Distributed Teaming on JPL Projects

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Abstract—NASA projects are created by *teams of people.* More frequently than ever before, these project teams include members who are "distributed" rather than co-located -- scattered in place, time, discipline or attention rather than collected and focused in every way.

Distributed teams share many characteristics with co-located teams, but their geographic distribution precludes frequent face-to-face meetings among team members. This physical distribution makes shared vision and trust much harder to achieve within the team, and creates a vacuum where social aspects of team behavior would normally be.

This paper addresses structures, actions and technologies that contribute to real team development of a distributed team, and the leadership skills and tools that are used to implement that team development.

Some of the information is extrapolated from literature describing team development -- I say extrapolated, because nearly all of that literature is focused on co-located teams, and almost none on "virtual" or "distributed" teams.

Much more of the information in this paper is gathered from real-life experiences of JPL (and other) project managers who have led distributed teams themselves. They were eager to describe the difficulties they encountered, the various means they used to solve those difficulties, and both the successes and failures of their efforts. They left it to me to compare their experiences with the theories of human dynamics, and to generalize on their experiences.

These generalizations are increasingly necessary, as the use of distributed teams increases in every industry.

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1. INTRODUCTION

The value of this paper is based on the simple (and often overlooked) premise that JPL projects are created by *people.* If we look at the system used to create JPL products in a complete way, we find that the system includes three main active elements: the people, their processes, and their tools.

First we need an agreement on terms, specifically the term *distributed.* There is frequent mention in popular management literature of *virtual* teams, usually described with these characteristics:

- Interdependent members who must rely on each other to produce the team's output in a systematic, synergistic way;
- Mutual accountability among the members for the output and its result, with associated mutual recognitions for the accomplishment;
- Regular and frequent use of technology-supported communications media and technology-supported information management and storage systems...

These characteristics of a *virtual* team seem to match those of a "real" co-located team pretty closely -- the difference is found in the final characteristic:

- Geographical distribution that precludes frequent face-to-face meetings among team members.

Since *virtual* teams share all those characteristics of *real* teams, but are geographically distributed, we'll call them *distributed* instead -- and we won't contrast them with "real" teams, but with *co-located* teams.

If we consider the technical, educational and even political complexities of modern space projects, we conclude that the only way to accomplish such a project in a reasonable amount of time and with a reasonable amount of money is to create a focused, dedicated multidisciplinary project team with "the best people" -- a team whose members can work concurrently on parts of the project, independently on others, and collaboratively always.

This often means working with individuals and companies

that are scattered across several time zones. Sometimes the distributed team has advantages for the project -- for example:

- Distributed teams reduce co-location costs, which could include anything from travel expenses to several years' worth of hotel bills and per diem charges...

- Distributed teams span boundaries *of all kinds,* bringing together individuals who can clearly make a contribution to the output, but who are separated by discipline, distance, culture, organizational affiliation, and so on. *The differences support innovation, by connecting a variety of perspectives in new ways.*

- Distributed teams can increase the learning and creativity within the team, since members have the chance to interact with a much larger variety of disciplines, experiences, and viewpoints.

- And distributed teams can increase team flexibility -- knowledge is an enabler to action, and a team with more variety of knowledge is capable of variety in action.

However, distributed teams have an increased difficulty in achieving an important condition of effective team performance -- convergence on a shared framework of understanding about the team's context, goals, and processes of achieving those goals. The greater the distribution of the team, the greater this difficulty becomes, because much of the convergence comes about through frequent contact and socialization among the team members. Behavioral, cognitive and emotional patterns are not formed in the same way on distributed teams, because the informal interactions among team members cannot be carried out in the same way. Distribution changes the "ground rules" for these interactions. Distributed teams must create these interactions deliberately, and structure them using a *technology* they develop for the purpose.

(I am using technology here with a very specific meaning -- if a *tool* is an implement or artifact used to help perform work, then *technology* is a *system* of tools or a systematic way of using tools to do work.)

There are three components of distributed teaming: the people on the team, the processes they use to do the work and to work with each other, and the project tools (including the facilities which will be used by the team). A technology is required to integrate these components, to satisfy the purposes of a distributed team, while mitigating its inherent difficulties. That technology is *a systematic way of creating and sustaining the traditional high-performance team behaviors.*

Professor Susan Cohen, a senior research scientist at the University of Southern California's Center for Effective Organizations, led a three-year study of "virtual" teams, under a grant from the National Science Foundation. Through a qualitative case analysis of twelve teams, she was able to identify certain conditions that contribute to the success of virtual teams -- success being determined by a team's completion of its "product" goals, with nominal effectiveness and efficiency.

Success factors (factors which produce alignment, trust, and a completed product) are remarkably similar for both distributed and co-located teams:

- Leadership competencies
- Technology (information and communication)
- Organization structure
- Human Resource management systems
- Member competencies
- Team processes
- Work processes

We will need agreement on the meaning (for this paper) of two more terms before going on:

I will define *alignment* as the shared understanding and commitment about what the team is doing together -- it necessarily involves a mutual reinforcement of individual and "shared" or "team" goals, since the individuals on the team must work toward realizing the shared goals. Developing alignment is an iterative process requiring frequency of contact and disclosure of individual goals by team members.

Trust is a personal belief that you can rely on someone else; a belief that you can predict someone's behavior in a given situation, and that their behavior will not be detrimental to you. Developing trust is also an iterative process requiring frequency of contact and the disclosure of individual needs, goals and attitudes by team members.

The frequency of contact and the disclosures necessary to build trust and alignment among members of co-located teams generally happen in an informal manner. Members of the teams are physically near each other, and meet face-to-face frequently. They share social norms and experiences directly. When they exchange attitudes, needs, and personal goals during moments not directly focused on work products, they receive immediate feedback from another person's presence, attention, verbal and non-verbal cues. Not only is the member's value to the project reinforced by acceptance of their technical contribution, *their value as an individual is reinforced by the social contact with their colleagues.* Distributed teaming adds a level of complexity to developing trust and alignment, because the same kind of immediate feedback and informal socialization is not possible.

2. INTERACTION GUIDELINES FOR DISTRIBUTED TEAMS

The interaction *technology* (processes and protocols) of a distributed team must be carefully structured to produce an effect *equivalent* to the effect produced by the immediacy available in a co-located team. Socialization among distributed team members must be planned, it cannot take place spontaneously in the hallway or the cafeteria. The collaborative schemas for distributed teams must be created deliberately. For distributed teams, the common context of a shared physical environment and shared management structure must be substituted for, with a created, more intangible context -- but it must be experienced as real and common by the team members.

Distributed teams require more complete *introduction* to each other, since much of the spontaneous interchange among team members serves the purpose of demonstrating competence and reliability in an informal way. Distributed teams also require better and more complete *contracts* at the beginning of the teaming process, since they will be less able to participate in spontaneous, informal negotiation regarding what they must receive from and deliver to each other. They need a deliberate way to conduct that negotiation through the project duration.

Distributed teams need *methods to practice collaboration* and to achieve collaborative results in the technical work they are doing. And the teams must *check their progress and process* -- their work products and work relationships -- more frequently, in a more structured way, to substitute for the immediate feedback available to co-located teams.

More complete introductions

The project members should learn each other as individual people, respect each other as professionals, and agree to responsibilities as soon as the project begins. This requires an initial face-to-face meeting for project team members. The initial meeting mixes socialization, definition of roles, and agreements on responsibilities.

The initial meeting should have a product-critical theme (understanding highest level requirements, reviewing phase-related documentation required, etc.) and an internal project theme (developing internal communication processes and protocols, developing a technical decision making process, etc.) Activities may include focused team building or not, but the methods used to do the "real work" should be facilitated in a way that creates and reinforces team behaviors.

An example: One JPL project began with a three-day retreat that had a product-related theme of developing a risk management approach and plan, and assigning the responsibilities for follow-up risk mitigation roles and actions. In order to work well at the retreat, as well as on the project itself, the thirty project team members present had to learn the type of contribution each colleague could and would make to the project. An introduction process allowed a non-threatening initial presentation by team members of backgrounds and cognitive abilities. Focused outdoor team building activities were alternated with facilitated work on the risk management planning. Team members were able to learn something about the motivations and work habits of their colleagues (and themselves) by participating in fun, challenging activities in a local park; they were able to transfer their learning to the "real" team work environment as the facilitator led them through the process of developing the risk mitigation plan. Team members more quickly learned the ways others worked and the ways others were comfortable interacting. The project manager was more easily able to articulate and assign roles and responsibilities. Both the focused team building and the collaborative work method served as in-depth *introductions,* allowing team behaviors to begin more quickly.

Later in the project, during implementation phase, the team was confronted with a seriously urgent problem, involving non-delivery of a subsystem. The team as a whole was able to respond quickly and decisively to solve the problem, and team members were willing to spend extra work time helping other team members get through the crisis. The project manager attributes the collaborative attitude to the ways of working initially developed during team building sessions.

More complete contracts

In addition to work on the product-critical theme at their initial meeting, the members of a distributed team should develop their own communication management protocols for internal contact by telephone, email, and collective teleconference. These will also include protocols for work collaboration, decision-making, conflict/problem resolution, documentation, tracking, and knowledge sharing and reporting. Project team members may also use the initial meting to determine their desired mix of face-to-face and distributed, media-facilitated team contact for the future.

An example: A JPL planetary project involving a system-contracted spacecraft fabricator began with a workshop addressing roles, responsibilities, and decision making that would take place during the project. All parties agreed on what information must be shared for anyone to make practical decisions, and this agreement was the basis for the project's communication processes and protocols. The contact was structured, and later managed, according to processes and protocols developed by and among the project team members. The frequency of contact, the content of communication, and the type of media used for contact were agreed upon in advance -- even the process for making changes in the communication protocols was decided. The project manager described the nature of communication

among the project team as "really honest and really complete."

Methods to practice collaboration.

Real time documentation, tracking, and modeling tools for the design process are becoming more common in the engineering world. Even when such tools are used in the context of co-located teams, they facilitate knowledge sharing and management of project technical progress. These tools are almost mandatory in the distributed project team environment. Video-capable meeting facilities, network-enabled document sharing systems, and the telephone all support working meetings among distributed team members. As in meetings with co-located teams, the technical information being addressed by the largest number of participants is displayed centrally, while real-time video and audio transmission of distant team members creates a sense of their presence. Small break-out groups can go off-line to work on specialized issues, using telephone and document-sharing software.

Example: A live, structured design session conducted for a JPL proposed project, with 12 project team members and the project manager in JPL's Project Design Center, and six European project team members in a similar facility in Amsterdam. Directional microphones and video cameras enabled individual team members to address each other directly across thousands of miles. Breakout sessions involving only a few people were held using special telephone circuits and MS NetMeeting, so that breakout participants were able to view and change documents collaboratively, in real time.

Example: Another ongoing JPL project conducts monthly science team meetings by teleconference, using a "script" that assures each scientist the opportunity to present and ask for information. Because the science team is scattered across America and Europe, the time of the conference is changed for each session, allowing participants to take turns waking up early, staying up late, or participating during normal working hours.

Initial work may be done collaboratively or individually, and modified or updated by individuals, using similar document sharing technology. Project libraries are set up, members on distributed teams have "write" access to areas under their cognizance, and "read" access to all other areas. Project members use various IT tools to document and track the entire project formulation and implementation processes, requirements, design, fabrication, test, delivery, and operations.

The information "capture and share" technologies have had major impact on project team work processes, and enabled high performance team behaviors to emerge much earlier in the project life cycle. The use of modeling tools (like Satellite Tool Kit) for design not only increases the *speed* and reduces the *cost* of project work, even with co-located teams, but often increases the *quality* of that work. The use of project documentation tools (my favorite example is the web-enabled e-STARS) makes *current* project information available to team members literally every minute of every day -- and it makes *all* project information available to future projects, organized in whatever way is useful to the new project team.

An ongoing, informal exchange of ideas and tacit knowledge is important to innovative development within a project team. Geographic distribution of a project team makes spontaneous informal chat -- over the cubicle wall -- impossible. Distributed project team members must develop and use distributed, media-facilitated informal channels of communication to exchange ideas, ask for help, and socialize in the project setting. These informal interactions, the equivalents of meeting in the hallway, help to develop a sense of community and trust within the distributed team. The infrastructure and technology for the communication channels can be provided as a standard function of organizational support or as a service purchased by the project; but the structure and "etiquette" of use must be put into place by the project team members.

Example: A proposed JPL project will provide an electronic "faculty club" bulletin board for science team members, similar infrastructure channels for other sub-sets of the project community, and specific focused "chat" opportunities among project team members and others. With help from the project manager and project team facilitator, project team members will develop specific protocols for use of these electronic communication channels themselves -- at the initial project team meeting. And they will be able to use these channels not only for exchange of project information, but for socialization interactions as well (such as "virtual" birthday parties for team members...)

Checking (and reinforcing) progress

People are different from each other in many ways, and the differences must be bridged to create trust and alignment within teams. The differences found on a distributed project team are likely to include:

- Culture (differences in assumptions about life, work, basic social behaviors, and basic responses to others)
- Language (differences in use and meaning of words, and in the structure of thoughts and the organization of communication)
- Discipline and knowledge base (differences in what each person knows and how they learn)
- Perspective (differences in how people understand the task and its value)
- Process (differences in how each person works, and how each understands the team and its value)

A distributed team requires a structured process for resolving differences (as well as conflicts) that can be applied over distance, and that will help to "translate" meanings among team members. This process may be part of the project decision process, which is usually developed early and included in NASA project implementation plans.

Example: The author facilitated a teleconference-based conflict resolution meeting among two project participants and a project manager, all of whom were in different cities in the United States. Traditional consensus building worked successfully, with the facilitator reminding participants regularly about what they had already reached consensus on, and what they still needed to resolve. (Since there was not a white board or flip chart participants could all see, I asked them each to write down on their own paper what items had been resolved, and what the resolution was -- and I asked the project manager to distribute his version of that list by e-mail after the meeting.) Reflective listening techniques were an important part of the facilitation approach, since the facilitator was not able to see any of the participants.

During early face-to-face or media-facilitated meetings, the team members should develop signals that help them identify or indicate when they are experiencing differences in understanding or perspective. When the signals are given, team members should try to identify the differences, assess the potential impact of those differences on the project results and on the team members themselves, and either accelerate or escalate the resolution process based on the nature of the differences.

3. What You Can Do

The key design "principles" for distributed teams are the same as for co-located teams:

- Alignment and Trust are critical
- Identify what is "the same" for the members
- Identify what is "different" among the members
- Bridge the differences

The difficulty is in the process of bridging the differences, because of the geographical distribution of the people. The differences may be exacerbated, because there is generally an increased cultural diversity that comes with geographical distribution, and it is more difficult for team members to develop a primary affiliation with the project team. Project leaders require a substantial set of competencies related to managing the interfaces among team members, and the interfaces between individual work and the work that the team as whole produces.

One successful JPL project was developed by a globally distributed team, with individuals and organizations in several parts of the world making distinct contributions which had to be integrated by the project leadership team:

Project Manager	Pasadena, CA
Principal Investigator	Seattle, WA
Spacecraft Manufacture	Denver, CO
Instrument manufacture	Pasadena, CA
Science team member and instrument manufacture	Germany
Science team member and instrument manufacture	Chicago, IL
Science team member	Mountain View, CA
Program Executive	Washington, DC
Launch team	Cape Canaveral, FL

Another proposed JPL project team is global as well:

Project Manager	Pasadena, CA
Principal Investigator	Los Angeles, CA
Spacecraft Manufacture	Reston, VA
Science team member and instrument manufacture	Germany
Science team member and instrument manufacture	GSFC, MD
Science team member and instrument manufacture	Los Alamos, NM
Project outreach	Denver, CO College Park, MD
Software integration, verification and validation	Hampton, VA
Program Executive	Washington, DC
Launch team	Cape Canaveral, FL
Mission operations	Pasadena, CA

Some important things you can do to help your project team build the bridges they need:

More complete introductions, more complete contracts

An initial face to face team meeting is critical! Dedicated team development activities or socialization are helpful during that meeting, in the context of conducting "real project work." Use the meeting to address the typical distributed team difficulties with internal communication, and let the team develop its own protocols and processes for ongoing communication, collaborative project work, and decision-making. Perhaps most importantly, the team should develop a process for identifying and resolving differences or conflicts.

Set up a schedule for future face-to-face meetings, rotating the locations and the participants, so that there are always a few participants who don't have to travel. Let these team members be "hosts" of whatever socialization activities you plan for the meeting in their hometown.

Project team members must learn each other as colleagues and teammates. We humans usually receive over 75% of day-to-day information visually -- when we try to learn each other as individuals, it helps us to see each other. Ask team

members to submit photos for the project library or web site -- photos could include families, offices, any personal or professional "cues" the person wants seen. Or use photos taken at the initial team face-to-face meeting.

Methods to practice collaboration, checking progress

Collaboration is not an information technology function, it is a human condition. Whatever collaborative engineering tools a project team uses, the process they follow to do the work is what makes collaborative actions effective, and the tools exist to support the process.

Team members must be *trained* in the process, and it must be scripted and facilitated until the collaborators internalize the process completely -- they will be learning the tools as they use them according to the script. As new project team members are added, or as outside contracting organizations begin to work on the project, these must also be trained, and the script brought back into use.

Create rewards for sharing knowledge and for solving problems collaboratively, and make the rewards publicly. Create rewards for identifying differences that must be resolved, and for taking steps to begin resolution. Perhaps the most valuable reward for team members is the attention of their peers and of the team leader -- consider creative ways of paying attention to distributed team members, and of letting all team members know where your attention is focused.

Above all, remember that many of the team behaviors of co-located teams develop because of the frequency of contact made possible by their co-location. Distributed teams must develop this frequency of contact deliberately, because it *can't* happen by accident. A project leader's prime role is to manage the relationships among the team members, so they can accomplish together what none of them can accomplish alone. The success of your distributed project team depends on the contact you help them create and maintain among themselves.

RECOMMENDED READING

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