Best Practices for Effective Reliability Program Plans

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SUMMARY & CONCLUSIONS

In this paper we take a comprehensive look into the practice of developing and executing reliability program plans. The paper is divided in three sections. In the first section we identify best practices concerning the process of developing and implementing a reliability program plan (RPP). The second section deals with the common pitfalls and the lessons learned from developing reliability program plans. In the last section, we present the results of a broad customer survey that captures and categorizes common practices and problems when developing and implementing a reliability program plan.

1 BEST PRACTICES FOR THE DEVELOPING AND IMPLEMENTING A RELIABILITY PROGRAM PLAN

The objective of the RPP is to focus on the best practice tasks that are most effective and applicable in providing highly reliable systems and products. The plan specifically avoids a long list of tasks that may exceed resources and capabilities. In other words, the emphasis is in performing the right activities at the right time in order to achieve high reliability, but to avoid the unrealistic goal of too many tasks requiring too many resources, time or budget. There are three high level steps to developing the RPP.

A reliability program plan starts by establishing a reliability strategic vision. Just like an organization needs a mission and vision statement to steer towards decisions that support the strategic goals, it is important for a team that is working on a new product, project or series of products to develop a reliability strategic vision: this goes beyond just setting specific reliability goals for a product. It includes process, business and cultural aspects. The reliability strategic vision needs to be supported at the highest management levels and understood by all employees. Without the appropriate management commitment, the vision is unlikely to become a reality.

After establishing a reliability strategic vision, the next step is to conduct a thorough "gap analysis" that can pinpoint gaps and shortfalls and can guide the development of the RPP. The purpose of a Reliability "Gap" Assessment is to identify the shortcomings to achieving company-wide or project reliability objectives so that a Reliability Program Plan can be properly developed. Many companies implement reliability tasks without first understanding what drives reliability task selection. The "gaps" are those issues or shortcomings that if closed or resolved would move the company in the direction of achieving its reliability vision. It is input to the Reliability Program Plan.

The third step in developing a Reliability Program Plan is to select which of the hundreds of potential reliability methods and tools will be most effective in achieving the program reliability objectives, taking into account the reliability strategic vision, the gap assessment and the company specific product development cycle. At each stage of product development, the objective is to focus on the vital few most effective "best practice" tasks. These will be different depending on the specific application and organizational capabilities. However, based on observations from thousands of different product development projects across hundreds of industries worldwide, there are common themes that can be drawn and used as high level guidelines in order to set a more structured approach when putting together a reliability program plan. Below we outline some of the identified best practices at each product development stage, which can be the beginning of a template and tailored to program specific circumstances.

1.1 *Concept Stage*

During the concept stage it is important to develop and agree on Best Practice Reliability Requirements and get them properly incorporated into technical specifications and flowed down (allocated) to subsystems and components. Properly specifying the reliability at system and component levels can drive the right tasks, both internally and externally with suppliers, in order to achieve high system reliability.

A partial example of concept stage best practice tasks includes:

- Generate system conditions of use and operating profiles.
- Develop system level reliability requirements.
- Flow down reliability requirements to subsystems and components.
- Generate a system reliability model (also called Reliability Block Diagram or RBD).
- Perform System FMEA
- Identify "reliability critical" components and subsystems.

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1.2 *Design Stage*

During the design stage of product development, the vital few tools that support Design for Reliability (DFR) will be identified for implementation. It is usually not possible to focus only on reliability testing as the primary way to achieve reliability objectives. It is important to focus on achieving reliability in design, when there are greater opportunities from a cost and feasibility basis. Many of these methods and tools are variously called Robust Design or Design for Six Sigma.

A partial example of Design Stage best practice reliability tasks includes:

- Perform Design Margin Analysis.
- Perform Design FMEAs (and Process FMEAs due to timing issues. It is usually too late to start Process FMEAs at the manufacturing stage).
- Address root cause of known reliability problems.
- Develop and use product Design Guides.
- Incorporate reliability input into Design Reviews.
- Identify and execute specific Robust Design tasks, such as design of experiments (DOE), physics of failure modeling and Highly Accelerated Life Testing (HALT).
- Perform supplier FMEAs for critical components.

1.3 *Assurance Stage*

Improving the effectiveness of reliability assurance and testing will ensure products are developed and launched with the highest possible system reliability. Properly analyzing test data will markedly increase the effectiveness of all forms of testing to improve product and process reliability. With Product Development times getting shorter and shorter it is essential to accelerate test methods. Doing this properly will not only yield more effective test results but will also facilitate buy in from customers.

A partial example of assurance stage best practice reliability tasks includes:

- Develop reliability test methods.
- Develop accelerated life test methods (where appropriate).
- Execute reliability test plan.
- Conduct system reliability growth testing.
- Verify that suppliers meet supplier reliability requirements.
- Implement ongoing management reviews to include test failure data.

1.4 *Manufacturing &Launch Stage*

Well done Design for Reliability tasks still need to be supported by manufacturing reliability tasks to ensure that the inherent design reliability is not degraded or unstable. During the manufacturing phase, Reliability tasks should primarily focus on reducing or eliminating reliability problems introduced by the manufacturing process.

Manufacturing introduces variations in material, processes, manufacturing sites, human operators, contamination, etc. Manufacturing control strategies include Process Control Plans, Statistical Process Control, Identifying and controlling Key Process Characteristics and Design of Experiments in the manufacturing environment.

A partial example of Manufacturing & Launch Stage best practice reliability tasks includes:

- Complete the Process FMEA.
- Develop and execute Manufacturing Control Strategies.
- Develop and execute Screening & Monitoring plans.
- Develop and execute a field test plan.
- Verify that all reliability requirements are met before launch.
- Document Product/Program Lessons Learned (during development, production and field).

1.5 *Other Guidelines for Task Selection*

In addition to the “best practice tasks” identified, some other elements to consider when selecting tasks for the RPP include the following:

- Consider the company’s unique business model in order to properly navigate towards selecting the right tasks: is the product high volume or low volume? Is it high or low cost? Is the technology brand new or leveraged? How much has changed from the previous design? Are there any unique safety requirements? Is the product serviceable, and by whom? Are there other unique elements in the business model?
- Consider the time horizon that is available during which new products are developed. Set realistic reliability goals based on the allowable timeframe to launch, and understand that reliability growth is proportional to the available time allocated for development.
- Consider the budget that is available for product development and specifically reliability tasks. This is going to drive decisions by making sure that the most critical items are designed with reliability in mind and tested thoroughly. Do not think that you can test for every possible scenario.
- Keep in mind the current reliability skill level of the reliability support staff and the larger project team. The reliability tasks need to be achievable with the current skill set in the organization, or you need to add tasks in order to bring in expertise, look for training or even outsource certain activities.
- Understand the degree of risk that is associated with the project. The risk can be safety related, it can come from using new technology, or by applying existing technology to new applications. Look back at the field history to see relevant risks. Study the regulatory requirements and understand the risk of not meeting them. Finally, understand the risk that your suppliers are introducing into your project.

1.6 *Integration with Product Development*

Reliability engineering activities do not just happen automatically in an organization. They are part of a Reliability Program Plan that is integrated in a product development process. The fundamental question of project management “Who does what by when and how” needs to be applied to the identified reliability tasks. A Work Break-Down Structure (WBS) of reliability activities that rolls down to the activity level needs to be clearly defined. Based on this structure, an RPP schedule is developed and each activity is linked with resources: engineers, technicians, facilities, equipment, testbeds, failure analysis labs, data capturing and analysis tools. Reliability tasks then can become critical path for the project, and reliability is managed and tracked at the highest level. A practical rule to identify if an RPP is properly integrated with an organization's program management is to see if the reliability organization within the company is empowered to raise the "red flag" and delay overall project schedule or negotiate more resources/budget in order to meet the project objectives. If the RPP is flowing in parallel with the product schedule, but does not influence overall decisions, then the integration has not been designed properly, or there are cultural and management structure issues that need to be identified and resolved.

2 *RELIABILITY PROGRAM MANAGEMENT - LESSONS LEARNED*

There is a wealth of experience in the reliability community on how to develop and execute Reliability Program Plans (RPPs) and what can go wrong. As the saying goes, "Experience is the name people give to their mistakes." The following are ten lessons learned that are based on application experience.

2.1 *Focus on the "Vital Few" Reliability Methods*

The reliability community has a plethora of methods and tools. SAE JA 1000/1001 Reliability Program Standard and companion Technical Guidelines (which replaced MilStd 785) outline dozens of reliability methods that can be used, each with their own strengths and limitations. The skill of the reliability practitioner is needed to determine which of the vast array of reliability methods and tools are best suited for a given set of design or process challenges. The reason for this is that many RPPs get bogged down with tasks that are not essential, which jeopardizes the tasks that absolutely must be done.

The lesson learned is to avoid inclusion of too many reliability methods in the Reliability Program Plan, and instead focus on the "vital few" tasks that will achieve the reliability objectives.

2.2 *Use the "Factor of Ten" Rule*

The earlier that changes are made to designs or processes the less costly they are to the program. This is often referred to as the "Factor of Ten Rule". This rule is a rough approximation of what is seen in actual product development. For example, if a design change costs \$.01 to make during the Concept Stage, it might cost \$.10 to make during the Development Stage, \$1.00 during early manufacturing, \$10 during final Production, and \$100 during service.

Every company and organization has strict budget requirements for new programs or changes to existing programs. It is expensive and time consuming to make numerous late changes, and it jeopardizes project reliability.

The lesson learned is to emphasize reliability tasks that support achieving reliability as early as possible in the product development process.

2.3 *Emphasize Design for Reliability Strategies*

Most companies have very high reliability goals, and yet must still meet financial and timing requirements. The best way to do this is to design in reliability to products and processes and use testing to confirm and grow reliability, as needed.

What is Design for Reliability? In simple terms, whereas reliability analysis methods enable computation of the reliability of an item, Design for Reliability provides the process of assuring that the optimum/desired reliability is designed into the item. This process encompasses multiple tools and practices in order to drive reliability into products.

The lesson learned is to emphasize Design for Reliability tasks when generating the RPP.

2.4 *Safety Comes First!*

At a minimum, reliability goals need to be separated between overall reliability objectives (such as 99% reliability at 90% confidence under stated conditions at a given time), and safety objectives (such as no safety problems during the life of the system). Systems or components may have limited failures and still meet reliability objectives. However, there should be zero tolerance for safety related problems.

A single safety related issue can put a company out of business. Specific reliability methods, such as Fault Tree Analysis and Hazard Analysis, should be used to ensure that safety related problems do not appear during the life of a product.

The lesson learned is to treat safety goals and problems more rigorously than non-safety problems.

2.5 *Understand the Role of Management*

Reliability engineering is a different subject than reliability management. Reliability engineering is the branch of engineering that implements reliability tools and methods, integrating statistics, physics and engineering principles to bring about high reliability in products and processes. Reliability management is the subject of developing and implementing reliability programs that utilize the "vital few" effective reliability tasks to accomplish program reliability objectives. The reason this distinction is important is that throughout product development, management must be involved in different ways than reliability engineers in order to successfully achieve reliability goals on a given program. The role of management must be clearly understood and executed.

The lesson learned is to ensure management is involved in a meaningful way, from beginning to end, during any reliability program.

2.6 *Create a Structured Mechanism for Execution of Reliability Program Tasks*

Some companies develop a reasonably good Reliability

Program Plan and then fail to execute it effectively. Execution of reliability tasks includes management buy-in of the initial plan, providing necessary resources, regular reviews of progress, and removing roadblocks to on-time successful execution.

The lesson learned is for management to provide a structured mechanism for execution of reliability program tasks.

2.7 *Clearly define Roles and Responsibilities for the Entire Team*

For years, top quality and reliability professionals have said that quality and reliability cannot be executed from bottom-up, but must come from top-down. A mistake is to assign the reliability engineer as the sole person responsible for reliability tasks. Reliability is a team effort and requires clear roles and responsibilities for each team member. These roles and responsibilities must be fully defined and agreed upon, and should be included as part of each person's job responsibilities.

The lesson learned is to clearly define the roles and responsibilities that relate to reliability for each project team member and to get these agreed upon and implemented.

2.8 *Reliability Subject Matter Expertise is Required*

Reliability Engineering is a skilled subject and requires expert implementation. It is not enough for engineers or staff from other disciplines to read a paper about reliability and begin to implement the tasks. Preferably the assigned reliability person has training in reliability methods and is certified.

There is a wealth of application experience that exists for most reliability tasks and methods, including books, proceedings and courses. Professional organizations such as SAE provide guidelines showing how to implement reliability tasks and methods. It is a mistake to not learn from the application experiences of reliability practitioners.

The lesson learned is for management to provide skilled reliability resources for each reliability program, including software, training, and technical guidelines.

2.9 *Use "Gap Analysis" as Part of Developing new Reliability Program Plans*

Each new system development project has unique requirements and constraints. Some have considerable new technology or new applications to existing technology. Some consist of minor changes to current system designs. In addition, companies have varying abilities to implement reliability tasks and analyses. A "Gap Analysis" is a thorough review of program requirements and reliability task capabilities to identify the "gaps", and to support identification of the "vital few" reliability tasks and methods that will accomplish program objectives within timing and budget constraints.

The lesson learned is to use "gap analysis" to support the development of effective Reliability Program Plans.

2.10 *Understanding the importance of "people" skills*

The objectives of Reliability Engineering and Management are team-based and support concurrent engineering. They cannot be accomplished by individuals acting entirely alone. In addition to ensuring proper training in reliability principles, management needs to ensure that reliability practitioners are trained in "people" skills, such as working on teams, effective meetings, presentation, and facilitation skills. Without integrating people skills with technical skills, reliability programs may not achieve the desired results.

The lesson learned is to train reliability teams in "people" skills to supplement technical skills.

3 *RELIABILITY PROGRAM PLAN SURVEY*

ReliaSoft conducted a global survey on current Reliability Program Plan practices. The total number of participants was 494.

3.1 *Survey Results*

The following charts show the survey results.

Figure 1 shows the participation breakdown by region.

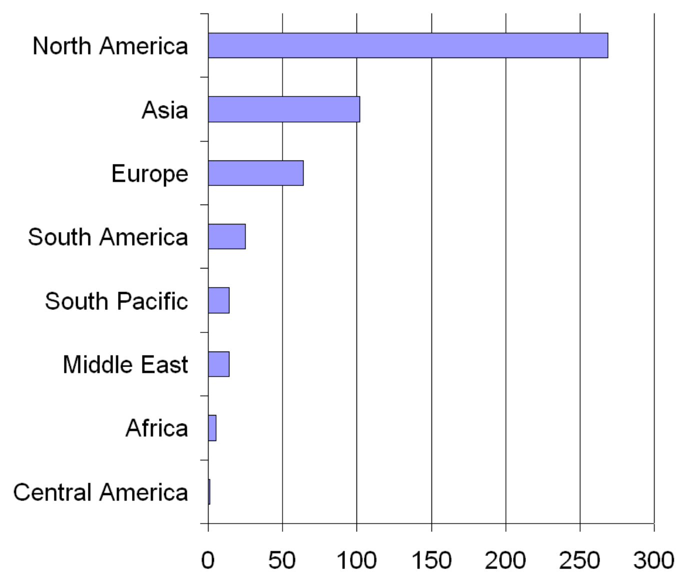

Figure 1 – Participation by region

Figure 2 shows at what product development stage an RPP is typically generated.

Table 1 shows what are the current most important RPP tasks (in other words what are companies currently doing). For comparison purposes, Table 2 shows what participants actually think they should be doing when asked to choose the 5 most important tasks in an RPP.

Figure 3 shows the practitioners' opinion concerning the overall effectiveness of the top 5 RPP tasks currently implemented in their organizations

43% of the participants identified that the support and development of the Reliability Program Plan in their company typically flows Top-Down (management to engineering) and

57% identified that it flows Bottom-Up (engineering to management).

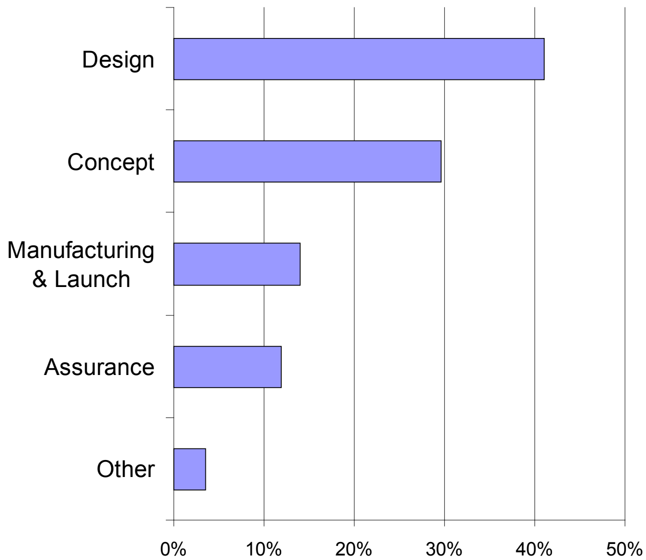

Figure 2 - Product development stage when an RPP is typically generated

Perform FMEA for system, subsystems and critical components	15.0%
Define system, subsystem and component level reliability requirements	12.7%
Develop a system reliability model	9.7%
Generate/confirm operating use profiles	7.6%
Conduct reliability demonstration testing	7.4%
Ensure supplier reliability for critical components	7.0%
Conduct Highly Accelerated Life Testing (HALT)	5.7%
Implement ongoing management reviews (e.g. via FRACAS)	5.5%
Develop and use product design guidelines	5.1%
Develop Reliability Centered Maintenance (RCM) plan	4.3%
Perform design margins analysis	4.2%
Implement reliability growth testing	3.9%
Identify and execute robust design projects	3.6%
Develop and implement burn-in and environmental stress screening	3.4%
Implement Design for Manufacturing and Design for Serviceability	3.1%
Other	1.8%

Table 1 – Scoring the 5 most important tasks in current industry practice

Figure 4 shows how formally reliability program plan processes are defined, documented and reviewed today in the industry.

Perform FMEA for system, subsystems and critical components	12.7%
Define system, subsystem and component level reliability requirements	12.2%
Develop a system reliability model	9.8%
Generate/confirm operating use profiles	8.8%
Ensure supplier reliability for critical components	8.4%
Implement ongoing management reviews (e.g. via FRACAS)	5.9%
Perform design margins analysis	5.8%
Conduct reliability demonstration testing	5.7%
Conduct Highly Accelerated Life Testing (HALT)	5.6%
Develop Reliability Centered Maintenance (RCM) plan	4.8%
Implement reliability growth testing	4.7%
Develop and use product design guidelines	4.3%
Identify and execute robust design projects	4.2%
Implement Design for Manufacturing and Design for Serviceability	3.6%
Develop and implement burn-in and environmental stress screening	2.3%
Other	1.2%

Table 2 – scoring the 5 most important tasks that participants think they should be doing

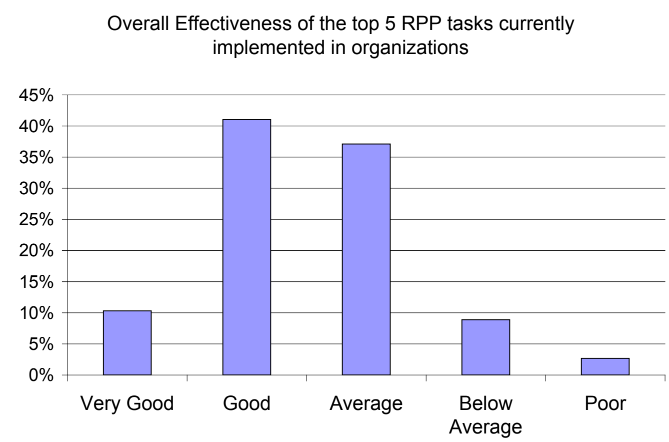

Figure 3 – Overall effectiveness for the 5 most important tasks in current industry practice

Figure 5 shows the scoring of RPP execution, the quality of integration with the product development cycle and the overall value, as considered by participants based on current industry practices.

In the open-ended question concerning other pitfalls in RPPs, the most common themes where:

- Lack of test time and resources to execute a proper RPP.
- Lack of management support and commitment for the RPP
- Lack of understanding of reliability engineering in the organization
- Lack of learning from field data

- Not embracing test failures as opportunities for improvement.

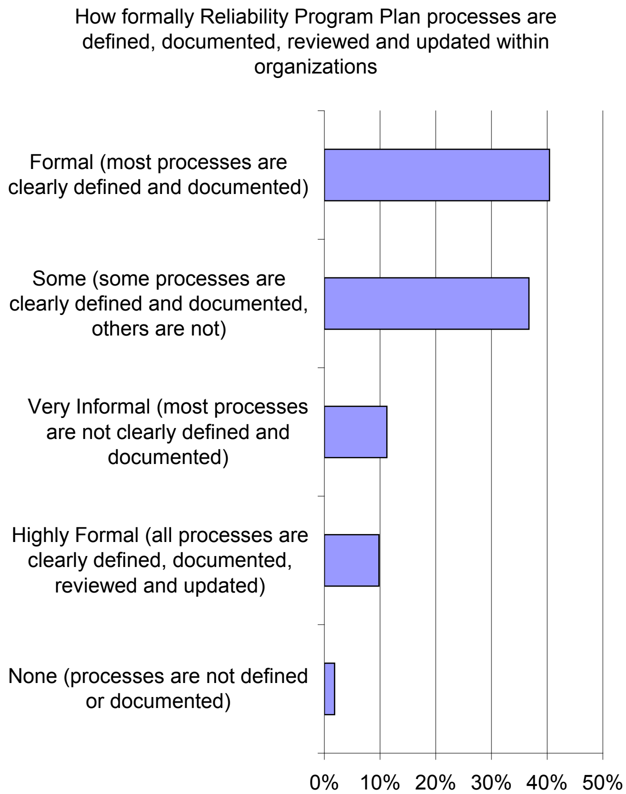

Figure 4 – Formality of RPP processes

Failure Modes, Effects and Criticality Analysis (or FMEA or FMECA)	14.7%
Reliability Life Data Analysis	10.9%
Failure Reporting, Analysis and Corrective Action System (FRACAS)	10.0%
General statistics and Six Sigma	9.7%
System Analysis (including Reliability Block Diagrams and/or Fault Trees)	9.3%
Risk/Safety Analysis	9.3%
Accelerated Life Testing Data Analysis	7.7%
Standards based reliability prediction (e.g. MIL-217, Bellcore/Telcordia, etc.)	6.6%
Experiment Design and Analysis (DOE)	6.4%
Reliability Growth Analysis	5.1%
Database repository and query tools (for analysis of test results)	4.8%
Custom software for test execution and support	4.4%
Other	1.3%

Table 3 – Reliability tools most used

Table 3 shows what reliability tools most used in the industry today.

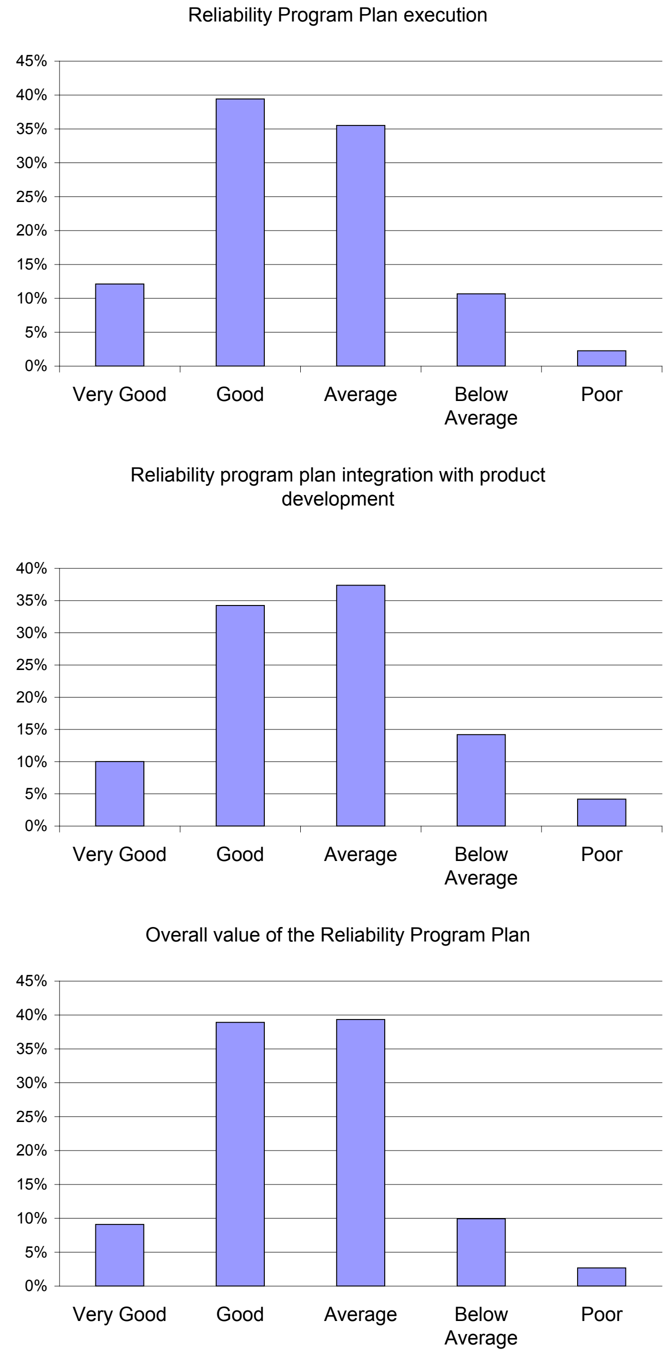

Figure 5 – Execution, integration with product development and overall value of RPPs as considered by participants.

3.2 *Reliability Program Plan Survey Summary*

The following conclusions can be drawn from the survey answers of respondents.

1. Most respondents develop the RPP during Design Stage of the Product Development Process. Ideally this would be done during the Concept Stage.
2. Performing good FMEAs and defining good reliability requirements are at the top of the list of current and desired best practice tasks for RPPs.
3. The majority of respondents say support and development

of RPPs flow bottom up in their companies. Ideally the RPP support and development flows from top down.

4. There is a great deal of room for improvement in the effectiveness, value and execution of RPP tasks.

4 CONCLUSIONS

Developing and executing an effective Reliability Program Plan is essential to achieving high reliability for products and processes. By following the steps outlined in this paper and using the lessons learned, companies can develop Best Practice Reliability Program Plans that can achieve high reliability, while staying within budget and timing constraints.

BIOGRAPHIES

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Carl Carlson is currently a Senior Consultant and instructor in the areas of FMEA, Reliability Program Planning and other reliability engineering disciplines. He has 25 years experience in reliability engineering and management positions, currently supporting ReliaSoft Corporation. Previous to ReliaSoft, he worked at General Motors, most recently Senior Manager for the Advanced Reliability Group. His responsibilities included Design FMEAs for North American operations, developing and implementing advanced reliability methods to achieve/demonstrate reliability requirements and managing teams of reliability engineers. Previous to General Motors, he worked as a Research and Development Engineer for Litton Systems, Inertial Navigation Division.

Mr. Carlson co-chaired the cross-industry team that developed the Society of Automotive Engineers (SAE) J1739 for Design/Process/Machinery FMEA, and participated in the development of the SAE JA 1000/1 Reliability Program Standard Implementation Guide. He has also chaired technical sessions for the Reliability Track of the Annual SAE Reliability, Maintainability, Supportability and Logistics (RMSL) Symposium, was a four-year member of the Reliability and Maintainability Symposium (RAMS) Advisory Board and served for five years as Vice Chair for the SAE's G-11 Reliability Division.

Mr. Carlson holds a B.S. in Mechanical Engineering from the University of Michigan and completed the Reliability Engineering sequence from the University of Maryland's Masters in Reliability Engineering program. He is a Senior Member of ASQ and a Certified Reliability Engineer.

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