Technical Leadership of
Virtual and Remotely Distributed Teams

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Abstract. The world is increasingly virtual and complex, with many relationships and teams at a global scale. The situation will not be changing any time soon. Sometimes, it is only possible to interact at a distance, of not only time zones and space, but also sometimes interpersonal distance, where names and voices make up another person. Regardless, technical teams will need good leadership to address complex situations in these virtual and remotely distributed (VaRD) environments. So, in a VaRD environment, do leadership practices and skills have to change? Do the tools, techniques, and technology make current practices for leadership in general, and the application of those practices obsolete? Maybe not.

This paper seeks to examine the nature of what is really changing when leading in a VaRD environment through the lens of engineers leading teams in global and complex technical challenges. Those perspectives are analyzed to determine the factors that go into a VaRD environment. In addition, this paper analyzes how interactions between teams compare to an in-person environment, how leadership practices are applied in this environment, and how technical leadership is tailored for these new environments.

Introduction

Technical leadership can be generally considered as actions related to inspiring, providing direction, and guiding a team focused on a technical effort. It requires understanding of both social and technical principles, and the skills to apply them. This may involve parsing through multiple factors, such as, but not limited to, culture, environment, context, behaviors, technology, and tools, each of which add their own layer of complexity to technical leadership. As many teams have moved to virtual and remotely distributed (VaRD) environments, or have been forced into one of these environments, organizations and technical teams now may have a new set of factors to consider and address.

VaRD environments are indirect, requiring working in different locations and collaborating using processes that allow individuals to work separately. It may seem that this environment will change much of how work and leadership will need to be performed in organizations. In fact, some guidance in past years on leading a virtual team states that it is not the same as leading a co-located team, and that new competencies and skills are needed (Nemiro, 2004) and others call into question whether or not leadership models have changed to match a "modern business environment" (Geurts, 2003). Except it appears that, at least for virtual teams in recent years, the principles of leadership have not fundamentally changed. Contrary to the idea of changing leadership models, leading a technical team in a VaRD environment will involve not changing what good leadership is, but instead involve tailoring the application and practices to the new context.

Identifying how to be effective in a VaRD environment can be explored through the following five questions.

- What are the input factors that impact technical leadership in VaRD environments?

- What are the similarities and differences between "in-person" and VaRD environments?

- How do teams develop in VaRD environments?

- How do leadership practices translate in general to VaRD environments?

- What specific behaviors have technical leaders and organizations used to adapt to VaRD environments?

These questions will be examined based on the context, experiences, and stories of the authors as systems engineering practitioners in each of their fields. This is supplemented by input from the experiences of other technical leaders who were engaged in a dedicated workshop (INCOSE 2020). These perspectives are used to evaluate if basic principles of technical leadership have changed, and what individuals and organizations can do to be effective in a VaRD environment.

Input Factors Impacting Technical Leadership

Success on technical projects or initiatives requires adapting leadership styles and models to different environments. Key input factors can be highlighted to help technical leaders understand how they may influence the success of their team and organization in such environments. Factors that are influential in leading teams in a VaRD environment are generally categorized as uncontrollable, organizational, and human. Uncontrollable factors, such as disruptive events, are environmental factors that technical leaders have little control over. Organizational factors, such as organizational culture, further shape

leadership style and require tailored leadership models. Human factors address adaptations needed in leading and managing teams in VaRD environments.

- **Uncontrollable or unpredictable events** – The economy, politics, competitors, customers, and even the weather are all examples of factors that are beyond the control of a leader or could not be foreseen. These events can influence a team's performance. Uncontrollable or unpredictable events requires technical leaders to adapt to new situational and environmental context. For example, in 2020, the Coronavirus crisis highlighted the needs for organizations and teams to adapt to restrictive measures, which have provoked new ways of leading teams in VaRD environments. Uncontrollable events shape leadership style in the face of unexpected adversity.

- **Organizational culture** – The culture of an organization is a critical factor for leaders since culture shapes leadership styles. Organizational culture consists of the shared system of beliefs, values, expectations, norms, and observable ways that members express their ideas. For example, the Competing Values Framework of Quinn and Rohrbaugh (Quinn and Rohrbaugh, 1983) identifies four types of organizational cultures: clan oriented, adhocracy oriented, market oriented, and hierarchically oriented. Each of these organizational types has a leadership style that tends to be more effective given the organizational culture, and some may be more effective than others in a VaRD environment. The organizational culture may also dictate what the roles are between "leadership" and "management," which can have an impact on how to lead a team in VaRD environments.

- **Human factors** – Human factors are about understanding the effects of human behaviors on performance. Human behaviors span a broad spectrum. Non-technical skills, often referred to as "soft skills", involve the negative and positive aspects of human behavior on performance. In technical environments, the principles of emotional intelligence and social intelligence are key components of soft skills. Moreover, on technical teams, leaders must practice soft skills such as the ability to influence and build trust to improve team performance. With the increased complexity in VaRD environments, soft skills become more critical, and using these skills becomes even more challenging due to the interfaces with information and communication technology (ICT).

Similarities and Differences in Environments and Contexts

A team is a group of individuals working together to achieve a common predefined goal. The traditional work environment, also known as an "in-person" environment, consists of individuals working in physical vicinity. The virtual teams refer to the group of individuals separated by physical distance but utilizing ICT to achieve a shared goal. Remote teams, like virtual teams, work away from each other, but usually that does not mean that everyone works remotely, or that the company distributes its team members around the world. The term "remote" in remote teams means that certain team members may work remotely away from the office or other members on the team. Remote teams can also be location based, potentially working from home, but within a specific distance to an office where they occasionally meet. When working on a remote team, rather than trying to connect across multiple time zones, there may be only one or two other remote workers while the rest of the team is centrally located. Conversely, remotely distributed teams are separated geographically and dispersed over a wide area – domestically or internationally.

Key differences and similarities between "in-person" and "virtual and remotely distributed" teams are listed below.

- **Team selection** – In person teams are often selected only based on their functional skills. VaRD teams will have the additional challenge of potentially making selections based on knowledge of technology over their necessary useful skills, like learning new ICTs, the ability to collaborate across functional and cultural boundaries, and exceptional time management.

- **Organization structure** – Compared to in person teams, which often have clear reporting lines and hierarchical organization charts, VaRD teams support a global organization structure and may be able to have weak authorities and fewer hierarchies. In fact, a hierarchical structure may be less effective in VaRD teams. VaRD teams could have trouble with collaboration if following complicated chains of command, but effective communication within the organization can address this. Communication and collaboration are key in any workplace, regardless of whether it is in-person or VaRD, especially when most interactions occur via email, chat or calls. This means ensuring a free flow of accurate information and using the right tools for the job. Both in-person teams and VaRD teams require leading by example by giving regular updates and holding check-ins with teams. If a team sees that the leader is an effective communicator, team members will follow suite.

- **Availability of information and communication technologies** – Companies cannot control where employees work in VaRD teams. But regardless of whether or not a team is in-person or a VaRD team, what they can control are in-house facilities and the physical technologies distributed teams use, including company-issued computers, smartphones, and wireless access cards. These types of technologies are tangible and bridge the gap between wherever the team members are and how they collaborate with the rest of the team.

- **Leadership or management style** – In some VaRD teams, team leads cannot control the day-to-day activities and monitor each team's activities as well. Therefore, they will need to delegate more, and will generally need to lead through influence more than directly. Frequent communication with clear delivery is critical in a VaRD team. This is in contrast with in-person teams where it is much easier for team leads to interact and participate in the day-to-day team activities.

- **Knowledge exchange and decision making** – For an in-person work environment, information exchange happens also during informative discussions. In VaRD teams, members have limited or no informal access to the data. A VaRD environment means there needs to be more frequent updates on project status and building a shared repository to provide important information to all team members.

- **Relationship building** – When in-person team members meet in the workplace, they tend to develop close ties. In a VaRD team, the interactions tend to be more task focused. Lack of verbal cues and gestures in a VaRD setting does not allow for a personal touch in communication.

- **Psychological contract** – An unwritten set of expectations between the employee and the employer is referred to as a psychological contract. The foundation of psychological contract is more fragile in the VaRD environment compared to an in-person environment. Smaller instances of misunderstanding or gaps in communication result in a violation of the psychological agreement, which negatively affects the team's effectiveness. VaRD teams also tend to experience difficulties in building trust, cohesion, and commitment among its members. In a VaRD team, developing this psychological contract will not be easy.

Considering the challenges posed by VaRD teams, it is necessary to pay close attention to communication, collaboration, and cultural issues.

Tuckman's Model of Forming Teams

Based on research conducted on team dynamic, the Bruce Tuckman's team development model shows that all teams go through the following five stages (see also Figure 1): forming, storming, norming, performing, and adjourning (Wilson, 2010). All stages are inevitable in order for a team to grow to the point where its members are functioning effectively together and delivering high quality results. Once a team has experienced the forming and storming stages, they may move through the other stages in any order or return to previous stages. For example, the team development cycle can start over at any time during a project, such as a team member moving off one project and a new team member joining. The team will be back in the forming stage until the new member is settled.

Forming
- Little Agreement
- Unclear Purpose
- Guidance and Direction

Storming
- Conflict
- Increased Clarity of purpose
- Power Struggles
- Coaching

Norming
- Agreement and Consensus
- Clear Roles and Responsibility
- Facilitation

Performing
- Clear Vision and purpose
- Focus on goal achievement
- Delegation

Adjourning
- Task Completion
- Good feeling about achievements
- Recognition

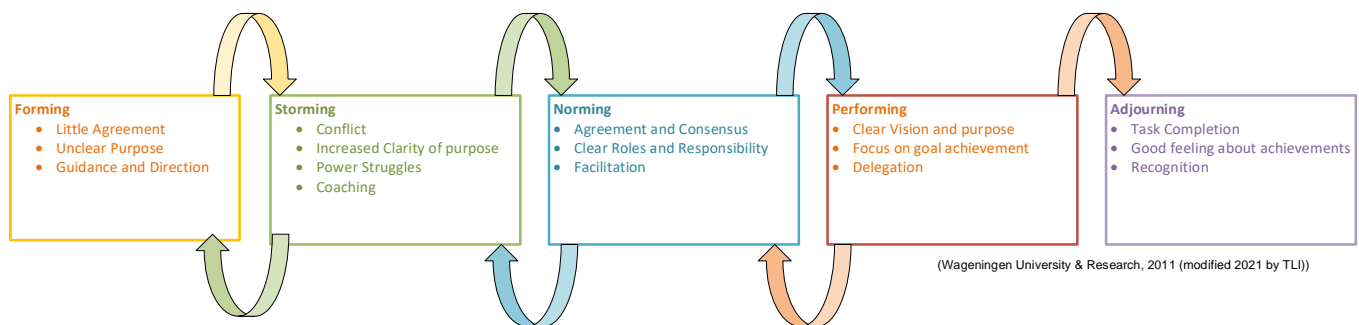(Wageningen University & Research, 2011 (modified 2021 by TLI))

Figure 1: Tuckman five stages of team development.

This development model should result in effective teams. The members in the team must be able to work together to take part together to team results. This does not happen automatically, but it happens through this team formation. Initially, team members are individuals assigned to work together, overtime they get to know each other, what to expect, how to divide and assign tasks, and how to coordinate work. Through this process is how team members function as a team instead of individuals.

The principle behind this model applies the same for VaRD teams as well, but they might go through a more complex development process, because they solely rely on electronic communication and collaboration technology to facilitate interactions. Cultural boundaries and time zone differences add to its complex nature. Leaders need to acknowledge that each stage may develop slightly differently and take longer, but the model is applied the same.

Forming Stage

The forming stage involves a period of orientation and getting to know everyone on the team. This may take more time in a VaRD environment because team members interact less frequently. The interactions in VaRD teams are often task focused, and do not have as many opportunities to interact informally. This could result in a team awareness that is strongly contextualized and work-centric, rather than having an awareness of the other team members.

Storming Stage

The storming stage is the most critical and difficult stage to pass. It is a period marked by conflict and competition as the individual personalities develop.

For a VaRD team, it may be more difficult to express differences of opinions, and one or two people could monopolize a conversation. The approaches of different cultures in this stage for a VaRD team could complicate the situation. A clear flow of communication and regular team meetings could help, as well as an understanding of the cultural behaviors for those that make up the team.

Norming Stage

The norming stage is where the team works more effectively as a team, but not necessarily at a high level. They are no longer focused on their individual goals but are focused on developing a way of working together. They are accepting of each other's opinions and value their differences.

In a VaRD team, norming can be encouraged by putting things in writing. Talking about the norms can help everyone see what they are doing and how things work on the team. Remember: norms may not be apparent unless they are documented and agreed upon.

Performing Stage

The performing stage is where the teams are performing at a high level. Team members trust and rely on each other and the focus is on reaching the goal as a team. The highly performing team functions without oversight, and the members have become independent at this stage. Decisions are made and problem solved quickly and effectively.

In VaRD teams, it is easy to slip out of this stage and return to earlier modes of operating. Team members can take things out of context or struggle with communication. With recognition and steady work, the performing stage can be maintained on VaRD teams.

Adjourning Stage

In the adjourning stage, the project is ending, and the team is moving off to different directions. This stage looks at the team from the point of view of the well-being of the team rather than from the view of managing a team through the original four stages of team growth.

This appears to be a difficult stage for VaRD teams. Celebrating the success of the project and sharing best practices for future use cannot be done in traditional ways, and alternative methods would need to be identified.

General Translation of Leadership Practices

A successful realization of a complex system requires abilities that go beyond the adoption of good managerial practices. Good managerial practices provide a sense of control, organization, and cause-effect rationale, and they are sufficient for the realization of known systems developed in known contexts and deployed in known environments. However, complex systems and systems of systems present emergent characteristics and pose unknown challenges. For these, good leadership practices will set the direction and guide the team throughout the adventurous and sometimes unknown journey towards the visionary destination.

The internationally best-selling book "The Leadership Challenge" (Kouzes and Posner, 2012) provides the following five practices for exemplary leadership:

- model the way,

- inspire a shared vision,

- challenge the process,

- enable others to act, and

- encourage the heart.

This model provides an abstract concept of the best practices a leader should adopt, independently from the nature of the team to lead, the engineered system to be realized, the surrounding environment, and the situational context. These practices are generalized and therefore useful to guide leaders in any endeavor. Nevertheless, it is important to contextualize these practices and take into consideration how the world is changing, how human interactions evolve, and the input factors affecting technical leadership described in the previous section. It is worth understanding how to translate these practices into behaviors and actions that help to lead effectively a VaRD team to successfully engineer a complex system.

Model the way

The practice "model the way" suggests that leaders establish principles and standards on how people should cooperate and pursue goals. Leaders should then implement these establishments leading by example. Leaders of VaRD teams should comprehend the cultures of the team members, their local habits, and their needs and feelings when they interact virtually. Once they have an understanding of those items, they should find the right trade-off that maximizes team member inclusion and comfort. Leaders should establish habits for virtual interactions that help to supplement what may be missing in non-verbal communication.

In a physical environment, technical leaders use their competencies and knowledge to lead by example. In a virtual environment, social and communication abilities may become even more important. Technical leaders should increase understanding of social aspects and their relationship with systems engineering aspects. Leaders should take the thought processes of an explorer of the interactions rather than a subject matter expert.

Leadership relies on communications, both verbal and non-verbal. The non-verbal cues are much harder to detect and transmit in a virtual environment, so it is important to be explicit about how the team should communicate.

Inspire a shared vision

The practice "inspire a shared vision" suggests that leaders create an appealing image of the final destination, communicate them with passion, and get the team members to envisage future and exciting possibilities.

This may be the most challenging practice to adopt in a VaRD team. Leaders should influence others and the surrounding environments with minimal feedback. Superb verbal and graphical communication skills are key to influence and inspire VaRD environments. Leaders should look at the VaRD environments with the eyes of the team members to build empathy. In addition, leaders should find alternative ways to make sure that the vision is really shared.

Leadership of VaRD teams requires more investment in inspiring a shared vision, because such teams diverge easily.

Challenge the process

The practice "challenge the process" suggests that leaders search for opportunities and change the status quo if there is room for improvement or a need to adapt to an emergent situation. Leaders should pioneer new solutions, keep the team confidence high, and promote a mindset in which mistakes and failures are accepted and perceived as opportunities to learn when exploring and probing new situations.

A VaRD team may provide an advantage to this practice, especially for global challenges. A multicultural team will have different perspectives that would not be present within a single culture, providing different perspectives on a problem based on the different contexts of the individuals. The diversity of perspective would also encourage unique solutions to a problem. Team diversity feeds knowledge sharing and enriches the creativity of team members. Leaders should promote culture sharing via dedicated social spaces and events, where it is possible to experience habits and traditions of the team members. Forums and places to talk about things not specifically related to the engineering effort could strengthen the relationship between team members. Conversely, when diversity is seen as a challenge, the team members could feel fear and introduce barriers in communications.

As demonstrated in paper (Lee, 2016), team dynamics in VaRD teams are different from collocated or in-person teams. The former generates more ideas in the same amount of time and team members may express opinions more openly, but the decision-making process may be less democratic, with the minority opinion having less influence. Therefore, in such an environment, it is easier to get new proposals for changes, but it is harder to implement them and get team members to buy in to the changes.

Finally, technical leaders should be aware that minor and apparently simple changes could have a significant impact in a new environment. Technical leaders should be quick and creative to tailor also very simple processes, such as a design review or a product acceptance, which could become complex in a VaRD environment or at least it will be different.

Enable others to act

The practice "enable others to act" suggests that leaders foster collaboration, build trust in the teams, and actively involve others.

In a virtual environment, reliability of both humans and ICT infrastructure are crucial to build trust and involve the team members. Leaders should envisage the adequate technological infrastructures and invest on reliability and knowledge sharing. Team members will maintain momentum and focus as long as they are not threatened by technical issues, and can keep in synch if they always have access to a unique source of truth.

Leaders should organize meetings and information well in advance to avoid wasting time, support team members facing technical problems, respect the agenda, and value all interventions and contributions. Last, but not least, leaders should seek feedback, because in a VaRD environment there is not direct contact, and it is more probable that team members will get distracted and not participate to the discussion. Leaders should not show anxiety about lack of control in virtual teams, which may cause some amount of micromanagement, and destroy trust. Leaders should focus on engaging team members.

Encourage the heart

The practice "encourage the heart" suggests that leaders keep hope and determination alive, and recognize the contributions that individuals make.

Leaders should find alternatives to celebrations in person, such as posts in social networks, videos, and newsletters, where leaders recognize the successes of their teams. Certainly, these alternatives are often less enjoyable than a party, but they have a greater visibility and professional value. Nevertheless, it is worth introducing as an important habit the celebration of a success with a fun event every time the team meets in person.

Effective Behaviors

The fundamentals of leadership do not change because a team is remote vs. distributed vs. virtual vs. co-located. The teams require direction, guidance, coaching, decision-making, problem solving, conflict-management, team building, and everything else associated with leadership. For a virtual, distributed, or remote team, specific leadership behaviors can help the realization of good leadership practices.

Based on the personal experiences of some technical leaders, behaviors or actions that may help someone new to leading a VaRD team are the following.

- **Get to know the people**

  o Deliberately and directly talk to individuals rather than using subtext or implicit communication. Get their attention by specifically using their name and get them involved.

  o Establish a new baseline for how team members speak and write in order to use this as a sort of non-verbal communication.

  o Specifically ask how people are and ensure that everyone has a chance to talk.

  o Talk to new people in the organization regularly to get them oriented on how they "fit in."

- **Encourage diversity**

  o Utilize backgrounds in virtual call that promote peculiar characteristics of a culture to trigger curiosity and questions on diversity.

  o Encourage diversity by organizing teams by product area in order to mix membership from different sites (Lee, 2016).

- **Use the camera**

  o Whenever feasible, propose to have video on in order to allow team members to use body language. If team members are not comfortable using their camera, continue to encourage them to do so, but do not push the team member into discomfort.

- **Find tools that support on-line collaboration**

  o From the experience of one technical leader, "Do not take a chance, if it is important, pick up the phone and talk." When writing an email or an instant message (IM), sometimes individuals will read into something that is not there, or write something that they did not think

would start an issue. Face-to-face communication has always been better. Things can still be talked out over the phone, and that will make it easier to hear when someone is not happy, but it will still not be as good as face-to-face.

- o Although IM may not be as reliable as face-to-face communication, it can be used as a back channel for the side conversations and comments that may need to occur during a meeting.

- o At the beginning of projects, set up a repository that everyone can get too and stress that all project related material must go into this repository.

- o Utilize pictures and screenshots in order to understand what others are seeing for trouble-shooting and problem solving.

- **Leverage process and standard work**

  - o Asking teams for status weekly instead of monthly and asking them for help on tasks gives them a sense of empowerment.

  - o Dashboards or visual management can be used to get a better idea of what is occurring both within a team and in other teams.

- **Leverage meeting basics**

  - o During virtual meetings, a moderator, a different person each time, can make sure all the required people are in attendance, reminds the host there is 15 minutes left and keeps a log of who has come in late or left early.

  - o Record virtual meetings, offering off-line listening to whom did not attend the event and need to get information.

  - o Whether the meeting can be recorded or not, document the results of discussions and decisions in writing and ensure that it is distributed to everyone.

- **Find alternative means of socialization, celebration, and recognition**

  - o Consider using videos for acknowledgement and communication rather than emails or other written communication and sending gift cards rather than having presentation of certificates.

  - o Many ICT tools have the option for "reactions" (such as emoji's). Although these may seem unprofessional to some, they provide a passable alternative to being able to react in person.

  - o Set up a virtual "coffee break" or virtual "happy hour" with the ground rules of no work being done to strengthen the bonds of the team members.

This is only an example of potentially effective behaviors. Ultimately, the specific leadership behaviors will need to be tailored to the specific organization.

Potential Future Analysis

As is often the case, as each of these items has been explored, additional questions and unknowns arise that need additional exploration. There are instances of conflicting processes, inconsistent trade-offs, and aspects of virtual technical leadership where no conclusion was evident in the experiences of the authors.

- **Leadership vs. management** – There are many perspectives on the differences and similarities between "leadership" and "management", and this is no different for the application of these terms to VaRD environments. While there has been some exploration of these ideas in this paper, there is likely to be disagreement on how they are used, what each of them entail, and who performs each of these functions.

- **Virtual and remotely distributed team development** – This topic has been touched on in this paper, but there are nuances to the complexities of team development in a VaRD environment that have not been explored or tested. This paper has been focused more on teams that are already in the "performing" stage of development, so the perspective of similarities and differences in team development is limited. There are still questions on how teams form, storm, norm, perform, and adjourn in a VaRD environment, and how or if these processes change.

- **Establishing or changing a virtual culture** – Not all organizations have a culture that is both efficient and effective for VaRD teams. Changing the culture of an organization or establishing a new culture is one that is difficult to start with and doing so as part of a VaRD team is likely to present additional challenges compared to an in-person or co-located team.

- **Resolving conflicts in VaRD environments** – As with any team, there is bound to be some conflict that arises between individuals. Methods of resolving conflicts in a VaRD team may remain the same, but this has not been examined in detail in this paper and could benefit from further evaluation.

- **Effects of different organizational structures** – Each organization will have a specific structure that will impact the effectiveness of a VaRD team. While this has been touched on in this paper, the perspectives captured and examined do not capture all types of organizational structures. Further study on multiple varieties of organizational structures could provide additional insight into the most effective ones for VaRD teams.

- **Quantitative studies** – This paper has been based on experiences in a VaRD environment, rather than any specific study. It would be beneficial in the future to examine how existing studies in soft skills tie into these leadership concepts. This could help to address and identify specific measures of effectiveness of leadership in a VaRD environment, as well as effectiveness of a team in this environment.

Conclusions

The quick shift to VaRD environments has brought on many challenges for organizations. In this suddenly almost exclusive virtual world, it is much easier for employees to become almost invisible. More than ever, leaders have to know the needs of their business and their people. The inability to bring external and internal stakeholders together in person for the foreseeable future adds more difficulty to decision-making and increases the potential for conflict. For organizations, the critical challenge in the current environment centers on how leaders can engage virtually in communication and key decision-making processes with stakeholders and internal team members in ways that enhance trust, transparency, and teamwork. It also offers a critical opening to rethink how decision-making is distributed and managed locally and globally.

Although there are differences in VaRD environments from in-person or co-located environments, teams will still require the application of good technical leadership practices, and many factors affecting teams and how teams are led are similar regardless of the environment. Fundamentally, these practices remain

the same, regardless of the environment. But teams will still need to adapt to different processes for the application of leadership practices. VaRD teams will also evolve more rapidly than co-located teams, so leadership practices should be tailored and quickly adapted to respond to the unpredictable changes. The tailoring process should be executed starting from the principles, because a direct tailoring of the processes could be ineffective in such environment where the team dynamics are a critical element of the system.

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