EUROPEAN COOPERATION

E|CSS

FOR SPACE STANDARDIZATION

Space engineering

Adoption Notice of ISO 16290, Space systems - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment

Foreword

This Adoption Notice is one document of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards. Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This Adoption Notice has been prepared by the ECSS TRL Task Force, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Change log

ECSS-E-AS-11C	First issue
1 October 2014	

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1
Scope

This document identifies the clauses and requirements modified with respect to the standard ISO 16290, Space systems - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment, First edition 2013-11-01 for application in ECSS.

2
Context information

The standard ISO 16290, Space systems — Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment, has been developed by ISO TC20/SC14. The TRL description and the achievements that are requested for enabling the TRL assessment at each level have been thoroughly discussed at international level, agreed by the ISO members and published as standard ISO 16290.

Aiming at the development of world wide implementation standards dealing with TRL, ECSS has proactively contributed to the preparation of ISO 16290.

With this Adoption Notice ECSS is adopting and applying ISO 16290 with a minimum set of modifications, identified in the present document, to allow for reference and for a consistent integration in ECSS system of standards.

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3
Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

a. For the purpose of this document, the terms and definitions from ISO 16290 (First edition 2013-11-01) apply, in particular for the following terms:

1. element

2. breadboard

3. laboratory environment

4. mature technology

5. relevant environment

6. reproducible process

7. validation

b. For the purpose of this document the terms from ECSS-S-ST-00-01C, except the terms listed in 3.1a. apply, in particular for the following term:

1. technology readiness level

c. For the purpose of this document the following terms from ECSS-M-ST-10 apply:

1. acceptance review

2. qualification review

3. commissioning result review

3.2 Terms specific to the present standard

None.

3.3 Abbreviated terms and symbols

The abbreviated terms from ECSS-S-ST-00-01 and the following apply.

Abbreviation	Meaning
AR	acceptance review
CRR	commissioning result review
QR	qualification review
TRL	technology readiness level

3.4 Nomenclature

The following nomenclature apply throughout this document:

a. The word "shall" is used in this standard to express requirements. All the requirements are expressed with the word "shall".

b. The word "should" is used in this standard to express recommendations. All the recommendations are expressed with the word "should".

> NOTE   It is expected that, during tailoring, all the recommendations in this document are either converted into requirements or tailored out.

c. The words "may" and "need not" are used in this standard to express positive and negative permissions respectively. All the positive permissions are expressed with the word "may". All the negative permissions are expressed with the words "need not".

d. The word "can" is used in this standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

> NOTE   In ECSS "may" and "can" have a complete different meaning: "may" is normative (permission) and "can" is descriptive.

e. The present and past tense are used in this standard to express statement of fact, and therefore they imply descriptive text.

4
Application

a. ISO 16290, Space systems - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment, first edition 2013-11-01 shall apply in ECSS system apply as written (Section 1 through Section 4) with the following additions and modifications listed in Table 4-1.

NOTE   Table 4-2 is a reproduction of Table 1 of ISO 16290:2013 "TRL summary: Milestones and work achievement".

Table 4-1: Applicability table for ISO 16290

Clause or requirement number	Applicability	Applicable text (the new/added text is underlined)	Comments	Text as in the original document (deleted text with strikethrough)
5	added	Requirements	Title	
5.1	added	General	Title	
5.1a	added	To assess the readiness of an element the TRLs specified in ISO 16290:2013 shall be applied.	requirement	
5.2	added	TRLs requirements	Title	
5.2a	added	A TRL shall not be called TRL1 unless the conditions specified in 3.2.1 of ISO 16290:2013 and Table 4-2 first row are met	requirement	
5.2b	added	A TRL shall not be called TRL2 unless the conditions specified in 3.3.1 of ISO 16290:2013 and Table 4-2 second row are met.	requirement	
5.2c	added	A TRL shall not be called TRL3 unless the conditions specified in 3.4.1 of 16290:2013 and Table 4-2 third row are met.	requirement	

Clause or requirement number	Applicability	Applicable text (the new/added text is underlined)	Comments	Text as in the original document (deleted text with strikethrough)
5.2d	added	A TRL shall not be called TRL4 unless the conditions specified in 3.5.1 of ISO 16290:2013 and Table 4-2 fourth row are met	requirement	
5.2e	added	A TRL shall not be called TRL5 unless the conditions specified in 3.6.1 of ISO 16290:2013 and Table 4-2 fifth row are met.	requirement	
5.2f	added	A TRL shall not be called TRL6 unless the conditions specified in 3.7.1 of ISO 16290:2013 and Table 4-2 sixth row are met.	requirement	
5.2g	added	A TRL shall not be called TRL7 unless: 1. the conditions specified in 3.8.1 of ISO 16290:2013 and Table 4-2 seventh row are met, 2. the element has passed through a successful QR. NOTE This successful QR can be from another programme.	requirement	
5.2h	added	A TRL shall not be called TRL8 unless: 1. the conditions specified in 3.9.1 of ISO 16290:2013 and Table 4-2 eighth row are met, 2. a system, integrating the element, has passed through a successful AR. NOTE 1 This successful AR at system level can be from another programme NOTE 2 Whatever is the hierarchy level of the element in the product tree, TRL 8 for that element can only be achieved upon successful completion of the AR at system level.	requirement	
5.2i	added	A TRL shall not be called TRL9 unless: 1. the conditions specified in 3.10.1 of ISO 16290:2013 and Table 4-2 ninth row are met, 2. a system, integrating the element, has passed through a successful CRR.	requirement	

Table 4-2: TRL summary: Milestones and work achievement (*reproduced from ISO 16290:2013*)

Technology Readiness Level	Milestone achieved for the element	Work achievement (documented)
TRL 1 - Basic principles observed and reported	Potential applications are identified following basic observations but element concept not yet formulated.	Expression of the basic principles intended for use. Identification of potential applications.
TRL 2 - Technology concept and/or application formulated	Formulation of potential applications and preliminary element concept. No proof of concept yet.	Formulation of potential applications. Preliminary conceptual design of the element, providing understanding of how the basic principles would be used.
TRL 3 - Analytical and experimental critical function and/or characteristic proof-of-concept	Element concept is elaborated and expected performance is demonstrated through analytical models supported by experimental data/characteristics.	Preliminary performance requirements (can target several missions) including definition of functional performance requirements. Conceptual design of the element. Experimental data inputs, laboratory-based experiment definition and results. Element analytical models for the proof-of-concept.
TRL 4 - Component and/or breadboard functional verification in laboratory environment	Element functional performance is demonstrated by breadboard testing in laboratory environment.	Preliminary performance requirements (can target several missions) with definition of functional performance requirements. Conceptual design of the element. Functional performance test plan. Breadboard definition for the functional performance verification. Breadboard test reports.
TRL 5 - Component and/or breadboard critical function verification in a relevant environment	Critical functions of the element are identified and the associated relevant environment is defined. Breadboards not full-scale are built for verifying the performance through testing in the relevant environment, subject to scaling effects.	Preliminary definition of performance requirements and of the relevant environment. Identification and analysis of the element critical functions. Preliminary design of the element, supported by appropriate models for the critical functions verification. Critical function test plan. Analysis of scaling effects. Breadboard definition for the critical function verification. Breadboard test reports.

Technology Readiness Level	Milestone achieved for the element	Work achievement (documented)
TRL 6: Model demonstrating the critical functions of the element in a relevant environment	Critical functions of the element are verified, performance is demonstrated in the relevant environment and representative model(s) in form, fit and function.	Definition of performance requirements and of the relevant environment. Identification and analysis of the element critical functions. Design of the element, supported by appropriate models for the critical functions verification. Critical function test plan. Model definition for the critical function verifications. Model test reports.
TRL 7: Model demonstrating the element performance for the operational environment	Performance is demonstrated for the operational environment, on the ground or if necessary in space. A representative model, fully reflecting all aspects of the flight model design, is build and tested with adequate margins for demonstrating the performance in the operational environment.	Definition of performance requirements, including definition of the operational environment. Model definition and realisation. Model test plan. Model test results.
TRL 8: Actual system completed and accepted for flight ("flight qualified")	Flight model is qualified and integrated in the final system ready for flight.	Flight model is built and integrated into the final system. Flight acceptance of the final system.
TRL 9: Actual system "flight proven" through successful mission operations	Technology is mature. The element is successfully in service for the assigned mission in the actual operational environment.	Commissioning in early operation phase. In-orbit operation report.

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