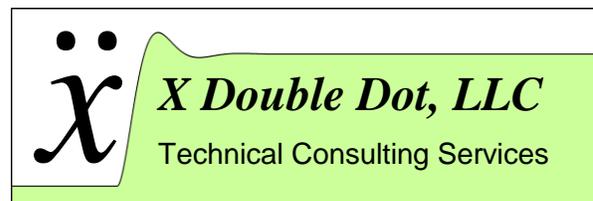


Reflections on Technical Management

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Introduction

I am occasionally asked about my experience managing the design and construction effort for the Discovery Channel Telescope, and in particular about what kinds of lessons I may have learned as a novice engineering manager over the course of my first major project. Many of these queries come from technically-focused engineers considering moving into a management role, so I write with this audience in mind. That is, an audience characterized by technical expertise, but little formal management training or experience.

While the Discovery Channel Telescope project was successful, based on the common project metrics and feedback from those involved, my experience is limited and I make no claim to any ultimate wisdom regarding management. Instead, I offer the perspective of someone who recalls well the steepness of the learning curve and where I started from. As I climbed that curve, I learned much the hard way, by direct experience, but was also fortunate to acquire a number of lessons the easier way; via the anecdotes and advice of other managers. As I found the experiences of others so helpful, I share the following with the hopes that someone may find some utility with a lesson learned the easier way.

I see the management role as divisible into two basic aspects: the cultivation of an effective team, and providing that team with a focused path towards goals. I've restricted this paper to the team building aspect, as this is the area where I learned the most. Also, the technical and programmatic lessons tended to be more specific to the field of large one-off opto-mechanical systems, which aren't as broadly applicable.

The Staff

A technical organization's primary assets are usually that organization's people and their relations, which allow goals to be achieved beyond the ability of any individual. Accordingly, maximizing the capability of an organization means assembling the best staff for the jobs at hand and cultivating that staff into an effective team. I should note that I use the term 'cultivate' here deliberately, as it is the process of establishing the group's culture and requires some sustained effort, is delicate and results can be slow to mature. In cultivating the team, the goal is a group where each individual member is effective at moving towards the organizational objectives and the communication and coordination between the members is functional and professional.

Foundations

Although an individual has innumerable facets to their personality and being, I found it helpful to think in terms of there being three basic requirements for effective team members: competence, motivation, and professionalism. That is, every member of the team must have the competence to do their job efficiently and accurately, be motivated to take care of their responsibilities and help the team achieve its goals, and conduct themselves professionally so their relations with colleagues are positive and increase the overall group's effectiveness.

Of these three requirements, competence is generally the easiest to work with, as everyone excels at something. The challenge is in matching and distributing the work at hand to the individual team

members. This may sometimes seem akin to an n-dimensional jigsaw puzzle, but with some flexibility on the part of the team members and the possibility of hiring or outsourcing work, solutions can be found. In addition to making best use of existing talent, it is also worth expanding that talent; e.g. via training, coaching, allowances for professional development and increasing responsibilities.

As every individual is motivated differently, this is usually the trickiest of the requirements for a manager to deal with. Some individuals are self-motivated and embrace the organization's goals, requiring little effort from the manager. Others may be more externally motivated or don't share the organization's goals, and some additional effort in this area may help realize the best of their potential. Either way, it is helpful to solicit your staff's personal goals to understand how you might best align those with those of the organization. Nearly everyone responds better to encouragement than criticism, no matter how constructive the intent; and I would suggest digesting the classic text "How to Win Friends and Influence People" by Carnegie¹ and the similarly themed "Bringing Out the Best in People" by McGinnis² for ideas on putting that principle into practice.

The last requirement, professionalism, requires of the manager a mixture of cultivation and establishing boundaries. I found most individuals to inherently be very professional, but the group dynamic and how individuals work with each other can be cultivated by fostering an open and collaborative team attitude. Likewise it is critical to establish boundaries, as dysfunctional and caustic behavior is poisonous to the collaborative spirit. The short summary article "Top 10 Workplace Dysfunctions" by Emmerich³ is worthwhile reading on common problems and ways to address them. For uncommonly difficult situations, the book "Toxic Coworkers" by Cavaiola and Lavender⁴ may be more helpful. Major problems aside, even in the best environments everyone has a bad day, communications are occasionally misinterpreted, and it can be hard to appreciate an opposing viewpoint. As a manager, you can help maintain positive relations by hearing out frustrations, smoothing ruffled feathers, and offering a neutral perspective to help bridge views.

The book "Teamwork" by Larson and LaFasto⁵ covers much of the above in greater detail and based on many cases studies. Although their nomenclature is different, their assessment of the important components correlated with effective teams is entirely consistent with my experience.

In organizational cultures, shifting attitudes and turnover reinforce existing norms, such that cultures tend to be very stable with time. I.e. Employees will either come to embrace or tolerate the organizational norms, or they will move on. Accordingly, implementing change in an established culture is likely to face strong resistance and require deliberate management effort. The book "The Seven Arts of Change" by Shaner⁶ provides a thoughtful discussion of these issues and would be useful reading for anyone contemplating leading a cultural shift.

Recruiting

In addition to cultivating the existing team, on occasion the manager will need to hire new employees. The challenge with recruiting is to find individuals with the potential to be good team members amid a very large pool of assorted jobseekers. The process can be thought of as the application of successive filters to the pool of job seekers. Hopefully, at least one qualified candidate will remain at the end. If

not, review your filters, repost and try again. I had the pleasure of hiring a number of very good team members for the DCT project and I briefly describe below the recruiting process I converged on. I don't know if the process is optimal, but it yielded a staff that was effective and evoked many compliments from those they worked with.

The first filter is the job posting, and it selects for those that will see the posting and respond with an application. I found the popular online job boards to be very productive, but professional association job boards may also be worthwhile for some disciplines. For the posting content, I liked to include a brief narrative on what we were doing and what special skills I thought would be desirable, in addition to the job duties and basic terms (full/part-time, exempt/non-exempt, location). Minimum requirements for experience, education, certifications, etc... are useful for keeping the applicant pool manageable, but may exclude otherwise qualified candidates so take care to avoid being more restrictive than necessary. Given the number of postings on the popular online boards, keywords are critical so consider what words your ideal applicants may be searching for. I requested a cover letter to avoid being inundated with casual applications and to see a writing sample for positions requiring written communication.

The second filter is the application review, selecting for applicants who seem promising in terms of the talent, motivation, and professionalism required for the position. I began by automatically rejecting those that failed to follow the basic application instructions or meet the posted minimum requirements, unless a reasonable explanation was provided for the nonconformance. I then tried to assess the applicant's history in terms of the opportunity to have acquired relevant talent and a demonstrated ability to learn; either through formal study or on-the-job experience and responsibilities. Motivation and professionalism can be harder to assess, but can be inferred to some degree by looking at relations with previous employers; with recognition and advancement over a period of years being very positive signs, and frequent job changes being a potential warning. It is worth noting that it may take a year or two for an organization to resolve a problem situation. I followed up on promising applications with a phone interview, to validate and expand the initial assessment, and to provide an opportunity for the applicant to ask questions and better determine if the position and organization are right for them. In the course of the phone calls, I found it helpful to walk through the applicant's resume; soliciting more detail about education and job history, reasons for job changes and gaps in employment, interest in the position, availability, any special conditions, etc...

The next filter was to invite the shortlist of applicants passing the application review in for in-person interviews, to confirm them as a good match for the position. In planning the interview itinerary, I tried to create relevant situations to demonstrate how they might perform in the job, and provide an opportunity to meet with a number of potential colleagues. I generally planned full days, to see how the candidates held up when tired. Asked them to explain their previous work in some detail, to gauge their ability to communicate with peers (whiteboards encouraged). Put them in front of technical hardware, to see what kind of questions they asked and gauge how fast they picked up new concepts. If the role might include presenting to a group, I would usually start with having the candidate provide a short presentation on their background to the people they would meet with individually later, to both gauge presentation abilities and avoid the candidate providing their background repeatedly throughout

the day. I found the informal lunch-time setting was conducive to soft questions about motivations and interests. Lastly, I would conclude with some time alone with the candidate to get feedback and explore what terms would be acceptable, should an offer be made.

Provided no deal-breakers arise during the interview and mutually agreeable terms exist, then the final filter is due diligence. At a minimum, this should include speaking with relevant references, meaning former supervisors or others dependent on the candidate professionally. A good starting point seemed to be asking the reference to describe the nature of their professional relations with the candidate, to put the reference's comments in context. I would then explore the reference's impression of the candidate's talents, including particular strengths and weaknesses, motivation and how the candidate performed best, and how well the candidate worked with colleagues. It is worth noting that people often hesitate to share negative experiences, so a lukewarm or evasive reference may be a warning (or might just mean you caught the reference at a bad time, etc...). It is fair to request additional references or supplemental information if there are lingering questions regarding the candidate's suitability for the position. If there are no surprises, then put the previously discussed terms in an offer letter and notify the candidate.

Retaining

Given the value of good team members and the time and effort required to recruit them, it follows that all reasonable efforts should be made to avoid losing them. And, although many factors in an employee's decision to change jobs may be beyond an employer's control, job satisfaction is always a consideration (either pro or con). Clearly, a manager should endeavor to keep their staff satisfied, and it is important to seek feedback rather than only react to obvious problems. An open door policy and checking in periodically (during annual reviews, over lunch, etc...) are good ways to stay in touch. An unexpected resignation is a warning sign of inadequate awareness.

It is worth considering what an employer can offer to help retain employees. Most obvious is the tangible pay and benefits, but payroll costs are always a concern so common practice is to offer a "competitive" compensation package. By definition, competitive means about the same as offered elsewhere, so in most situations this probably isn't a strong factor in retention. It would be negligent to lose a valuable employee due to unwillingness to pay a competitive salary, so don't be cheap. Where an organization can really excel is in the intangible area of job satisfaction. E.g.: providing worthwhile and appreciated work, a positive community of colleagues, and opportunity for personal growth, learning, and advancement. An organization should also avoid overworking employees. While overtime will sometime be necessary, if it becomes the norm then seek additional help for overworked employees or otherwise find a way to provide relief.

Job related issues aside, changing life circumstances will mean that some turnover is inevitable. Regardless of the reasons for departure, I can say from experience that while disheartening to lose people you rely on heavily, it is important to keep in mind that everyone is replaceable. It may not be quick or easy, but responsibilities can be redistributed, positions can be refilled, and the team will move on.

Addressing Problems

One of the least enjoyable aspects of the management role is addressing an employment relationship that isn't working. This is unfortunately not that uncommon. A rough consensus among managers I've spoken with is that one in five new hires does not work out for various reasons. Whatever the cause, management is obligated to address the problem. Otherwise, team performance and staff morale will suffer due to an underperforming colleague and/or dysfunctional behavior and the slippery slope of declining standards.

Despite the importance, it is not unusual for managers to feel reluctant about addressing behavior and performance issues. One reason is the management role of helping everyone perform at their best leads to viewing a personnel problem as a management failure. While seeking the best from employees is certainly important, it must be remembered that it isn't the manager's responsibility to be satisfied with the results. Conflict avoidance is another common reason for reluctance to address problems. Like public speaking or any task uncomfortable to the novice, you make yourself do it initially and it gets easier with practice. I have observed situations where problems were not addressed; morale and productivity suffered, and management invariably spent much more time and energy treating the symptoms of poor organizational health than it would have taken to address to the causes.

A good place to start is a careful assessment of the problem; as it is easy to feel dissatisfied without always knowing why in terms that can be clearly communicated. Ask yourself why you are dissatisfied or frustrated with the situation, and what a satisfactory situation would look like for comparison. Consider also the root cause of the problem; e.g. is a productivity problem rooted in more fundamental behavioral issues? Putting these answers to paper is useful for clarifying what the problem really is and determining a path forward.

Like any other bilateral agreement, the employment contract exists for the mutual benefit of both the employer and employee. And, like any such contract, there are terms and conditions as part of the agreement. Some of these are explicit (attendance, compensation, etc..) but key aspects like minimum standards for competence, productivity and professionalism are usually not. In an at-will employment agreement, the implicit standard is effectively the employer's satisfaction (and the employee's satisfaction for working conditions and treatment). If the conditions aren't being met, then the first major decision is whether to terminate or attempt to salvage the employment relationship.

The decision to terminate or attempt to salvage the relationship is very much a judgment call, so I merely present one perspective on that decision. In my experience, for the relationship to be salvageable, both parties must be willing and able to work on improving the situation. In general, most people would be willing and able to salvage the employment relationship. Unfortunately, the fraction will be much lower among those you have difficulties with. Sometimes an employee's worldview is such that they won't accept responsibility for a share of the problem (e.g. redirecting blame), or they don't care if the relation is mutually beneficial (e.g. feeling of entitlement). If judged unsalvageable and employment is at-will, then be respectful of people's emotions, but terminate the relationship and move on. Remember that a poor employee may be a fine person, and might well thrive in a different work environment.

If a salvage attempt is the path forward, then provide the other party with notice and an opportunity to address the problem. Drawing upon your written description of the problem, the following are key points that must be made:

- 1) That you are dissatisfied with the present situation
- 2) The changes necessary to achieve satisfaction
- 3) A definite time-frame for effect changes or providing assurances
- 4) What action will otherwise be taken

Humans have an amazing ability to ignore problems and idly hope they will go away, so it is vital to be explicit on all points. I've frequently seen the fourth point omitted in an attempt to avoid a threatening tone, with the consequence of no improvements being made and surprise expressed at the resulting actions. While the actions may be reasonably inferable from the first three points, people aren't usually at their rational best in those situations. To avoid a threatening tone, I would suggest being explicit on all points, but appealing to the bilateral nature of the contract. The situation isn't an authoritarian declaration of "you must do this", but rather an attempt to negotiate an extension of the employment contract complete with terms and conditions.

As it is natural to give people the benefit of doubt, it is easy to be strung along and waste much time and effort. I would suggest a short initial time-frame to respond, e.g. 30 days, and if compelling assurances of future change are provided (that you actually believe rather than just want to believe) then negotiate a reasonable probationary period for those changes. Some changes may not occur quickly, but a willingness to change shouldn't take long to demonstrate.

The Extended Team

The benefits of a motivated, coordinated and functional effort extend beyond direct employees to include everyone working towards the goal. The same principles of encouragement, clear expectations, and maintaining standards apply with contractors as with direct employees, but are usually made more formal in a written agreement.

A good agreement should be mutually beneficial and align the interests of both parties. Generally, the customer needs something done with limited resources and the contractor needs to make a reasonable profit to stay in business. The limited resource constraint puts the two parties somewhat at odds, which is usually addressed with competitive bidding and negotiation to settle on a compromise acceptable to both parties. Once an agreement is reached, rather than view this as an adversarial situation, it is more productive to address both parties' needs by focusing on accomplishing the necessary work as efficiently as possible. The contractor should have an interest in seeing the customer's needs met, and likewise the customer should be interested in seeing the contractor rewarded for a good job.

A condition for a good collaborative relationship is reciprocal interest. As with individuals, I found that by far most organizations desire to be helpful and respond well to a positive relationship, some only do the minimum required but are professional and can be worked with, and a small few are dysfunctional or truly adversarial and it is best to part ways as expediently as possible. If you find yourself in a serious

contractual dispute, call your attorney and include alternative dispute resolution, such as mediation, in the discussion of options. Although the attorneys I've worked with were all professionals interested in the best outcome for their client, they tended to be more familiar with and rely on litigation rather than diplomacy.

The actual contract documents are merely a written record of the agreement between the parties. Akin to the saying that good fences make good neighbors, the contract is helpful in managing the relationship between the parties. While a minor agreement can be entrusted to memories and a handshake, a large complex agreement between organizations is subject to fading memories, personnel changes and unforeseen circumstances which can lead to disputes. The written record addresses fading individual and institutional memory, and some "what if" exercises and a good contract attorney are valuable during the negotiation of terms and conditions by preemptively addressing potential sources of disputes.

An overview of contract law would be useful for anyone responsible for forming or executing large contracts. I found the business law audio lectures published by The Teaching Company^{7,8} to be an informative way to pass the time while traveling.

The Leader

The cultivation of an effective team should include the leader as well. Moving from a technical position to a management role requires a shift from doing to delegating. This requires a different set of knowledge and skills and the responsibilities can be more stressful.

Learning to delegate is a traditional challenge facing new technical managers long accustomed to performing work directly. The major barriers tend to be habit and learning to trust the work of others. The habitual response can be overcome with conscious effort to keep the staff productively occupied, with an idle staff member being a reminder of insufficient attention in this area. Learning to trust other's work can be more difficult. It is worth recognizing the common bias of illusory superiority and remembering that there is usually more than one satisfactory solution to any problem. We all have our ideas on the 'best' ways to do things, but what constitutes best is very subjective and what is really needed is an objective assessment of good enough. On a related note, consider the potential loss of ownership and motivation before dispensing any constructive criticism.

The leadership role draws more upon the social sciences, rather than the natural sciences and engineering where a new technical manager's expertise usually lies. This requires a shift in focus and some on-the-job self-education to develop the appropriate knowledge base. As mentioned in the introduction, I found soliciting the perspectives of experienced managers to be very useful. In addition there is a lot of good literature available as well. I have previously mentioned some texts regarding specific topics, but would also suggest the works by Badawy⁹, Shainis et al¹⁰, and Walesh¹¹ for more general discussions on technical management.

One duty of technical leadership is directing complex decision making processes, which usually must be made with incomplete information. While as scientists and engineers we may like to think of ourselves

as very logical and objective, a recognition and understanding of our limitations and cognitive biases is helpful to making better decisions. I found the audio courses from The Teaching Company on critical decision making¹² and effective reasoning¹³ provided a good introduction to some of these issues.

Many technical failures are probably better described as programmatic and cultural failures, rooted in cognitive biases. As examples, it is worth considering the failure reviews for the Hubble Space Telescope¹⁴ and Challenger Shuttle disaster¹⁵. These both involve an element of what might be called “wishful thinking” under pressure for certain conditions to be true, when not actually supported by evidence. It was a sobering epiphany early in my project management experience to meet the team responsible for a significant, and seemingly obvious, design flaw in another large telescope, and discover a group that was talented, experienced and well-functioning. They had simply fooled themselves into believing their technical approach was viable under pressure to meet cost and schedule objectives, and showed that every group is susceptible to those sorts of errors and that the prudent technical leader should be wary of them.

Lastly, with the buck stopping at the leader’s desk, and responsibility for addressing conflicts and personnel problems, leadership positions can be more stressful than technical roles. Increasing your capacity to manage stress can improve both your ability to work effectively and your enjoyment of the position. In addition to the classic stress management advice of looking after the body with a healthy diet and exercise, a proper frame of mind is helpful as well. It is easy to embrace the organization’s goals and see failure as unacceptable, but this isn’t a realistic standard. There will be circumstances beyond your control and you will make mistakes, so I would suggest a personal standard of simply doing the best you can and then enjoying the successes and learning from the failures. The only serious unhappiness I experienced was associated with situations that weren’t working which I felt that I *had* to continue. These situations all improved upon acknowledging them as failures and taking action accordingly. This may seem obvious, but it can be difficult to appreciate from within a troubling situation. I’ve found the insight and serenity promoted by meditative practice to be helpful with maintaining perspective, and would encourage some exploration of the many forms available.

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