SurvivingThe Lead Reliability Engineer Role In High Unit Value Projects

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SUMMARY & CONCLUSIONS

A project with a very high unit value within a company is defined as a project where a) the project constitutes one of a kind (or two-of-a-kind) national asset type of project, b) very large cost, and c) a mission failure would be a very public event that will hurt the company's image. The Lead Reliability engineer in a high visibility project is by default involved in all phases of the project, from conceptual design to manufacture and testing. This paper explores a series of lessons learned, over a period of ten years of practical industrial experience by a Lead Reliability Engineer. We expand on the concepts outlined by these lessons learned via examples. The lessons learned are applicable to all industries.

1 INTRODUCTION

There are many good technical books on the practice of Reliability Engineering [1]- [4] but very little information on how to navigate the job, especially for a reliability engineer in a leading role. There is a large level of responsibility exercised by the Lead Reliability Engineer (LRE) of a very high unit value project. The lessons learned as a result of this role are discussed and are divided into three categories: a) strategic, b) managerial, and c) technical. The LRE, in order to be successful, must manage these three types of lessons learned. *Strategic* lessons learned address the intangible aspects of the role that are only learned with experience (or the experience of others) but which will allow the LRE to better prepare himself/herself during second and subsequent opportunities at the lead role. Strategic lessons learned are hardly ever part of the job description for the LRE role. Some will argue that the strategic lessons learned are not only the most useful in a lead role but are often the determining factor in the success of the lead role. *Managerial* lessons learned are often described by managers as those lessons that the LRE can "read between the lines" of a very well described (which most often is not) job description of the LRE role in a project. Managerial lessons learned are likewise mostly learned from experience, though not necessarily. However, they are often tangible and cannot be overlooked if an LRE is thorough in the job.

Technical lessons learned for an LRE are the most tangible and the easiest to learn for a competent Reliability engineer. However, they are often overlooked and/or underestimated because the LRE feels that most are of programmatic nature and therefore, carry lower risks. Lessons learned over the years have pointed out that underestimating technical risks can have severe consequences to the high unit value project.

2 STRATEGICALLY SURVIVING THE ROLE OF LEAD RELIABILITY ENGINEER

We plan to outline a series of lessons learned that an LRE should *strategically* implement soon after he gets into this job. Some real world examples will be described that will emphasize a given strategic lesson learned.

2.1 Be Visible to Stakeholders Throughout All Phases of The Project

In high unit value projects, stakeholders within the Project and outside the Project hold considerable influence in the way the Project will be executed. High unit value projects have very influential stakeholders at all levels above the Project Manager. Successes and failures that the LRE will have in the performance of duties can reach the eyes and ears of many stakeholders the LRE may not have even met or heard of, and it can influence the LRE's career in ways not imagined.

The LRE must be visible in all phases of the project, but specially, during the design phase. It is during the design phase that the LRE has the most influence on design engineers and management for the success of the Reliability program. It is in the design phase where the inputs of the LRE are most value added.

2.2 Get to Know Critical Players That Interface With Reliability Engineering

The LRE should get to know individually all the important technical personnel that he/she will interface with during the course of the Project. The LRE must take the initiative to talk to these individuals concerning ways they can work together for the benefit of the Project. This proactive approach is especially needed during the design phase of the project, since it is in the design phase where most reliability engineering products are needed.

Example Scenario: The LRE decides to meet with one of the design engineers to discuss critical electronics in an assembly. During the course of the conversation the build of materials (BOM) parts list is shared. The LRE notices that one of the electrical components in the BOM has had a history of poor reliability during past tests and reliability analyses.

LRE's response should be: Discuss the concern with the design engineer. Show the data that describes the problem. The LRE just saved the project from schedule and costs impacts.

2.3 Attend Important Meetings Even if Marginally Related to Reliability Engineering

The LRE must choose which non-reliability related meetings to attend. Important meetings should be attended even if the subject of the meeting is not related to Reliability Engineering. This is important because decisions and courses of actions in those meetings may have an impact to Reliability Engineering that only the LRE is capable of discerning at the time, and if the LRE is not there, the LRE has no influence on the decisions taken. An important meeting is any meeting that is 2 degrees of freedom (or less) removed from Reliability Engineering (this author has coined this principle as "the rule of 2 for attending meetings").

Example Scenario: The LRE attends a software meeting where the discussion on the design aspects of fault management will be addressed. During the fourth time the LRE attends this meeting it is noticed that there is an incompatibility between the way fault management software treats a fault and what the actual FMECA says concerning this particular fault detection.

LRE's response should be: The LRE can quickly ask two questions: 1) was this subassembly subjected to reliability requirements that needed to be complied with (e.g. via tests or analysis) ? 2) is the software update impacting one of those requirement. If the answer is yes to both questions—it is an important meeting. Explain to the software fault management engineers the incompatibility issues and make an effort to change the way fault management treats this particular fault.

2.4 Keep Immediate Management Up to Date

Don't wait for programmatic status meetings with the immediate management to let them know of important issues, concerns, decisions, and important progress reports. Communicate with them sooner. Programmatic meetings should never be used for adverse facts finding but rather to discuss options and solutions. Management should not be surprised in a meeting with an important issue they didn't know about Reliability Engineering but that the LRE already knew.

Example of Scenario: The LRE finds out that there is a significant issue that needs to be addressed. The LRE thinks it is under control, hence, no need to let management know of the concerns and solutions.

LRE's response should be: The LRE needs to communicate the issue even if the LRE thinks it will be resolved. The LRE does not want management to find out about it through a third party. Furthermore, if the LRE is wrong the issue becomes an unresolved major problem.

2.5 Delegate The Minor Stuff to Competent Individuals

Do not micromanage the job but stay focused only on the value added items that management cares about. If there are opportunities to delegate certain tasks to others, be comfortable in doing so, as long as the LRE delegates such tasks to trusted and competent individuals that the LRE knows personally. Delegation of some duties is just as much a matter of trust as it is also a matter of competency.

2.6 Maintain Technical Integrity

Always do what is best for the Project based on technical abilities. What is best for the Project is not necessarily what the LRE thinks it is. The LRE must be tactful to make sure the decisions are based not only on his own understanding but on the inputs of others as seen objectively without bias. Therefore, to maintain technical integrity the LRE must be seen as inclusive of the opinions of others, specially, if such other individuals already have a good reputation.

Example of scenario: The LRE comes up with a significant technical issue. LRE's management believes it should not be a big concern because previous issues of a similar nature have not had any adverse results. Therefore, the LRE is tempted to agree with management and identify the issue as low risk.

LRE's response should be: Discuss the findings with other technical personnel who can provide expert opinions on the matter. The LRE will find that their help will help clarify the level of risk the project is facing,

hence, the LRE will be able to agree or disagree with management and have the necessary data or technical information to defend the case.

2.7 Ask For Help When Help is Needed

You might be the LRE, but the LRE does not know it all and the LRE will need the help of those specialists and analysts who are the subject matter experts in several disciplines. You are the LRE because of a combination of your technical and leadership skills have earned you that position. However, there are many competent individuals who have developed several skills (niche competencies) over the years, that the LRE may need. The LRE should pursue such individuals (and recognize them publicly) when the LRE needs their expertise.

2.8 People Skills Are as Important as Technical Skills

There are many managers with lesser technical skills that excel at their functions and are well regarded by both superiors and subordinates because they portray good relational skills in their jobs. You will hardly see a manager with poor people skills, no matter how technically competent he/she might be, gain the same level of respect. There are many more of the former than of the latter in most successful projects. The LRE should work hard to attain both objectives; good people skills and technical skills.

2.9 Confront Issues Head –on.

This axiom is more to do with office politics than engineering practice and this principle is true in most of life's endeavors. The LRE should not allow to come to the point where he/she is told what to do because of inactions. Inactions just compound the problem. It is better to be wrong (and the chances of that are small if the LRE requests assistance) than to be indecisive.

2.10 Have a Mentor

There is no substitute for experience, not matter how much technical knowledge the LRE has. Engineering is an art, not a science. Engineering problems are often interdisciplinary in nature and engineering careers are often shaped in non-traditional fashions. There is no reason to duplicate the errors of others but rather try to benefit from lessons learned by others who have gone before you. A mentor is in the capacity to give the LRE advice based on experience, which is actually the best kind of advice the LRE can get.

3 SURVIVING THE MANAGERIAL ROLE OF LEAD RELIABILITY ENGINEER

We plan to outline a series of lessons learned that a LRE should *managerially* implement throughout the course of this job. Some real world examples will be described that will emphasize a given managerial lesson learned and the actual example.

3.1 Step Cautiously Through The Minefield of Budget Creations And Maintenance

No task is more important for an LRE, from a management point of view than that of creating a budget that is both realistic and accurate. There are two main reasons why there are budget overruns in many projects. The first reason is that budgets were optimistic, not realistic. This has more to do with management doing a poor job in cost accounting; not counting all the costs items and the magnitude of each of the cost items. The second reason is that projects fall into technical difficulties at some phase in development which increases the costs.

Most LREs inherit budgets passed down to them by upper management and often these budgets are based on previous versions of such budgets from other near-similar past projects. The LRE must find ways to participate or have inputs into the Reliability Engineering budget to make sure that: a) the budget properly accounts for all the reliability tasks and b) a reasonable contingency reserve of approximately 15-20% of the Reliability budget is allocated. The LRE must find his place in the budget allocations decisions early in the hardware development process (definition or requirements phase), so that the LRE inputs can be heard and can influence the final outcome of the budget. Always be ready, with good technical arguments, to defend your budget requests. If the budget that the LRE finally gets is not what is expected, be ready to tailor the tasks to meet the new budget realities, but also make sure that management knows what technical risks will be incurred from the Reliability Engineering tasks that will not be performed.

Example Scenario: The LRE has been asked by the project to develop a budget for your reliability tasks in the requirements phase of the project. The LRE develops the budget and present it. Management asks some questions in the meeting but there are not major objections (a good indication the LRE has done the job well in budgeting). The LRE might expect good results. Two weeks later management hands over the LRE what they think the budget allocation should be. It is 25% less of what was requested.

LRE's response should be: The LRE prepares a budget "gap analysis" showing what the LRE can do with the 75% budget. Though the LRE should try to minimize the risks at 75%, the LRE must also present the levels of risks involved with the unbudgeted tasks; including potential waivers that may be needed. The LRE must explain the risk to Project Management.

3.2 Provide Leadership

As the LRE of a project the LRE is the leader. The LRE calls the shots and management will be looking at the LRE to get the job done from a Reliability Engineering point of view. This job involves doing new things in obviously new ways and doing old things in innovative ways. As the leader of Reliability Engineering the LRE is an innovator who must also perform certain management functions. The LRE must make decisions daily. The LRE must communicate some of those decisions to management and other subordinates. In both cases, decisions must be communicated clearly and promptly. Do not delay a decision that you know needs to be made. This is important because the LRE needs a reaction time for those decisions to go through the Project stakeholders and the LRE also needs some slack time in case the decision needs to be modified.

Example Scenario: A previous reliability analysis was waived. Later the LRE discovers, in collaboration with other engineers (remember the importance of going to their meetings?), or based on own assessments, that the risk is not low, but rather medium to high. This item was not in the LRE's budget originally or was later deleted due to its low risk.

LRE's response should be: Make the decision quickly to talk to management about this particular change of circumstances. Explain well the pre and post rationales of the scenarios, together with a budget request. If management concurs, communicate the new actions to your subordinates and provide them with the needed rationales for the new actions. If management agrees but resources are not available, then get concurrence for writing a waiver.

3.3 Watch Out For Creeping Requirements In The Statement Of Work

Sometimes Reliability Engineering tasks are not well defined at the beginning of the project because there is a genuine lack of knowledge of the hardware being supplied. Often the scope of the reliability efforts turns out to be more involved than previously thought. There are additional requirements that need to be imposed on the hardware in order to satisfy higher level requirements. The additional reliability requirements will impact overall schedules and budgets.

Example Scenario: Previous reliability requirements have been evaluated on a RF transmitter assembly. A series of reliability analyses have been performed to satisfy those requirements. This assembly is later found to interfere with other receivers in an integrated system. It is important that the whole system performs well in an integrated fashion. Any new reliability requirements imposed after the hardware is built and delivered can cause serious schedule and budget implications.

LRE's response should be: Shift the effort from complying with original reliability requirements to performance requirements. There may be possible alternatives that will guarantee adequate performance within certain reliability. If such solutions are found, the performance requirements can be changed which will cause a change in the reliability requirements, including a possible relaxation of such requirements.

3.4 Watch The Budget

Each reliability engineering task must have a specific allocation of hours and budget to be performed. It is important that the LRE be involved in the assessment of the proper level of effort needed to perform each reliability task. The LRE's experience is important in the accuracy of the required level of efforts for tasks performance. Task orders must be developed for each task so that all the tasks can be tracked in an accurate manner. The LRE must also develop a method for tracking the costs at the earliest opportunity possible.

3.5 Have Excellent Charts to Show Status

There are 3 types of charts the LRE must always produce: 1) status, 2) budgets, and 3) compliance. The LRE should create charts on a regular basis that inform management on the status of all the reliability tasks. The status charts must indicate efforts which have been completed, efforts in progress, and those to be performed. Status charts should include dates. There must also be charts addressing the costs of tasks completed and those yet to be completed and how those costs track with the previously realized budgets. It is important for the LRE to also show how well the reliability tasks comply with the requirements that originated those tasks, including areas of concern or areas that do not meet the requirements and what the LRE is doing to address those shortcomings (e.g. risk evaluations and resolution plans).

3.6 If Given a Choice, Choose The Team Members.

How well the LRE can do the job is determined on two factors: 1) how good the LRE is at doing the job and 2) how good is the LRE's team. The LRE does not want to be in the situation where the LRE is carrying the team or the team is carrying the LRE. A symbiotic relationship where the LRE and the team work well together is optimum. Therefore, if there is such a possibility, choose the team members that will be part of the reliability group for the project. If the LRE does not know them well, they should ask for the advice of those who know them well so that the LRE can sort out who are the best candidates. Remember that the smartest persons are not necessarily the best team members; the LRE must choose team members that will work well with him/her.

4.0 SURVIVING THE TECHNICAL ROLE OF LEAD RELIABILITY ENGINEER

We outline a series of lessons learned that a LRE should technically implement during the course of the job. Some real world examples will be described that emphasize a given managerial lesson learned.

4.1 Understand The Requirements Being Flowed Down by The Project

The LRE cannot perform the job well unless the LRE has a good understanding of what is needed to do the job. Projects come with their own Reliability Engineering requirements developed by the customer and applicable stakeholders. The LRE must understand the "big picture" of what such reliability requirements represent and all the "small implications" of such reliability engineering requirements. It is important that the LRE understand the complete "map" of the reliability engineering effort which is made up of the larger and smaller efforts.

Example Scenario: A design requirement states that assembly XYZ needs an interface FMECA. The LRE identifies the interfaces for the interface FMECA in order to evaluate the scope of the effort. However, the LRE discovers that a subassembly of XYZ interfaces not only with XYZ, but another assembly. Should the LRE do the interface FMECA of the subassembly also?

LRE's response should be: The LRE needs to find out the extent of the requirement. There is a possibility that the customer is not aware of the technical implications of the whole effort that needs to be done. The LRE needs to inform the customer, or the appropriate stakeholder, that the subassembly interface FMECA should also be performed in order to comply with the higher level requirement.

4.2 Get Involved In Writing the Reliability Requirements

The more complex the system, the more difficult it is to provide good definition of the Reliability Engineering requirements needed. The customer may need help in the proper definition of the Reliability Engineering requirements and the LRE is in the perfect position to help. It is a very good idea for the LRE to get together with the stakeholders or the customer(s) and review the stated (and possibly not stated) reliability requirements. It is important for both the customer and the LRE to get agreement and a good understanding on the full scope of the reliability engineering effort.

Example Scenario: The LRE is reviewing the reliability engineering requirements for a given assembly with the customer. Suddenly the LRE discovers that because of the specific performance requirements of this hardware that another reliability requirement needs to be added that was not previously present.

LRE's response should be: Discuss with the customer the need for an added reliability requirement write the requirement and discuss it with the customer.

4.3 Perform Reliability Tasks When They Are Value Added.

The reliability engineering tasks must be scheduled and performed in a timely manner, when the results of such analyses can still make a difference and influence the proper development of the hardware. Preferably, the reliability analyses should be performed early in the hardware development cycle, in the design phase for most cases. If the reliability analyses are performed later than when they are really needed, then they will be of very little added value.

Example Scenario: Due to budget problems and other delays a certain reliability analysis known as Parts Stress Analysis for a given assembly was not performed in the design phase, as it should have been, but rather after the assembly was built and tested. In the performance of the analysis it is discovered that several parts do not meet the reliability requirements.

LRE's response should be: At this point there are only two options. If the requirement violation is of low risk, then a waiver should be written. If it is of medium or higher risk then the design should be changed to eliminate the requirement violations. This will impact both the schedule and cost of the assembly development.

4.4 Close The Loop in All Open Items And Do Quickly.

The performance of reliability analyses will result in open items that will need to be addressed. All non

conformances from the analyses should be compiled and organized in a manner that can be easily understood and addressed. The better the LRE can organize the open items data, the easier it will be to close those open items. The LRE should find ways to address the open items in a systematic fashion (schedule and tools) so they can be closed in a matter that represents value added to the original analyses. Delaying this process will decrease the value added of closing the open items.

Example Scenario: A reliability concern has arisen in a given assembly. After evaluation, the LRE concludes that the original concern is not significant. However, the issue remains open as the LRE attends to more pressings needs. The lesser open issues on this assembly remain open until management realizes that in order to deliver the hardware all open issues must be closed.

LRE's response should be: Though the LRE could be late, the LRE still needs to close the issues. The longer the LRE waits the worse the schedule for closing opens items will get, and the LRE will encounter the displeasure of management.

4.5 For Significant Issues Pay Attention to Details

The LRE will be exposed to reliability technical issues that must be resolved. Technical issues will result from either the outputs of the reliability engineering analyses or from the normal daily engineering efforts. The LRE should identify those issues that can be resolved programmatically (i.e. more analysis, a different approach to an analysis, talking to colleagues about the problem) but also, and more important, should identify issues whose level of importance is significant. A significant issue is defined in this context as an issue that could degrade the hardware performance, if not addressed, to the point that the mission objectives could be compromised. The resolution of programmatic issues can be delegated to responsible subordinates. Significant issues must be carried by the LRE and the LRE must be seen as the owner. Because the LRE is responsible for the closure of reliability significant issues, the closure must be addressed in significant details to provide confidence in the resolutions of these issues.

Example Scenario: A reliability study shows there is a significant risk with one of the electrical components being used in an electronics assembly. The quick solution will be to replace the component and incur the cost and schedule impact.

LRE's response should be: The LRE needs to understand the problem well before it is concluded that replacing the component is the best solution. It is possible that further studies of the problem will reveal alternative solutions that are not easily perceived at first.

4.6 Keep Immediate Stakeholders Informed of Reliability Engineering Efforts

Communication is the essence of the LRE job from a top level point of view. There is no such thing as too much communication with stakeholders. Stakeholders feel that they are important and their views are of value when the LRE communicates with them, on a regular basis, about the reliability engineering efforts. The stakeholders will be on the LRE's side in difficult times if they feel the LRE has always been there for them.

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The author has been the Lead Reliability Engineer for over 10 years in most of the Mars orbiter missions. He has also been the Lead Reliability Engineer in two additional interplanetary missions to asteroids. Presently, he is the Reliability Lead of the *Juno* spacecraft development, bound for the planet Jupiter. The author has 22 years of experience in the aerospace industry and has performed many other engineering functions such as avionics hardware design, software development, testing, and flight operations. He is professionally active in both AIAA and IEEE (senior member of both) where he has served in multiple capacities including associate editor of journals in both societies. He has received nine NASA and aerospace industry technical achievement awards. He has authored 60 papers (journals and conferences) and 4 books.