



New Reliability Prediction Methodology Aimed at Space Applications

TN-03/04 Fact Sheet on

Requirement specifications and ground rules for the development and Criteria and requirements for the verification of the NRPM

Under a programme of and funded by the European Space Agency

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**Executive Summary
Technical Note 3 & 4**

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Introduction and role of the two Technical Notes

The Technical Notes TN-3 and TN-4 provide the findings and major results of the Task 3 and 4 prepared in the frame of the study “New Reliability Prediction Methodology Aimed at Space Applications”, under a programme of and funded by the European Space Agency.

The objective of the study is the development of a new methodology for reliability prediction (RP) for space applications, aiming to overcome the limitations and shortcomings of the methods and approaches currently used in practice. The final outcome of the study will be a handbook for reliability prediction in space applications, which will serve as an input for the development of a new ECSS handbook. The role of the Technical Notes TN-3 and TN-4 for the overall study is shown in Figure 1.

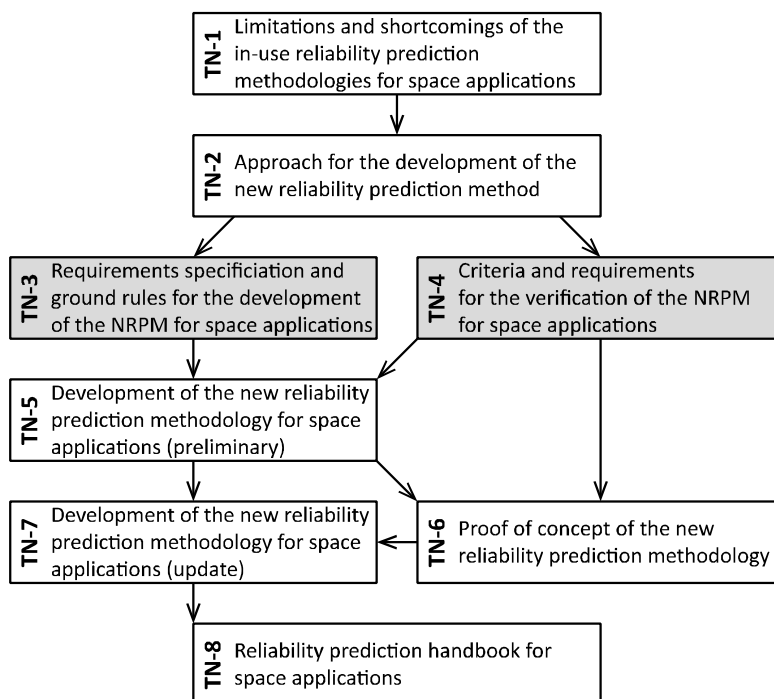


Figure 1: Overview on the content and interrelation of the Technical Notes.

The objective of TN-3 is the definition of requirements specifications and ground rules for the development of the new reliability prediction methodology. It serves as an input for the development of the new methodology, which will be described in TN-5.

The objective of TN-4 is the definition of criteria and requirements to evaluate the value and usefulness of the new methodology, and to determine to which extent the new prediction methodology has the required degree of accuracy and sound technical basis to satisfy the specific needs of space applications. It serves as an input for the proof of concept, which will be documented in TN-6.

TN-3 Executive Summary

TN-3 provides a complete set of ground rules and requirements as an input for the development of the New Reliability Prediction Methodology (TN-5). Ground rules are general rules that have to be kept in mind during the development but cannot be linked to a specific target to check its applicability. The requirements are rooted from the ground rules and are formulated such that they can be verified after the finalization of TN-5.

To ensure completeness, the outline of TN-3 has been developed based on the key characteristics defined in TN-1 (see also TN-1 Fact Sheet), leading to the following main structure

- **Levels within a system:** Parts, equipment/assembly, interfaces and spacecraft level
- **Methodology and Methods:** Specifications related to the overall methodology and to the reliability prediction methods (statistical approach, Physics of Failure, combined approach)
- **Inputs:** Use and preference ordering of manufacturer data, test data, in-orbit return, existing reliability data sources and failure mechanism analysis
- **Characteristics:** Consideration of the confidence in and pertinence of the prediction results
- **Items / technology covered:** Coverage of EEE, Mechanical and Miscellaneous items
- **Failure root causes:** Treatment of Random, Systematic, Wear-out and Extrinsic failures
- **Stress contributors:** Consideration of use conditions and space environment
- **Quality levels:** Quality of EEE, Mechanical and Miscellaneous parts or items
- **Mission and System level modelling:** Mission lifetime, functions and performances, and system level methods

For each of the topics listed above, TN-3 contains relevant definitions, a discussion of the basic concepts and a list of ground rules and requirements for the development of the new methodology.

TN-4 Executive Summary

The purpose of TN-4 is to already define the approach for the verification and proof of concept of the New Reliability Prediction Methodology before starting its actual development. The proof of concept foreseen for TN-6 will comprise both a qualitative evaluation and a quantitative benchmarking of the new methodology.

For the qualitative evaluation, TN-4 starts with a discussion of various needs for reliability predictions in space applications. These needs have been defined based on different sources, including the space stakeholder needs discussed in TN-1 (see also TN-1 Fact Sheet), the vision for the new reliability prediction methodology formulated in TN-2 (see TN-2 Fact Sheet), the criteria for methodology selection

defined in the IEEE Standard Framework for Reliability Prediction of Hardware (IEEE Std 1413TM-2010) and in the associated Guide (IEEE Std 1413.1TM-2002), and a survey performed with users of current methodologies.

Based on the collected needs, verification criteria are formulated as open questions addressing specific aspects of the methodology, which can be grouped under the following three headings:

- **Practicality:** Criteria to assess the feasibility and practicality of the new reliability prediction methodology from a model user's perspective
- **Applicability:** Criteria for the area of application and coverage of the new methodology.
- **Pertinence:** Criteria for the relevance of the methodology regarding its scope and foundations, and for the comparison between prediction and reality.

To assess the fulfilment of each criterion, a set of evaluation requirements is specified, which can be verified once the new methodology is defined (i.e. after completion of TN-5). It is not mandatory to be compliant to all listed evaluation requirements; the goal is rather to highlight the strengths and weaknesses of the new reliability prediction methodology, allowing space community users to evaluate whether their needs are sufficiently addressed.

In addition to this qualitative evaluation, the proof of concept in TN-6 will also include a quantitative benchmark between predictions based on the New Reliability Prediction Methodology, predictions based on other methodologies, and In Orbit Return. To specify the approach for this quantitative benchmarking, TN-4 also contains different requirements for the quantitative assessment:

- **In Orbit Return data collection and processing:** Requirements concerning the estimation of the achieved reliability based on In Orbit Return.
- **Reliability Prediction implementation:** Requirements regarding the way reliability predictions with different methodologies shall be conducted to allow for a relevant comparison.
- **Comparison with In Orbit Return and other methodologies:** Requirements regarding the comparison between predictions and In Orbit Return, and between different methodologies.

Compliance with these requirements can be verified once the quantitative benchmarking in the proof of concept (TN-6) has been completed.