Recent status of lean satellite related standards

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Lean Satellite

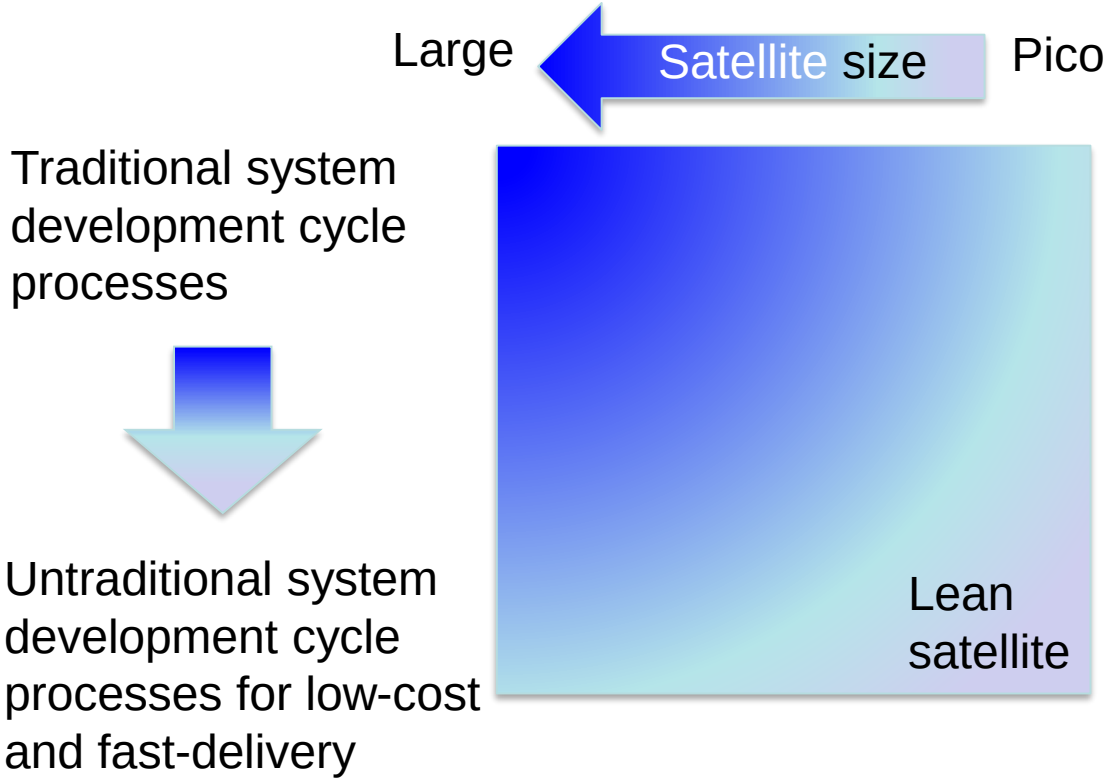
- International Workshop on Small-Scale Satellite Standardization (IWS4)
  - November 18 – November 20, 2014 at Kyushu Institute of Technology, Kitakyushu, Japan
- Round Table Discussion
  - Definition of small satellite (Panel discussion & brain storming)
  - "Mass" nor "size" is not suitable for definition of the satellites of current concern
    - "Small satellite" is not an appropriate word
  - Should be defined by philosophy of design, manufacturing, mission, program management, etc
- Finally agreed on "**Lean Satellite**"

Workshop proceeding is available on website

Google "NETS satellite standard"

Lean satellite

A lean satellite is a satellite that utilizes non-traditional, risk-taking development and management approaches – with the aim to provide **value** of some kind to the customer at low-cost and without taking much time to realize the satellite mission.



When we adopt untraditional development processes to achieve low-cost and fast-delivery, the size becomes inherently small

Lean Satellite

- Further study on lean satellite was conducted at IAA study group 4.18, “Definition and Requirements of Small Satellites Seeking Low-Cost and Fast-Delivery”
- The study group final report is under review by IAA

- For the rest of presentation, the wording of “lean satellite” will be used

Lean satellite issues

- Explosive growth of lean satellites in orbit
  - Concern over debris and safety
- Commercial application of lean satellites
  - Reliability of individual satellites is low
  - Different way of achieving the mission success
- Frequency
  - Lengthy process of frequency coordination
  - Concern over compliance with ITU rule
- Lean satellite is the fast growing area in the space sector
  - Under-50kg satellite market expected to grow to 1.8BUSD in 2019 form 0.7BUSD in 2014
- To promote the growth of lean satellite further
  - Launch, satellite technology, ground station, development & testing infrastructure, international standard, investment promotion, etc

Standards, regulation and law

- Standard
- Regulation
- Law

- Standards are made based on consensus
- It is voluntary whether you adapt it or not
- No sanction for violation as long as it stays as a *standard*

Why do we need standard?

- In perfect world, everybody trusts each other.

Photo: Asahi Shinbun

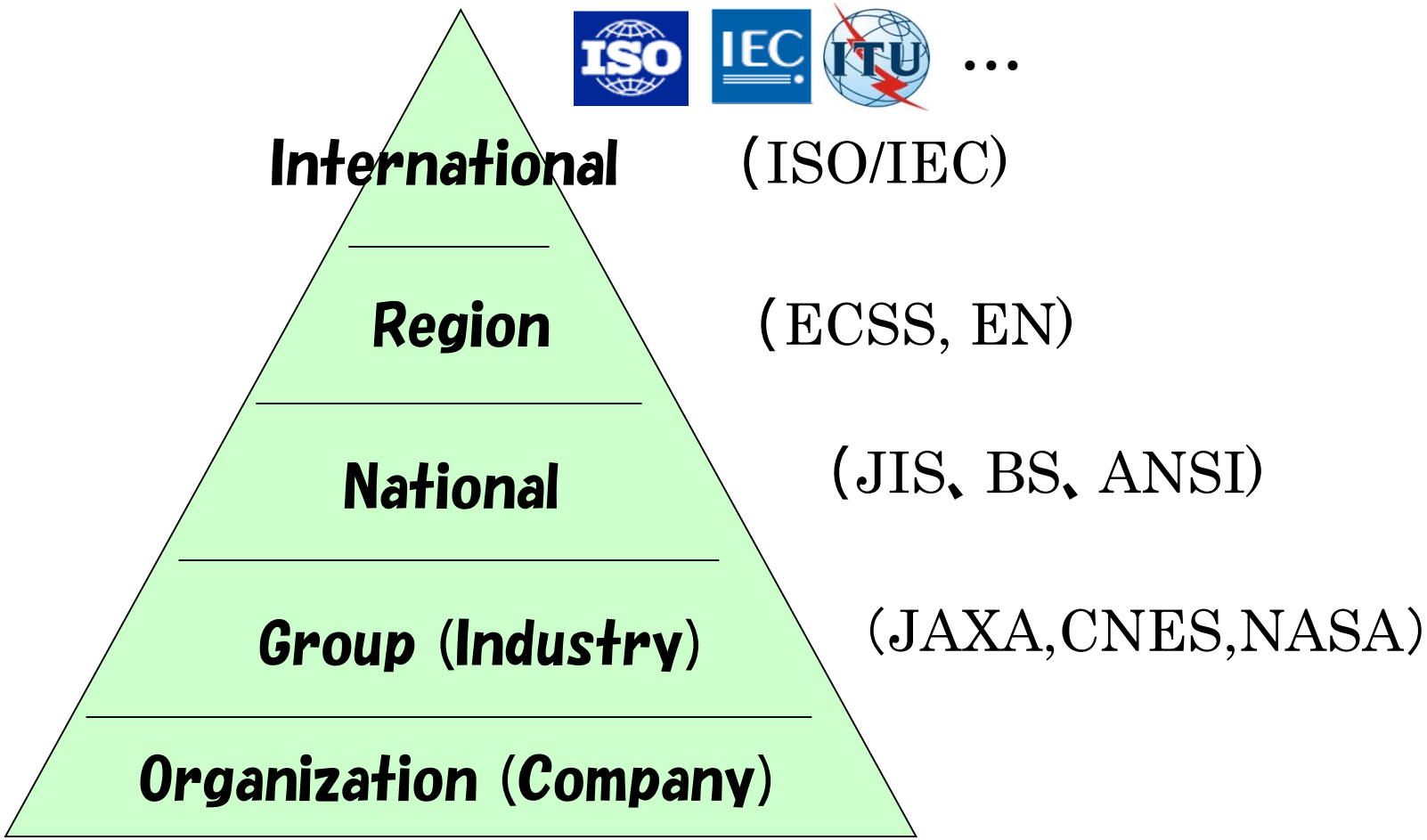
Why do we need standard?

- But, we live in an imperfect world

Photo: Asahi Shinbun

Tier Structure of Standards

International: the First Tier



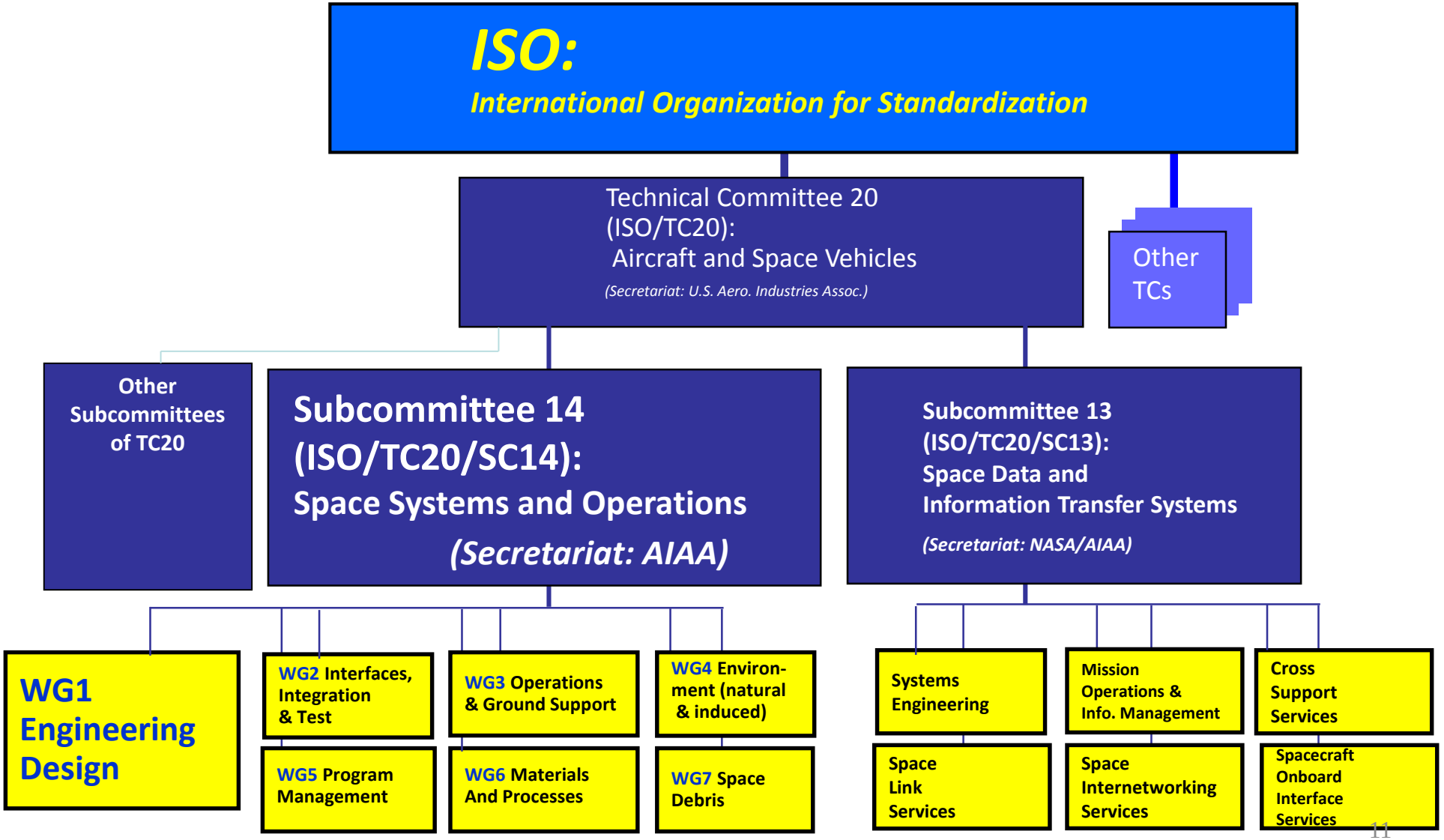
Aim of international standardization

- To facilitate the **exchange of goods and services** through the elimination of technical barriers to **trade**.
- International standards for expressing requirements as well as capabilities and the means of verifying performance are essential to facilitate **fair and equitable trade** that will result in reliable commercial space systems.
- **International collaboration on major civil space programs** has become necessary and the norm. International Standards are therefore essential to ensure such programs can be reliably integrated in a cost-effective manner.

From AIAA Website

https://www.aiaa.org/Secondary.aspx?id=6921

International Space Standards



Lean satellite related ISO projects

- ISO/DIS/17770 Space Systems – CubeSats
- ISO/DIS/19683 Space Systems – Design Qualification and Acceptance Tests of Small Spacecraft and Units
- ISO/CD/20991 Space Systems – Requirements for Small Spacecraft

ISO stages

NWI ⇒ WD ⇒ CD ⇒ DIS ⇒ IS

（⇒ associated with voting）

NWI: New Work Item, WD: Working Draft

CD: committee draft, DIS: Draft International Standard, IS: International Standard

ISO/DIS/17770

- Title: Space Systems – CubeSats
- Adaption of CalPoly CubeSat standard with minor modification
  - Up to 3U
- DIS voting passed
  - Now at Final Draft International Standard

ISO/DIS/19683

- Title: Space Systems – Design Qualification and Acceptance Tests of Small Spacecraft and Units
- Why “small spacecraft”?
  - Use of the word of “small satellite” was rejected by UK
  - Use of the word of “lean satellite” was rejected by US
  - “Small spacecraft” was adapted as compromise
- Minimum test requirements and test methods of commercial small spacecraft and their units, and to accept the final products
- Emphasis on achieving reliability against infant mortality while maintaining low-cost and fast-delivery
- Includes CubeSat as long as it is developed with the untraditional processes
- Now under DIS voting (due November 15, 2016)

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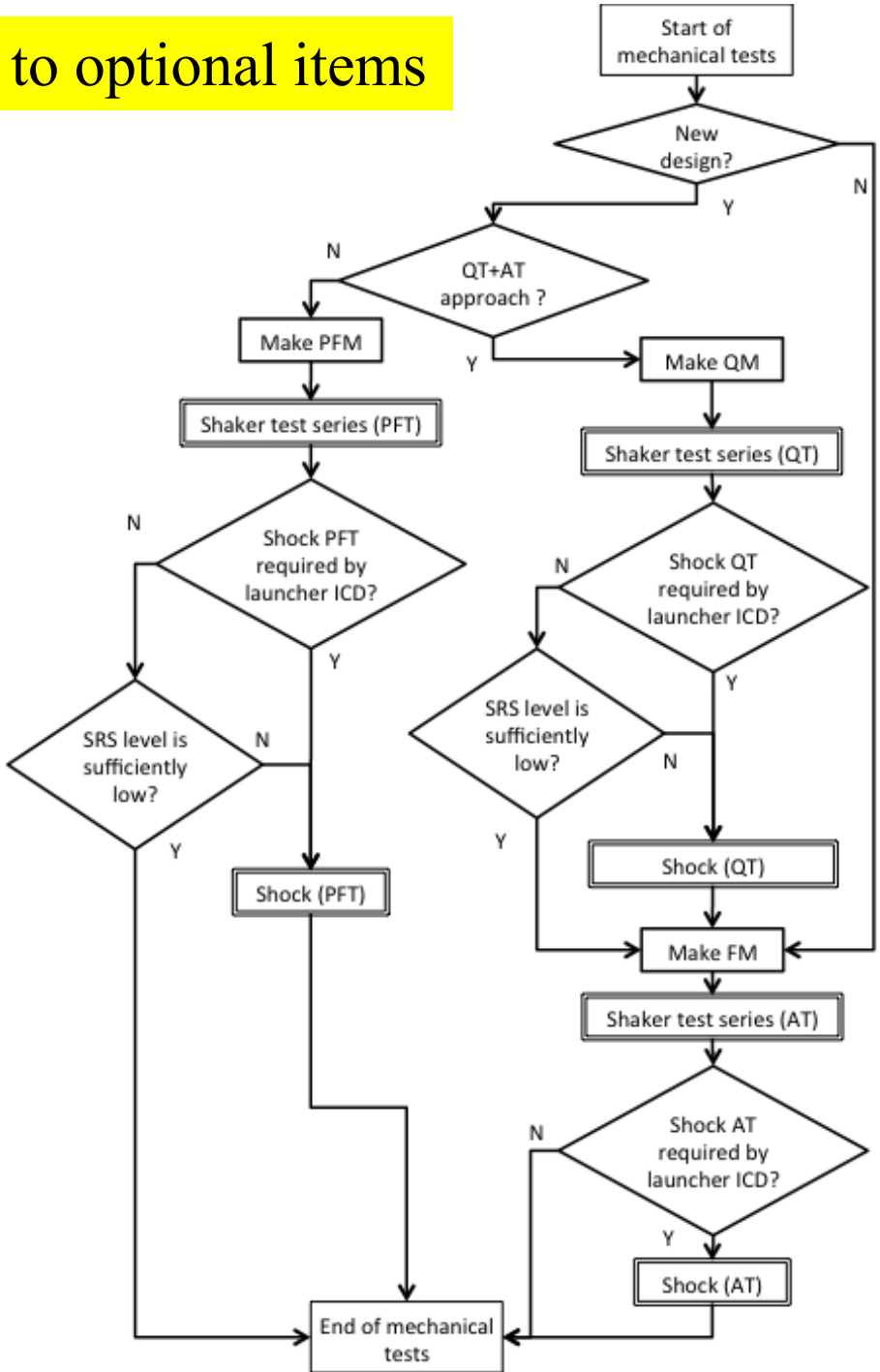
System test requirement

Table 1: System Test Items

Test items	QT	AT	PFT
Electrical Interface	R	R	R
Functional test	R	R	R
Mission test	R	R	R
Total Ionization Dose (TID) test	O*1	-	O*1*2
Single Event Effects (SEE) test	O*1	-	O*1*2
Spacecraft Charging Induced Electrostatic Discharge (ESD)	to be done in the unit level		
Electromagnetic Compatibility (EMC) Test	R	O*3	R
Deployment	R	R	R
Magnetic Field Test	O*4	O*4	O*4
Antenna Pattern Test	to be done in the unit level		
Alignment Measurement	O*5	O*5	O*5
Physical Property Measurement	R	R	R
Launcher/Spacecraft interface test	R	R	R
Quasi-static load test	O*6	O*6	O*6
Modal Survey	O*7	-	O*7
Sinusoidal Vibration Test	O*8	O*8	O*8
Random Vibration Test	R	R	R
Shock Test	O*9	O*9	O*9
Thermal Balance Test	O*10	-	O*10
Thermal Vacuum Test	R*11	O*12	R*11
Functional test in vacuum		-	
Thermal Cycle Functional Test		O*13	
Cold/hot start	O*14	O*14	O*14
Thermal Cycle Endurance Test	to be done in the unit level		
Pressure Test	O*15	O*15	O*15
Leakage Test	O*15	O*15	O*15
Micro-vibration Test	to be done in the unit level		
Burn-In and Wear-In Test	to be done in the unit level		
End-to-End Mission Simulation	-	R	R
Bake Out and Outgas	-	O*16	O*16

All the optional items listed as “O” come with the condition where the test is required.

Logical flow is given to optional items

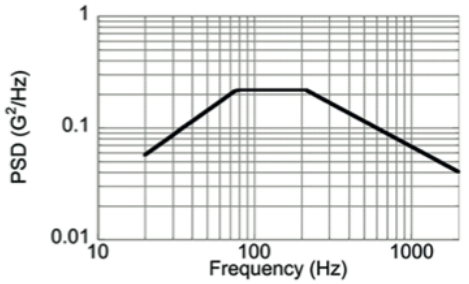


Unit qualification test level

- Lean satellite units often procured via Internet
  - Test record is not transparent to buyers
- Unit qualification test (QT) in ISO/DIS/19683 provides a **minimum** guarantee that a given unit sold as “a satellite unit” has a certain level of tolerance against the space environment.
- Not include proper margin against the maximum predicted environment stress, which depends on each satellite.
- Provides numeric values for the test level and duration of unit QTs
  - Their rationales are given in Appendix

Unit qualification test level

Table 5 *(continued)*

Test item	Test level and duration	Requirement	Note
Sinusoidal vibration	Vibration amplitude	8.4$G_{0\text{-}p}$ or higher	
	Frequency	5 ~ 100Hz	
	Sweep rate	4 Oct/min up and down	
	Number of applications	Once in each axis	
Random vibration	Root mean square	13.3 Grms or higher	
	PSD		This PSD may be tailored according to the satellite mass for which the manufacturer expect to use the unit under test.
	Lower tolerance limit on PSD	0dB	
	Duration	1 min for each orthogonal axis	
	Frequency	20 Hz to 2000Hz	
	Number of applications	Once in each axis	

Numerical values of unit qualification test are give with reasons

Test documentation

- Test documentation standard for traditional satellites already exists. ISO-17566, “Space systems – General Test Documentation”
- To avoid duplication, ISO/DIS/19683 puts an emphasis on specification of test reports and datasheet **for unit test results**
- Specifies **the minimum level of information** that will help the customer, i.e. satellite integrator, to judge whether a given unit is suitable for the use in space.
- Other aspects of test documentation are referred to ISO-17566.

Test requirements

- In ISO/DIS/19683, test requirements for 31 types of test are given
- Testing standard for traditional satellites
  - ISO-15864, “Space systems — General test methods for space craft, subsystems and units
- ISO/DIS/19683 deals with lean satellites, but ISO-15864 is simply referred for
  - Pressure Test (8.25), Leakage Test (8.26), Burn-In and Wear-In Test (8.28), Magnetic Field Test (8.9), Antenna Pattern Test (8.10), Alignment Measurement (8.11), Physical Property Measurement (8.12), Launcher/Spacecraft interface test (8.13)
- For other tests, whenever applicable, ISO-15864 is referred in terms of test purpose, facility, etc

ISO/CD/20991

- Title: Space Systems – Requirements for Small Spacecraft
- Describes minimum requirements for small spacecraft. Regardless of the development philosophy, there are minimum requirements every spacecraft shall comply with. This standard explicitly states those requirements and also refers to existing applicable standards
- Reflects findings of IAA Study group 4.18
  - Collected experiences of 18 lean satellite experts from 15 countries about requirements they had to comply with.
- CD/V voting closed on September 28, 2016
- **Passed the voting** with two negative votes (US and China) in September 2016
- Major negative comments (US & China)
  - The document is just a compilation of other related standards, itself contains no normative content

Table of contents (ISO/CD/20991)

ISO/CD/20991 Example

- **Safety(5.2)**

  Every small spacecraft, regardless of its size, mission, value, capability or any other nature, shall comply with safety requirements (ISO 14620-1[12]).

  Specific safety requirements depending on the launcher and mission are commonly stated in the launcher ICD.

  Every small spacecraft shall also comply with the given safety launch site regulation (hazards related to pressure, pyrotechnics, EMC, contamination, chemical and others).

- **Debris mitigation(5.4)**

  Every small spacecraft, regardless of its size, mission, value, capability or any other nature, shall comply with the debris mitigation requirement (ISO 24113[13]).

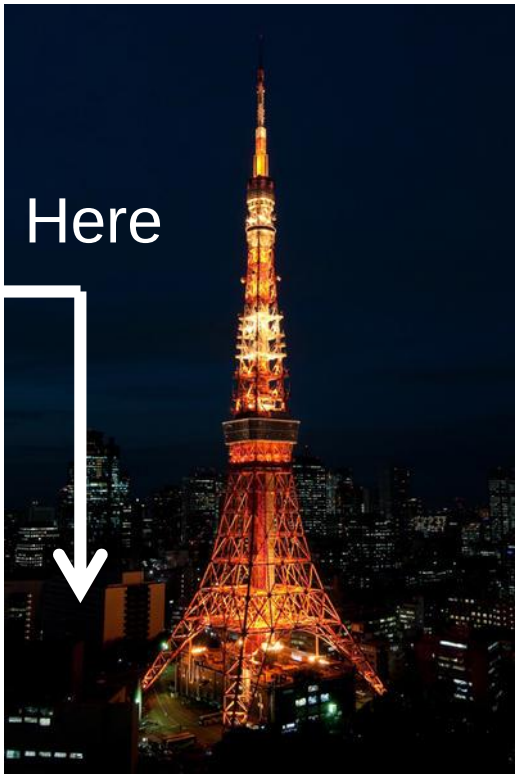
ISO/CD/20991

- Choose one of the following three options
  a. Proceed as DIS in the current contents
  b. Revise to add more original contents
  c. Change to less-normative document, TS (Technical Specification) or TR (Technical Report)
- Notify the ISO/SC14 secretariat (AIAA) by January 31

Next stage

- **International Workshop on lean Satellite Standardization – 2017**
- Date: January 16 ~ January 18, 2017
- Venue: The Kikai Shinko Kaikan Building, Tokyo
- Will discuss the broader issues of standardization
  - Lean Satellite Concept, Satellite Testing, International Projects, Capacity Building, Debris, Safety, Frequency, Interface, CubeSats, Communication Protocols, Software testing, Certification, Ground station network and more !
- *If you are interested, give me your business card*

http://www.enjoytokyo.jp/img/s_s/l/_26/l/lm_26IMG2.jpg



Tokyo Tower

Or, Google “NETS satellite standard”