report directly to a manager based at their site, who in turn can report to the remote manager [61]. This will reduce the threat that a manager may give undue priority to their own divisional or organizational needs rather than the requirements of the full global team and the specific project on which they are working [61].

Task allocation can vary widely. Research by Smite [65] shows that the variety of collaboration models can be substantial. Thus, GSE can lead to increased risks [61,67] especially when organizational boundaries are crossed. For example, some aspects of a software application if outsourced could compromise the organization's competitive advantage [61]. This is because the remote teams or organization that is outsourced to (the vendor) must be trusted with the intellectual property (IP) of the organization who owns the code. Knowledge sharing and code sharing requires that all parties understand and keep to their contractual agreements relating to IP, while maintaining the overall business objectives.

To mitigate each of these threats, the subpractices "Determine team and organizational structure between locations" and "Determine the approach to task allocation between locations" have been included within Specific Practice 1.1, Global Task Management.

4.2.2. Threats to Successful Knowledge and Skills Management

Cost advantages of GSE can be leveraged by integrating lower cost labour with higher cost communications. Employing a team or team members in another country allows access to a wider customer base and associated local knowledge. An example of this benefit is where the local team understands the fiscal policy within their home country. However, if the reason for undertaking GSE is...
4.2.3. Threats to Successful Global Project Management

Global project managers are required to do the tasks of the local project manager, but must also plan, facilitate, implement and monitor global communication, coordination and related activities with effective policies and procedures. Project Managers will often be based remotely from their team members and may not have the opportunity to see the contribution of each team member first-hand. The project manager may not have a good grasp of each member's skills, knowledge and how they contribute to the project. The threat here is that competent people in the distributed location may agree to undertake unrealistic amounts of work [77]. This can be attributed to their respect for more senior people and their reluctance to say ‘no’ (for cultural reasons) to requests from a superior [2,78]. This can have serious implications for the individuals and ultimately the projects involved and is only sustainable in the short term given the level of effort required [43].

Effective partitioning and allocation of work across the GSE team must be addressed. This can be achieved by implementing one or more different approaches for task allocation [2]. Partitioning can be component based [68] or lifecycle based [65]. There is a threat that opportunities for making the best use of a global team could be lost if the most appropriate partitioning of tasks is not investigated, recognized, planned and implemented.

Project managers must recognize and understand the cultural needs of the global software team. Culture may differ according to the following areas: organizational, geographical, national, religious, gender and power distance [79]. Attitudes can be further reinforced by religious belief and by the legal system. For example, some men may have problems reporting to women team leaders or managers, e.g. on religious grounds, a male project manager from the Far East would not work with a female project manager from Ireland [8]. Some organizations consider that their corporate socializing process is adequate to address the cultural issues which arise when managing a GSE team. However, where there are major differences between corporate and national cultural norms, this socialization is generally not sufficient [55]. A lack of respect for cultural differences can negatively impact communication and trust and will adversely affect the project.

Teambuilding is a cooperative activity and the project manager must establish an effective cooperation procedure within the global team to reduce threats to the project. Effective coordination ensures that adequate planning is carried out and the required resources are provided to undertake GSE [1,55]. Global distance negatively impacts the level of cooperation and coordination [1,6] between global team colleagues.

The project manager needs to be aware of how the project is progressing. In the global team, there is rarely the opportunity for informal updates. In some cultures where often the objective is to avoid conflict at all costs, to disagree may be considered impolite [61]. Organizational hierarchy can take priority and may be adhered to strictly. In some Far Eastern cultures requests and instructions are accepted without question if they come from a senior figure [80]. Without implementing formal reporting structures, there is a risk that the remote team may not report correctly, due to cultural differences and misunderstandings. The related threat here is that global team members may accept tasks which they are poorly equipped to perform. However, implementing formal reporting structures can have some negative effects. For example, implementing rigid formal reporting structures can threaten the free flow of ideas and interactions between management and team members [48].

Risk management should be incorporated into all well planned software projects. Globally distributed global team projects carry additional exposure to risks which are associated with managing a culturally diverse global team [61]. Managing a global team has an additional risk if there is a lack of information among local team members concerning the culture of remote staff as identified by some Far Eastern cultures’ revering of hierarchy [2,61]. This manifests itself in a number of ways, often resulting in them not expressing a negative opinion and constantly agreeing to undertake additional work. Without an appropriate risk management strategy organizations may encounter problems with require-I. Richardson et al. / Information and Software Technology xxx (2012) xxx–xxx 7
Please cite this article in press as: I. Richardson et al., A Process Framework for Global Software Engineering Teams, Inform. Softw. Technol. (2012), http://dx.doi.org/10.1016/j.infsof.2012.05.002
ments, feature volatility, unrealistic schedules, budgetary overruns and personnel associated problems [14] as well as cultural misunderstandings [2,61]. A lack of risk awareness can threaten the success of the project as a whole [17].

4.2.4. Threats to Successful Operating Procedures

For successful GSE, an effective and defined conflict management strategy should be implemented [2,61]. Some types of conflict are open and easy to recognize. Trust is more difficult to establish due to lack of socialization [53]. Fear of jobs being outsourced to remote locations can create conflict. Conflict and a lack of trust can create a ‘them and us’ culture which can lead to uncooperative and obstructive behaviour [81].

Effective communication is key to the successful operation of global teams [2,61]. Good communication facilitates dissemination of relevant information. The communication process is hampered by global distance. Loss of face-to-face contact and the need to rely on asynchronous tools can negatively impact on communication levels [1]. This then impacts on the amount of information that is transmitted between global team members.

Global teams require information about basic issues such as local time and public holidays, e.g. knowledge of a team member’s appearance, personality and preferences; whilst such details may be taken for granted in a collocated environment, they are not always clear when dealing with remote colleagues. Project managers should be aware that, if communication is made too difficult, there is a threat that important information relevant to other global team members may not be shared until it is too late to recover project difficulties. A lack of knowing when and how to communicate with team members can adversely impact the project schedule.

Poor communication will lead to inefficiencies, de-motivated team members, conflict and blame [53]. A poor communication interface could delay projects on a day to day basis, e.g. members of teams may not know how and when they will receive inputs to, distribute outputs from and complete work products.

Some employees may not be comfortable participating in meetings held via audio or video, particularly if they have not had the opportunity to meet their global colleagues face-to-face. Project managers may need to change how they conduct shared meetings.

When hosting a meeting, many GSE companies circulate minutes to all attendees, articulating what was agreed at the meeting. Although this is an extra overhead, it pays to keep track of agreed work. Important contributions may be missed if team members do not have the confidence to voice concerns or ideas. If meetings are not minuted and circulated it may be impossible to track agreed actions.

4.2.5. Threats to Successful Collaboration between locations

Poor collaboration between locations will threaten the project as global team members do not readily consider themselves to be part of a single global team. Therefore, effort should be made to ensure that the team work together, not only on the development of the software project, but also, as developers of the processes used within the team.

Goals and objectives should be agreed and understood by all the team members, regardless of location. Team members can then focus on meeting these goals. Resulting successes should be measured by the team’s accomplishment [14]. To actively foster this approach, the global team must be seen as an entity in its own right and, regardless of the location, performance should be judged and rewarded accordingly. Success should never be measured by the achievements of members at one geographical location. There is a threat that a lack of shared goals and objectives may result in poor team motivation, poor productivity and a ‘them and us’ culture [82].

A reward in one culture may not be appropriate or may even insult someone from another culture. The idea that ‘money talks’ in every culture is too simplistic [83]. Cultures place different values on different types of rewards such as money, status and group achievement [84]. As well as cultural diversity, the economic situation and income tax laws at each location need to be considered when determining the form of reward provided. If inappropriate, an intended reward may be ineffective or give offence and alienate and de-motivate a team member [55].

Work product ownership boundaries can be defined through the effective partitioning and allocation of work across GSE teams. It is likely that different stages of product development will occur at different sites [66,68], e.g. requirements changes distributed to specific locations rather than to all sites may result in unsuccessful product interfacing [9].

Good software practice recognizes that process ownership and development are best placed with those who are closest to the process [85]. A collocated process from the parent site cannot be simply exported and implemented in the distributed site [86,87]. Although common process goals should be established across locations, the input of team members at all locations should be sought, encouraged, and valued. The process should address specific challenges associated with GSE. This will ensure relevant structures and procedures from all sites are taken into account to achieve agreed goals. A lack of input from distributed team members threatens the alienation of those team members whose needs are not met by the process and whose suggestions for improvement are ignored [2,48,61].

Effective coordination within a distributed software project requires planning and agreeing achievable milestones. In GSE, effective monitoring will help oversee ongoing progress with reference to costs, time, productivity, quality, and risk. Provision of contingencies to address potential risks should be considered and procedures established to coordinate their implementation when and if required. Effective use of synchronous and asynchronous communication tools is essential to GSE communication. Therefore, it is important that within the commitments made, team members explicitly include communication plans. If this does not happen, and work is not monitored, there is a threat that the work could adversely affect costs, schedule, productivity and quality.

The inclusion of sub-practices “Identify common goals, objectives and rewards for the global team”, “Collaboratively establish and maintain work product ownership boundaries”, “Collaboratively establish and maintain interfaces and processes”, and “Collaboratively develop, communicate and distribute work plans” will support the mitigation of threats due to a lack of collaboration between locations.

5. Development of Global Teaming Process Area

5.1. Gap Analysis: CMMI® GSE factors

To understand how GSE is supported within the CMMI® for Development process model Version 1.3 [12] we performed a gap analysis. In our analysis of all process areas, we matched the GSE factors identified in our previous research (Table 2), to the statements in the CMMI® model documentation. This is similar to the analysis carried out by Paulk [88,89], who mapped “sentence to sub-practice” when comparing ISO:9000 with CMM. Our gap analysis was carried out systematically. First, we identified synonyms for each GSE factor. Second, we searched the CMMI® model for each GSE factor and relevant synonyms to identify whether the factor was explicitly considered within either a process area or a process area component, e.g. specific practices and work products. Third, we established three GSE factor categories.
(a) GSE factors for which there are explicit process areas in the CMMI.
(b) GSE factors for which there are implicit processes defined.
(CMMI recognizes that the factor is required for software engineering, but fails to specify the process in global or distributed terms).
(c) GSE factors which are not mentioned in the CMMI.
(d) Finally, each of these three categories was catered for differently as described in the following sub-sections.

5.1.1. GSE factors explicitly identified in CMMI

When carrying out the gap analysis, we identified 3 GSE factors which are explicitly mentioned in the CMMI (see Table 3). In examining all CMMI Process Areas, Specific Goals, Specific practices and sub-practices we found no Process Area which took the complexity of the GSE factors into account. However, some will support these factors. For example, we identified that the Integrated Project Management Process Area is included in the CMMI process model, and this clearly identifies relevant project management specific practices. However, specific GSE project management organizational issues are not dealt with in the CMMI, but we have added them in Specific Practice 1.3 in the GT model: “Global Project Management”. Within this practice, we only note practices that relate to Project Management in a global situation, such as allocating a ‘bridge person’ to substitute for the project manager at the remote site. What we have included in the model are over and above the Integrated Project Management sub-practices aimed at collocated teams, already present in the CMMI.

Risk management is a further example of a GSE factor that is explicitly mentioned in the CMMI. Within the CMMI model documentation, risk management is mentioned many times, to ensure that the user is directed to the Risk Management process area whenever there is a risk associated with a given process. The drawback we identified is that there is no mention of the specific risks associated with carrying out GSE. In fact, in the CMMI’s list of “typical internal and external risk sources”, the global environment, or any similar phrase, is not included. For this reason, we added the Identification of a Risk Management strategy as a practice within Specific Practice 1.3: Global Project Management.

5.1.2. GSE factors implicitly identified in CMMI

The second category comprises practices mentioned in the CMMI that, according to our gap analysis, do not adequately address specific GSE factors. As seen in Table 3, we identified 10 such GSE factors. This observation led us to include a more detailed and tailored version of the given practice in the Global Teaming Model. An example of a specific practice in the CMMI that lacks a GSE context is skills management (synonyms: competency management, knowledge management). According to the CMMI, skills management must be effective for efficient software development. However, the CMMI guideline does not recognize that project managers may be located remotely from their team members and they may not recognize these remote employees’ skills. In our model, this is dealt with under Specific Practice 1.2 Knowledge and Skills Management, where, for example, there is a sub-practice: “Identify business competencies required by team members at each location”.

5.1.3. GSE factors not included in CMMI

The third category of 12 GSE factors we identified (see Table 3) are those not mentioned in the CMMI. For example, there is no mention of temporal issues (synonyms: time zones, time difference) in the CMMI model, and this resulted in our explicitly identifying software development across global distance, where, for example, in Specific Practice 2.1: Operating procedures, we note the need to “Implement strategy for conducting meetings between locations”.

6. Global Teaming Model Structure

Having completed the literature review, case studies, threat analysis and gap analysis, we were in a position to develop the GT model. As shown in Fig. 1, we developed the GT model to reflect the current CMMI structure to include Specific Goals, Specific Practices and Sub-practices. We adapt and customize this structure as the CMMI is internationally recognized and used extensively by industry in their Software Process Improvement activities. Given that there is little guidance as to how to specialize the CMMI to specific domains, we answer our RQ1 “Can our Global Teaming research be integrated in the CMMI model?” by actually fitting the GT practices to the structure (shown in this section), and then validating the model (Section 6.1). The GT Model presents practices not currently found in the CMMI by either adding new practices, or augmenting existing practices (see Fig. 1). Although based on

Table 3: Global Software Engineering Factors and Gap Analysis Results.

<table>
<thead>
<tr>
<th>GSE Factor</th>
<th>Summary of results from gap analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management</td>
<td>Explicit Process Area: Risk Management</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Establishment and maintenance of teams in Integrated Project Management, sub-practices contribute to cooperation: not specific to GSE</td>
</tr>
<tr>
<td>Coordination</td>
<td>In Integrated Project Management: not specific to GSE</td>
</tr>
<tr>
<td>Define Roles and Responsibilities</td>
<td>In Product Integration, Project Planning: not specific to GSE</td>
</tr>
<tr>
<td>Effective Partitioning</td>
<td>In Requirements Development, Technical Solution, Product Integration: not specific to GSE</td>
</tr>
<tr>
<td>Reporting Requirement</td>
<td>In Measurement and Analysis, Quantitative Project Management, Integrated Project Management: not specific to GSE</td>
</tr>
<tr>
<td>Skills Management</td>
<td>In Project Planning, Integrated Project Management: not specific to GSE</td>
</tr>
<tr>
<td>Teamness</td>
<td>Establishment and maintenance of teams in Integrated Project Management, sub-practices contribute to teamness: not specific to GSE</td>
</tr>
<tr>
<td>Team Selection Tools</td>
<td>In Project Planning: not specific to GSE</td>
</tr>
<tr>
<td>Visibility</td>
<td>In Integrated Project Management, Project Monitoring and Control: not specific to GSE</td>
</tr>
<tr>
<td>Communication</td>
<td>No discussion relating to GSE Communication</td>
</tr>
<tr>
<td>Communication Tools</td>
<td>No discussion relating to GSE Communication Tools</td>
</tr>
<tr>
<td>Culture</td>
<td>Organizational rather than GSE culture included in Organizational Performance Management</td>
</tr>
<tr>
<td>Fear</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>Information Management</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>Knowledge Transfer</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>Language</td>
<td>No discussion relating to Language issues in GSE</td>
</tr>
<tr>
<td>Motivation</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>Technical Support</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>Temporal Issues</td>
<td>Keyword not found</td>
</tr>
<tr>
<td>True Cost</td>
<td>Cost relating to GSE not included</td>
</tr>
<tr>
<td>Trust</td>
<td>Keyword not found</td>
</tr>
</tbody>
</table>

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the CMMI®, the Global Teaming process area has been developed as a stand-alone set of guidelines that can be used in isolation, with the CMMI®, or with other process models.

We present the thesis that software project teams involved in GSE need to be cognizant of the Specific Goals, Specific Practices and the Sub-practices for GSE that we shown in Fig. 3 and in Tables 4 and 5. The GT process area should be used as a supplement to the organization’s current process, whether this is CMMI® or another process model, where GSE is being implemented within project teams.

As we have demonstrated, the CMMI® as it stands is not sufficient as a process model for GSE. Therefore, it is necessary to develop a process model which supplements the CMMI® to fit the global environment. Fig. 3 illustrates that the Global Teaming process area has two Specific Goals (SGs): “Define Global Project Management” and “Define Management Between Locations”. Each SG has Specific Practices (SPs) and sub-practices. SG1 represents practices required at project initiation (all specific practices are listed in Table 4); whereas SG2 classifies practices required when the project is operational (all specific practices are listed in Table 5). SG1 recognizes that global project management, while including tasks that would be expected within collocated project management, must also encompass extra tasks that exist because of the global software engineering team. SG2 focuses on global project management between locations. This is done through two specific practices. The first ensures that operating procedures are set up correctly. The second focuses on collaboration between locations.

6.1. GT Model Validation

In order to answer our second research question, “Can our Global Teaming research be integrated in the CMMI® model?” we presented the GT model practices as listed in Tables 4 and 5, to groups of experts to gain some informal feedback on the model. This informal evaluation took place in two organizations that develop software in a globally distributed environment. Ten senior managers and project managers were given a presentation and paper copy of the model. The experts voiced support for each of the listed practices, and some reflected that they would have benefitted from knowing about these practices prior to moving from a collocated development to a global development process. The experts found the guidelines immediately accessible and easy to follow. They were quickly able to identify areas they needed to consider in their next projects, such as Specific Goal 2, Operating Procedures: 2.2.1: Define how conflicts and differences of opinion between locations are addressed and resolved: recommendation: “Set up a strategy to handle, monitor and anticipate where conflict between remote locations may occur. The strategy should include how conflict will be resolved and how a person responsible for that resolution is selected”.

In order to gain more formal feedback as to how the model could be improved we are currently conducting an in depth validation of the GT processes based on a Decision Support System (DSS) we are developing. In ICGSE 2010 we piloted a subset of the model’s recommendations with experts in the field. While the response was mixed (especially as we did not pilot all the processes), the general feeling was that the GT Model filled a very important gap. Current work is continuing in developing an automated version of the GT Model, with a complete set of recommendations to support project managers in their GSD decisions [20].

Our future evaluation plans include implementing the model in an organization at the start of a GSE project and monitoring the project’s progress to the end of the project. This evaluation will help to ensure that key practice areas in the GT Model do indeed...
### Table 4
Guidelines for Specific Goal 1: Define Global Project Management.

<table>
<thead>
<tr>
<th>SPECIFIC GOAL 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SG1: Define Global Project Management</td>
<td></td>
</tr>
<tr>
<td><strong>SP1.1: Global Task Management</strong></td>
<td>Goal: distribute tasks so that GSE advantages are leveraged and negative factors inherent to its operation are minimized</td>
</tr>
<tr>
<td>1 “Determine team and organizational structure between locations”</td>
<td>Create roles, relationships and rules to facilitate coordination and control over geographical, temporal and cultural distance</td>
</tr>
<tr>
<td></td>
<td>Structure global team and monitor operation to minimize fear and alienation in teams</td>
</tr>
<tr>
<td></td>
<td>Be aware of problems with unbalanced team sizes; e.g. smaller teams may be threatened and fear job loss</td>
</tr>
<tr>
<td></td>
<td>Team structure should cater for possibility of dual reporting to management at more than one location, e.g. team structure could be cross divisional or multi-organizational and management remote</td>
</tr>
<tr>
<td></td>
<td>Ensure that supervision, support and information needs of all team members are met regardless of location</td>
</tr>
<tr>
<td>2 “Determine the approach to task allocation between locations”</td>
<td>Identify and document reason for working with global team</td>
</tr>
<tr>
<td></td>
<td>Base task allocation on the organizational requirement, e.g. if proximity to market is reason development team is located in a particular country, then customer-related tasks should be allocated to that team</td>
</tr>
<tr>
<td></td>
<td>Retain tasks that require frequent communication between groups within co-located teams</td>
</tr>
<tr>
<td></td>
<td>Where GSE teams are subdivided into work modules (e.g. different parts of the life-cycle), management must allocate tasks based on core competencies of each sub-team, and clearly define which stages are carried out at which location</td>
</tr>
<tr>
<td></td>
<td>Confidential software development activities that provide competitive advantage should be developed within organization</td>
</tr>
<tr>
<td></td>
<td>Related non-confidential development activities can be undertaken by external remote team colleagues</td>
</tr>
<tr>
<td><strong>SP1.2 Knowledge and Skills Management</strong></td>
<td>Goal: Identify business competencies and skills of team so that the advantages of GSE are leveraged and the negative factors which are inherent to its operation are minimized</td>
</tr>
<tr>
<td>1 “Identify business competencies required by global team members in each location”</td>
<td>Document and define customer base and functions relative to the application being developed</td>
</tr>
<tr>
<td></td>
<td>Provide training to ensure that global team has required understanding of the customer base and the business functions to take full advantage of the proximity of the team to the customer base</td>
</tr>
<tr>
<td>2 “Identify the cultural requirements of each local sub-team”</td>
<td>Cultural diversity: Each team member should be trained to understand the culture of the global team. Face-to-face meetings are recommended when and where possible, ideally at the start of the project and/or when a new member joins. Having individuals visit locations for extended periods can also be a successful strategy and should be fully leveraged at every possible opportunity</td>
</tr>
<tr>
<td>3 “Identify Communication Skills for GSE”</td>
<td>In order to develop the right practice, a new communication protocol needs to be set up. Policies should be put in place to support these new requirements to the satisfaction of all global team members. For example, in synchronous communication, ensure that link up times are shared between core team working hours in each location</td>
</tr>
<tr>
<td>4 “Establish relevant criteria for training teams”</td>
<td>Effective knowledge transfer: Carry out evaluation of training needs to include cultural and linguistic issues. Undertake training onsite and face-to-face so team members can be directly assessed and training provision tailored to their specific requirements</td>
</tr>
<tr>
<td><strong>SP1.3 Global Project Management</strong></td>
<td>Goal: To plan, facilitate, implement and monitor global communication and coordination of related activities with effective policies and procedures</td>
</tr>
<tr>
<td>1 “Identify GSE project management tasks”</td>
<td>Define ability and potential productivity of team: Global project manager should allocate tasks and timescales that are realistic. Where possible, the project manager should be actively involved in the recruitment and selection of team members. Failing this, they should gather all information relating to the technical and professional experience of potential and existing team members. When teams are in place and project details reported project managers should understand and document how individuals contribute to that project along with their skills and knowledge</td>
</tr>
<tr>
<td>2 “Assign tasks to appropriate team members”</td>
<td>Assign according to one or more of three different approaches; Modularization; Phase-based approach; and Integrated approach</td>
</tr>
<tr>
<td></td>
<td>Modularization: partition work into modules which have a well defined functional whole</td>
</tr>
<tr>
<td></td>
<td>Phase-based approach: Use when phases of the development cycle are relatively independent. Ensure that the team members developing a specific phase have a good understanding of what is required at each specific stage</td>
</tr>
<tr>
<td></td>
<td>Integrated approach: Set up a protocol to allow handover from one geographic location to another to ensure a successful follow the sun development</td>
</tr>
<tr>
<td>3 “Ensure Awareness of cultural profiles”</td>
<td>National cultural differences should be identified and communicated to the management and team members. Cultural training can be communicated in following way</td>
</tr>
<tr>
<td></td>
<td>Provide training to give all team members an opportunity to learn and understand about each other’s culture</td>
</tr>
<tr>
<td></td>
<td>Address national, religious and relevant ethnic issues, all team members should understand acceptable and unacceptable forms of behaviour</td>
</tr>
<tr>
<td></td>
<td>Training should be tailored to team member’s specific needs and location</td>
</tr>
<tr>
<td></td>
<td>Project managers should ensure that cultural profiles for teams are established. E.g. Management and staff should show respect for gender-related cultural values of all colleagues. All employees’ legal rights must be upheld</td>
</tr>
<tr>
<td>4 “Establish cooperation and coordination procedures between locations”</td>
<td>Ensure that a suitable infrastructure, process and management procedures are in place to help establish cooperation and coordination between locations. Achievable milestones should be planned and agreed. Projects should be monitored with reference to costs, time, productivity, quality and risk</td>
</tr>
<tr>
<td>5 “Establish reporting procedures between locations”</td>
<td>Regular formal reporting will help the project manager to remain aware of how project is progressing. Procedure should include and encourage team members to report whether or not they can take on that task in the given time and report any problems before it is too late</td>
</tr>
<tr>
<td>6 “Establish a Risk Management Strategy”</td>
<td>All potential risks should be identified and addressed to include: risks in misunderstanding cultural differences, misunderstanding requirements, feature volatility, schedule, budget, and timeline. In addition, risk associated with outsourcing activities to politically unstable locations needs to be identified</td>
</tr>
</tbody>
</table>
Table 5

Guidelines for Specific Goal 2 Define Management Between Locations.

Global Teaming Guidelines

SPECIFIC GOAL 2
SG2: Define Management Between Locations

SP 2.2 Operating Procedures
Goal: Set up operating procedures for effective collaboration between locations

1. "Define how conflicts and differences of opinion between locations are addressed and resolved"

- Set up a strategy to handle, monitor and anticipate where conflict between remote locations may occur. The strategy should include how conflict will be resolved and how a person responsible for that resolution is selected.

When defining the global strategy for dealing with conflict, different types of conflict have to be taken into account, for example conflict due to fear as well as cultural differences.

2. "Implement a communication strategy for the team"

- Plan, facilitate, encourage and monitor communication between teams.
- Provide training on how best to communicate with remote colleagues, including the effective operation of communication tools and procedures.
- Consider linguistic and cultural implications inherent when communicating remotely.

3. "Establish communication interface points between the team members"

- Strategies need to be put in place which encourages both formal and informal reporting.
- Ensure that relevant team members are made aware of how and when they will receive inputs to products, needs to distribute outputs from and when complete work products are required.
- Ensure teams are aware of potential constraints such as legal restrictions and holidays in countries within which they are developing the product.
- Information about each team member is easily accessible by colleagues. Information of an individual’s role within the team and their specific areas of responsibility should be combined with a photograph, their first name, surname, friendly name (if appropriate) and their preferred form of address.
- Intranets and wikis can be invaluable for this form of communication.

4. "Implement strategy for conducting meetings between locations"

- Identify appropriate global meeting technology is used.
- Try to ensure all participants are comfortable with global meeting and are given opportunity to agree or disagree with points raised, and offer new ideas.
- Circulate agenda prior to meeting, and clearly minute actions agreed a meeting.
- Ensure that no delay occurs between the meeting and the circulation of minutes as people may be waiting for the minutes before implementing the actions

SP 2.2. Collaboration between locations
Goal: Develop a motivated and focused team who share a common purpose and objectives

1. Identify common goals, objectives and rewards for the global team

- Global Project manager sets project goals and objectives.
- Goals at project level are common to all locations.
- Project goals and objectives communicated, understood and agreed across all team members regardless of location.
- The global team is viewed as an entity in its own right, regardless of the location of its team members and its performance should be judged and rewarded accordingly.
- Acknowledging team success may require tailoring rewards to the needs of different cultures.
- Project Managers need to understand the cultural motivation of the different team members and identify and apply appropriate rewards in each situation when and where relevant.

- Consideration should be given to cultural issues, economic situation and income tax laws when planning rewards.

2. Collaboratively establish and maintain work product ownership boundaries

- Define product ownership boundaries through partitioning of work across GSE teams.
- Each location should understand their role within the life cycle of the product.
- Each location should understand how their modifications to the product unit can affect the other locations.

3. Collaboratively establish and maintain interfaces and processes

- Define common process goals across all locations.
- Define process ownership – placing ownership with those closest to process where possible.
- Seek and encourage input from team members at all locations.
- Let team members know their input to process development and ownership is valued.
- Processes should address specific challenges associated with GSE.
- Processes should take into account the relevant structures and procedures from all sites.

4. Collaboratively develop, communicate and distribute work plans

- Achievable milestones should be planned and agreed.
- Within the commitments made, team members must explicitly include communication plans to include use synchronous and asynchronous communication tools.
- Contingency plans should be in place to address potential risks.
- Establish procedures to coordinate implementation of contingencies when and if required.

cover all the areas that can cause the project to fail, or cause additional problems. We plan to use the following strategy: initially introduce the model (goals and practices) to quality managers or project managers, and then roll out a training programme as to how to implement each practice. We will later revisit the organization after an agreed period of time to assess progress or the extent of implementation and observed changes.

Evaluating the model in this way, has created a basis for the next phase of development, plus we have the support of several multinational and Small to Medium sized Enterprises (SMEs) GSD organizations who would like to be involved in future evaluations, to ensure that the model continues to be based on both empirical and research evidence of good practices.

7. Conclusion

Many organizations have discovered to their cost that implementing a GSE strategy is a complex and difficult task [6,14,56]. Extensive research in this area has identified that this is due to a number of factors which include the nature and impact of geographical, temporal, cultural and linguistic distance [56,51]. In addition, whether undertaken in a collocated or geographically dis-
distributed environment, team-based software development is not simply a technical activity. It also has important human, social and cultural implications which need to be specifically addressed.

While the technical aspects of software development cannot be underestimated, neither can the importance of establishing and facilitating the effective operation of these teams.

While we have structured the GT process area to be similar to the CMMI® model, it can either be used with other CMMI® process areas or as a stand-alone process which organizations can implement when establishing global software teams. It therefore has a similar relationship to other CMMI® extensions that have been developed to complement the CMMI® Development process model such as +SAFE [92] and RMCM [93]. Our research supplements the CMMI® for Development model with one additional process area for GT. The GT model adheres to the same assumptions, structure and terminology as the CMMI®. This is particularly important in relation to GT as CMMI® certification is often a common attribute of global software development organizations.

In this paper, we focused on two research questions. In the first instance we asked: What are the threats faced by global software organizations if they do not implement GSE processes correctly? An analysis of the literature and our empirical studies, found that ignorance of associated risks can lead to a loss of competitive advantage, practitioner de-motivation and poor quality software.

In summary, failing to implement GSE processes correctly means that organizations are putting themselves at risk of project failure.

We also found that organizations lack support in how to implement a GSE strategy, which provided a rationale for our second research question that looks at how to present a set of practices for GSE teams.

Our second research question queried whether the CMMI® software process improvement structure could be used as a basis for developing a process area to support team management in a global software engineering environment. Having carried out the gap analysis between the CMMI® and the GSE factors identified in our previous research, we established that there were three categories of factors within the CMMI®, two of which require more explicit definitions to apply to GSE processes. Using this information as a basis, we were able to use the CMMI® structure as a basis for the development of the GT process area. This process area can be used as a CMMI® supplement, but can also be used in conjunction with other processes which a global software project team may choose to implement. We have embarked on further research in conjunction with a Financial Services company to establish how well this process area can work within a regulated environment.

The Global Teaming process area presented in this study focuses on the importance of establishing and managing effective software teams in the globally distributed setting. Much of the research on GSE has focused on understanding why there are difficulties with implementing GSE within organizations. While this provides a needed understanding of GSE, it is also important that we, the GSE researchers, present industry with solutions to their GSE difficulties. The Global Teaming process presented in this paper is a step in this direction. Through its development we provide specific goals, specific practices, sub-practices and guidelines which can be used by industry implementing a GSE strategy. We also explain the potential threats to GSE if these practices are not considered.

When implementing software process improvement there is a requirement for tangible results to be achieved in a reasonable time frame. This is particularly important to sustain the level of effort required for improvement to take place. Practitioners should therefore find the practical guidelines provided by the GT process area particularly helpful as they address key aspects of GSE and discuss threats if particular practices are not implemented.

We are at the initial stages of developing the Global Teaming model. This GT model has a foundation in Software Process Improvement and the model’s future development will include a formally validated set of GSE practices based on a longitudinal study. We have made a start in this direction, by applying the Global Teaming high level practices to specific implementable practices relating to architectural knowledge management in a global setting [19]. Our current and future work involves working with our industrial partners to validate the Global Teaming model, and early results indicate that all the model’s practices are relevant to a global software organization. We recommend that organizations implementing structured processes in a globally distributed environment should also implement the Global Teaming process area.

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Appendix A. Grouping and Summaries of the 25 GSE Factors

The 25 GSE factors identified in our empirical study can be grouped under four broad headings of Distance, Infrastructure, Management and Human Factors as follows:

A.1. Distance

A.1.1. Communication

Effective communication is a key factor for the successful operation of global teams. Good communication in the global team setting does not just occur; it has to be planned, facilitated and monitored. Training on how to communicate with remote colleagues also needs to be provided to team members and managers at all locations.

A.1.2. Language

English is the lingua franca of the software industry the implications of dealing with remote colleagues whose first language is not English needs to be considered and addressed. Measures should be taken to determine the language competency of staff who are not fluent English speakers. If there is a requirement for English language classes they should be provided. Where linguistic difficulties are encountered all parties need to be encouraged to request clarification and steps put in place to address and if possible prevent such issues arising again.

A.1.3. Culture

An important issue which has to be recognized and addressed to successfully manage geographically distributed team based software projects is the cultural diversity of global team members. If the full implications of cultural diversity are not properly understood and measures taken to address them it can have serious negative repercussions on the operation of global teams.

A.1.4. Temporal Issues

The full implications of temporal distance on the operation of global teams needs to be considered and steps taken to leverage its advantages and minimize its potential for negative impact. The necessity for the reliance on asynchronous communication tools requires due consideration. Where possible the overlap in working hours between sites should be maximized and measures...
taken to ensure that this time is fully leveraged. The full implications of the implementation of an integrated follow the sun strategy has to be considered and specifically addressed.

A.2. Human Factors

A.2.1. Fear

The impact fear has on the operation of global teams is considerable and should not be underestimated. This can manifest itself in numerous ways including the desire to prevent or limit communication with remote colleagues. In some instances the objective can be to directly hinder the work of these remote colleagues. Our research has highlighted the severity and persistence of these types of problems which did not decrease with time. The implications fear has on the operation of global teams should never be underestimated. It needs to be recognized, understood and specific measures put in place to address and prevent its potential for negative impact.

A.2.2. Motivation

A key factor in the successful operation of global teams is motivation. Geographical and temporal distance negatively impact on the motivation of global team members. This is due to the problems which arise when developing working relationships in an asynchronous environment. It is equally difficult to be motivated to cooperate and support remote colleagues who are often perceived as about to take the jobs of those at the location where the work is being outsourced/offshored from. These issues all negatively impact on the level of motivation of team members.

A.2.3. Trust

A related factor in the successful operation of software testing teams is the establishment of trust. In a global environment it can be difficult to develop and maintain trust between remote team members. Numerous factors come into play, which include the lack of opportunities for the development of personal relationships between remote team members. These can be compounded by cultural, linguistic, motivation and fear related issues.

A.2.4. Cooperation

Teamwork is a cooperative activity and without cooperation teams cannot operate effectively. Like so many other factors which are essential for global teams, distance negatively impacts on the level of cooperation that takes place between remote team colleagues. The reality is that team members must be motivated to establish effective cooperation with their remote colleagues. Like so many other factors outlined in this list of 25 GSE factors, numerous issues directly mitigate against the establishment of cooperation in the global team environment. In these circumstances from the project management perspective cooperation between team locations has to be developed, established and effectively managed.

A.3. Management

A.3.1. True Cost

It is imperative that the true cost of global team operation be determined and outlined to all the relevant parties. A key factor in the selection of a global team strategy is to leverage the potential benefits of labour arbitrage between geographical locations. The reality is that the cost difference in salary levels between sites is not in fact the true cost. There are additional factors which include operational, management, training, travel and productivity costs which need to be factored in. This ensures that unrealistic returns are not anticipated and sustained management support is provided for the implementation of a global team strategy.

A.3.2. Project Management

To implement a successful global team strategy, all the factors that impact on the operation of collocated software projects come into play and need to be addressed by effective project management. There are also additional global team factors which require specific attention. In these circumstances it is clear that a collocated project management approach is not adequate and the development of a global team project management strategy is required.

A.3.3. Risk Management

The implementation of a global team software development strategy to undertake organizational mission critical activities is a risky endeavour. There are micro- and macro-risk elements which need to be carefully assessed and addressed. Micro-risks can often be correctly determined and alternative strategies put in place to mitigate their potential impact. Macro-risks on the other hand may not even be considered. These include political risk and the implications of an inadequate understanding of the culture of staff at other locations and the negative impact of implementing inappropriate strategies which can result.

A.3.4. Defined Roles and Responsibilities

It is important that roles and responsibilities for all team members should be clearly defined, articulated and effectively disseminated. This should be supported by a clearly defined common vocabulary that is understood by all team members. This vocabulary needs to cover areas such as activities, tools, the process, milestone deliverables and artefacts.

A.3.5. Team Selection

The selection of global team members needs to be based on the technical requirements of the project. The Project Manager requires direct access to information regarding potential team members’ academic, technical skills and experience. When relevant, ‘linguistic capability’ needs to be determined and given due consideration. When all team members have been recruited, their training requirements (regardless of location) need to be evaluated and addressed.

A.3.6. Effective Partitioning

The effective partitioning of tasks across team members and sites is a very important aspect of an efficient global team operation. In these circumstances three strategies may be considered to effectively partition work. They are modularized, phased or an integrated approach. Each has their own distinct advantages and disadvantages, but their selection is often dependent on the nature of the work being undertaken or and the physical location of tools or specific skill sets.

A.3.7. Skills Management

To facilitate effective global team operation the technical capability and skill level of all global team members needs to be made available to the Project Manager. This information should be presented in a format that can be understood, easily maintained and efficiently accessed. There is also the requirement for an effective mechanism and procedure for all team members to be able to access and identify relevant technical and subject matter experts.

A.3.8. Knowledge Transfer

Effective knowledge transfer is a key activity when establishing and operating a global team. Adequate training measures and methods need to be implemented to ensure this activity is sufficiently supported and carried out. A procedure to evaluate the effectiveness of knowledge transfer activities should be put in
The global team environment needs to be developed and implemented team that sees itself as a single unit regardless of its development of a one team approach. Teamness is based on team and transmitted between sites. There is the specific requirement for the availability of relevant information regarding team members, remote locations i.e. public holidays, project procedures, activities and project status.

A.3.10. Visibility

Due to the loss of informal contact and temporal and geographical distance visibility is directly hampered by the operation of global teams. There are two aspects to visibility. The first is that roles and responsibilities need to be clearly articulated and understood by all the relevant parties. As outlined when discussing the defined roles and responsibilities factor this is best supported by the use of a common vocabulary. The second aspect is to ensure there is adequate visibility into the process to monitor team effort and performance and to determine project status.

A.3.11. Reporting Requirement

Given the requirements of the global team environment and the impact it has on visibility there is a need for the establishment of an effective reporting schedule. Adequately detailed and timely reports are required to provide effective visibility into the process. There is also the need (where relevant) for these reports, or summaries to be communicated to all team members at regular intervals to outline the progress of the project.

A.3.12. Information Management

A key component in successful global team operation is the dissemination of relevant information between team members. As with the other factors outlined in this section information dissemination is negatively impacted by distance. The loss of face-to-face contact and the need to rely on asynchronous communication all impact on the level and quality of information that is available and transmitted between sites. There is the specific requirement for the availability of relevant information regarding team members, remote locations i.e. public holidays, project procedures, activities and project status.

A.3.13. Teamness

Within the global team context there is a clear need for the development of a one team approach. Teamness is based on team member relationships that facilitate the development of mutual respect and trust. This leads to the development of a cohesive motivated team that sees itself as a single unit regardless of its members’ location. This is achieved through the establishment and maintenance of a shared common vision, goals, and objectives. Teamness has to be fostered, developed and effectively managed.

A.4. Infrastructure

A.4.1. Process Management

A process which directly addresses the specific requirements of the global team environment needs to be developed and implemented. Such a process needs to be documented and stored in a format that can be accessed from all the relevant team locations.

A.4.2. Tools

Where possible the selection of standard development and problem reporting tools should take place across locations. This insures the validity of the development process and the compatibility and interoperability of artefacts produced. The provision of and use of effective Configuration Management (CM) tools and a well-documented CM procedure is also essential for efficient team operation in the global environment.

A.4.3. Technical Support

The issue of technical support requires particular consideration in the global team environment. When tools are distributed across a number of geographical locations the issues of who and how technical support will be provided needs to be considered. Specifically the geographical locations covered by warranties and service agreements should be identified and addressed to ensure that all team member locations are adequately covered.

A.4.4. Communication Tools

An adequate selection of synchronous and asynchronous communication tools should be provided to allow effective communication to take place between team members regardless of location. An important aspect of the provision of such tools is to ensure staff are motivated and trained to leverage their capabilities.

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