47th CEEES Meeting

Minutes of R and ESS WG

Meeting location : Ostende Thermae Palace Hotel

Date : 15th February 2007

Attendees : see list hereafter

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1 - ADOPTION OF THE 45rd CONGRESS R&ESS MEETING MINUTES

The minutes are adopted.
Virtual members: TR 6 members?, at least Klaus Kangas/ABB, chairman

2 - Apologies FOR ABSENCES

No. None (no info from Marco Perego, the chairman of ESS WG).

3 - INTRODUCTION OF NEW MEMBERS

Dave Corben, Philips Applied Technologies, PLOT, Netherlands.

5- ESS ACTIVITY

Definition of terms paper was reviewed. Michel Holy distributed an updated version which was reviewed and discussed. For example, the definition for HALT is to be corrected – TAB members shall send their comments to Michel ASAP. Much debate took place about some definitions – there was also a misunderstanding in the present text about HAST (which would have been a better name for HALT, but has been reserved for non-saturated pressure cooker testing of integrated circuit encapsulation quality).

A question was raised about an introduction or explanation about the creation of the document. Definition /vocabulary of terms might also be needed.

6- R ACTIVITY

6.1 Different types of tests

6.1.1 List of withhold tests

Type of test	In charge of	
feasability , design aid	Colin	Done : see att.2
Development test	Michel	Done : see att 5
Reliability growth test (RGT)	Colin	
Higly accelerated tests	Henri	Done : see att.3
Accelerated tests	Helge	Under progress : see att 4
Qualification	Michel	
Reliability demonstration	Colin	
ESS including HASS	Henri	Under progress see att 7
Acceptance test	Bengt *	
Production reliability acceptance test (PRAT)	To be determined	
Pre production (zero production)	Gunnar	
Life duration	Colin	
Verification (validation)	Bengt *	

* to be confirmed

6.1.2 Template to apply to each of these tests

1	Test objective (purpose,definition…)
2	What is driving you for performing the test ?
3	Level of assembly of the product submitted to test
4	Number of items submitted to test
5	Type of product relevant to be submitted to the test (mass volume low price product ,..)
6	Test duration (days, weeks, months..)
7	Separate or combined environments
8	Product strength and environment stress variabilities are or aren't considered (in the process of deriving the test severity)
9	Does the test bring knowledge on reliability parameters ?
10	Does the test consume totally or partially the life potential ot the equipment submitted to test ?
11	main norms , standards, technical references relative to this type of tests

Gunnar Ruding: proposed combination of PRAT and preproduction parts. Gunnar shall soon prepare text for that.

Accelerated testing – AST not to be included. Instead, see ISTIA paper (in French) for three approaches – experimental (DOE, design of experiments), statistical and physical. Gunnar: how about virtual testing? Contact Fabrice Guérin if necessary.

Helge shall modify the Accelerated testing text and include HAST there as an example of a very special and dedicated type of life testing and make a proposal for a text including the three approaches of the ISTIA paper.

7- Other topics

About the questionnaire – the proposed full questionnaire was reviewed and changes were proposed.

6- TOUR OF TABLE

- Colin and the others:
- Helge
    - KOTEL –project, TUPA: A handbook is developed with a general process and methodology for cost effectively manufactured, transported and assembled environmentally compatible product design and packaging.
    - A new project proposal : Virtual environmental condition testing of a product – linked to the Swedish corresponding EUREKA project
    - EU –project has started : Magic, management of ageing of I&C equipment of NPPs
    - EU –project in preparation : LOTUS, long term use of electronics – emphasis on advanced IC technologies (DSM, nanotechnology etc.), VTT interest is in the methods for evaluation (accelerated testing, life testing, simulation of these, models)

- Henri :
    - ASTE working group has produced a guide “Environmental Stress Screening for Electronic Equipment using Highly accelerated Tests” . An extract of it has been introduced in the section of the report on HASS. This guide , in English, is open to sell on ASTE web site.

List of virtual members

Current members + following list.

TOOLA	Arja	NOKIA	+358 40 7685072		arja.toola@nokia.fi
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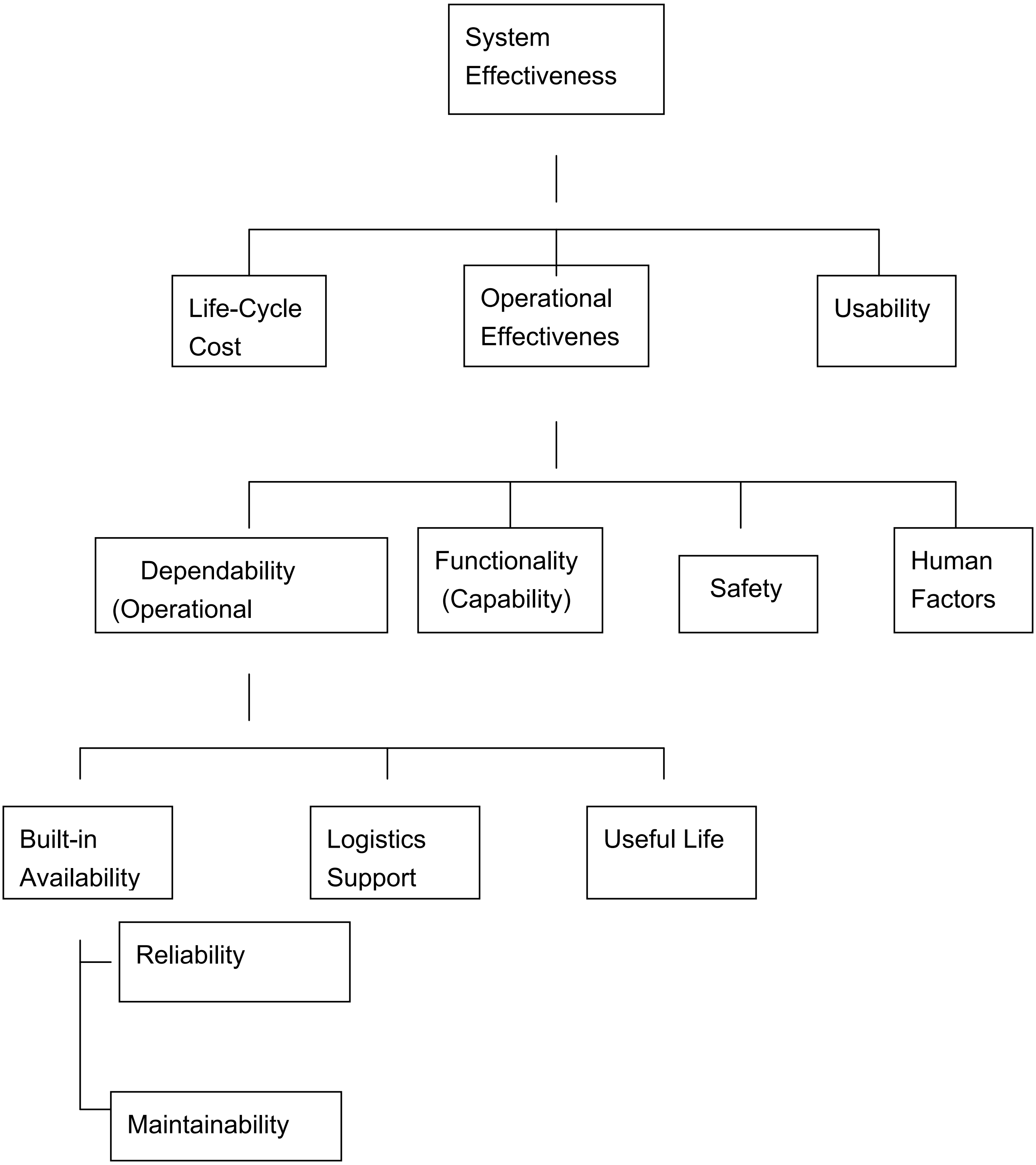
Attachment 1

Definition(s) of Terms Dedicated to Availability, Reliability & Maintainability

Purpose of this paper

The technical Terms given in this paper are used in standards, technical books, tachnical papers ore technical documents like specifications, data sheets etc.
For the correct reading of such documents, it is very important to understand the exact meaning of those terms. Otherwise serious misunderstandings are for sure. For example, if a vendor accepts a Reliability of 500 hours in a customer- specification, he must know that such a value is only valid in correlation with a well defined life profile , with clear stated maintenance conditions and that the **Reliability** is represented by statistical values which can only be evaluated with a big amount of operating hours and that induces costs and consumes time . An other exemple is the use of **MTBF** and **MTTF.** The term "Mean Time Between Failures" MTBF can only be used for an item with constant failure rate. If the item is subject to wear out, only the term "Mean Time To Failure" MTTF is admissible.
Often different definitions exist for a given technical term. In such case it is of great importance to give the exact wording of the used definition to avoid misunderstanding. (Statement to clarify).

1 Terminology-Structure


System Effectiveness
Life-Cycle Cost
Operational Effectivenes
Usability
Dependability (Operational
Functionality (Capability)
Safety
Human Factors
Built-in Availability
Logistics Support
Useful Life
Reliability
Maintainability

Environment Stress has direct influences on "Reliability" and "Maintainability"

2) Terms of Reliability and their abbreviations

- Reliability Function $\mathbf{R_{(t)}}$
- Failure Rate $\boldsymbol{\lambda_{(t)}}$
- Mean Time Between Failures **MTBF**
- Mean Time To Failures **MTTF**
- Mean Time To Mission - Failures $\mathbf{MTTF_M}$
- Lifetime $\mathbf{T_L}$
- Life Cycle **LC**
- Mission Profile **MP**
- Life Cycle Environmental Profile **LCEP**
- Durability
- Dependability

2.1) Relations between the terms of Reliability

$$\mathbf{MTTF} = \int_0^{\infty} R_{(t)} \cdot dt \qquad \text{(for Lifetime = } \infty\text{)}$$

for a finite Lifetime the upper limit of the integral is T_L

$$\lambda_{(t)} = d\,R_{(t)} / R_{(t)} \cdot dt$$

This equation shows that the reliability function $\mathbf{R_{(t)}}$ is completely defined by the failurerate $\boldsymbol{\lambda_{(t)}}$**.**

With $\mathbf{R_{(0)} = 1}$**,** the reliability function reads as follows:

$$R_{(t)} = e^{-\int_0^t \lambda_{(x)}\, dx}$$

For $\lambda_{(t)} = \lambda$ = constant it follows:

$$R_{(t)} = e^{-\lambda t} \text{ and in this case is } \mathrm{MTTF} = \int^{\infty} e^{-\lambda(t)}\, dt = 1/\lambda \quad *)$$

0

*) with t= MTBF = 1/λ → $R_{(t)} = e^{-1}$ **=** 0.368

It means that, regarding one functioning single item which is started the first time at t = 0 and will not be repaired if it failed, at the time t = MTBF the probability that this item is still functioning is 0.368

Or regarding a big population of functioning identical items which are started the first time at t = 0 and will not be repaired if they failed, at the time t = MTBF only 36,8 % of the items are still functioning.

2.2) Terms related to Reliability

Reliability
- Analysis
- Blockdiagramm
- Requirements
- Verification
- Program
- Improvement
- Assurance of mechanical Items

Failure
- Analysis
- Failure Cause
- Failure Mode
- Failure Symptom
- Failure Criticality
- Failure Effect
- Failure Detection
- Failure Localisation

Fault
- Fault Analysis
    - FMEA (Fault Modes and Effects Analysis)
    - FMECA (Fault Modes, Effects and Criticality Analysis)
- Specification-fault
- Engineering-fault
- Manufacturing-fault
- Using-fault

Reliability Improvement during Engineering
- R-Verification
- R-Analysis
- R-Test
    - HASS (Highly Accelerated Stress Screening)
    - HALT (Highly Accelerated Lifecycle Testing)

- R-Demonstration

Reliability Improvement during Manufacturing

- ESS (Environmental Stress Screening)
- HASS (Highly Accelerated Stress Screening)
- Qualifications-Tests

Reliability Improvement during Product Use

- Reliability Growth

3) Terms of Maintainability and their abbreviations

- Maintenance
- Preventive Maintenance [every time based on given conditions (working time, number of km., wear .....)]
  - Mean Time To Preventive Maintenance **MTTPM**
  - Time Between Preventive Maintenance **TBPM**

- Corrective Maintenance
  - Mean Time To Repair **MTTR**
  - Repair Rate μ

3.1) Relations between the terms of Maintainability

If: T_1 is the random value of the time expected to carry out a repair

and T_2 is the random value of the time expected to carry out a preventive maintenance

then:

Reparability = Probability of $[T_1 \leq t]$ and Serviceability = Probability of $[T_2 \leq t]$

t is the parameter of the distribution functions of T_1 and T_2

For a rough characterisation of the expected mean values of T_1 and T_2 of an item, the following values can often be used:

Expected value of T_1 = MTTR (Mean Time To Repair

Expected value of T_2 = MTTPM (Mean Time To Preventive maintenance)

3.2) Terms related to Maintainability

- Maintainability
  - Analysis
  - Requirements
  - Verification
  - Program
  - Improvement
  - Assurance of
  - Evaluation

4) Definitions

Defect

[1] Nonfulfillment of an intended usage requirement or reasonable expectation, essentially present at t=0

Remark:

From a technical point of view, a defect is similar to a nonconformity, however not necessarily from a legal point of view. Defects do not need to influence the item's functionality. They are caused by flaws (errors, mistakes) during design, production, or installation. Unlike failures, which always appear in time (generally randomly distributed), defects are present at t=0. However, some defects can only be detected when the item is operating and are referred to as "dynamic defects". Similar to defects, with regard to the cause, are systematic failures; they are not necessarily present at t=0

[3] Nonfulfillment of an intended usage requirement or reasonable expectation, including one concerned with safety

Note: The expectation must be reasonable under the existing circumstances.

Defect- Immunity (only used for software)

[2] The capability of the Software product to maintain a level of performance when used under specified conditions

Note:

Wear or ageing does not occur in software. Limitations in "reliability" are due to faults in requirements, design, and implementation. "Failures" due to these faults depend on the way the software product is used and the program options selected rather than on elapsed time.

Dependability

[1] Collective term used to describe the availability performance and its influencing factors, such as reliability performance, maintainability performance, and logistical support performance

[3] Collective term used to describe the availability performance and its influencing factors, such as reliability performance, maintainability performance, and logistical support performance

Note 1: Dependability is used only for general descriptions in non-qualitative terms

Note 2: Dependability is one of the time-related aspects of quality

Note 3: the definition of dependability and note 1 given above are taken from IEC 50(191), which also includes related terms and definitions.

[5] together capacities of a product allowing it to arrange functional specified performances at the deliberate moment, during foreseen duration, without damages for itself and for it's environment

Durability

[4] Capacity of an Item to execute a required function in specified conditions of use and of maintenance until it's end of useful life or until it does not meet any more with it's expected economical or technological requirements

ESS Environmental Stress Screening

ESS is a test or a set of tests intended to remove defective items, or thoses likely to exhibit early failures. The applied stress levels are normaly similar as those expected in field operation.

Remark: ESS is often performed at assembly level (PCB) or equipment level on a 100 % basis to find defects and/or systematic failures during a preproduction phase or to provoke early failures during the series production and therefore to improve the reliability of a lot of items by elimination of the defectives one. To be efficient and cost effective, ESS has to be tailored to the kind of item and the used production process.

Failure

[1] Termination of the ability of an item to perform a required function.

Failure Rate $\lambda_{(t)}$

[1] The failure rate of an item is the probability (referred to dt) of a failure in the interval (t, t+dt) under the condition that the item was new at t=0 and did not fail in the interval (0,t)

Fault

[1] State of an item, characterised by the inability to perform a required function, excluding inabilities due to preventive maintenance, other planed actions or lack of external resources.

A fault can be a defect or a failure, having thus as possible cause a flow (error, mistakes) during design, production or installation (for defect or systematic failure) or a failure mechanism (for failures)

Fault

I__ Defect [as result of flaws (errors, mistakes) during design, production or installation]

I__ Failure [as result of a failure mechanism]

FMEA Fault Modes and Effects Analysis

[1] Quantitative method of reliability analysis which involves for each element of an item the investigation of possible fault modes, and of the corresponding effects on other elements as well as on the required function(s) of the item
(see also FMECA)

FMECA Fault Mode, Effect and Criticality Analysis

[1] Qualitative/quantitative method of reliability analysis which includes the analysis of fault modes and effects (FMEA) while considering for each fault mode the probability of occurrence and ranking of its severity
The Goal of an FMEA or FMECA is to determine all potential hazard and to analyse the possibilities of reducing their effects or their probability of occurrence. All possible failure- and defect-modes and -causes have to be considered from the lowest to the highest integration level of the item considered (FMECA was formerly used for "Failure Mode, Effect and criticality Analysis" by considering only the possible <u>*failure modes*</u> *and corresponding effect and criticality)*

FTA Fault Tree Analysis

[1] Analysis to determine which fault modes of the elements of an item and/or which external event may result in a stated fault mode of the item considered, presented in the form of a fault tree.
(FMEA is a top-down approach, which allows the inclusion of external causes more easily than an FMEA or FMECA)

Functionality (Capability, Technical Performance)

[2] The capability of a product to provide the required function when it is used under specified conditions.

[1] Ability of an item to meet a service demand of stated quantitative characteristics under given conditions

HALT Highly Accelerated Life Testing

HALT is a type of highly accelerated test for the identification of design- and process- weakness by applying a combination of thermal shocks and multi axis (3 axis with totally 6 degrees of freedom) vibration stress.

Remarks:

1) During the test the unit under Test must be operational

2) Contrarily to ESS is HALT not a screening method but a test intended to verify the result of a development or the quality of the manufacturing process after a preserie. Consequently the applied stress levels are normally still higher then for HASS.

3) To reduce the test time and the among of items to be tested, the applied stress are much higher than those expected in field operation. Items going through HALT shall not any more be sell.

4) The results of HALT are used to defined the stress limits for HASS

HASS Highly Accelerated Stress Screening

HASS is a screening method, like ESS, but the applied levels of constraint are far above the specified values while staying below the destructive limits . The aim of HASS is to increase the reaction velocity of the failure mechanisms and consequently to reduce test time.

Remarks:

- The purpose of HASS is not to highlight design problems, but to detect any defects in the unit that have arisen during the production process before the unit cams in it's using phase.
-The gain of HASS, compared to ESS, is first the time-factor but also the ability to detect weak points which would not be detected by normal ESS during it's test-time.
-Typically the HASS limits are determined by the HALT results

HAST Highly Accelerated Stress Test

(Definition given by Henri)

Development Test where the applied constraints rose in a progressive way in very upper values in comparison to the qualification specified values and the essential objective of which being to investigate the limits of functioning and of destruction of the product in order to push them away, by suited actions, in the limits imposed by the state of the art of technology of its constituents. This is defined as the stress level at which a small increase in stress causes a large increase in the number of failures. Highly Accelerated Test brings robustness or design margins to the product.

Life Cycle LC

LC consist of all phases of the life of an item including acquisition, operation, storage, maintenance and disposal.

Life Cycle Profile LCP

The Life Cycle Profile LCP is the sum of all state of an item under given conditions over the complete Life Cycle of the item. (The Life Cycle Profile defines the required functions and the environmental conditions during the different Life Cycle Phases as a function of time)

Lifetime T_L

T_L is the Time span between the start of operating and a failure of a nonrepairable item (for repairable items the term " **Useful Life**" is used.

Logistical Support

[1] All activities undertaken to provide effective and economical use of an product during ist operating phase.

Maintainability

[1] Probability that preventive maintenance or repair of an item will be performed within a stated time interval for given procedures and resources.

Remark:

A qualitative definition is:

Ability of a product to be retained in or restored to the ability to perform its required function in a given time interval under stated procedures and resources.

Maintainability is subdivided in serviceability (preventive maintenance) and reparability (corrective maintenance or repair)

Mean Time Between Failures MTBF

[1] MTBF= 1/ λ is the expected value (mean) of the item's failure-free operating time under the condition that the item was new by starting the operating time**.**

MTBF should only be used for items with constant failure rate λ. For items with time-dependent failure rate $\lambda_{(t)}$ the term MTTF= Mean Time To Failure shall be used

Mean Time To Failure MTTF

[1] MTTF is the expected value (mean) of an item's failure-free operating time under the condition that the item was new by starting the operating time.

Mean Time To Mission - Failures $MTTF_M$

$MTTF_M$ is the expected value (mean) of the operating time of an item without any failure which would prevent the fulfilment of a defined mission (failures not having an influence on the mission are not relevant for $MTTF_M$)

Mean Time To Preventive Maintenance MTTPM

[1] MTTPM is the expected value (mean) of an item's preventive maintenance time

Mean Time To Repair MTTR

[1] MTTR is the expected Value (mean) of an item's repair time

Mission Profile MP

[1] The Mission Profile MP is a specific task which must be fulfilled by an item during a stated time under given conditions (The Mission Profile defines the required functions and the environmental conditions as a function of time)

Operational Availability; Point Availability

[1] Probability that a product will perform its required function under given conditions at a stated instant of time.

Operational Effectiveness

Capability of an item to fulfil the specified functional requirements.

Qualification

[3] Process of demonstrating wether an entity is capable of fulfilling specified requirements.

Reliability

[1] Probability that a product will perform is required function under given conditions for a stated time interval.

Remark:

This does not mean that redundant parts may not fail. Such parts can fail and be repaired.

Safety

[1] Ability of a product to cause neither injury to persons, nor significant material damage or other unacceptable consequences

Remark:

Safety is subdivided into accident prevention (the product is safe working while it is operating correctly) and technical safety (the product has to remain safe even if a failure occurs)

[3] State in which the risk of harm (to persons) or damage is limited to an acceptable level
Note 1: Safety is one of the aspects of Quality
Note 2: The above definition is valid for the purposes of quality standards. the term "safety" is defined differently in ISO/IEC Guide 2

Security

[2] The capability of the Software product to protect information and data so that unauthorised person or systems cannot read or modify them and autorised persons or systems are not denied access to them.

System effectiveness

Characteristic of an item to fulfil the required functions with the best possible ratio between using profile and lifecycle costs.

Supportability, Maintainability (for software)

[2] The capability of the software product to be modified. Modifications may include corrections, improvements or adaptation of the software to change in environment, and requirements and functional specifications.

Time Between Preventive Maintenance TBPM

TBPM is a predetermined time interval between 2 preventive maintenance actions.

Remark:

An item may required several different TBPM. in this case, the shortest one is specified and normally the longer TBPMs are multiples of the shortest one.

Usability

[2] The capability of a product to be understood, learned, used and efficient for the user, when used under specified conditions.

Useful Life

[1] Total operating time of a product, ending for a nonrepairable product when the failure probability becomes too high or the product functionality is obsolete, and for a repairable product when the intensity of failures becomes unacceptable or when after a failure the product is considered to be no longer repairable.

Remark:

The term "Life Time" is only used for nonrepairable products. It is the time span between initial operation and failure of a nonrepairable item.

Validation

[3], confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled

Notes:

1) In design and development **Validation** concerns the process of examining a product to determine conformity with user needs
2) **Validation** is normally performed on the final product under defined operating conditions. It may be necessary in earlier stages.
3) The term **"validated"** is used to designate the corresponding status
4) Multiples **Validations** may be carried out if there are different intended uses.

Remark:

Validation is done against the "Product Specification" with the aim to prove that the customer requirements are fulfilled.

Verification

[3] confirmation by examination and provision of objective evidence that specified requirements have been fulfilled

Notes:

1) In design and development **Verification** concerns the process of examining the result of a given activity to determine conformity with the stated requirements for that activity
2) The term **"verified"** is used to designate the corresponding status

Remark:

MIL-STD 961 uses the following definition of **Verification** which is not compatible with the ISO-definition and from the CEEES- point of view shall not be used.

Verification:

All methods (Analysis, Demonstration, Examination and Test) to be performed to determine that the entity to be offered for acceptance conforms to all requirements of the specification.

Referenced Documents

[1] A. Birolini, Quality and Reliability of Technical Systems
Springer- Verlag

[2] ISO/IEC 9126-1, Software Engineering - Product Quality Part 1

[3] EN ISO 8402 Quality management and quality assurance - Vocabulary

[4] Reliability, Maintainability and Availability, October 1993

[5] BNAE RG Aéro 00040

[6] MIL-STD-961 Defense Specifications

Attachment 2

1.0 **What is a Feasibility Study?**

A feasibility study is designed to provide an overview of the primary issues related to a technical and business idea. The purpose is to identify any "make or break" issues that would prevent the test from being successful. In other words, a feasibility study determines whether the technical issues make sense, as well as the business issues but I am concerned with technical issues here.

A thorough feasibility analysis provides a lot of information necessary for the technical plan. For example, a good market analysis is necessary in order to determine whether the project is feasibility. This information provides the basis for the market section of the business plan.

Because putting together a technical and business plan is a significant investment of time and money, you want to make sure that there are no major roadblocks facing you when the test plan is finalized and you make the investment in time and equipment. Identifying such roadblocks is the purpose of a feasibility study.

A feasibility study looks at three major areas:

1. Market issues (Not dealt with)
2. Organizational/technical issues
3. Financial issues (Not dealt with)

Again, this is meant to be a "first cut" look at these issues. For example, a feasibility study should not do in-depth long-term financial projections, but it should do a basic break-even analysis to see how much revenue would be necessary to meet your operating expenses.

The purpose of the business plan is to minimize the risk associated with a new business and maximizes the chances of success through research and maximizes the chances for success through research and planning.

(cf. University of California)

Technological Issues

The cost and availability of technology may be of critical importance to the feasibility of a project, or it may not be an issue at all.

For example, a service organization, such as a childcare centre, will have a few equipment and other technology- related issues to address. A manufacturing enterprise, on the other hand, may have a number of complex technology questions to analyze in order to determine whether or not the business is feasible.

Key questions to answer include:
a. What are the technology needs for the proposed business?
b. What other equipment does your proposed business need?
c. Where will you obtain this technology and equipment?
d. When can you get the necessary equipment?
How does your ability to obtain this technology and equipment affect your start-up timeline?
e. How much will the equipment and technology cost?
Keeping in mind that technology doesn't necessarily mean complex machinery; if your business simply needs a personal computer, printer, and fax machine, those are your technological needs.
However, making wise decisions on even simple purchases such as office machines may require some research. Obviously there are numerous types of personal computers on the market. You many want to check Consumer Reports for their recommendations, do some comparative shopping, and ask acquaintances about their experiences with different companies. Your cost estimates will get plugged into your financial projections.
Naturally, the more complex the technology you need, the more research that will be required to make good decisions about it. This is important and should not be looked at trivially.

Feasible:
“an examination of a situation to decide whether a suggested method, plan or piece of work is possible or reasonable”.

Feasibility: noun {U}
Whether something is feasible:
"People who consider only price, and not value, are the lawful prey of those who purvey shoddy goods" John Ruskin (1819 - 1900)

In the commercial market we have to decide what we trying to achieve with a certain test. The main thrust is always the reliability of the product being manufactured.
The product life cycle begins at the component level and continues through assembly level; the life cycle includes exposure to the following environments

Assembly/process
Testing
Storage
Transportation
Operating
Servicing (preventive and corrective maintenance)

2.1.1 Assembly/Process

During processing and assembly of electronic assemblies, temperature excursions take place, e.g. soldering including reflow, cleaning or imposed thermal cycling tests. These temperature excursions can be damaging to some parts of the assembly and consume some part of the available life. This damage should be minimized by keeping the number of excursions to a minimum and the damage needs to be considered in the overall reliability estimates.

2.1.2 Testing

When devising the overall reliability test plan the frequency of applied test to the device and the fatigue that the testing induces into the product will be identified.

2.1.3 Storage

Storage tests will be defined by the product specification. The storage life of the product will be identified which may range from a few months to many years. A storage life cycle may include storage in a mobile unit to storage in a temperature-controlled warehouse.

2.1.4 Transportation

Transportation is not a single event that is simply defined. Each vehicle type may impose unique environmental loads. Each may also provide protection from certain environmental conditions. Duration and frequency of occurrence will influence how environmental effects are accumulated over time. The transportation configuration and degree of loading can also affect the loads imposed on the product.

2.1.5 Operating

It is assumed that the operational characteristics will not affect the reliability test as the unit is a low power device and operational tests.

2.1.6 Environmental Stress Screening (ESS)

ESS has the potential to identify latent defects that may cause early failures in a product. ESS needs to be specifically designed to accelerate the failure of 'weak' elements in the assembly. ESS does not add to the number of such failures but causes them to occur in a significantly shorter period of time.
Effective ESS programmes should be supported by well planned `Root Cause Analysis' (RCA) and corrective action resources. These enable timely corrective actions, elimination of latent defects and ultimate removal of the ESS process subject to continued monitoring and control of the manufacturing process.

3.0 Conclusion

All the above tests will be scrutinized during a feasibility study, equipment, infrastructure human resource and all the associated cost that go with these requirements.
This is the first part in looking at a reliability test programme.

Colin Weetch

Attachment 3

Highly accelerated tests

1	Test objective (purpose,definition…)	Test where the applied constraints rose in a progressive way in very upper values in comparison to the qualification specified values and the essential objective of which being to investigate the limits of functioning and of destruction of the product in order to push them away, by suited actions, in the limits imposed by the state of the art of technology of its constituents.
2	What is driving you for performing the test?	- time to market of the product - safety consideration (avionics) - maintnability costs - technological limit: the limit of resistance imposed by the technology of a product or of a particular constituent, toward a given constraint (temperature, vibration, electric tension, etc.). This limit establishes so an unbridgeable barrier. Ex: melting point of a plastic building material, temperature the maximum of a functioning a semiconductor in the silicon, elastic limit of a building material, etc.
3	Level of assembly of the product submitted to test	At the lowest possible level of assembly
4	Number of items submitted to test	The statistical aspects in relation with the number of realized HIGLY ACCELERATED TESTS on a new product intervene to at least two levels: - The capacity of the HIGLY ACCELERATED TESTS to discover relevant causes of failing; - The obtaining the limits of functioning and / or of destruction and the associated variableness. With regard to the capacity of the HIGLY ACCELERATED TESTS to discover relevant causes of failing, two cases are be considered: - 1-st case: the relevant causes of failing presumed are of abstract nature and have for effect to reveal a problem on every copy subjected to attempt, since an applied constraint exceeds the specified value. It is translated generally by an incapacity of margins, typical case of the use of a badly calibrated constituent. In that case, the realized HIGLY ACCELERATED TESTS on a very limited sample of copies, even on the single copy, turns out effective to reveal the existence of the relevant cause of defect and power so to correct it. - 2-nd case: the relevant causes of failing presumed can affect a priori only a weak fraction of the complete population of the product (for example: less than 5 % of the population). In that case, it is not very probable that a limited number of HIGLY ACCELERATED TESTS allows to reveal this relevant cause. As example, the use of the model binomial indicate us that if one hopes to reveal an relevant cause of failing affecting only 5 % of the population with a probability of the success of 80 %, it would be necessary to subject about 30 copies to the test of HIGLY ACCELERATED TESTS. Such quantity is totally incompatible with the imperative manufacturers. Consequently, the HIGLY ACCELERATED TESTS realized in the phase of conception / development on an always very limited number of

		copies can not have a great efficiency toward the revealing of this type of defects. Only, higly accelerated ESS (HASS) in the phase of production will be susceptible to reveal, in addition to the manufacturing defects, these defects of the conception which would affect only a weak fraction of the products during their profile of life. With regard to the obtaining the limits of functioning and / or of destruction of the product, the major difficulty places itself in the statistical character associated to these sizes. So, the obtaining in a different way given value on the limit of functioning the single copy does not reveal inevitably the central value of the statistical distribution of this limit which could be associated to an important population of the tested product. In particular, this unit experimental value can be a value of tail of distribution, placed to the left or to the right of the distribution. It proves why it is hardly recommended, when it is compatible with the imperatives of development, to make the HIGLY ACCELERATED TESTS on several copies and not on the single unity. The number of available copies being always very limited in the phase of development; one can consider that a number of unities which are able to go from 3 to 5 establish an acceptable compromise.
5	Type of product relevant to be submitted to the test (mass volume low price product ,..)	**1. Factors bound in costs and in the strategic context** " Strategic aspects bound(connected) to the market (ex: any right for the error from the launch of the first copies on the market, maturity of the product from the starting, …) " The imperatives of reducing the costs of resumption of the defects of conception " The imperatives of reducing the times of development " The imperatives of reducing the durations of ESS " Also applicable in case of change of technologies if conditions of use are corresponding to a light environment " High mass production with weak environmental conditions " off the shelf equipment submitte to light environment in operation **2. bound(connected) Factors on the return to experience (REX)** " The insufficient operational reliability of similar products already developed and produced by the company (REX in operation) " Numerous problems generated in production on similar products of the previous generation (REX in production) **3. Factors bound to the uncertainties**

		" The use of technologies in very innovative character or of the new strategies of implanting of constituents " Use of new processes in production " The conditions of employment of the product not or little tried " Strong variableness of the profile of use of the product (ex: produced " general public ") " Strong variableness of the performances or of characteristics of the product in some constraints of environment or of use " Supply beside new suppliers " The use of constituents except specification (ex: the case of constituents " civilians " used in the military or spatial applications)
6	Test duration (days, weeks, months..)	" The duration of a higly accelerated tests campaign is very brief : of the order of 5 days on average
7	Separate or combined environments	Combined environments are not a condition but can be employed if necessary to disclose a failure. For example, we can gradually increase the vibration level for a given rate of temperature variation or by increasing gradually this rate for a given level of vibration.
8	Product strength and environment stress variabilities are or aren't considered (in the process of deriving the test severity)	no
9	Does the test bring knowledge on reliability parameters ?	no
10	Does the test consume totally or partially the life potential ot the equipment submitted to test ?	Yes , the product under test is normally destroyed
11	main norms , standards, technical references relative to this type of tests	no

Attachment 4

Accelerated tests; proposal: Helge Palmén

1	Test objective (purpose,definition…)	Objective: to make quicker investigations in reducing the test duration. Principle: the product is subjected to conditions of use or to constraints of environment amplified in order to accelerate the mechanisms of failure and to reduce the necessary duration to estimate some behavioral characteristics of the product in the normal conditions of employment Don't make the confusion between the "accelerate testing" with "highly accelerate testing" whose aim is very different (see § XX). The accelerate testing has nothing to do with ESS or highly accelerated tsting. Conditions of application : Know the analytical model making the relation between the mechanism of falure with the amplitude and duration of the applied conditions . Know the value of the parameters involve in these models The provoked mechanisms of failure have to be representative of those arising in the normal conditions of use The phenomena of interactions between several constraints of use and of environment must be taken into account. Testing is done until failures take place and the key is to understand the failures and their relationship to the applied stresses and to correct them. Accelerated life testing is performed to obtain information about the product (component, module, system etc.) lifetime distribution or a particular reliability parameter in a timely manner. This can be done in two different ways or in a combination of them: - using time compression, for example by changing the length of on and off cycles - accelerating the loading conditions The purpose of life testing is to identify the relevant failure mechanisms that would occur, and correlate these with the point in the product's life the failure would occur. All the stresses during the product's whole life cycle need to be addressed – e.g. transportation, storage and the actual use conditions. These conditions usually include different and changing temperatures, humidity, mechanical stresses (vibrations, shock, bumps etc.), electrical and electromagnetic phenomena etc.
2	What is driving you for choosing the test?	- time to market of the product To be generalised
3	Level of assembly of the product submitted to test	Quite often the greatest benefit of accelerated tests (in term of knowledge acquisition) is achieved by performing tests at the lowest level of assembly. Test should also be made early in the product development process. However, testing should be continued during the different phases of the product development and the production phases.
4	Number of items submitted to test	For statistical confidence the need is often higher than what is practically possible ; about five being a minimum but few tens would be needed. In general one ; the application on higher amount might be a response for product variability considerations : see following § 8
5	Type of product relevant to	All types.

	be submitted to the test (mass volume low price product ,..)	
6	Test duration (days, weeks, months..)	Accelerated stress test can be made variably in days or few weeks. Life testing typically requires several weeks, even some months.
7	Separate or combined environments	Different types of stresses are needed to precipitate the different failure mechanisms. Their simultaneous combination is sometimes necessary. Proper combination of stresses may be used to realise synergistic effects – for example thermal cycling and vibration. Humidity is also usually applied with constant or varying temperature.
8	Product strength and environment stress variabilities are or aren't considered (in the process of deriving the test severity)	Yes.
9	Does the test bring knowledge on reliability parameters ?	Life testing aims at getting an estimate of for example of the failure rate (or MTTF, MTBF) or the on-set of wear-out mechanisms (life time) or at least the relevant failure mechanisms.
10	Does the test consume totally or partially the life potential of the equipment submitted to test ?	Accelerated stress tests and life tests are destructive.
11	main norms , standards, technical references relative to this type of tests	- Environmental testing, accelerated stress tests: IEC 60068-2 – standard series - Mechanical and climatic test methods (semiconductor devices): IEC 60749 standard series

Accelerated tests, proposal by Henri Grzeskowiak

principle	Conditions of application	Expected results
Objective: reduce the test duration Principle: the product is subjected to conditions of use or to constraints of environment amplified in order to accelerate the mechanisms of failure and to reduce the necessary duration to estimate some behavioral characteristics of the product in the normal conditions of employment	Know the analytical model making the relation between the speed of damage with the amplitude of the applied conditions Know the value of the parameters involve in these models The provoked mechanisms of failure have to be representative of those arising in the normal conditions of employment The phenomena of interactions between several constraints of employment or of environment must be taken into account.	Evaluation of the behavioral characteristics of a product in the normal conditions of employment, it for the compatible periods with the calendar constraints associated to the phase of development of the product

Development test

1) Test objective

Development tests are used to determine the aptitude of components, materials and/or designs to meet the requirements (functional and operational) of a given specification . These tests may prepare for the qualification, or the RDGT or reliability demonstration , but not only : they also can contribute to prepare R&D decisions.

Outgoing from the specified environmental requirements relating to operation, transportation and storage, the appropriate test procedures, the stress levels and the test duration shall be chosen, considering the experiences with earlier development and the know-how of the test specialists.

The test results are used to make design decisions as well as to evaluate the "Reliability" and/or the "Life Time" of a product and to prove the rightness of a design. Therefor the test results, methods, tools and conditions shall be documented and stored on such a way, that the probability of loosing or distracting then is very low.

1) What is driving you for performing the test ?

The tests are done during the development and design phase of a project with two aims:

- to determine the ability of materials, components and/or designs to resist on effects of specified environmental conditions, where experience is missing and/or calculation or virtual simulation is not possible or not enough accurate.
- to determine the ability of a design solution to meet the functional requirements of a given specification.

While being an substantial part of development costs and an important design tool, it is necessary to plan and to budget it at the very beginning of a development project. The principal input for this planning activity is the product specification

3- "Level of assembly of the product submitted to test

Material, component and sub assemblies.

4-Number of items submitted to test

In general one . But several may be retained for qualification in order to reduce the duration of it : the sequence of tests applied to each of them must be in relation with the real sequence expected in the field

5-Type of product relevant to be submitted to the test (mass volume low price product ,..) :

Not relevant for those constrains covered by other specified tests (which must be stated in the test plan) such as higly accelerated tests , …;

6- Test duration (days, weeks, months..) :

Depending of :

- what is the goal of the specific development test
- the type of test : endurance (several hours or days) , reliability (in general 10 times the specified MTBF for one equipment or 10/n for n equipments)

7-Separate or combined environments

As much as possible : to be separated ; not possible in somme specific cases : presence of polymer material in a suspension (requires vibration and temperature) …

To allow to determine the effect of single stress factors on a material or item respectively to avoid the reciprocal influence of several stresses, the test conditions are usually special lab conditions, not equal to the real environmental conditions of the product.

Remark: Combined tests (Humidity/Temperature; Vibration/Temperature etc.) are also often used, but normally applied on the final product and not for the purpose stated out under point 1).

8-Product strength and environment stress variabilities are or aren't considered (in the process of deriving the test severity)

To be seen next time

9 -Does the test bring knowledge on reliability parameters ?

Yes if the test is dedicated to Reliability growth

10-Does the test consume totally or partially the life potential of the equipment submitted to test ?

The sub assemblies , component ……..submitted to test are no more entering in the delivery for the customer

. They might be used for mock up, study or prototype purposes,

11 - main norms , standards, technical references relative to this type of tests

The results of these tests are normally only for internal use (in general not given to the customer) . So the reference to the standards is not mandatory . No known standards are related to the development tests.

Test objective (purpose,definition …)	***The principle of the Highly Accelerated Environmental Stress Screening is to submit equipments coming out of production to levels of constraint far above the specified values while staying below the destructive limits which could have been revealed by a campaign of Highly Accelerated Tests*** The most evident objective of screening is to discover and precipitate any weaknesses in the product ; the consequences are to improve - the operational reliability of the population of similar (same definition) items by precipitating latent failures and removing the weak items - the manufacturing processes - and eliminate residual design defects Its main objectives are to: • Reveal more quickly the latent defects • Detect more quickly the production process faults • Identify the defects that may not have been revealed by a «conventional ESS" operation • Reinforce the product maturity and robustness Other objectives can be associated; either for the supplier, or for the customer : • Detect an unacceptable change in product quality • Reduce the manufacturing and guarantee costs. • Lower the operational maintenance costs. • Obtain a better profitability during the guarantee period. • Establish or preserve the brand image of the manufacturer.
What is driving you	- time to market of robust product

for performing the test?	- safety consideration (avionics,automotive…) - maintnability costs For ESS The above expressed principle where all the products are submitted to constraints levels higher than specified values must be applied in a sensible way in order to preserve the maximum of efficiency, while at the same time keeping the cost at minimum level. The efficiency of an ESS operation (Highly Accelerated or not) must be measured by : • Its capability to reveal the latent defects at the manufacturer premises, (those which, by lack of ESS tests would occur very quickly at the customer location), • and the non reduction, in a substantial proportion, of the healthy products life duration when submitted to high constraints In a conventional ESS, the levels of constraints do not traditionally exceed the specified values, which means that all manufactured products will be submitted to these constraints without any risk regarding their potential life duration. • In the case of Highly Accelerated Environmental Stress Screening, the applied level of constraint is, by definition, far above the specified values and it is therefore advisable to ensure that all the constituents of the product can accept such level without unacceptable effect on the product life duration.
Level of assembly of the product submitted to test	At the lowest possible level of assembly
Number of items submitted to test	The usual ESS rule, which is an integral part of the manufacturing operation, is to apply it to all the manufactured equipments. However in the case of high volume_production, such as car industry , apply ESS to 100 % of the production is impossible for cadence as well as cost reasons (see appendix C). In that case the ESS will be applied by sampling to detect the quality drifts (machines, components …) Before possibly deciding for the implementation of a Highly Accelerated Environmental Stress Screening test, the product must have been prior submitted to a campaign of Highly Accelerated Tests during its development phase, in order to: • put in evidence, and / or correct according to decision, the weak points of the product • determine the operating and / or destructive limits of the product. The existence of known elements or identified during a Highly Accelerated Test, as being technologically weaker than the others, should be taken into account.

	As the case may be: • the level of constraint will be aligned on the limits of the weakest element with the risk not to be high enough for an efficient ESS for the remainder part of the product • the level of constraint will exceed the limits of the weakest element with the assumed risk of premature damage of this part of the product • the ESS will be realised in one single step and a "surrounding *" technique allowing to isolate and / or to protect the weak elements will be implemented • the ESS will be realised in several steps with levels of constraint adapted to every homogeneous part of the product *<u>*Surrounding :</u> Method of protection of elements, aiming to avoid that they will be submitted to too high constraint values* This choice is not neutral, it impacts directly the efficiency of the ESS process, the reliability of the delivered products and the importance of the testing means to put in place. The example of an homogeneous product is a product constituted by a set of electronic cards of identical or nearby technologies. As example, an heterogeneous product is constituted by : sub-sets of different technologies (ex electronic cards, pressure gauges , gyroscope, LCD screen, some analogical components, etc …) sub-sets of different masses sub-sets with different levels of integration (partial shields, closed boxes, etc …)
Type of product relevant to be submitted to the test (mass volume low price product ,..)	***4. Factors bound in costs and in the strategic context*** " *Strategic aspects bound (connected) to the market (ex: any right for the error from the launch of the first copies on the market, maturity of the product from the starting, …)* " *The imperatives of reducing the costs of resumption of the defects of conception* " *The imperatives of reducing the times of development* " *The imperatives of reducing the durations of ESS* " *Also applicable in case of change of technologies if conditions of use are corresponding to a light environment* " *High mass production with weak environmental conditions* " *off the shelf equipment submitte to light environment in operation*

	5. bound (connected) Factors on the return to experience (REX) " *The insufficient operational reliability of similar products already developed and produced by the company (REX in operation)* " *Numerous problems generated in production on similar products of the previous generation (REX in production)* ***6. Factors bound to the uncertainties*** " *The use of technologies in very innovative character or of the new strategies of implanting of constituents* " *Use of new processes in production* " *The conditions of employment of the product not or little tried* " *Strong variableness of the profile of use of the product (ex: produced " general public ")* " *Strong variableness of the performances or of characteristics of the product in some constraints of environment or of use* " *Supply beside new suppliers* " *The use of constituents except specification (ex: the case of constituents " civilians " used in the military or spatial applications)*
Test duration (days, weeks, months..)	" *The duration of a higly accelerated tests campaign is very brief : of the order of 5 days on average*
Separate or combined environments	*Combined environments are not a condition but can be employed if necessary to disclose a failure.* *For example, we can gradually increase the vibration level for a given rate of temperature variation or by increasing gradually this rate for a given level of vibration.*
Product strength and environment stress variabilities are or aren't considered (in the process of deriving the test severity)	*no*

	Does the test bring knowledge on reliability parameters ?	*no*
	Does the test consume totally or partially the life potential ot the equipment submitted to test ?	*Yes , the product under test is normally destroyed*
	main norms , standards, technical references relative to this type of tests	*no*

Environmental Stress Screening (ESS) : production operation consisting to submit the equipment coming out of manufacture to specific tests (climatic, electric, mechanical, …) so as to accelerate the outcome of latent defects in order to eliminate them

Highly Accelerated Environmental Stress Screening (HA-ESS): ESS test during which the values of the applied constraints are far above the specified values.

> *Note: the **HASS** (Highly Accelerated Stress Screening) is a particular case of the "Highly Accelerated Environmental Stress Screening" allowing to combine two environmental constraints (temperatures and vibrations) following a well defined methodology*

Operating limits: level of constraint above which the product does not operate any more properly . When one comes down afterwards from this level, the product performances become again nominal (character of reversibility).

Destructive limit: level of constraint above which the product will suffer irreversible damages , not enabling to come back to nominal performances when the constraint is brought back under the specified value (character of irreversibility).

Following pages are extracted from ASTE guide on HASS , intitled "Environmental Stress Screening for Electronic Equipment using Highly accelerated Tests" . Can be ordered on line on ASTE SITE (google "ASTE").

7.1 - Comparison of both methods

The ESS such as defined in the ASTE document of 1986 will be called « conventional environmental stress screening » by opposition to the "Highly Accelerated Environmental Stress Screening "

This paragraph has for objective to give elements allowing to evaluate the efficiency of the conventional ESS and of the Highly Accelerated ESS

7.1.1 - "Conventional environmental stress screening" method

The experience shows that, for a serial production, some products are much more fragile than others; as shown on the graph below, we have two statistical distributions, the one relative to healthy products , the other to fragile products.

The healthy population is located around a mean value situated beyond the specification.

In the case of conventional ESS use, Highly Accelerated Tests do not have been necessarily conducted during the product development phase and the margin (as defined on the graph) is not known.

In this method, the constraints are generally applied separately, and the laws of defects appearance acceleration are known in principle. One will note also that the constraint level is always lower or equal to the specification value .
It is besides recognised in electronics, that every set containing latent defects will «age» faster than every healthy set (fuse effect).
The following graph then shows that, after a conventional ESS, the healthy population slightly decreases its duration of life.
On the other hand, the products with latent defects failed in majority. But, the constraints being relatively low, and the technical margins being unknown, the danger is that some products with latent defects (weaknesses) could still be identified as being good.

7.1.2 – "Highly Accelerated Environmental Stress Screening" method

In this method, as previously mentioned, it is compulsory to have prior performed a campaign of Highly Accelerated Tests and to have obtained a robust design and a robust manufacture
. Furthermore it will also allow to define margins.
The graph below shows the increase of both the robustness and the margins by the distributions gap (healthy and with latent defects) towards the right, compared to the previous graph. (based on the hypothesis of identical distributions).

For the Highly Accelerated ESS itself, the product robustness (design and manufacture) acquired during the Highly Accelerated Tests, will allow to define a profile which constraints levels will be situated beyond the specifications.
It is certain, even if not easy to demonstrate, that the impact of this ESS on the product life duration will be more important than the one brought by a conventional ESS
This is shown in the following graph, by the more significant translation towards the left of the distributions after Highly Accelerated Tests .

It will of course be necessary to verify that the obtained life reduction is not too important (see detail in paragraph 10 : Validation of the initial profile and of the implemented tests means).
For the products with latent defects, due to the high levels applied, the proportion of the revealed failures is far more important than those obtained with a conventional ESS .

7.2 - Comparison of the environmental stress screening methods

The tab below puts in evidence the differences between the main characteristics of the conventional ESS and of the Highly Accelerated ESS.

ESS Characteristic	**Conventional ESS**	**Highly Accelerated ESS**
Objective	Eliminate the products presenting early defects bound to manufacturing and to the components dispersion	
Principle	The application of constraints within the limits of the product specification	The application of constraints beyond the specification NB: allows to detect the components dispersion
Input data	The product specifications and its life profile	Knowledge of the operation margins and of the product limitations NB: The product robustness has been improved by increasing the operation margins (tolerance increased in components dispersal)
Responsibility	Manufacturing only	R&D and Manufacturing
Constraints application mode	sequential type :Temperature, vibration,…	Combined : temperature., mechanical shocks , electric constraints,…
Efficiency	Moderate or weak on the stabilized products	Good : increased efficiency in terms of control of the operation margins Maturation and faster mastery of the manufacturing process
Profile acquisition	Long and iterative because based on the return of experience 1 year or more	Fast due to the methodology Around 3 to 6 months
Speed	Indicative duration: 2 to 4 days	Indicative duration : 2 to 8 hours (reduces the production cycles)

7.3 - Other advantages

In addition to the benefits already mentioned in paragraph 5, the implementation of the Highly Accelerated ESS presents the following advantages:

- A standard process applicable by the Company both internally and externally
- The facilitation of the dialogue between the design actors and the manufacturing actors
- The satisfaction for the employees to be better involved in the possibility to touch the state of the art of the manufacturing process ;
- A systematic approach of Quality.

7.4 - Potential problems and precautions:

To set up an Highly Accelerated ESS operation within the manufacturing phase could be delicate, especially at the level of the communication within the company community, and therefore require a certain number of pre-requisites, as follows.

- The implementation of Highly Accelerated Tests at upstream stage being necessary for the definition of the Highly Accelerated ESS profile, it is thus necessary to involve the design teams very early in this process.
- It is necessary to increase the subcontractors awareness in the method , and to draw up with them the adapted procedures; if not, the risk is to get them not adhering to the process, and the manufacturing transfers to them would become difficult.
- A message to the customers explaining the pro's and con's of the ESS process could also become interesting, or even necessary .