

A research methodology in the study of requirements negotiations in geographically distributed software teams

Daniela E. Damian
Department of Computer Science
University of Victoria, BC
DanielaD@cs.uvic.ca

Abstract. This paper discusses the research methodology used in a study of requirements negotiations in geographically distributed settings. The methodology was based on a multidisciplinary paradigm that considered research methods and models from requirements engineering, soft system methodologies, group research and negotiation literature, and computer supported cooperative work. An integral part of the research methodology was the design of a laboratory study that empirically compared computer-supported distributed requirements negotiations with traditional face-to-face requirements decision meetings. The paper describes the components of the study design in the context of the research methodology, and discusses lessons learned from designing this study. Insights related to the necessity of interdisciplinary approaches to the study of RE, the intrinsic tension between control and realism of context in laboratory studies and ways in which the study brought a better understanding of a RE problem are discussed.

1. Introduction

Software development world is experiencing an irreversible trend towards the globalization of business, a phenomenon that is rapidly gaining the attention of the research community. Projects developed between USA and India [16] as well as other continents such as Asia and Europe [4], are among the many reported in the literature. Seeking lower costs and access to a global resource pool are main factors that accelerated this trend. As a consequence, the communication of system stakeholders, i.e. managers, customers, end-users and developers, and in particular decision making is taking place across geographical and cultural boundaries [16]. Hence the need to support collaboration and decision making in software global teams is emerging.

Weaknesses in managing system requirements have been recognized as a fundamental problem of the software industry [5]. Moreover, requirements management strongly depends on a successful negotiation of stakeholders' interests and priorities. The quality of decision making in requirements negotiations affects not only the quality of the software product but also the time taken to satisfy the stakeholders' requirements. Poorly managed requirements issues can escalate in win-lose situations that undermine the project's success and unresolved requirements conflicts can lead to significant delays in project development, even to canceled projects [5].

The traditional setting for decision making in requirements engineering has been the face-to-face meeting, which is considered a rich communication medium necessary for involving relevant stakeholders in an effective negotiation of requirements [24]. However, the increasing globalization of the industry makes the releasing of relevant

participants to attend requirements meetings at remote sites problematic. Case studies of requirements meetings reveal that when it comes to selecting participants for such meetings, managers try to strike a balance between allowing the software practitioners to talk to 'the right people' and maintaining the smooth running of the rest of the business [1]. Furthermore, frequent meetings that involve key stakeholders from engineering and marketing departments are an integral part of software development in multi-site organizations [12][29].

Hence there is a demand to study requirements negotiations in geographically distributed settings, and ways in which they can be supported effectively. From a practical point of view, the software industry regards development teams as task performance systems and the outcome of requirements negotiations become of critical importance to the success of software projects. Thus the study of productivity in global teams, in particular in requirements negotiations, is the topic of research with significant practical implications for the research community as well as software industry.

In this paper we describe the research methodology used in a study of requirements negotiations in distributed settings, with a focus on comparing the productivity of decision making teams in face-to-face and geographically distributed settings. While the empirical study itself and its results were reported in previous publications [9][10][11][13][14], the focus of this paper is on the research methodology and the insights gathered through its application. The research yielded a better understanding of RE, emphasized the necessity of interdisciplinary approaches to the study of RE, and exemplified the intrinsic tension between control and realism of context in laboratory studies.

Section 2 begins the paper by presenting the overall research goal, followed by a description of the research methodology in Section 3, where a multidisciplinary research approach is described in Section 3.1. The methodology considered research methods and models from several research fields in the design of the study. In particular, as described in Section 3.2, the study involved an empirical comparison of computer-supported distributed requirements negotiations and the traditional face-to-face requirements decision meetings. While elements of the laboratory study design and its rationale are presented to enhance the understandability of methodology, the emphasis of the paper is in Section 4 where lessons learned from the application of this research methodology are discussed.

2. Research goal

As introduced above, the research goal was to study geographically distributed requirements negotiations, with a focus on comparing the productivity of decision making teams in face-to-face meetings and distributed settings.

3. Research methodology: a multidisciplinary approach

Requirements negotiations are a complex phenomena, and their study in distributed settings required a multidisciplinary approach. Requirements conflict resolutions are governed by a complex set of aspects of technical, organizational and social nature. Requirements represent the interests of a wide range of stakeholders of the system (which may be conflicting or contradictory) and the final system requirements are inevitably a compromise between them [32].

Thus the research methodology draws upon a research paradigm that considered models and methods of study from relevant research fields of requirements engineering, soft system methodologies, group research and negotiation literature, and computer supported cooperative work, as illustrated in Figure 1 and described in the next section.

3.1 Research paradigm

Requirements Engineering and Soft System Methodologies. System development involves a wide range of system stakeholders, ranging from system developers, users, managers and customers. Requirements conflicts reflect that different system stakeholders have different needs and priorities, and negotiations are necessary to achieve a resolution that satisfies all stakeholders involved. Thus the processes of requirements engineering are dominated by human, social and organizational factors and take place within a human activity system [26] and Soft System Methodologies (SSM) [7] are particularly relevant in the analysis of such a human activity system. SSM provided a framework for the identification of relevant roles in the conflict situation and for understanding the context in which conflict resolutions become meaningful.

Group research. The majority of literature in group research assumes that group interaction processes are an important basis by which group task performance is shaped [25]. Research into socio-psychological effects of computer-mediated communication suggests important dysfunctional aspects of face-to-face decision-making groups such as unequal participation and dominance by some group members [19][21]. It is reasonable to expect that these aspects would have an influence on requirements negotiation sessions as well, and their study became important in the current study.

Negotiation behavior. Models of negotiation behavior are important in understanding the conflict resolution strategies in requirements negotiations. In the current study, an important issue to consider was the concept of distributive vs. integrative negotiation. The distributive approach to negotiation reflects the zero-sum situation in which one negotiator's gain is the other's loss, in contrast to integrative approaches which are possible when multiple issues are considered and there is potential for an exchange of concessions in the negotiation. While it is possible that

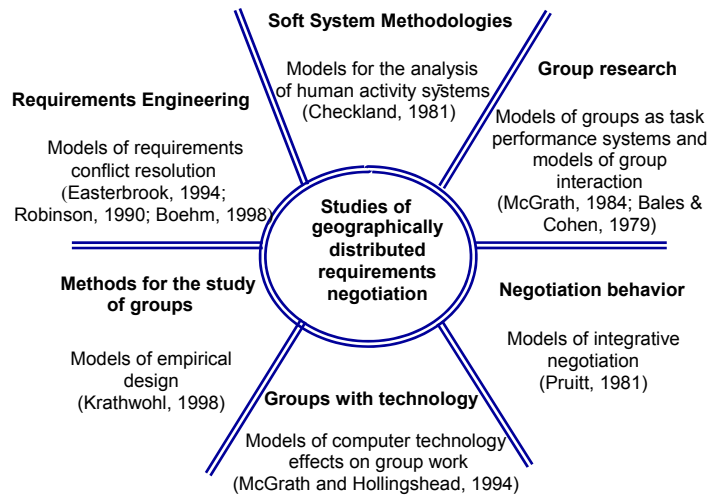


Figure 1. Research paradigm

requirements conflicts result in situations characterized by both distributive or integrative approaches, and that there is little empirical evidence on actual practice in system definition, existing models of conflict resolutions in Requirements Engineering [28][3][30] emphasize the need for an integration of stakeholders' views and interests in the process. This aligns with the message of classical schools of thought in negotiation literature (e.g. [28]) that potential for integrative agreements is much greater than it is believed and that it is important to study it. Investigating requirements negotiations tasks that have integrative potential became important because integrative agreements have significant benefits [28][29].

Computer supported-cooperative work and media effects theories. While studies of the impact of communication technology on group work have been of interest of behavioral and computer scientists since the 70's (e.g. [6]), evidence of group performance on different tasks is mixed. On the one hand, theories of media effects [31][8][25] claim that that negotiations will not be as effective when carried out in communication media other than face-to-face interaction. Hence one could expect that requirements negotiations will be less effective when face-to-face communication is replaced by computer-mediated communication. On the other hand, this claim has been challenged recently by studies that, for example, indicate that the performance of groups defining requirements with audio/video and computer support can be "as good as of those in face-to-face meetings" [27].

Methods for the study of groups. The study of requirements negotiations benefits from research methods from social and behavioral sciences, where theoretical and empirical methods are used in the systematic advance of knowledge about groups. While theoretical methods include formal theory and computer simulations [25], empirical methods have a wider spectrum and include laboratory and field studies, and surveys. Systematic empirical studies, although difficult and time-consuming, are very important to advance knowledge and research in Requirements Engineering, especially in under-investigated areas such as conflict resolution and software teams' productivity in geographically distributed settings. As detailed in section 3.2, Krathwohl's [23] chain of reasoning presents a useful model to design empirical studies that involve the testing of a hypothesis in laboratory experiments or development of theory in exploratory studies.

Based on the exploration of this literature, research methods and models, a two-part hypothesis was drawn with respect to requirements negotiations in distributed settings and a laboratory study designed to test the hypothesis. The hypothesis was that (1) The quality of decisions will be at least as high in distributed settings as in face-to-face requirements meetings and (2) The reduced richness of social behaviors available in computer-supported distributed requirements negotiation hinders its human facilitation. The next section briefly describes the study design and results, followed by a discussion of the choice of research method.

3.2 Study design

From the research paradigm described above, Krathwohl's chain of reasoning [23] was considered as a roadmap in the design of the laboratory study. As illustrated in Figure 2, the model prescribes a sequence of logical arguments followed in the testing of the hypothesis (at the top of the chain). The study design represents choices of elements of *participants, task, treatment, variables, data collection* and *analysis*, and

procedure. These choices of research design represent a guide in demonstrating a relationship (expressed by the hypothesis) by means of analysis of data.

While several research reports have been published about this study and described this design in detail [10][12][13][14], this paper outlines the elements of design in the context of this research methodology. Without attempting to systematically describe the study, this section briefly describes its design and the motivating rationale, for clarity of reading. Further, without attempting to duplicate information in this section, Table 1 presents the relationship between the study design and the elements of the research paradigm.

The rationale behind the study was to setup a comparison of (facilitated) groups of system stakeholders meeting for deciding on requirements, in face-to-face and geographically distributed communication settings. The comparison was made along several dimensions, including an investigation of group performance (productivity) operationalized by decision quality, negotiation behavior operationalized by negotiation trajectories in considering the possible alternatives in the negotiation [28], and interpersonal relationships [31] and group interaction [2] as an indication of factors that contributed to certain group performance results.

Fifteen three-person groups and three professional facilitators participated in 40-minute decision making meetings during which requirements for a banking management system had to be negotiated. Different stakeholders had differing requirements and time and budget constraints created the need to negotiate in order to achieve an agreed set of requirements to be implemented. Several integrative agreements that considered requirements of varying levels of importance for each stakeholder were possible.

The five experimental conditions included a face-to-face control condition and four distributed communication settings supported by a videoconferencing system that featured real-time audio, video and data sharing capabilities. A list of requirements was negotiated by real time access to an editor in which the stakeholders could input their preferences.

4. Discussion

As illustrated in Figure 2, the study used multiple data collection procedures to gather data on several aspects related to group performance, interaction and interpersonal relationships. The intention was to analyze data on multiple dimensions of requirements negotiations in order to gain an understanding of a complex phenomenon. The main result of the study was on teams' productivity in the different communication settings. Not only was there no increase in the group decision quality in the face-to-face meetings, but one particular distributed setting (in which the stakeholders in negotiation were completely separated by distance) stood out as an environment significantly more conducive to requirements negotiations than the face-to-face setting. Further, analysis of data on other aspects such as negotiation behavior, group interaction and interpersonal relationships, and group facilitation, enabled the formulation of possible explanations of the evidence on decision quality and thence of why requirements negotiations appeared as more productive in certain distributed settings than in face-to-face meetings. The results obtained in the context of this research methodology provide some interesting lessons:

HYPOTHESES

H1. The quality of decisions will be at least as high in distributed settings as in face-to-face requirements meetings.

H2. The reduced richness of social behaviors available in computer-supported distributed requirements negotiation hinders its human facilitation.

DESIGN

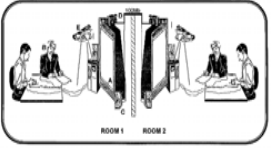
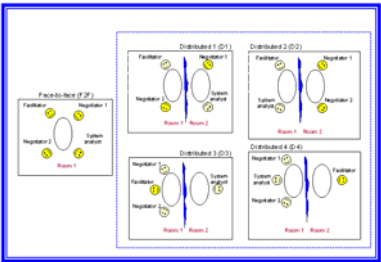
PARTICIPANTS

15 three-person groups student volunteers from the University of Calgary
 16 females and 29 males
 Three professional facilitators
 Gave informed consent
 Paid for participation

TASK

	Teller Representative	Personal Banking Representative
Critical operations	TC1. Browse client's list of accounts TC2. Access client's banking accounts profile (owner, date created, balance) TC3. Access client's credit accounts profile (owner, date created, balance) TC4. Pay bills, deposit, transfer/withdraw funds	LC1. Open/activate new accounts LC2. Update terms of one accounts LC3. Browse client's list of accounts LC4. Obtain history of transactions on client's credit accounts
High priority operations	TH1. Obtain history of transactions on client's banking accounts TH2. Obtain list of due dates on client's credit accounts TH3. Order new cheques	LH1. Access client's credit accounts profile (owner, date created, balance) LH2. Obtain payments overdue on client's credit accounts LH3. Obtain credit rating from an external agency
Medium priority operations	TM1. Obtain history of transactions on client's credit accounts	LM1. Access client's banking accounts profile (owner, date created, balance)
No authority/responsibility to perform	TN1. Open/activate accounts TN2. Update terms of credit accounts	LN1. Pay bills, transfers, deposits LN2. Order new cheques

TREATMENT



DATA COLLECTION

Recording of negotiation behavior
 Videotaping group Data collection interaction
 Post-session questionnaires
 Interviews

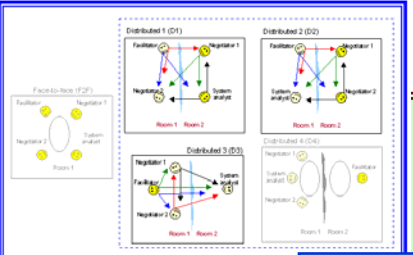
ASPECTS INVESTIGATED

Task-related aspects e.g. group performance
 Group-related aspects e.g. interpersonal relationships
 Group interaction aspects e.g. task vs. social oriented behavior
 Human facilitation

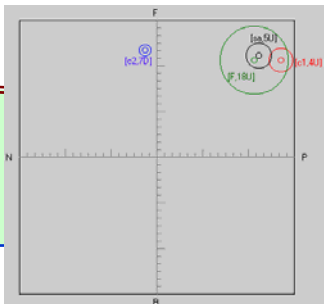
PROCEDURE

Validate the understanding
 Warm-up task
 10 min break
 Negotiation task
 Questionnaires
 Interview with participants

INTERPERSONAL RELATIONSHIPS

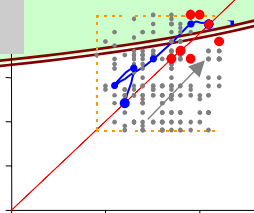


GROUP INTERACTION

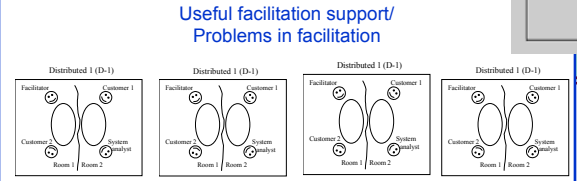


ANALYSIS

NEGOTIATION TRAJECTORY



FACILITATION



Useful facilitation support/
 Problems in facilitation

DECISION QUALITY

	F2F	D1	D2	D3	D4
Facil 1	A	A	C	B	A
Facil 2	F	A	B	B	B
Facil 3	B	A	B	D	F

Figure 2. Laboratory study design

Table 1 Summary of research methodology elements and lab study design

STUDY DESIGN COMPONENT		RESEARCH PARADIGM Concepts, methods and models from relevant research fields	CURRENT STUDY DESIGN
STUDY PARTICIPANTS		<ul style="list-style-type: none"> • Representative sample • Random selection from a well-defined population for generalization • Careful description of study participants [23] 	<ul style="list-style-type: none"> • Forty-five university student participants with experience in software engineering processes • Random selection from this well-defined population • Three professional facilitators mediated the sessions • Careful description of participants' characteristics (e.g. demographics, personality traits, experience levels)
TASK DESIGN		<ul style="list-style-type: none"> • Requirements conflicts arise when stakeholders have differing requirements and priorities [21] • Effective communication is essential to effective resolution of requirements conflicts [1][24] • Soft System Methodologies are useful in the analysis of human activity systems [7] • Requirements negotiations considers different viewpoints and often there is no single correct answer but rather a consensus [7][28][26] • Models of conflict resolution prescribe integrative approaches in RE [3][28][30] • Integrative agreements in the negotiation are important to study [28]; 	<ul style="list-style-type: none"> • The task featured the communication of relevant stakeholders • There was enough conflict inherent in the task to create the need to negotiate • There was integrative potential in the task • Integrative agreements were achievable in the allotted time. • Participants' roles in the negotiation were well defined and communicated • The task design was piloted in the laboratory setting
TREATMENT	DISTRIBUTED SETUP	<ul style="list-style-type: none"> • Distribution of the experimental roles (stakeholders) in separate distributed locations 	<ul style="list-style-type: none"> • Four distributed settings (experimental conditions) in which stakeholders negotiating were either physically co-located or geographically distributed • Participants were randomly assigned to experimental conditions
	COMPUTER TECHNOLOGY	<ul style="list-style-type: none"> • External validity of study results is sought [23] thus technology be: <ul style="list-style-type: none"> • Relevant to current industry practice • Widely available • Easy to learn and use, and reliable (in laboratory settings) • Access to a real-time shared workspace important in RE meetings [24] • Audio channel is important for synchronous work [33] • Video channel provides visual cues important for negotiation tasks [35] 	<ul style="list-style-type: none"> • Videoconferencing system included NetMeeting with real-time audio, video and data sharing capabilities <ul style="list-style-type: none"> ▪ 100 MB internet connection between distributed rooms ▪ Large electronic whiteboard for the videoconferencing display • Echo-canceling microphones • Few seconds delay in the video transmission
OBSERVATIONS AND	STUDY VARIABLES	<ul style="list-style-type: none"> • Investigations of task performance, group-related and group interaction variables [25]; [22] and human facilitation [34][24] are important 	<ul style="list-style-type: none"> • Variables investigated: <ul style="list-style-type: none"> ○ Task-related (i.e. productivity: group performance) ○ Group-related (i.e. interpersonal relationships) ○ Group interaction (task vs. emotional oriented behavior)
	DATA COLLECTION	<ul style="list-style-type: none"> • Use of multiple methods to obtain information from multiple sources [23] 	<ul style="list-style-type: none"> • A combination of quantitative and qualitative methods was used to obtain a rich picture of the phenomena: quantitative instrument for the decision quality, pre- and post-session questionnaires, interview, group behavior video taping.

BASIS FOR SENSING	CRITICAL COMP. and DATA ANALYSIS	<ul style="list-style-type: none"> • The research design and type of measurement define statistical tests to be used for data analysis • Models of visualization of negotiation behavior are useful [28] • Models of visualization of group interaction are useful [2] 	<ul style="list-style-type: none"> • Comparisons of decision quality: <ul style="list-style-type: none"> ◦ Face-to-face with each of the four distributed settings • Use non-parametric statistical tests • Behavioral analysis (e.g. Kelley-Schenitzki model (Pruitt, 1981) and SYMLOG methodology (Bales & Cohen, 1979)) is useful in visualizing group social and negotiation behavior and formulating explanations processes
PROCEDURE		<ul style="list-style-type: none"> • The order of investigator's actions needs careful documentation • The procedure documents the what, who, when, and how of the study [23] 	<ul style="list-style-type: none"> ▪ Random assignment of participants to experimental conditions (roles and group settings) ▪ Pre-session questionnaire ▪ 40 minute decision making sessions ▪ Real-time use of the collaborative technology (audio+video+data sharing) ▪ Post-session questionnaire and interviews

4.1 Designing the study brought a better understanding of RE

As a research outcome, this endeavor raised an awareness of the impact of physical distribution of global teams this on productivity in requirements negotiations. In this respect, of equal importance to the actual study results is the better definition of the problem of requirements negotiations in geographically distributed settings and the research questions this research generated. This aspect raises an interesting point in discussion in the context of this workshop: This study advanced research and knowledge in RE, though not through the study of an RE tool or method. The research methodology described here enabled the identification of evidence that requirements negotiations can be effective in distributed teams and this represents an advance of knowledge in requirements engineering in particular and in global software engineering in general. The process of designing the study enabled a better definition of a RE problem.

4.2 The necessity of interdisciplinary approaches to the study of RE

First, this research confirmed the earlier research (e.g. [26]) and our understanding of requirements negotiations as complex phenomena characterized by factors of technical, organizational and social nature. As illustrated in Figure 1, a multidisciplinary approach was necessary to address these factors and to study effectiveness in (geographically distributed) RE. Requirements conflicts and their resolution were analyzed in the context of human activity systems. From a practical point of view, effectiveness in RE and negotiations in particular was studied in the context of stakeholder groups as task performance systems. Further, models of negotiation strategies were applied in understanding negotiation behavior in requirements conflict situations. Last but not least, empirical methods emerged as critical in basing explanations and description of phenomena on evidence from a well-defined and open to replication study, rather than pure speculation.

Second, and as a consequence of the above point, there is a clear research implication to the design of RE tools. The use of interdisciplinary approaches emerges as critical to any design/study/evaluation of RE tools. Although the tool used by groups in this study was not RE specific, the evidence of its use indicates that factors other than

technical come to have an impact on groups' performance. Adoption issues that take related to social and organizational factors of introducing any RE tool need to be studied and evaluated through research methodologies of interdisciplinary nature.

4.3 Laboratory studies: the intrinsic tension between control and realism of context

Another important point in discussion is the choice of research method. It is known that each research method has its strengths and limitations. While the choice of studying requirements negotiations in distributed settings by designing a hypothesis and a laboratory study to test it had a number of advantages over other empirical methods, it created a tension between control vs. realism of context.

The laboratory setting offered the luxury of control over the experimental situation and precision with respect to the measurement of variables in the study. A task representative of requirements conflict that required decision making and negotiation could be designed and given to all groups in all experimental conditions. To aid the assessment of the negotiation outcome (the variable of interest in face-to-face and distributed settings), an instrument for measurement of the decision quality could be devised, since the structure of the conflict and possible outcomes were known as part of the task design.

As a result, a relationship between cause and effect could be inferred, namely between varying the communication medium (face-to-face to several distributed settings) (the cause) and changes in groups' productivity in environments mediated by these communication media (i.e. negotiation outcome) (the effect). The fact that the same task, i.e. requirements negotiations, were carried out in experimental conditions which differed on the communication medium at large, the effects of the physical distribution on the decision quality could be inferred. We say at large because, by random selection from the population, as well as random assignment of participants to experimental conditions, the effect of the confounding variables could be controlled and minimized. These confounding variables included participants' individual characteristics such as personality traits, experience with the technology or personal interrelationships.

At the same time, however, laboratory studies score least on realism of context, as the experimental situation takes place outside industrial settings; the randomness in selection of participants and their assignment to experimental conditions eliminates in fact the richness of real-world requirements conflict situations. For instance, requirements negotiations in industrial software projects are fueled by real interests and priorities, which motivate the positions in the negotiation; these characteristics of real-life negotiations could not be captured in the lab setting because of the contrived nature of the experimental task. Similarly, the field setting would enable the consideration of other aspects specific of geographically distributed software teams such as cultural and temporal aspects of global teams, and which could also affect the outcome of requirements negotiations in addition to the communication medium. However, investigations of requirements negotiations in industrial projects would very likely lessen the ability to design true comparisons of face-to-face and distributed negotiations, since groups would not be engaged in the *same task* of requirements conflict, and the structure of the conflict would be much less understood (hence lowering the ability to design an instrument to assess the decision quality). To further the discussion of research method, one could consider that, within the same research methodology, Krathwohl's chain of reasoning could be used to investigate distributed requirements negotiations by conducting an exploratory field study instead of a

laboratory experiment. As discussed above, this choice is then favoring realism of context and possibly increased external validity of research results, at the expense of lowered confidence in the effects of a single variable such as the communication medium (from face-to-face to geographically distributed).

5. Conclusion

This paper described a research methodology used in the study of requirements negotiations in geographically distributed settings, and discussed the choice of a laboratory study in the context of this methodology. We raised important points in the discussion of methods to advance knowledge and research in Requirements Engineering, and we look forward to discussing these issues further at the RE03 workshop on Comparative Evaluation Methods in Requirements Engineering.

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