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Raumfahrttechnik - Handbuch zur Analyse von mechanischen Lasten

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European Foreword

This document (CEN/TR 17603-32-26:2022) has been prepared by Technical Committee CEN/CLC/JTC 5 “Space”, the secretariat of which is held by DIN.

It is highlighted that this technical report does not contain any requirement but only collection of data or descriptions and guidelines about how to organize and perform the work in support of EN 16603-32.

This Technical report (CEN/TR 17603-32-26:2022) originates from ECSS-E-HB-32-26A.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any TR covering the same scope but with a wider domain of applicability (e.g.: aerospace).

Preface

The "Spacecraft Mechanical Loads Analysis Handbook" has been developed with the aim to harmonize methodologies, procedures and practices currently applied for the conduct of spacecraft and payloads loads analysis. It makes available to the European Space Community a set of well proven methods, procedures and guidelines for the prediction and assessment of structural design loads and for the evaluation of the test loads. In particular, recent advances in the area of structural dynamics and vibrations, in both methodology and performance, have the potential to make spacecraft system analysis and testing more effective from technical, cost, and hardware safety points of view. However, application of advanced analysis methods varies among the Space Agencies and their contractors. Identification and refinement of the best of these methodologies and implementation approaches has been an objective of the Working Group.

The handbook is intended to be a practical guide rather than a theoretical treatise. The emphasis is on dynamic environments of spacecraft, however other mechanical environments are addressed and often the principles are broad enough to be applicable in many cases to launch vehicles as well. It is assumed that the reader has a general knowledge of spacecraft structures and structural dynamics without necessarily being an expert in these disciplines.

This first edition represents a collection of contributions by a number of engineers from throughout the European Space Community. It reflects the insight gained from their practical experience. The contributions have been harmonised and the handbook completed by the "harmonization team". The level of treatment varies among topics, depending on the issues each author feels is critical and the overall assessment performed by the harmonization team concerning the level of detail in each topic that is important to the loads analysis process.

The book is not intended as a selfstanding textbook since in some cases it is rather complementary to other ECSS documents and more in general to textbooks and publications on spacecraft structures and structural dynamics. It can be a key tool for spacecraft designers, system and structural engineers who need to find out more about mechanical loads analysis and for those in charge of developing requirements and specifications.

The reader benefits best by reading the book sequentially, although most of the chapters are selfcontained, with references to other parts of the book provided as needed. An overview of the chapters is presented below:

- Chapter 4 gives an overview of the loads analysis process aimed at establishing appropriate loads for design and testing.
- Chapter 5 presents a summary of the principles of structural dynamics addressed throughout the different chapters of the present handbook.
- Chapter 6 addresses the launcher / spacecraft coupled loads analyses performed to check that a spacecraft design is compliant with the overall mechanical environment generated by a launcher during all flight phases and to ensure that the mission can be achieved.

- Chapters 7 to 10 deal with analysis and testing related to the various types of mechanical environments generated by the launcher: static in chapter 7, sine vibrations in chapter 8, random vibrations (including vibro-acoustic environment) in Chapter 9, shocks in chapter 10.
- Chapter 11 is devoted to dimensional stability i.e. the behaviour of highly accurate structures to maintain their dimensions under all kinds of conditions.
- Chapter 12 deals with fracture control and fatigue life verification, discussing the various aspects involved in deriving fatigue load spectra to perform analyses or tests.
- Chapter 13 addresses the micro-gravity and micro-vibration environment for which the spacecraft systems should be designed and operated such that limit acceleration levels are not exceeded.
- Chapter 14 is related to soft stowed equipment and the verification process of items packed in foam, to assess the compatibility of the cargo item with the attenuated environments.
- Chapter 15 tackles the problems generated by a nonlinear behaviour of the structures, which can significantly affect the verification process.
- Chapter 16 addresses the mathematical models used for loads analysis, with emphasis on finite element analysis quality and acceptance of the results.

Funding and resources for the handbook were provided by the European Cooperation for Space Standardization leading to the creation of the initial Working Group. However the number of contributors soon increased with time and substantial additional volunteer support was provided by individuals and organizations.

These additional resources have been crucial to the successful accomplishment of the “handbook project”. All the volunteer contributors that have sacrificed their time are gratefully acknowledged, as well as the contributors that made an effort beyond the allocated resources. This first edition of handbook is thus the result of two and a half years of effort by the “enlarged” Loads Analysis Working Group.

A substantial effort has been made to eliminate mathematical and factual errors. Nevertheless it is possible (and likely) that some errors will be found through readers’ use of the handbook. Detected errors along with any omissions, corrections or comments may be sent to either the ECSS Secretariat or to the addresses below. If, as hoped, the book is of use to the space community, it could be updated and made more useful and practical.

1 Scope

This document recommends engineering practices for European programs and projects. It may be cited in contracts and program documents as a reference for guidance to meet specific program/project needs and constraints.

The target users of this handbook are engineers involved in design, analysis and verification of spacecraft and payloads in relation to general structural loads analysis issues. The current know-how is documented in this handbook in order to make this expertise available to all European developers of space systems.

It is a guidelines document; therefore it includes advisory information rather than requirements.

2 References

Due to the structure of the document, each chapter includes at its end the references called in it.