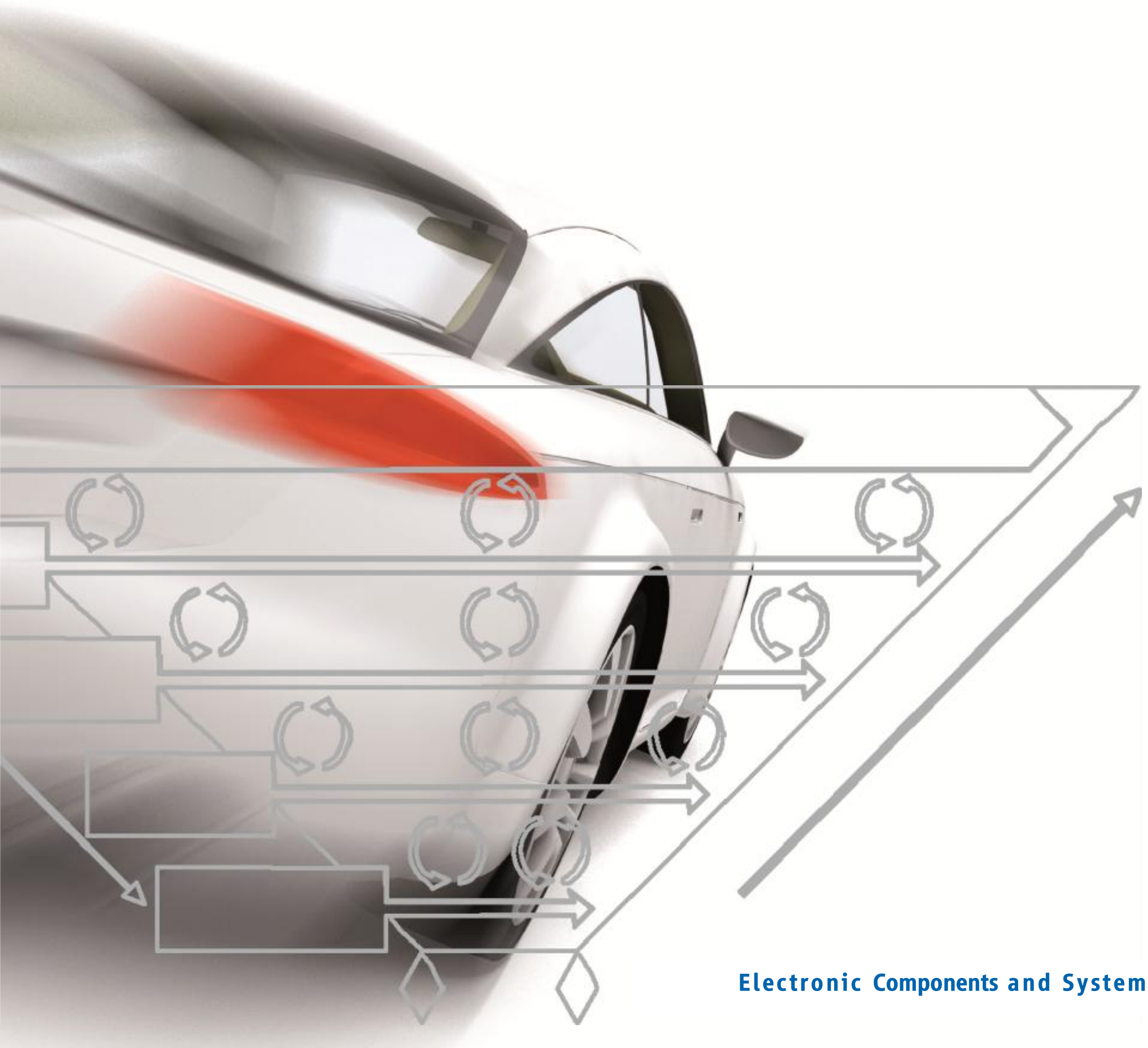
ZVEI: Die Elektroindustrie

Robustness Validation Manual

– How to use the Handbook in product engineering –



Electronic Components and Systems Dipvision

Robustness Validation Manual
– How to use the Handbook in product engineering –

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CONTENT

1 Introduction

Frontloading is the key to enable success at qualification of a semiconductor component or electric and electronic module [EEM]. This requires early integration of the Robustness Validation [RV] approach in the development project. This also ensures the use of the available knowledge of the project team, starting at the requirement management phase where the Mission Profile is created until the robustness assessment after completion of the qualification tests. The basic deliverable of Robustness Validation is knowledge for decision making. The RV flow describes the framework to generate the required knowledge throughout the entire development process. RV is based on experience and knowledge about the behaviour of semiconductors and EEMs under application conditions and the relevant physics of failure. Generation of MP creates knowledge for future/further designs. To enable development teams to perform RV, training is prerequisite but expertise (learning) is generated by doing. Coaching by experts is recommended for roll out phase of RV.

This Manual is intended to be a guideline supporting the application of RV as described in the RVHB.

2 Scenarios for the application of Robustness Validation

The application of Robustness Validation is not restricted to the development of new electronic components but can also be beneficially used in a lot of different situations. In this section these scenarios are compared to the situation of the development of an Application Specific IC, and are described with their specific constraints which have to be known to apply Robustness Validation correctly. An overview of the different scenarios gives table 1.

	ASIC	ASSP	Commodity
Mission Profile	According to customer specification	According to target application	Envelope for target market (segment)
Specification	Defined by customer for target use cases	Defined by supplier for target use cases	Defined by supplier typically oriented at market standards
Owner of MP and specification	customer	Supplier (option: support by lead customer)	Supplier
Development driven by	Customer innovation (functional, could be enabled by technology innovation)	Supplier or customer innovation (functional)	Cost reduction enabled by technology innovation
Example	Airbag sensor controller for one specific sensor dedicated to specific system architecture	System basic ICs	Small signal, standard logic

Table 1: Scenarios for product development (here: semiconductor component)

2.1 Application Specific ICs (ASIC)

An ASIC is an electronic component customized for a particular use. It is developed in a tight cooperation between semiconductor component manufacturer and its customer. According to the process described in section 3 there are well defined roles in such a project. The customer, who buys the semiconductor component, has to

- support the creation of the Mission Profile for the ECU at the OEM,
- create the Mission Profile of the electronic component,
- review the risk and potential failure modes evaluated by the supplier,
- support the risk assessment at the supplier, needed to generate the qualification plan,
- support the robustness assessment and follow on items based on risk assessment of Robustness Validation data.

ASICs are supplied by two different types of companies: Integrated Device Manufacturers (IDM) and fabless companies. In case of fabless companies' third parties, the silicon foundry and assembly subcontractor have to participate in all validation topics related to failure mechanisms. For IDM with partly outsourced services the relevant third party has to be involved, too.

2.2 Application Specific Standard Product (ASSP)

An ASSP is an open market product designed for a specific purpose within one or more dedicated market segments. Now the role of the component user, typically the Tier1, and the OEM has to be taken over by functions at the component supplier. Experts at the component supplier have to consider typical use cases resulting in potential impact to the customer for example regarding thermal management or system architecture.

ASSPs could be started as ASICs, where additional requirements for further customers are already anticipated.

2.3 Commodity devices

There is a broad range of commodity devices, which could be an IC for a group of specific customers or a product for one or more market or application segment(s) or standard ICs like a standard logic IC or a small signal transistor. Typical for these cases is that there are either several customers with different shares of a specific application segment or even an application segment with many customers not all specifically known to the semiconductor supplier. This means that commodity products are not developed for automotive applications only, but have significant market share in non automotive segments, too.

This situation has a major impact on the process of Mission Profile generation and robustness assessment. Experts at the component supplier have to make assumptions on the Mission Profile required by the market segment(s). Whether the complete market or an application segment is chosen and how this correlates to Mission Profile and specification is a strategic decision which is dominated by the question which application segments in the market to be addressed. The target Mission Profile becomes part of the internal requirements list for a new technology and the corresponding designs. The derived validation requirements and acceptance criteria have to become check items for the relevant project gates or milestones. If the targeted application segment is dominated by one company it makes sense to review the Mission Profile with this partner and also to assess the measured robustness margin.

Finally the component supplier has to define which information of the result of Robustness Validation should be documented within the specification or application notes. Based on proven robustness, an envelope Mission Profile may become part of the published specification (datasheet).

All other steps of the Robustness Validation process can be performed as in the case of the ASIC. It is the task of the market interface function of the component supplier to provide the requested knowledge from the market. The task owner should know the specific application requirements and should take care that they are in line with the requirements of the targeted application segment.

2.4 New technology

For product qualification based on an already qualified technology many data are referenced to already existing technology qualification data and related reliability models. But developing a new technology also requires information of the market or customer requirements for the products which are planned for this technology. This means that the Mission Profile for a technology has to cover the Mission Profiles of the planned products as an envelope. A successful strategy is to qualify a lead product using most or all of the technology features together with the technology. The Mission Profile of this lead product could be the starting point, and for the final technology related Mission Profile only a delta discussion is needed. To make the results of Robustness Validation of technologies available for referencing they have to be documented in a more generic way, also giving information how to handle the associated reliability models.

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The creation of a solid baseline is a key success factor for the application of Robustness Validation; therefore the major effort has to be focussed on the technology development and its reliability characterisation along the failure mechanisms. The detailed verification based on the process lead product allows the transfer of the results of the technology and their corresponding design rules to product (IC) level.

2.5 Change management

Change management needs fast, efficient and risk reducing implementation processes. Application of Robustness Validation can support these targets.

The overall strategy should be to concentrate on the changes in robustness by doing a delta assessment with respect to qualification data. Especially if the first qualification is performed with Robustness Validation, application of RV for project changes will benefit from the fact that the most critical failure mechanisms with their associated activation energies and finally the associated times to failure are already known. Therefore the qualification of the change can focus on the failure mechanisms, failure locations and effects associated with the change.

In case of a demonstrated increased robustness margin, changes can be approved and implemented on short term. Referencing to existing data allows reduction of further evaluation such as product validation and field testing.

2.6 EEM Platform

The Robustness Validation methodology does not only apply to semiconductor components but also to electric and electronic modules (EEMs). For the EEMs the major project categories can be identified as described in the following sections.

An EEM Platform is represented by a set of mechanical, electrical and software building blocks which can be combined and scaled to a large variety of individual applications.

During the development the target applications and their Mission Profiles have to be considered. This means that the Mission Profile for a technology has to cover the Mission Profiles of the planned products as an envelope. The Mission Profile on EEM level has to be translated to the individual building blocks and design elements.

A successful strategy is to qualify a lead product using most or all of the technology features together with the building blocks and design elements. The qualification results of the design elements and the lead product based on the envelope Mission Profile should act as knowledge base for assessing further changes.

This assessment can be facilitated once the understanding of the failure mechanisms is reflected in design rules with known robustness margin.

The creation of a solid baseline is a key success factor for the application of Robustness Validation; therefore the major effort has to be focussed on the platform development and its reliability characterisation along the failure mechanisms resulting in known robustness. The detailed verification based on the process lead product allows the transfer of the results of the platform and their corresponding design rules to product level.

2.7 Customer / Application specific EEM

Once the requirements of an application segment are very unique they may not fit into an EEM platform or it does not make sense to develop a new platform for this segment. In this case the target Mission Profile is defined by the target application. This Mission Profile has to be translated to the individual components. The verification of the fulfilment of these specific requirements has to be performed on component and on EEM level.

2.8 EEM variant

Once a new product is created by applying moderate changes to an existing EEM, the new product is called an EEM variant to an already existing product. An EEM variant may be a variant of a customer/application specific EEM of a new product within an EEM platform. The Mission Profile of the new product may significantly differ from the Mission Profile of the original part; therefore special attention has to be applied to the application requirements.

	Platform	EEM variant	Customer Specific EEM / ECU
Mission Profile:	Envelope for target application	According to generic customer specification	According to dedicated customer specification
Specification:	Defined by system and EEM development at Tier1 based on experience considering an envelope of current requirements and anticipation of future customer requirements	Defined by tier 1 for a group of similar EEM target use cases and mounting locations.	Defined by customer (OEM) related to a specific use case and / or mounting location. Specification has significant impact on system architecture and technology selection.
Owner of MP and specification:	Tier1 (System and EEM development)	Costumer	Costumer
Development driven by:	Joint approach of experts along the supply chain. Development driven by EEM and/or system development at Tier1. OEM typically involved within pilot projects.	Specific trigger by OEM if necessary but basic initial profile already available at tier 1 level	Dedicated customer team
Example:	Generic functional units (e.g. Engine control unit platforms Airbag EEM platform)	Generic control units with similar installation and use cases and non safety relevant (e.g. door module) – brand dependant	Specific EEM for individual and / or brand / type specific use cases. (e.g. Dashboard head units, Car Multimedia Body computer)

Table 2: Scenarios for product development (here: EEM component)

3 Process

3.1 Robustness Validation Process for Semiconductor Components

The RV Handbook for Semiconductor Components (Section 4.1) describes contents and generic workflow of RV. In addition, this manual provides a more detailed workflow for implementing RV into the product engineering processes.

Robustness Validation is a methodology to design for reliability and to validate against specific application requirements. This approach considers reliability aspects from the first concept evaluation along the whole product lifecycle.

The Robustness Validation flow is described in figure 1. The Robustness Validation process can be described in five major phases:

- Concept Phase
- Requirements development phase
- Design Phase
- Qualification Phase
- Production Phase

PROCESS

First two phases are essential for the success. Strong cooperation between all participants is needed to generate the Mission Profile (details see section 4). These two phases are iterative in order to achieve the work package targets. The number of iterations depends on the complexity of the product. A key success factor is the close and interactive co-operation of all involved parties (companies, departments ...).

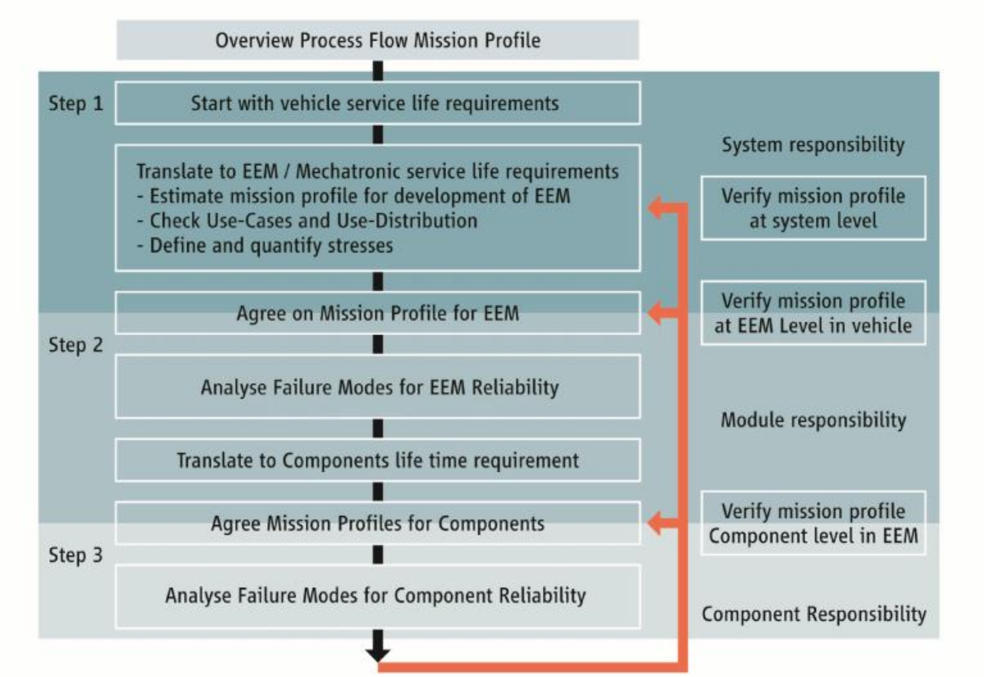


Figure 1: ***Generic flow of Robustness Validation Process***

In the following paragraphs the Robustness Validation Flow will be explained in detail.

The milestones during a Robustness Validation process are:

- Mission Profile at EEM level
- Initial Mission Profile at Component level
- Requirements freeze (Spec. and Mission Profile)
- Final qualification plan
- Robustness Assessment and Component Release
- Monitoring Plan and Volume Production Release

Work packages per phase are described in the process description in figure 2:

Every work package consists of

- Input required for the work package (could be output of a previous work package)
- Output generated by the work package as deliverable of the process
- Tasks to be performed
- Tools for efficient execution of the tasks
- Defined responsibility within the work package

The roles within the Robustness Validation Process for Semiconductor Components are assigned for

- OEM: Car Manufacturer / Responsible on system level (vehicle)

- Customer: Tier 1 , responsible for EEM development or sub system development (e.g. engine control unit plus additional components)
- Component supplier: Supplier of a semiconductor component within the EEM

The responsibilities for the work packages and milestones vary for different scenarios (see section 2) and are described with the following attributes (see figure 1):

R: Is responsible for work package or milestone

A: Has to approve the milestone or the output of a work package

S: Has to support the team during a work package

I: Will be informed

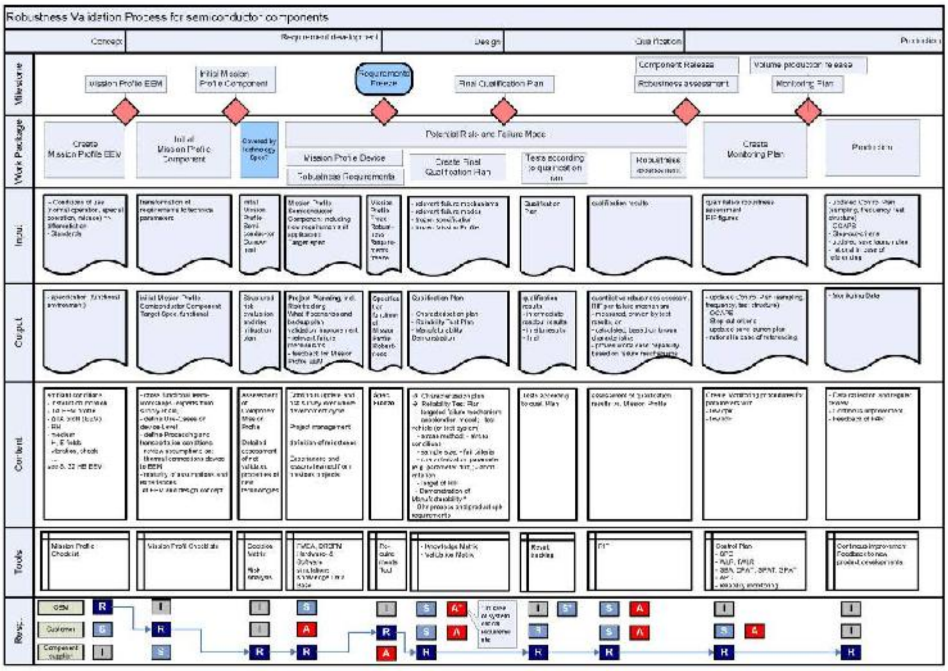


Figure 2: ***Chronological workflow of Robustness Validation Process for Components including responsibilities***
(To enlarge schematic, please click into the picture)

The process during the different phases:

1) Concept phase

During the concept phase the OEM provides the basic information about the functional and environmental target definition of the EEM. In addition the conditions are collected in order to describe:

- typical use cases
- extreme use cases
- non relevant use cases
- misuse / abuse
- forbidden use cases

This work package is under responsibility of the OEM with additional support from the customer (Tier1) in order to match system level requirements with expected capabilities on hardware level. An interactive team approach is a major success factor to create a meaningful Mission Profile on EEM level.

2) Requirements development phase

During requirements development phase the Mission Profile on EEM level will be translated into the Mission Profile on component level. This phase is one of the most intensive and iterative work packages during the whole Robustness Validation Process. The translation of the EEM-Mission Profile into the component Mission Profile requires a lot of assumptions on design and technologies used for the EEM and the particular component. Since they are not available at this point in time, an iterative process on EEM concept, component requirements, impact on component EEM and system will create a continuous flow of information in order to optimize the whole system approach. During this phase, two major milestones are in place: after creating the first baseline Mission Profile (Mile-Stone: "Initial Mission Profile Component"), the work package is finished with the Requirements Freeze Milestone regarding the components target specification including its Mission Profile. Between these milestones, a dedicated feasibility analysis is performed (WP "Covered by technology specification"). With this input the first analysis of "potential risks and failure modes" has to be performed and shall be tracked and evaluated further and evaluated during the next process steps.

This work package "Covered by technology specification" is most crucial to the success of the whole Robustness Validation process, since this phase is supposed to have the most significant impact on the definition of all further requirements. During this work package a close co-operation and interactive teamwork of all involved companies is the major success factor.

3) Design Phase

After the requirements freeze, the design phase can be started according to these requirements. Based on the "potential risks and failure modes" a continuous risk tracking will be performed. By knowing the relevant failure mechanisms the validation and qualification plan can be created. Depending on the failure mechanisms certain tests on dedicated structures can be done during early sample phases. The results can be used to validate these failure mechanisms. The qualification plan should consider the risk analysis done in the previous work packages in order to create the knowledge on the most critical failure mechanism as early as possible and to ensure a qualified robustness assessment.

4) Qualification Phase

During the qualification phase, the execution of the qualification plan is in focus. A regular tracking of the results and comparison with the required robustness is crucial to be able to take the right decision on a timely basis. Update of qualification contents have to be considered in the project planning. At the end of the qualification phase the component will be released based on a qualified robustness assessment. This assessment can only be based on the results created before and is not based on assumption and thoughts.

A documented decision based on facts is a key success factor. Therefore the thorough planning process in advance is essential to have the right results available in time.

5) Production Phase

After the robustness of the component has been proven based on its intrinsic properties, further interaction of product reliability with the production process has to be taken into account. By knowing the relevant failure mechanisms and their impact on EEM- or system level, the criticality of the relevant product parameters was already assessed during the design and qualification phase. For the critical failure mechanisms the potential impact of process parameters and their typical distributions has to be performed. If the component robustness over the whole parameter range is not assured or in doubt, additional monitoring during the volume ramp-up phase can create this required knowledge. A dedicated monitoring plan, based on robustness-process interactions will be implemented into the process control plan during the ramp up phase. Based on the fulfilment of the pre-defined step-out criteria, the monitoring can be reduced after successful volume ramp-up.

3.2 Robustness Validation Process for EEMs

The target of Robustness Validation is not only to achieve robust components but also to realize robust electronic systems. Therefore only a consistent application of the Robustness Validation flow in the whole chain from system level over EEM down to component level allows a systematic optimization over the complete supply chain.

The generic RV flow for E/E-Modules is descriped in figure 2. The chronological work flow including responsibilities and work package descriptions is shown in figure 3. The flow starts with the system level requirements. The flow itself is structured in the same way as the Robustness Validation low for semiconductor components. In fact it implicitly contains this flow. Once the initial Mission Profiles for the critical components are created, a Robustness Validation flow for components (compare to figure 1) has to be applied for each of these components.

The structure in terms of phases and milestones are identical to the Robustness Validation flow described in section 3.1. The major difference is the fact that the EEM itself is an individual design with a potentially high number of constituents. The major challenge is to coordinate the planning and the results of all elements of the EEM during the whole development

The robustness assessment of the EEM has to take into account the design, materials and processes applied for the production of the EEM as well as the robustness of the components used.

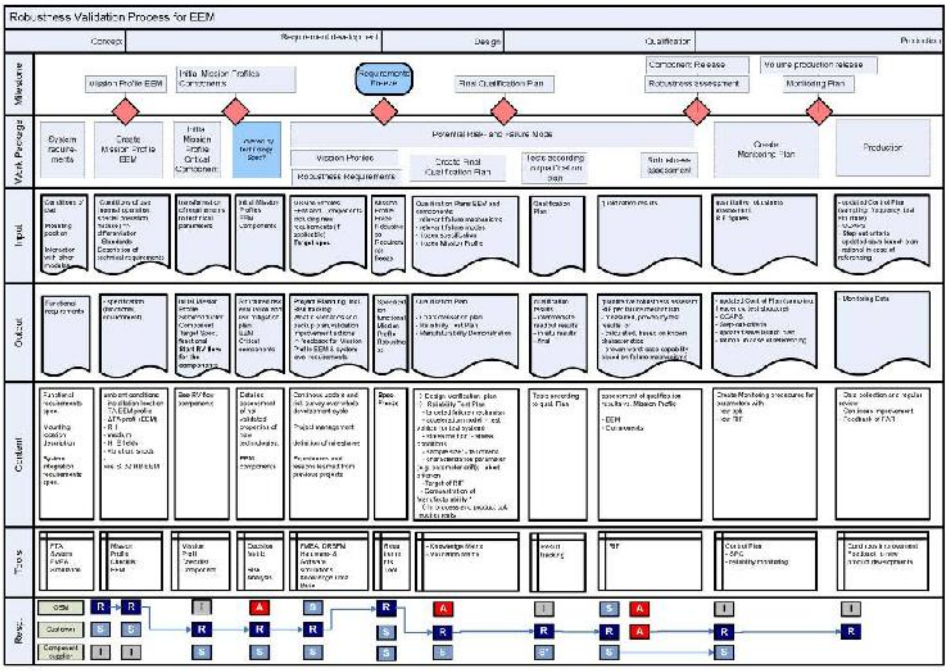


Figure 3: ***Chronological workflow of Robustness Validation Process for EEM including responsibilities***
(To enlarge schematic, please click into the picture)

4 Mission Profile

Building a good Mission Profile requires good understanding of the application. As mentioned above the timely distribution and the stress magnitude are important details of the “Mission Profile” for the product’s total lifecycle. All relevant stressors and loads have to be considered during the overall use life of the product. The collection of loads and stressors can be facilitated by applying the Mission Profile Checklist and results in the Mission Profile, where all operational modes (on, off, idle, sleep …) shall be considered.

The generation of the Mission Profile is not a one-time activity, and it is not a one-way street of data transportation. Rather, as already described in the RV handbook [Chapter 6.1 in RV ECU], it is an interactive process that needs communication and reiteration to ensure mutual understanding of the issues and requirements of all participants. This is essential to finding the best solution for the overall system.

Much of the information needed for the Mission Profile will come from application engineering and product definition/development. In order to support the gathering of data, a questionnaire (ZVEI Automotive Application Questionnaire for Electronic Control Units and Sensors, http://www.zvei.org/index.php?id=347) is provided that contains a list of items that may be relevant It is not claimed that the questionnaire is comprehensive; depending on the case under consideration, some questions may not be applicable, other relevant items may not be included. Comments are made to several of the items that try to help interpret the point.

In most cases more than one application segment will be targeted, so the requirements for each application segment have to be specified. Therefore the Mission Profile of each segment has to be created and documented individually. At the end the definition of an overall Mission Profile as an Envelope Profile make sense as long as the influence of the individual profile to the overall profile is understood. Although one may tempt to seemingly simplify matters by defining an “enveloping profile”, no attempt should be made in the phase of collecting data for the Mission Profile to somehow condense, convert, or select requirements from different applications with respect to their importance, criticality, or whatever criterion one may imagine. Special attention has to be put on the fact that relevant information must not get distorted or lost due to misinterpretation in an early phase.

Having pointed out the cautions that should be taken when generating a Mission Profile, one does need to consider how to create a Mission Profile as input for new technology (e.g. wafer process) developments as well for new product development once a specific customer application is not available. This can be based on the best-known market applications at the time the technology or the product is developed. Then the Mission Profile is an envelope covering the planned product application segments.

Some help for generating Mission Profiles may come from considering usage profiles [see also Handbook for Robustness Validation of Automotive Electrical/Electronic Modules; Chapter A.1.4]:

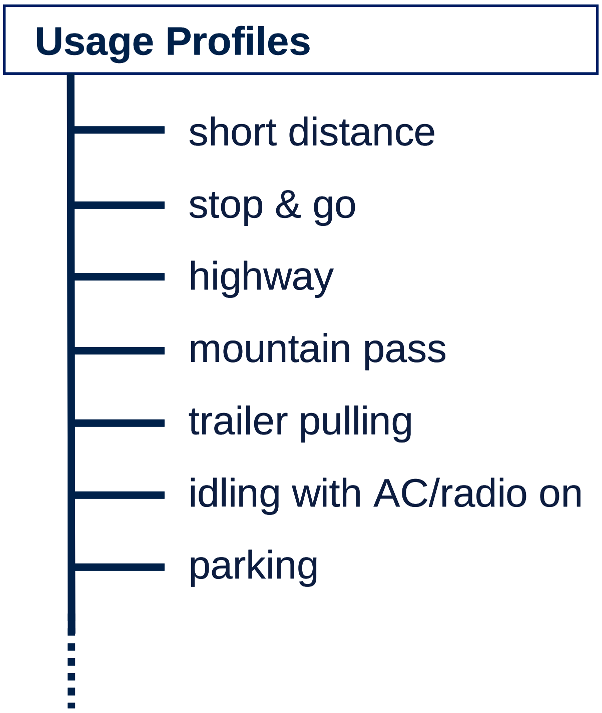


Figure 4: Examples of different usage profiles of a car

While it is relatively easy to list relevant environmental loads such as climatic conditions, it will become difficult to generate quantitative measureable figures.

A wide range of operation conditions may apply, e.g. normal operation, short circuits, and the load applied to the semiconductor device may depend on the system's behavior.

5 Basic needs and Stressors

In pursuit of low failures rates it is mandatory to be aware of the kind of stressors and the effective stress intensity, duration and mix that reach the product. A questionnaire like Mission Profile Checklist helps to cover the entire set of stressors related to the Mission Profile. (see ZVEI Automotive Application Questionnaire for Electronic Control Units and Sensors, http://www.zvei.org/index.php?id=347).

The Robustness Validation Knowledge Matrix offers a list of failure mechanisms and therefore it's a valuable basis for reliability planning with the product's Mission Profile in mind. From these Mission Profiles, stress requirements can be derived for standard reliability tests based on industry-accepted standard (as defined in JEDEC/IEC-JEP122) and on best knowledge (such as the ZVEI Knowledge Matrix).

Stressors are resulting from outside environmental conditions and can also origin from product operations themselves. It is important to know whether they could be influenced by product or process design or not. For each stressor it is also important to define the point where the failure happens to decide on mitigation techniques because not every stress necessarily reaches the critical areas of the product in full magnitude. Interaction of stressors has to be taken into account, for instance combinations such as thermo-mechanical effects (e.g. delamination) can lead to excessive strain and therefore a significant decrease of reliability.

One aspect of a Mission Profile creation is the breakdown of temperatures over time. For each temperature block the dominant failure mechanism has to be determined and is an element for reliability predictions on the basis of commonly used models.

From all these information the trade-off between reliability and product performance can be optimized. Finally the reliability performance has to be demonstrated by successful completion of the reliability stress tests. The product performance on the other hand is documented in the specification after final optimization and demonstrated by characterization.

6 Risk assessment and Qualification Plan

To generate a correct and efficient Qualification Plan the Mission Profile has to be completed. Otherwise weaknesses of the Mission Profile can result in erroneous Risk Assessment and Qualification Plans that may contain irrelevant tests or have gaps in risk coverage.
Therefore prerequisites for starting the Risk Assessment are:

- Mission Profile is defined
- Data from predevelopment are available on level of the electronic component
- No open items with respect to MP and results of pre-development

Risk Assessment can only be done if in addition to the Mission Profile the product concept is known with detailed information on:

- Technologies
- Materials
- Specific requirements like design strategies and design rules

In an expert/peer review the Mission Profile has to be reviewed with respect to criticality. If data are available, criticality can be quantified as the difference between the point of fail (reliability performance) and the requirement extracted from the Mission Profile. Data that could be used for this risk assessment are:

- Qualification and reliability assessment results from other products using similar technologies and comparable materials.
- Reliability and material studies done in the predevelopment phase.
- Extrapolations of characterized failure mechanism related results to new Mission Profile.
- Data from process qualification

The list of potential failure mechanisms could be taken from the

- ZVEI Knowledge Matrix (see section 8) or
- Standards like JEP122 (see section 8) or
- Company internal sources.

Not all failure mechanisms are relevant for certain Mission Profile-Technology-Material-Combinations. (Design-, if already done) Criteria for the selection could be:

- Mission Profile above or close to proven design target
- Failure mode critical to application: how does the failure mechanism result in a failure mode on product level
- Engineering expertise available: failure mechanism mitigation strategies known and proven

- Experience from previous qualifications: was the criticality assessment supported by field data; was a certain failure mechanism assessed as critical in similar design situations and for similar Mission Profiles

The tool to support and document this risk assessment process could be FMEA, Risk Register or a similar tool. It should be considered how this information could be further used during development and qualification.

The RVKM could be used to select the relevant stress test including the test vehicles best suited to generate the intended data.

If the stress test, the Mission Profile and the relevant acceleration model are known the stress conditions, the characterization parameter and its failure criterion for determining the lifetime for a certain failure mechanism could be generated. For selecting the stress condition also the following aspect should be considered:

- Overall test time
- Maximum acceleration possible
- Detectability of the fail condition
- Sensitivity of the device to be stressed

The selection of the stress conditions could require some pretesting to determine the expected time-to-fail. From this consideration it should be also possible to generate a break off criteria in case there are no failures.

Qualification Plan:

Each Qualification Plan consists out of three basic elements:

- Characterization Plan
- Reliability Test Plan
- Proof of Manufacturability

Details are described in the Robustness Validation Handbook section 9 and in the reporting template for semiconductor components on the ZVEI homepage.

Requirements:

Final Qualification Plan is a milestone in the RV process flow. However, changes are unavoidable during project execution. To ensure the tracking of risks, the chain of arguments from Mission Profile & Design to stress test in the Qualification Plan should be documented. This is needed to do a fast Qualification Plan update in case of Mission Profile or design changes. If reliability data show unexpected results the traceability should also be possible backwards to rearrange the risk pareto with respect to the requirements.

End of life data used for assessment of reliability and for referencing only make sense in combination with a failure mechanism, a fail criterion and a reliability target

Adding the results to the Qualification Plan generates the robustness assessment automatically. This could be directly used for the reporting.

7 Benefits from experiences / Success Stories

The use of a Robustness Validation approach or at least parts of it are useful on any stage of the supply chain. Experiences from first pilot projects have shown that the full benefit of this procedure becomes effective, when used regularly and with involvement of all parties along the supply chain.

Projects applying Robustness Validation and involving all major participants of the development process, the semiconductor manufacturer, Tier-n and OEM have successfully demonstrated the benefits of this approach. A consistent application of this method generates more advantages than just a successfully qualified product:

- Robustness- and lifetime assessment

  This seems obvious as it is the key point of the Robustness Validation approach. However, the main benefit of this approach is the change in the basic attitude. Only by testing samples until they fail one will get reliable information on the lifetime of the component. Once one accepts the occurrence of failing parts during end of life testing, Robustness Validation provides valuable information on the expected lifetime of the electronic component.

- Deep understanding of the system

  Robustness Validation encourages the participants to become aware of the strengths and weaknesses of their system and its components and manage them actively.

  The necessary involvement of all participants in the development and validation process (IDM, TIER1 and OEM) leads to a deep understanding of the system, the relevant failure mechanisms and the requirements in a very early stage of the development process. This aspect becomes more and more effective as the experience and the knowledge base growths with each project.

  Furthermore the feedback process established during a Robustness Validation oriented design flow helps to enhance the communication between all participants along the supply chain. This leads to a very procreative working atmosphere.

- Potential for optimization by applying RV

  Knowledge of product lifetime for certain use cases successfully avoids over-engineering combined with a high level of robustness and reliability. A detailed understanding of the real requirements of an application is the base for optimization. This becomes effective in either costs or functionality.

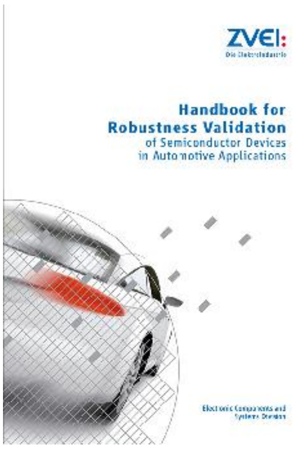
Practical experiences have proven that the benefit achieved by Robustness Validation is more than just an extended qualification plan but it is an advanced engineering process. All the points mentioned above finally lead to quality improvement, cost reduction and a better knowledge of the abilities of the product.

Supporting Material

Material	Description	Source	Usage
1) RVHB of SC Devices (or SAE J1879)	Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications	http://www.zvei.org/RobustnessValidation	Basic information on Robustness Validation
2) Knowledge Matrix	Database containing data on the current state of knowledge of failure mechanisms	http://www.zvei.org/?id=3796	Risk analysis Generation qualification plan Assessment of reliability data
3) JEP122	Failure Mechanisms and Models for Semiconductor Devices	http://www.jedec.org/	Reference of RVKM Understand failure mechanisms
4) JP001	Foundry Process Qualification Guidelines (Wafer fab)	http://www.jedec.org/	test and data methods for the qualification of semiconductor technologies
5) RVHB for EEM (or SAE J 1211)	Handbook for Robustness Validation of Automotive Electrical/Electronic Modules	http://www.zvei.org/index.php?id=3795	Use case analysis
6) JESD22-Axxx	Description of stress test methods to be used for qualification	http://www.jedec.org/	Perform stress tests on products, acceptance and fail criteria according to RV validation matrix
7) Risk Register	Generic risk assessment	http://www.continuitycentral.com/feature0414.htm	Assessment of non technical or generic risk assessment
8) FMEA	Technical risk assessment method	http://www.aiag.org/	Technical risk assessment
9) Questionnaire	Automotive Application Questionnaire for ECUs and Sensors	http://www.zvei.org/RobustnessValidation	Generation of UCE Mission Profile

Notes: 2) The usage of the Knowledge Matrix is described in the RVHB of SC Devices (section 8)

Annex A
Related Documentation



Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications
(Pages 60, April 2007, Revision February 2013)

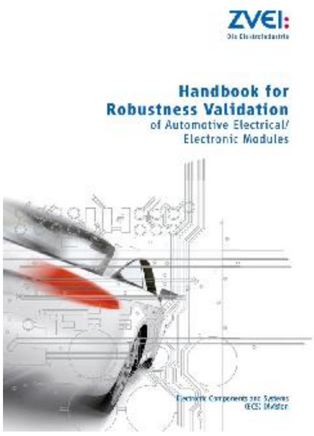
The quality of the vehicles we buy and the competitiveness of the automotive industry depend on being able to make quality and reliability predictions. Qualification measures must provide useful and accurate data to provide added value. Manufacturers of semiconductor components must be able to show that they are producing meaningful results for the reliability of their products under defined Mission Profiles from the whole supply chain.

This includes screening methods and reliability methodologies applied on technology level during development.

Contents:
- Terms, Definitions, and Abbreviations
- Definition and Description of Robustness Validation
- Mission Profile / Vehicle Requirements
- Technology Development
- Product Development
- Potential Risks and Failure Mechanisms
- Creation of the Qualification Plan
- Stress and Characterization
- Robustness Assessment
- Improvement
- Monitoring
- Reporting
- Examples

This handbook gives guidance to engineers how to apply Robustness Validation during development and qualification of semiconductor components. It was made possible because many companies, semiconductor manufacturers, component manufacturers (Tier1) and car manufacturers (OEMs) worked together in a joint working group to bring in the knowledge of the complete supply chain.

REALATED DOCUMENTATION



Handbook for Robustness Validation of Automotive Electrical/Electronic Modules
(Pages 148, June 2008, Revision June 2013)

This document addresses robustness of electrical/electronic modules for use in automotive applications. Where practical, methods of extrinsic reliability detection and prevention will also be addressed. This document primarily deals with electrical/electronic modules (EEMs), but can easily be adapted for use on mechatronics, sensors, actuators and switches. EEM qualification is the main scope of this document. Other procedures addressing random failures are specifically addressed in the CPI (Component Process Interaction) section 10. This document is to be used within the context of the Zero Defect concept for component manufacturing and product use.

The Robustness Validation approach emphasizes knowledge based engineering analysis and testing a product to failure, or a predefined degradation level, without introducing invalid failure mechanisms. The approach focuses on the evaluation of the Robustness Margin between the outer limits of the customer specification and the actual performance of the component. These practices integrate robustness design methods (e.g., test-to-failure in lieu of test-to-pass) into the automotive electronics design

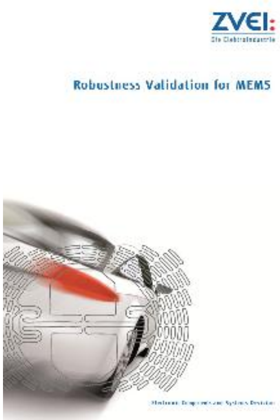
and development process. The objectives of improved quality, cost, and time-to-market can be realized.

Contents:

- Introduction
- Scope
- Definitions
- Definition and Description of Robustness Validation
- Information and Communication Flow
- Mission Profile
- Knowledge Matrix for Systemic Failures
- Analysis, Modeling and Simulation (AMS)
- Intelligent Testing
- Manufacturing Process Robustness and its Evaluation
- Robustness Indicator Figure (RIF)
- Appendix:
- Section Examples
- Prototype Test Examples

This Robustness Validation Handbook provides the automotive electrical/electronic community with a common qualification methodology to demonstrate robustness levels necessary to achieve a desired reliability.

RELATED DOCUMENTATION

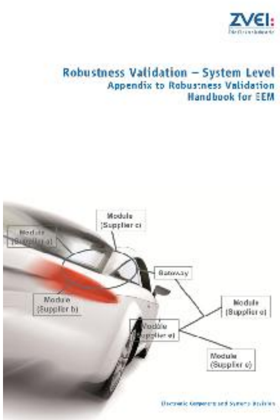


Robustness Validation for MEMS –
Appendix to the Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications
(Pages 38, October 2009, Revision March 2014)

Robustness Validation (RV) is a valuable failure-mechanism-driven approach to product reliability and qualification, which relates real application conditions to test conditions.
MEMS sensors present a special category of devices that need specific considerations. By their very nature, MEMS sensors are often exposed to harsh environmental conditions that are in an obvious way not covered by standard stress test conditions used in product qualifications. Neither commonly referenced product qualification standards nor “Handbook for Robustness Validation of Semiconductor Components in Automotive Applications” published by ZVEI in April 2007 adequately represent the sensor needs. It is for this reason that sensor manufacturers and users joined in a team organized by ZVEI to discuss the application of Robustness Validation to sensor devices.

1. Introduction
2. Terms, Definitions, and Abbreviations
3. Mission Profile
4. Knowledge Matrix
5. Acceleration Factors / Testing
6. Summary and Outlook
7. References and Additional Reading
8. Participants of the Working Group

A.1 Mission Profile Examples
A.2 Knowledge Matrix Table
A.3 Overview Stress Tests



Robustness Validation - System Level
Appendix to Robustness Validation Handbook for EEM
(Pages 14, January 2010, Revision March 2014)

The project „Robustness validation System Level" is the 3rd project of the joined Robustness Validation Groups of ZVEI and SAE.
With this publication the focus is drawn to the validation of robustness of a group of two or more interacting Electronic Control Units respectively Electrical/Electronic Modules.
This appendix to the Handbook for Robustness Validation of Automotive Electrical/Electronic Module highlights additional points which originate from the interaction of EEMs.
The total robustness assessment is expected to be done on system level by taking all the relations into consideration. This will not only feedback some robustness numbers but as well closing the loop to modify or change the Mission Profiles for the stand alone units.

1 Introduction
2 Definition - Vehicle Functional System (Vfs)
2.1 Physical Classification
2.2 Functional Classification
3 Flow of RV on System Level for “Vehicle Functional Systems”
3.1 Unexpected Loss of Robustness During System Integration
3.2 Example: Robustness loss due to Manufacturing Process
4 Questionnaire For A Mission Profile
5 Objectives Of The Intelligent Testing Table

The results are free for download under ZVEI Homepage:
http://www.zvei.org/RobustnessValidation

REALATED DOCUMENTATION

Automotive Application Questionnaire for Electronic Control Units and Sensors

This Automotive Application Questionnaire helps the parties involved (OEM, Tier1, Tier2...) to select critical application parameters (= environmental loads) in a simplified and standardized way:

- Evaluation of loads
- Better, failure free communication between all parties:
  - Car manufacturer
  - Supplier of the ECU or Sensor
  - Supplier of the electrical (mechanical) devices

The filled in data content has to be handled confidentially by request of one of the parties:

- Therefore the affected parties can decide to put down the contact persons and companies over the whole supply chain by name or not.
- The parties are responsible for validation and sufficiency of the questionnaire, not the ZVEI.

The application questionnaire will help to describe the different loads in the cars and important functional/electrical loads of the components in a short, compact way, so that the parties could make estimations about reliability and quality in order to create ‘zero defect’ over the supply chain.
With progress in product development Mission Profiles and functional loads will be rendered more precisely. Therefore changes and revisions in the loads during development are admissible.
The questionnaire will also help to check new mounting positions in the car of a well established product.

Free Download under http://www.zvei.org/index.php?id=347

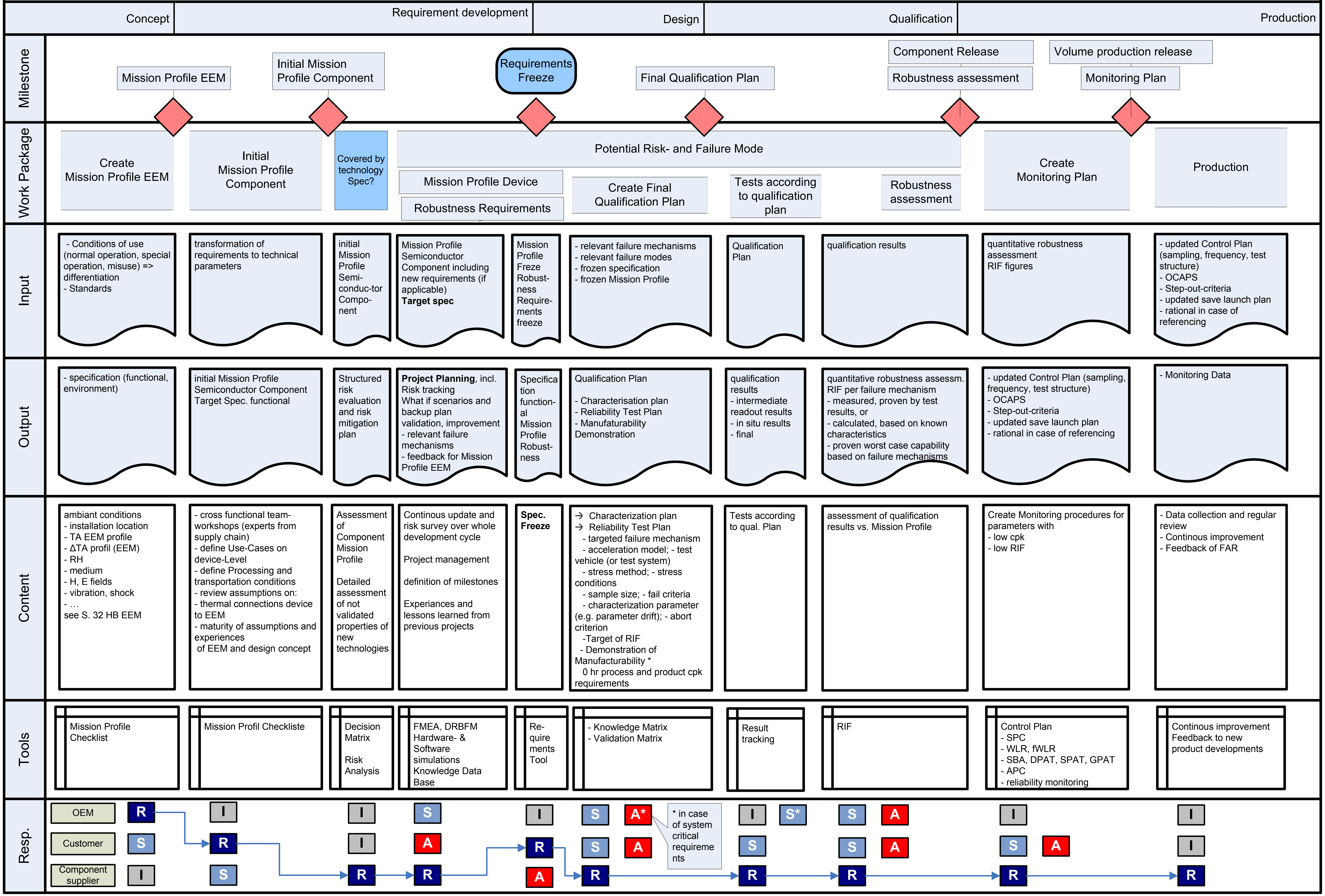
Annex B: Abbreviations

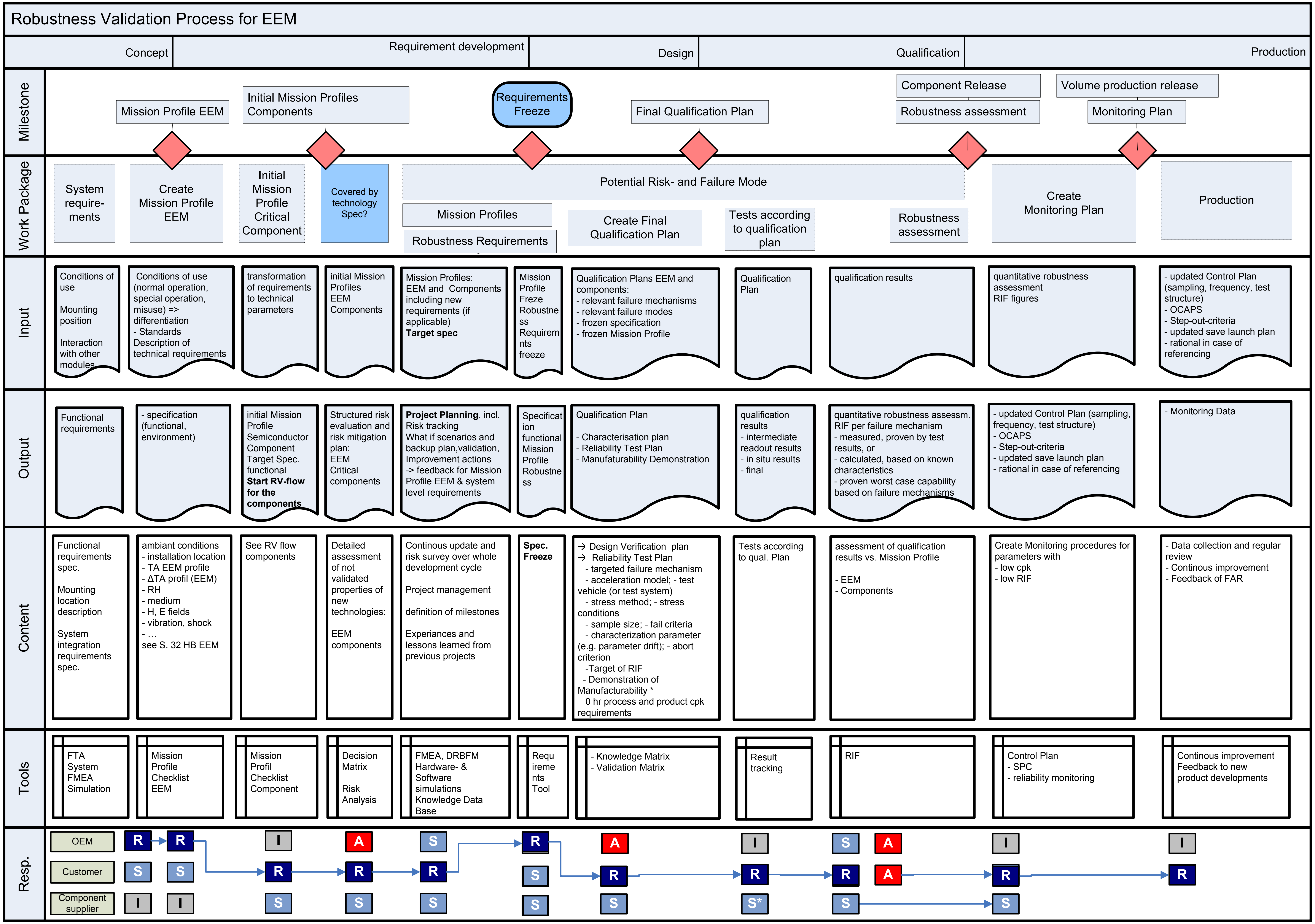
ASIC	Application Specific Integrated Circuit
ASSP	Application Specific Standard Product
ECU	Electronic Control Unit
EEM	Electric and Electronic Module
IDM	Integrated Device Manufacturer
JEP	JEDEC Publication
MP	Mission Profile
OEM	Original Equipment Manufacturer
RV	Robustness Validation
RVHB	Robustness Validation Handbook(s)
RVKM	Robustness Validation Knowledge Matrix
SAE International	Society of Automotive Engineers
TIER 1	Supplier of a system to an OEM
ZVEI	Zentralverband Elektrotechnik und Elektronikindustrie e.V. (German Electrical and Electronic Manufacturers Association)

Annex C: Terms

second level interconnect	The interconnect made by the attachment of the device/component to the printed circuit board ….
application	Aerea an electronic product is used in (e.g. automotive or medical)
application segment	specific part of an application (e.g. dashboard for automotive application)

Robustness Validation Process for semiconductor components




Robustness Validation Process for EEM
Concept
Requirement development
Design
Qualification
Production
Milestone
Mission Profile EEM
Initial Mission Profiles Components
Requirements Freeze
Final Qualification Plan
Component Release
Robustness assessment
Volume production release
Monitoring Plan
Work Package
System require-ments
Create Mission Profile EEM
Initial Mission Profile Critical Component
Covered by technology Spec?
Potential Risk- and Failure Mode
Mission Profiles
Robustness Requirements
Create Final Qualification Plan
Tests according to qualification plan
Robustness assessment
Create Monitoring Plan
Production
Input
Conditions of use
Mounting position
Interaction with other modules
Conditions of use (normal operation, special operation, misuse) => differentiation
- Standards
Description of technical requirements
transformation of requirements to technical parameters
initial Mission Profiles
EEM
Components
Mission Profiles:
EEM and Components including new requirements (if applicable)
Target spec
Mission Profile Freze
Robustness
Requiremnts freeze
Qualification Plans EEM and components:
- relevant failure mechanisms
- relevant failure modes
- frozen specification
- frozen Mission Profile
Qualification Plan
qualification results
quantitative robustness assessment
RIF figures
- updated Control Plan (sampling, frequency, test structure)
- OCAPS
- Step-out-criteria
- updated save launch plan
- rational in case of referencing
Output
Functional requirements
- specification (functional, environment)
initial Mission Profile Semiconductor Component Target Spec. functional
Start RV-flow for the components
Structured risk evaluation and risk mitigation plan:
EEM
Critical components
Project Planning, incl. Risk tracking
What if scenarios and backup plan,validation, Improvement actions
-> feedback for Mission Profile EEM & system level requirements
Specification functional Mission Profile Robustness
Qualification Plan
- Characterisation plan
- Reliability Test Plan
- Manufacturability Demonstration
qualification results
- intermediate readout results
- in situ results
- final
quantitative robustness assessm.
RIF per failure mechanism
- measured, proven by test results, or
- calculated, based on known characteristics
- proven worst case capability based on failure mechanisms
- updated Control Plan (sampling, frequency, test structure)
- OCAPS
- Step-out-criteria
- updated save launch plan
- rational in case of referencing
- Monitoring Data
Content
Functional requirements spec.
Mounting location description
System integration requirements spec.
ambiant conditions
- installation location
- TA EEM profile
- ΔTA profil (EEM)
- RH
- medium
- H, E fields
- vibration, shock
- …
see S. 32 HB EEM
See RV flow components
Detailed assessment of not validated properties of new technologies:
EEM components
Continous update and risk survey over whole development cycle
Project management
definition of milestones
Experiances and lessons learned from previous projects
Spec. Freeze
→ Design Verification plan
→ Reliability Test Plan
- targeted failure mechanism
- acceleration model; - test vehicle (or test system)
- stress method; - stress conditions
- sample size; - fail criteria
- characterization parameter (e.g. parameter drift); - abort criterion
-Target of RIF
- Demonstration of Manufacturability *
0 hr process and product cpk requirements
Tests according to qual. Plan
assessment of qualification results vs. Mission Profile
- EEM
- Components
Create Monitoring procedures for parameters with
- low cpk
- low RIF
- Data collection and regular review
- Continous improvement
- Feedback of FAR
Tools
FTA
System FMEA
Simulation
Mission Profile Checklist EEM
Mission Profil Checklist Component
Decision Matrix
Risk Analysis
FMEA, DRBFM
Hardware- & Software simulations
Knowledge Data Base
Requirements Tool
- Knowledge Matrix
- Validation Matrix
Result tracking
RIF
Control Plan
- SPC
- reliability monitoring
Continous improvement
Feedback to new product developments
Resp.
OEM
Customer
Component supplier
R R I A S R A I S A I I
S S R R R S R R R A R R
I I S S S S S S* S S

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