# ISO TRL Definitions and Assessment Criteria

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15th Annual Systems Engineering Conference
San Diego, CA
October 22-25, 2012

# ISO TRL Definitions and Assessment Criteria

- What is ISO?
- The ISO Process
- The ISO TRL Scope
- ISO TRL Working Group Meetings
- TRL Working Group Participation
- The Draft International Standard for circulation.
- Summary

# ISO TRL Definitions and Assessment Criteria

- "ISO (International Organization for Standardization)

is a global network that identifies what International Standards are required by business, government and society, develops them in partnership with the sectors that will put them to use, adopts them by transparent procedures based on national input and delivers them to be implemented worldwide."
  - ISO is not a Government or treaty Organization; like IEC, ITU
  - **Members: 157** national standards bodies (e.g. ANSI)
  - **208** technical committees, **531** subcommittees
- ISO TC20/SC14 Space Systems and Operations– Estab. 1992
  - 12 Participating countries ; 7 Observers ; 7 Liaison Orgs.
  - May 18-22, 2009, Berlin, Germany : 19th Plenary, 31st WG1 meeting,
  - ~100 attendees, 11 countries represented

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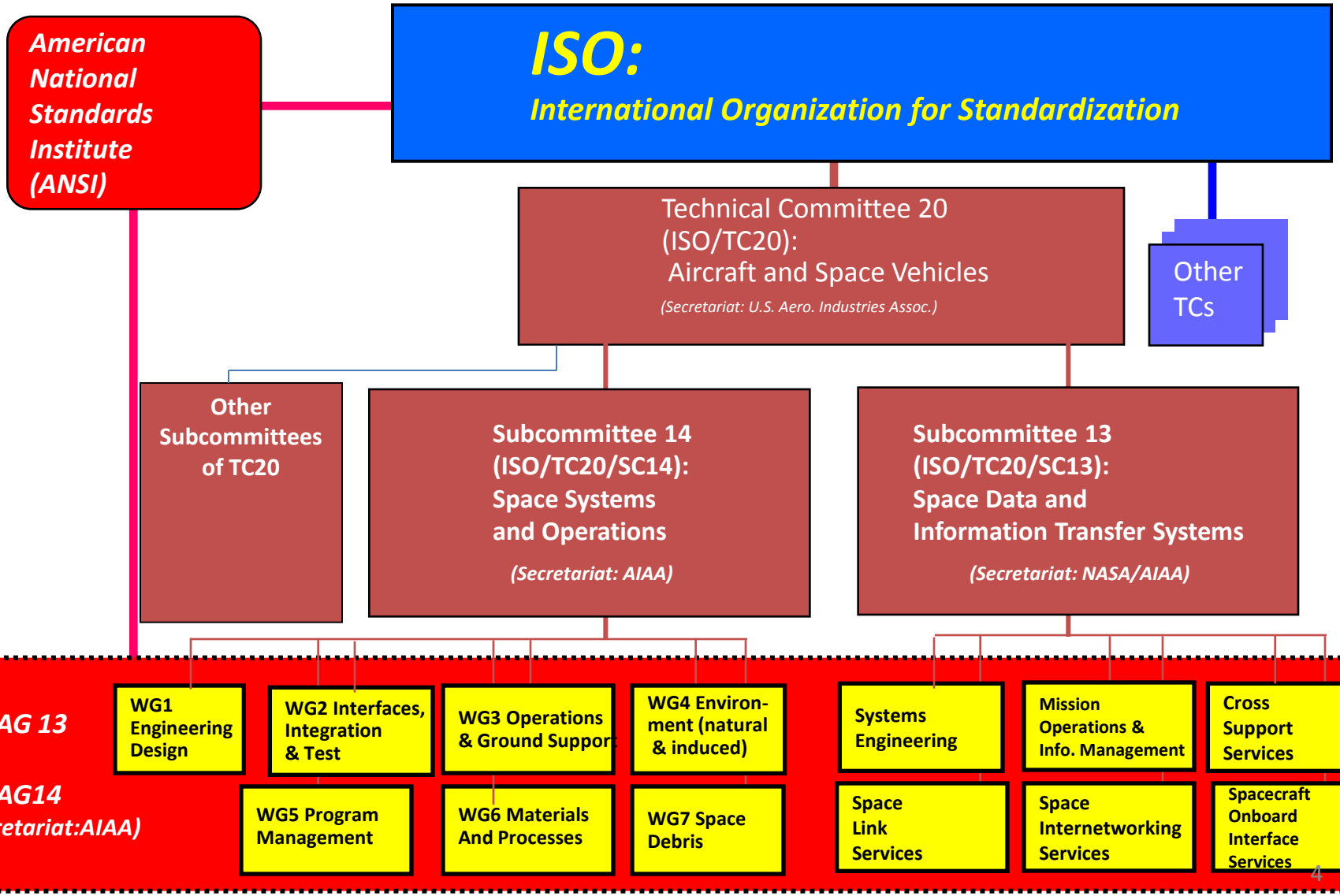

# ISO TRL Definitions and Assessment Criteria

**International harmonized stage codes**

| STAGE | SUB-STAGE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 00 | 20 | 60 | 90 Decision | | | |
| | Registration | Start of main action | Completion of main action | 92 Repeat an earlier phase | 93 Repeat current phase | 98 Abandon | 99 Proceed |
| 00 Preliminary stage | 00.00 Proposal for new project received | 00.20 Proposal for new project under review | 00.60 Close of review | | | 00.98 Proposal for new project abandoned | 00.99 Approval to ballot proposal for new project |
| 10 Proposal stage | 10.00 Proposal for new project registered | 10.20 New project ballot initiated | 10.60 Close of voting | 10.92 Proposal returned to submitter for further definition | | 10.98 New project rejected | 10.99 New project approved |
| 20 Preparatory stage | 20.00 New project registered in TC/SC work programme | 20.20 Working draft (WD) study initiated | 20.60 Close of comment period | | | 20.98 Project deleted | 20.99 WD approved for registration as CD |
| 30 Committee stage | 30.00 Committee draft (CD) registered | 30.20 CD study/ballot initiated | 30.60 Close of voting/comment period | 30.92 CD referred back to Working Group | | 30.98 Project deleted | 30.99 CD approved for registration as DIS |
| 40 Enquiry stage | 40.00 DIS registered | 40.20 DIS ballot initiated: *5 months* | 40.60 Close of voting | 40.92 Full report circulated: DIS referred back to TC or SC | 40.93 Full report circulated: decision for new DIS ballot | 40.98 Project deleted | 40.99 Full report circulated: DIS approved for registration as FDIS |
| 50 Approval stage | 50.00 FDIS registered for formal approval | 50.20 FDIS ballot initiated: *2 months.* Proof sent to secretariat | 50.60 Close of voting Proof returned by Secretariat | 50.92 FDIS referred back to TC or SC | | 50.98 Project deleted | 50.99 FDIS approved for publication |
| 60 Publication stage | 60.00 International Standard under publication | | 60.60 International Standard published | | | | |
| 90 Review stage | | 90.20 International Standard under periodical review | 90.60 Close of review | 90.92 International Standard to be revised | 90.93 International Standard confirmed | | 90.99 Withdrawal of International Standard proposed by TC or SC |
| 95 Withdrawal stage | | 95.20 Withdrawal ballot initiated | 95.60 Close of voting | 95.92 Decision not to withdraw International Standard | | | 95.99 Withdrawal of International Standard |

# ISO TRL Definitions and Assessment Criteria

**ISO TRL WG objectives**

14N665 *Definition of the Technology Readiness Levels (TRL) and their criteria of assessment*

The scope of this project is to standardize the definition of the Technology Readiness Levels (TRL) and of their criteria of assessment.

# ISO TRL Definitions and Assessment Criteria

## ISO TRL Working Group meetings

- British Standards Institute, London, UK, May 11, 2010.
- Centre National d'Etudes Spatiales(CNES), Paris, France, October 26-27, 2010.
- European Space Agency (ESA), Paris, France, March 24-25, 2011.
- Berlin, Germany, May 23-24, 2011.
- European Space Technology Center (ESTEC), Noordwijk, The Netherlands, December 15-16, 2011.
- European Space Technology Center (ESTEC), Noordwijk, The Netherlands, July 9, 2012

# ISO TRL Definitions and Assessment Criteria

**Project Leader: Frédéric Safa (ESA/ESTEC)**

**WG members – Country Leads**

US: Jim Bilbro

FR; Franck Durand-Carrier

Japan: Satoshi Kikuchi

UK: Nicolas Chesher

DE: Andreas Jain (represents also WG5)

Brazil: Paulo Roberto Sakai

Ukrainian: Yuriy Stryzhak

# ISO TRL Definitions and Assessment Criteria

## US Team Members

| Name | Organization |
|---|---|
| Jim Bilbro | JB Consulting International |
| Tim Barth | NASA Kennedy Space Center |
| Neil Dennehy | NASA Goddard Space Flight Center |
| Prasun Desai | NASA HQ, Office of Chief Technologist |
| Mike Ellis | DMD Group Inc. |
| Oscar Gonzalez | NASA, Goddard Space Flight Center |
| Jenny Holzer | Institute for Defense Analysis |
| Hoyt Johnson | DOE, Office of Waste Processing |
| John Kelly | NASA HQ, Office of Chief Engineer |
| Corinne Kramer | Institute for Defense Analysis |
| Steve Kapurch | NASA HQ, Office of Chief Engineer |
| David McGowan | NASA HQ, Office of Chief Technologist |
| Karen Mcnamara | NASA HQ, Office of Chief Engineer |
| Bill Nolte | Air Force Research Laboratory |
| Bob Rassa | Raytheon |
| James Reuther | NASA HQ, Office Chief Techonologist |
| Brian Sauser | Stevens Institute |
| Sandra Smalley | NASA HQ, Office Chief Engineer |
| Ellen Stigberg | NASA HQ |
| Dick Weinstein | NASA Consultant |
| Rich Widmann | Boeing |

# ISO TRL Definitions and Assessment Criteria

- CNES TRL Handbook was the basis of the ISO proposal
- Additional Documents were provided by participants
  - DLR TRL Handbook
  - DoD TRA Deskbook
  - DoD "Technology Readiness Assessment (TRA) Guidance, April 2011
  - NASA SE TRA Process
  - NASA TRL Description & Definitions
- ISO TRL document drew on all of the above sources to develop a consensus set of definitions and criteria.
- Considerable effort was taken to ensure that the resulting document was not in conflict with any of the National documents.

# ISO TRL Definitions and Assessment Criteria

- The ISO TRL Document was submitted for vote and approved (with comments) in May 2012 to be circulated as a Draft International Standard (DIS).

# ISO TRL Definitions and Assessment Criteria

## Result of voting

| Ballot Information | |
|---|---|
| **Ballot reference** | ISO/CD 16290 |
| **Ballot type** | CD |
| **Ballot title** | Definition of the Technology Readiness Levels (TRL) and their criteria of assessment |
| **Opening date** | 2012-02-06 |
| **Closing date** | 2012-05-06 |
| **Note** | |

| Member responses: | |
|---|---|
| **Votes cast (11)** | Brazil (ABNT)<br>China (SAC)<br>France (AFNOR)<br>Germany (DIN)<br>India (BIS)<br>Israel (SII)<br>Japan (JISC)<br>Russian Federation (GOST R)<br>Ukraine (DSSU)<br>United Kingdom (BSI)<br>USA (ANSI) |
| **Comments submitted (0)** | |
| **Votes not cast (1)** | Italy (UNI) |

# ISO TRL Definitions and Assessment Criteria

| Answers to Q.1: "Do you agree to the circulation of the draft as a DIS?" | | |
|---|---|---|
| 6 x | Yes | Brazil (ABNT)<br>China (SAC)<br>Japan (JISC)<br>Russian Federation (GOST R)<br>United Kingdom (BSI)<br>USA (ANSI) |
| 4 x | Yes with comments | France (AFNOR)<br>Germany (DIN)<br>India (BIS)<br>Ukraine (DSSU) |
| 0 x | No | |
| 1 x | We abstain | Israel (SII) |

# ISO TRL Definitions and Assessment Criteria

- Comments were addressed at a meeting in Noordwijk, The Netherlands, July 9, 2012.
- The revised draft for Draft International Standard (DIS) stage was submitted July 17, 2012.
- Voting on the DIS is in progress and is to be completed  December 12, 2012.

# ISO TRL Definitions and Assessment Criteria

| 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.<br>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.<br>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.<br>Conceptual design of the element.<br>Experimental data inputs, laboratory-based experiment definition and results.<br>Element analytical models for the proof-of-concept. |

# ISO TRL Definitions and Assessment Criteria

| | | |
|---|---|---|
| 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.<br>Conceptual design of the element.<br>Functional performance test plan.<br>Breadboard definition for the functional performance verification.<br>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.<br>Identification and analysis of the element critical functions.<br>Preliminary design of the element, supported by appropriate models for the critical functions verification.<br>Critical function test plan. Analysis of scaling effects.<br>Breadboard definition for the critical function verification.<br>Breadboard test reports. |

# ISO TRL Definitions and Assessment Criteria

| | | |
|---|---|---|
| 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.<br>Identification and analysis of the element critical functions.<br>Design of the element, supported by appropriate models for the critical functions verification.<br>Critical function test plan.<br>Model definition for the critical function verifications.<br>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.<br>Model definition and realisation.<br>Model test plan.<br>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.<br>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.<br>In-orbit operation report. |

# ISO TRL Definitions and Assessment Criteria

## Summary

- A set of explanatory material to accompany the circulation of the DIS will be developed by the team at the Program Management Working Group (WG #5) meeting in Paris, November 13-15, 2012.
- The document should be available as an ISO standard by early summer 2013.

# ISO TRL Definitions and Assessment Criteria

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