CubeSat Interface Standardization Project Update for year 2020

Mengu Cho

Laboratory of Lean Satellite Enterprises and In-Orbit Experiments

Kyushu Institute of Technology

Kitakyushu, Japan

April, 2021

2021 CUBESAT DEVELOPERS WORKSHOP

Introduction

- It has been said that the advantage of CubeSats is “low cost and fast delivery”.
- Low cost is probably true.
  - Some can build a CubeSat with 30K$ or less
- But, is it fast?
  - Not really
  - Many projects still take 2 years or longer from the project kick-off to the launch

CubeSat Interface survey

Answers to how to improve the CubeSat delivery time (multiple choices)

In your opinion, what are necessary or need to be improved to accelerate the CubeSat delivery time?	Developers	Vendors
Interface	7	3
Improving software and clear software interface	6	1
Integration and testing	4	2
Improving the information within datasheets	3	0
accelerate administrative overhead (export control by government, frequency allocation, etc.)	3	0
Skill-up of designers	3	0
Integration of payload	0	3

Survey done during IWLS-2019

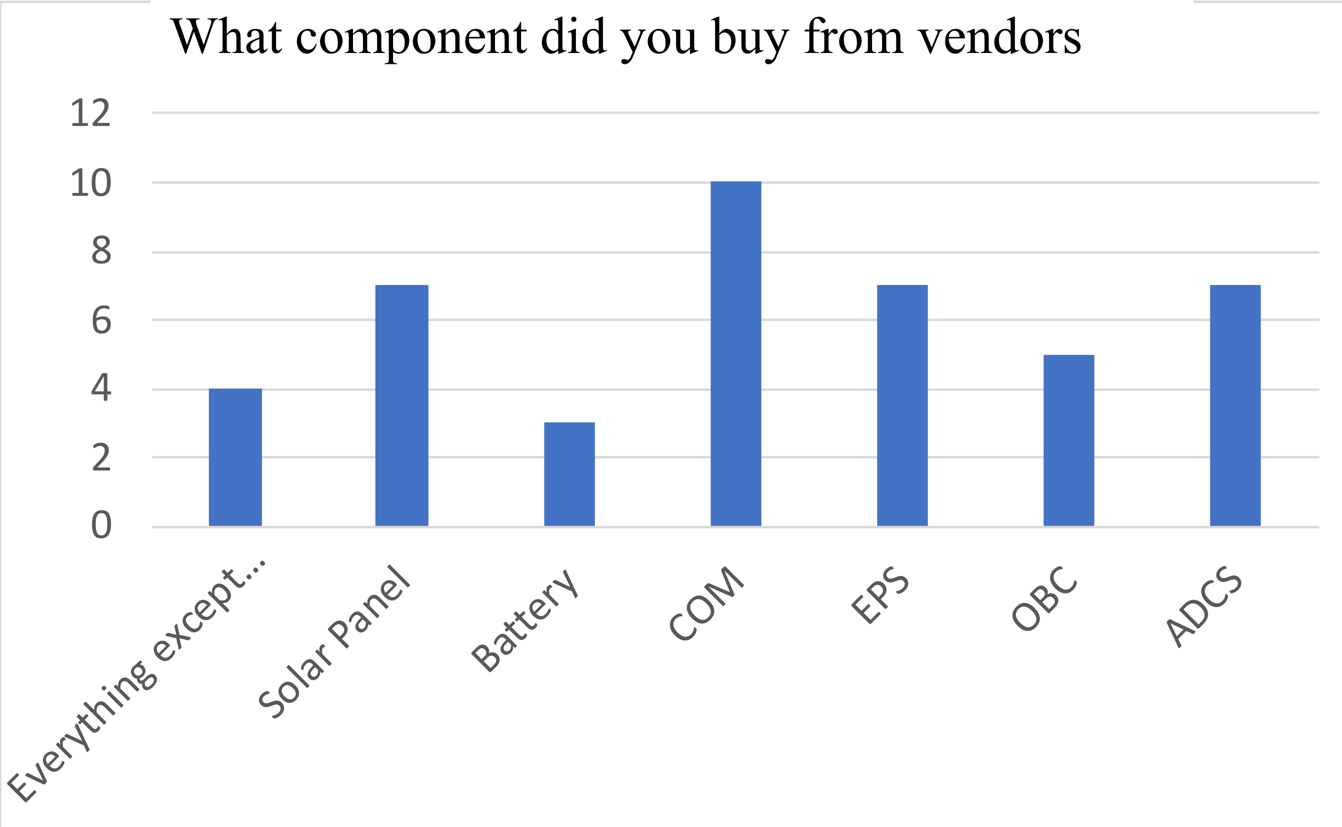
Effects of interface incompatibility

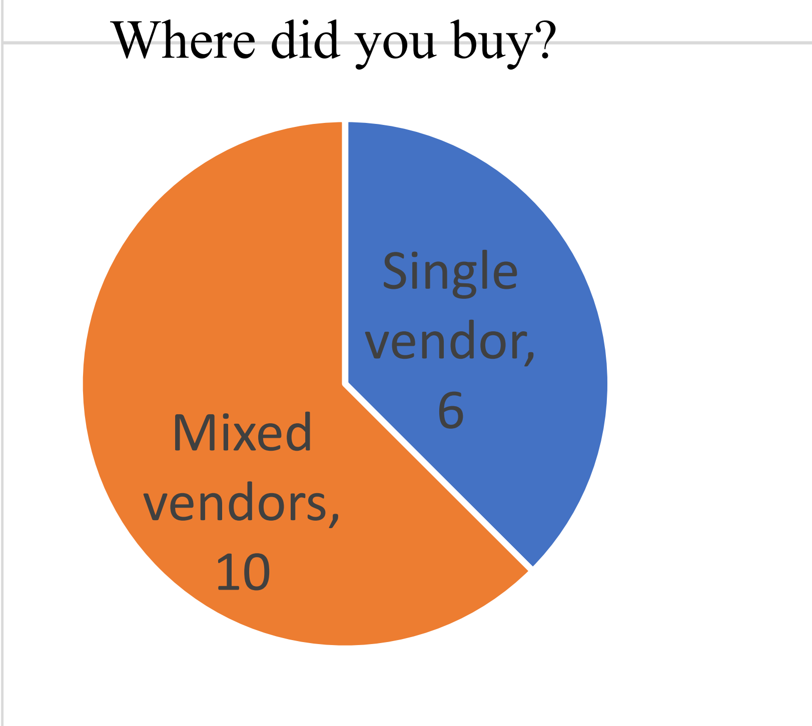
- Not directly affects satellite reliability directly
  - Must be solved during the system integration
  - Not many issues unsolved before launch
- But, direct delay in the schedule
  - Need more time to solve the interface incompatibility issue
    - Many try & errors
  - Less time to spend in other verification processes
    - Deployment, software, communication, thermal, others
- **Overall decrease in mission success rate**
- **Longer delivery time**

CubeSat Interface Survey

Single vendor vs mixed vendors

Did you buy components from single vendor or mixed vendors?





Survey done during IWLS-2019

CubeSat Interface Survey

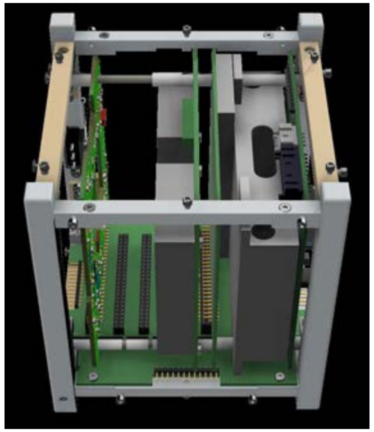
Reason of choosing single vendor or multiple vendor solutions (CubeSat developers)

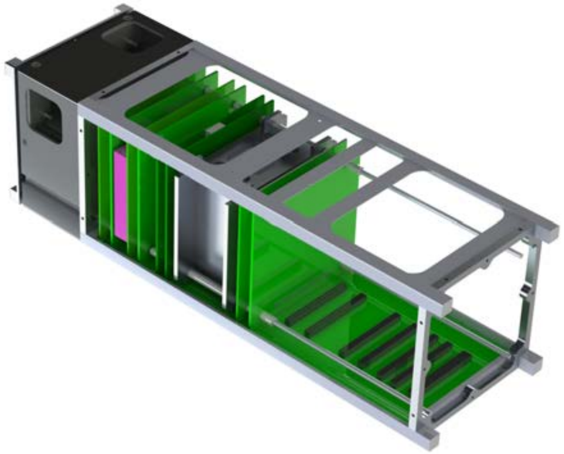
Single vendor solution		Multiple vendor solution	
Not interested in bus development	1	Not possible to buy all components from the same vendor.	3
Avoid interface problems	3	Can provide wider rage of options	1
Bought only one component	2	Price	2
		Depending on requirements and performance, functionality	8

Survey done during IWLS-2019

CubeSat Platform

- More CubeSat developers prefer the single vendor solution
  - To avoid interface issues
- Some are not interested in making a satellite
  - Want to demonstrate their ideas or payload only
- Many vendors moving to offer “CubeSat Platform”
  - Found 27 companies worldwide
- “Hosted Payload” service based on CubeSat Platform
  - Found 6 companies worldwide





Platform Providers

Company name	Country	1U	3U	6U	12U	Others	ICD in public	URL
AAC Clyde Space	UK	x	x	x	x		No	https://www.aac-clyde.space/
Adcole Maryland Aerospace	US				x		No	https://www.adcolemai.com/
Argotec	Italy			x	x		No	http://www.argotec.it/online
Artemis Space	Cyprus				x		No	https://www.spaceartemis.com/
Astro digital	US			x		16U	No	https://astrodigital.com/
Blue Canyon Technology	US		x	x	x		No	http://www.bluecanyontech.com/
C3S	Hungary		x	x			No	https://www.c3s.hu/
EnduroSat	Bulgaria	x	x	x		1.5U	No	https://www.endurosat.com/
GAUSS	Italy	x	x	x	x	2U	No	https://www.gaussteam.com/
German Orbital Systems	Germany		x	x		8U	**Yes**	http://www.orbitalsystems.de/
GomSpace	Sweden	x	x	x		2U	No	https://www.gomspace.com/
GUMUSH	Turkey		x				No	https://www.gumush.com.tr/
Hermeria	France				x	8U, 16U	No	https://www.hemeria-group.com/en/nanosatellite/
IMT	Italy		x				No	http://www.imtsrl.it/
ISISpace	Netherlands	x	x	x	x	16U	No	https://www.isispace.nl/
NanoAvionics	Lithuania		x	x	x	16U	**Yes**	https://www.n-avionics.com/
Open Cosmos	UK		x	x	x		No	https://www.open-cosmos.com/
Pumpkin	US		x				No	https://www.pumpkinspace.com/
SatRevolution	Poland		x				No	http://www.satrevolution.com/
Smart Satellite	China		x	x	x		No	http://www.smartsatellite.com/
Space Flight Laboratory	Canada		x	x	x	16U	No	https://www.utias-sfl.net/
Space Information Labs	US			x	x	27U	**Yes**	https://www.spaceinformationlabs.com/
Space Inventor	Denmark	x	x	x			No	http://www.space-inventor.com/
SPACEMANIC	Slovac	x		x			No	https://spacemanic.com/cubesat-platforms/
SPUTNIX	Russia	x	x	x			**Yes?**	https://sputnix.ru/en/
Tyvak	US, Italy			x	x		No	http://www.tyvak.com/
U-Space	France		x	x			No	https://u-space.fr/

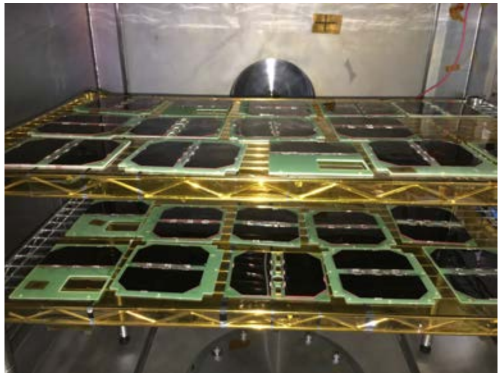
List of CubeSat Hosted Payloads

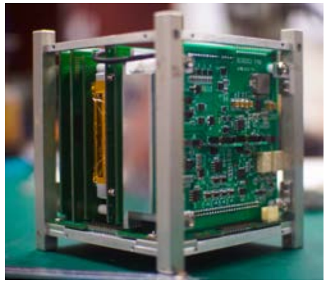
Company name	Country	1U	3U	6U	12U	Others	ICD in public	URL
Boreal Space	US						No	https://www.borealspace.com/
Crest Astra	Japan	x		x			No	http://astra.crest-grp.com/
German Orbital Systems	Germany		x	x		8U	Yes	http://www.orbitalsystems.de/
In-Space Mission	UK			x			No	https://in-space.co.uk/
SpacePharma	Switzerland, Israel		x				No	http://www.space4p.com/
Spire	US	x	x				No	https://www.spire.com/

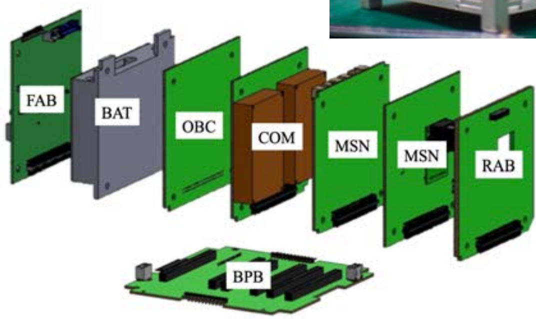
Mass Production

- Satellite Assembly, Integration and Testing can be done in parallel
  - Harness-less
  - Batch production
  - Batch testing

Parallel assembly of 5 satellites (BIRDS-1)





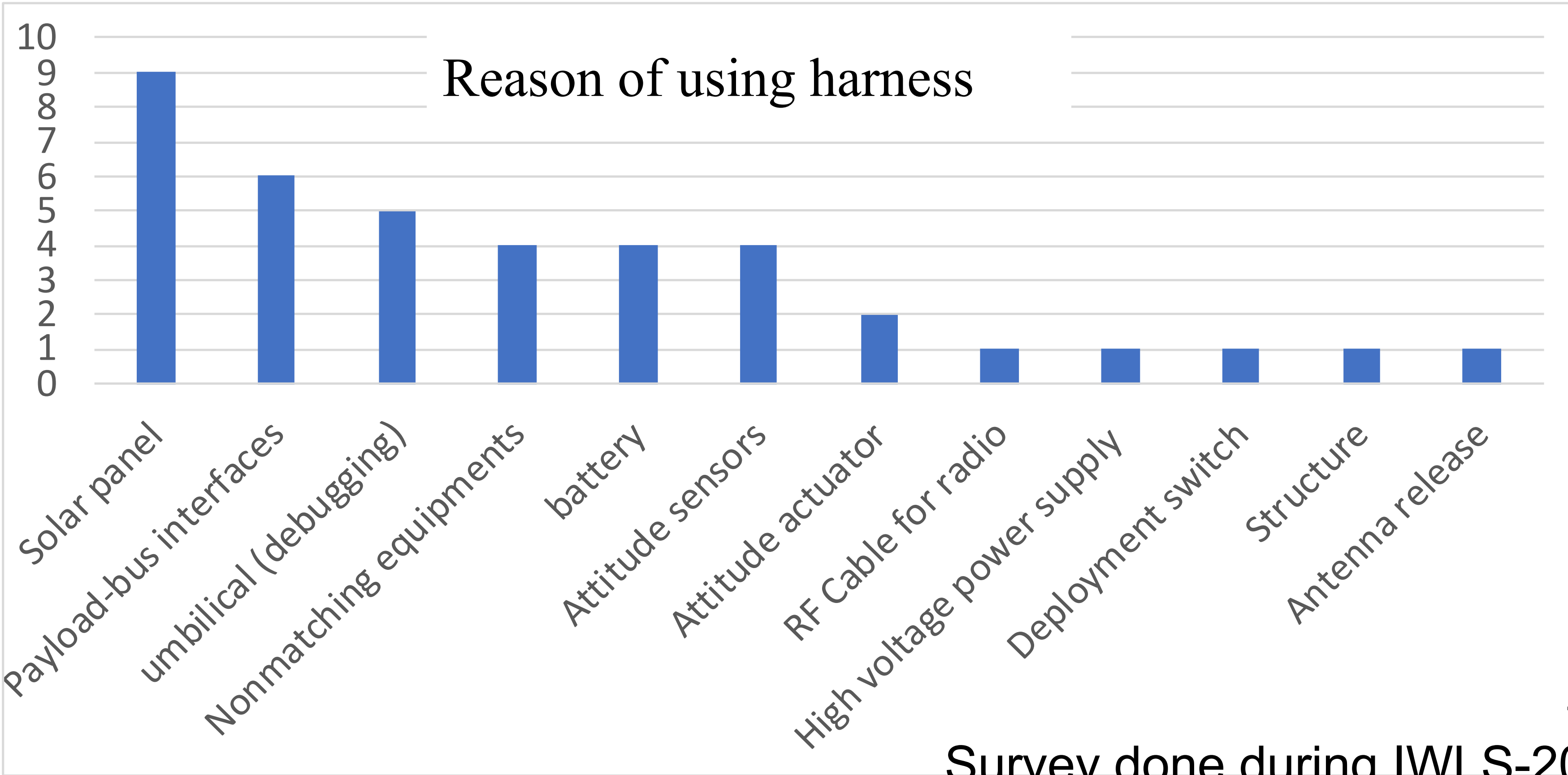


Interface designed for rapid and uniform assembly

CubeSat Interface survey

Number of harness lines used in the flight model (CubeSat developers).

No harness except RF cables	1~5	5~10	10~
1	4	6	8



Survey done during IWLS-2019

Needs of standard

- CubeSat components and platforms are traded worldwide via Internet
- Standard exists to define CubeSat external shapes
- No standard on CubeSat interface
  - Between components
  - Between CubeSat bus (platform) and mission payload
- Satellite design phase
  - Detailed Information about product interface
- Satellite assembly phase
  - Physical interface
- Satellite integration and testing phase
  - Physical and data (software) interface

Benefits of interface standard

- Shorten the time required for design, development, assembly, integration and testing
- Promote mass production
- Assure component compatibility to promote
  - International trade of CubeSat components and platforms
  - International collaboration

CubeSat Interface Standardization Project

- Funded by Japanese Ministry of Economy, Trade and Industry (METI)
  - 3 years (April 2019 ~ March 2022)
- Goal
  - Make an ISO standard to define interface of CubeSat
  - Submission of NWIP (New Work Item Proposal)
    - 2021 Summer
  - Target date of publication
    - 2024

What we do

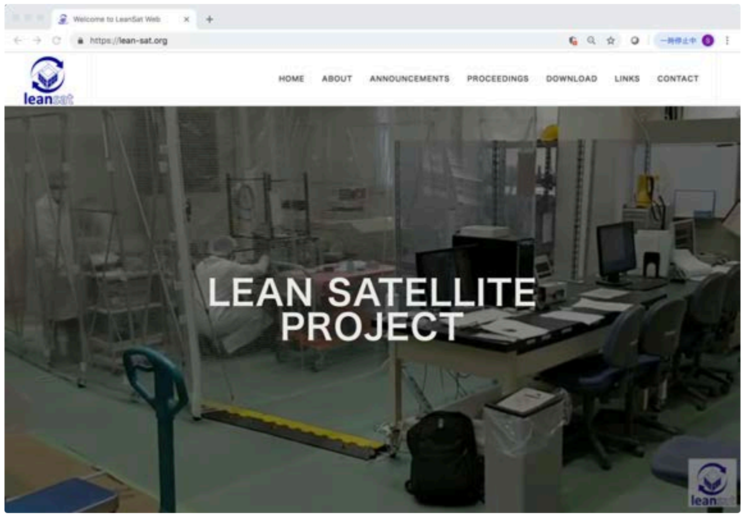
1. Making and revising the standard draft
2. Coordinating with ISO/TC20/SC14
3. Investigating compatibilities among CubeSat components in the market
4. Collecting inputs from the worldwide experts and stakeholders through IAA (International Academy of Astronautics) SG-26
5. Organizing international workshops to exchange information and to discuss the standard

How to proceed

- The method used for ISO-19683 and 20991
- Lean satellite community
- Work in parallel with **IAA study group 4.26**
- IAA SG is used as a frame work to ensure participation of
  - Academia
  - Industry
  - Agency
- Meetings in various CubeSat related conference
- E-mail list and a file-server will be utilized to exchange opinions and materials
- If you want to join, send e-mail to

  cho.mengu801@mail.kyutech.jp

https://lean-sat.org/



What to be included in the standard

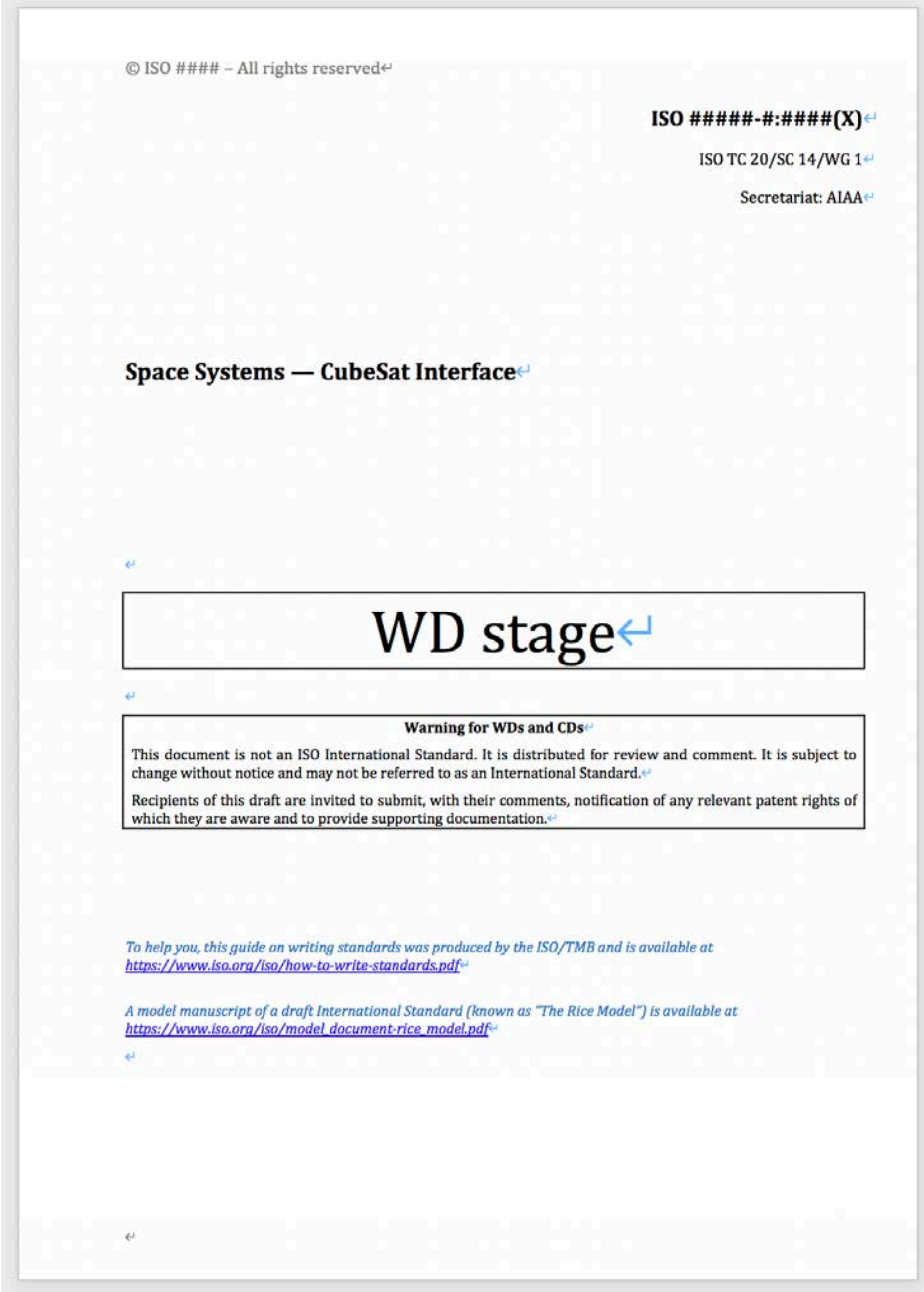
- Interface among components
- Interface between platform (bus) and mission payload
- Document specification to describe the component interface
- Document specification to describe the platform interface
- External electrical interface (umbilical)

Why documents?

- Discussion at the Lean Satellite Workshop 2019
- Proper documentation (datasheet) helps
  - Selection of components to buy
    - Common items listed for comparison
  - System integration and testing
    - Depth in technical information
- For CubeSat products, the communication between the customer and the vendors are limited
  - Documents associated with the product are often the key to ensure smooth system integration and testing

Standard Draft

- Standard draft is available at
  https://lean-sat.org/download.html
- Please send an e-mail to
  nets_office@space-kyutech.net
  for the password



ISO #####-#:####(X)

ISO TC 20/SC 14/WG 1

Secretariat: AIAA

Space Systems — CubeSat Interface

WD stage

Warning for WDs and CDs

This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

To help you, this guide on writing standards was produced by the ISO/TMB and is available at https://www.iso.org/iso/how-to-write-standards.pdf

A model manuscript of a draft International Standard (known as "The Rice Model") is available at https://www.iso.org/iso/model_document-rice_model.pdf

Table of contents

Scope

This document describes internal and external interface of CubeSat. The internal interface includes the interface between components and the interface between a CubeSat platform and a mission payload. The document also describes the items to be included in the datasheet of the CubeSat components and platforms. The datasheet requirements apply to catalogued commercial products ready for sale. The interface between CubeSat and its deployer, i.e. POD, is not included in the scope.

Unit to Unit Interface Requirements

- 5.1 Unit to unit interface
  - 5.1.1 General
  - 5.1.2 PC-104 Style
    - 5.1.2.1 Envelope and mounting holes
    - 5.1.2.2 Connector
    - 5.1.2.3 Ground lines
    - 5.1.2.4 Power lines
    - 5.1.2.5 Analogue lines
    - 5.1.2.6 Digital lines
    - 5.1.2.7 Others
  - 5.1.3 Backplane Style

Unit to Unit Interface Requirements

5.1.2 PC-104 Style

5.1.2.1 Envelope and mounting holes

5.1.2.2 Connector

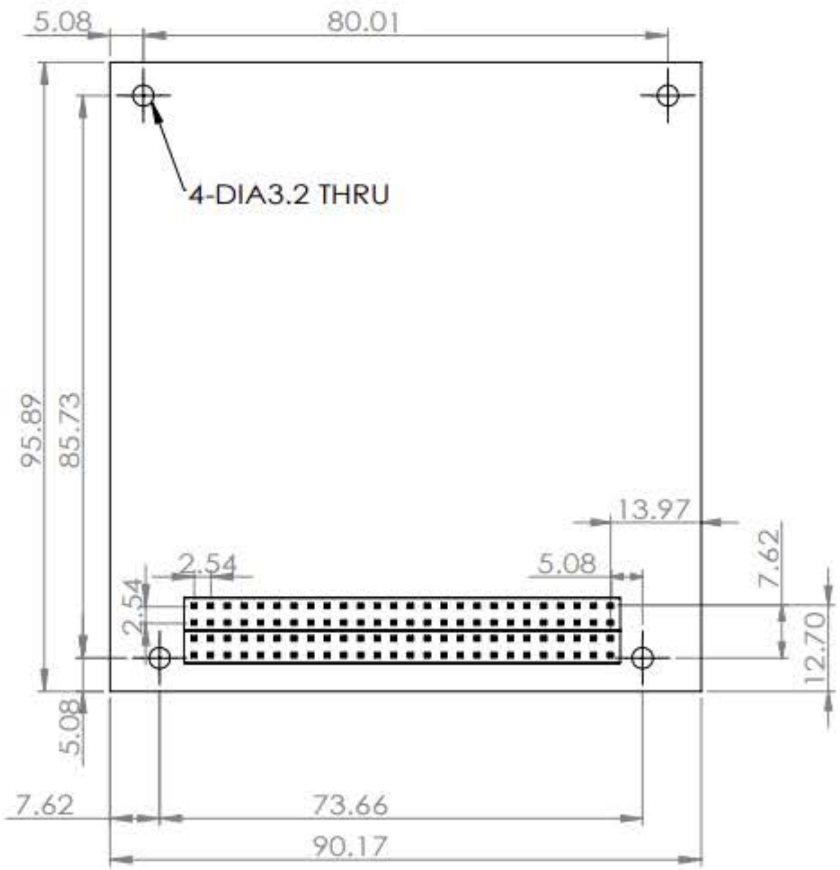


Figure 1 - PC-104 Style UNIT

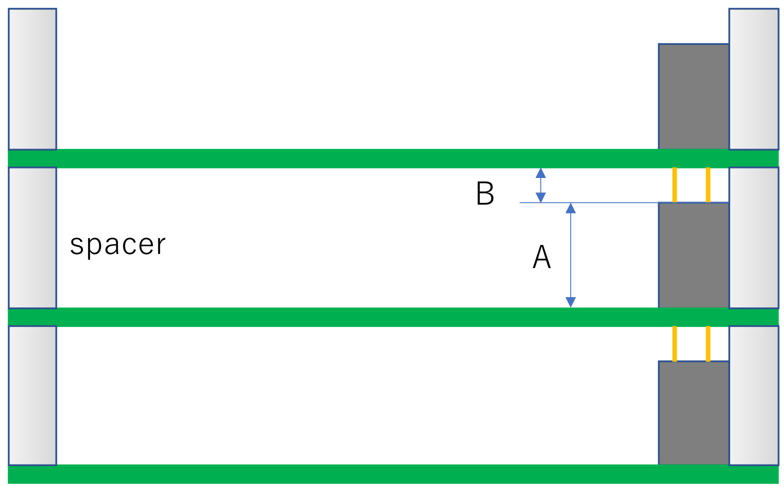


Figure 2 - PC-104 Style stacking condition

Unit to Unit Interface Requirements

5.1.2 PC-104 Style

- 5.1.2.3 Ground lines
- 5.1.2.4 Power lines
- 5.1.2.5 Analogue lines
- 5.1.2.6 Digital lines

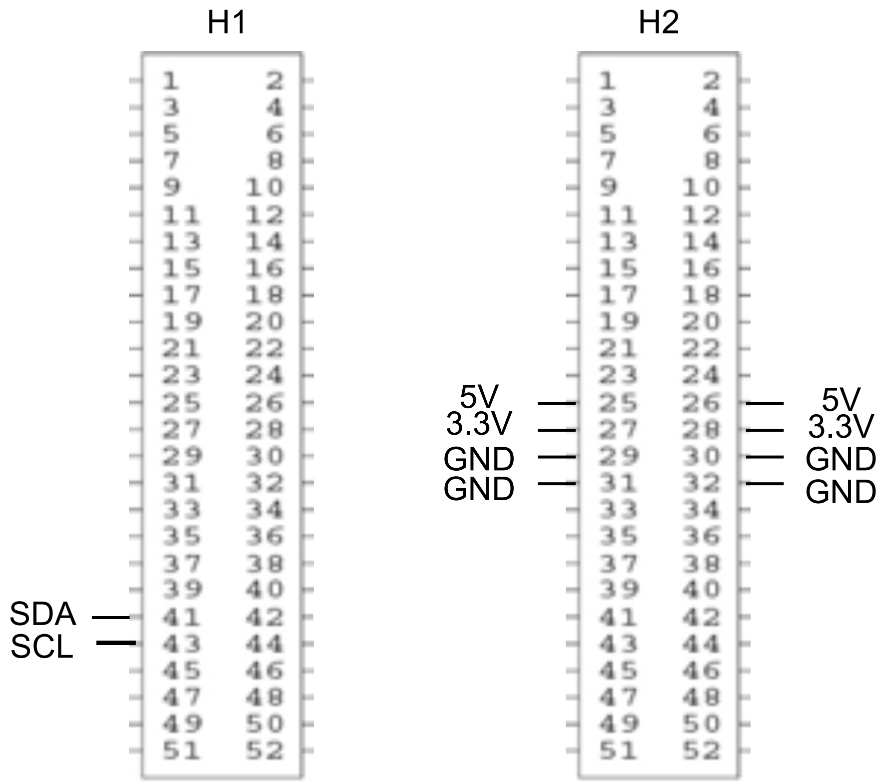


Figure 3 - PC-104 Style pin assignment

Unit to Unit Interface Requirements

5.1.3 Backplane Style
Annex C (Informative)

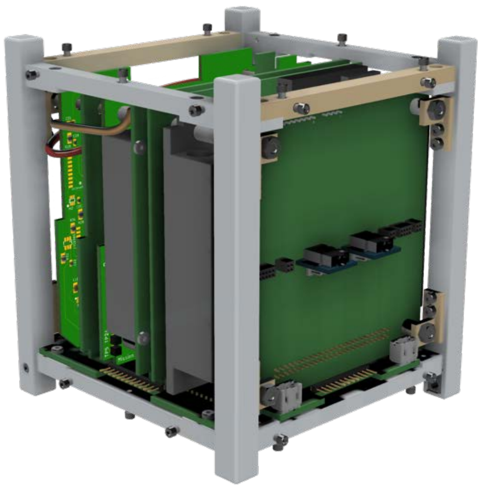


Figure C.1 – Example of Backplane style 1U CubeSat

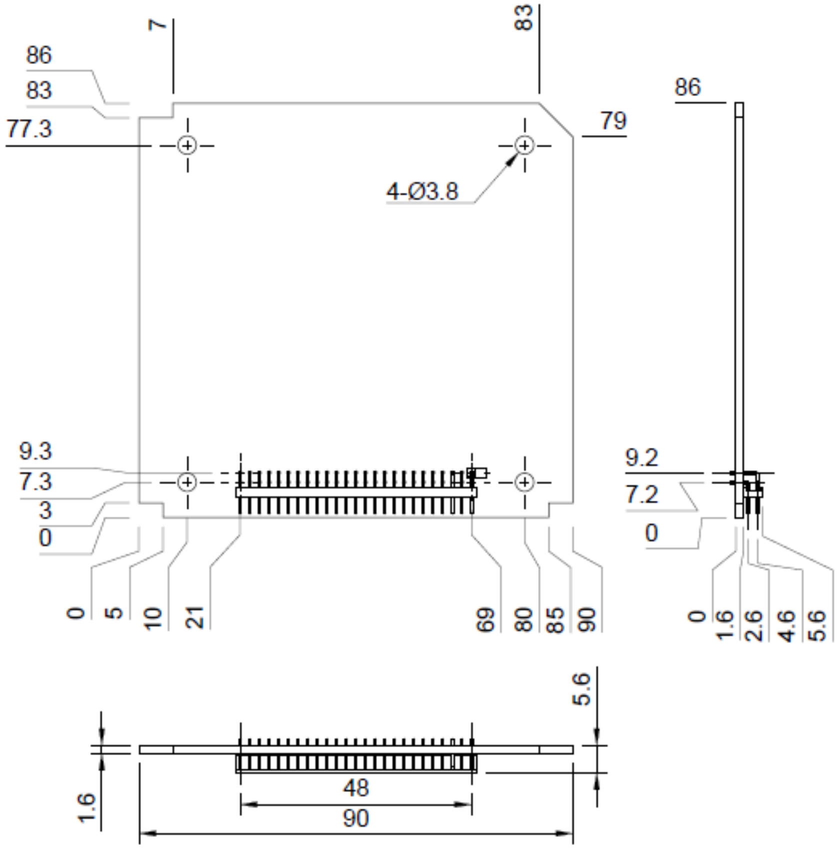


Figure C.2 – Example of PCB size requirement for backplane style

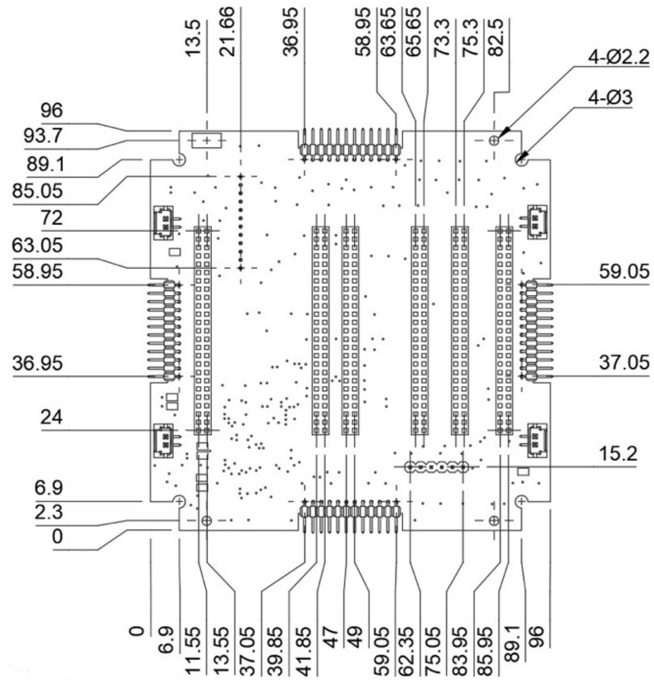


Figure C.4 – Example of connector requirements on BPB

Mission Payload to Platform Interface Requirements

5.2 Mission payload to platform interface

- 5.2.1 Mechanical connection
- 5.2.2 Connection methods
- 5.2.3 Ground lines
- 5.2.4 Power
- 5.2.5 Analogue data interface
- 5.2.6 Digital data interface
- 5.2.7 Debugging
- 5.2.8 EMC
- 5.2.9 Fault isolation and recovery
- 5.2.10 Harmlessness to other payloads, platform and missions
- 5.2.11 Safety requirements

6. Datasheet requirements for CubeSat units

6.1 General requirements

The items listed in Table * shall be provided in datasheet in public domain.

	Note
Document information	
Document number and issue date	
Revision number	
Revision dates	
Summary of revision contents	
Mechanical	
Mass	Unit: kg
Size	Unit: mm
Physical configuration*	Indicate the physical configuration and the outline dimension in drawing
Mounting hole location*	Indicate the mounting hole location and quantity in drawing
Fastener information*	Describe the type of fastener and the fastener torque with tolerance in unit of Nm
Center of mass location*	Indicate the location of centre of mass in drawing
Three-dimensional CAD model	In a standard format electronic file such as STEP
Thermal	
Heat dissipation	Unit: W Describe in each operational mode with tolerance considering input voltage, current and RF output (if any)
Allowable temperature range	Describe allowable temperature range in non-operational, operational, and start up
Temperature sensor type	Describe type of temperature sensor
Electrical	

More items in the draft

Tailored from ISO 11892 Subsystems/units to spacecraft interface control document

6. Datasheet requirements for CubeSat units

6.2 Electrical Power System Unit

6.3 Communication Unit

- Frequency including bandwidth
- Data rates
- Receiver sensitivity
- Transmitter output power
- Data protocol
- Modulation options
- RF cable interface specification

6.4 Command and Data Handling Unit

6.5 Attitude Determination and Control Unit

An example is available at Lean Satellite Website

https://lean-sat.org/download.html

Specific items written for each type of units

7. Datasheet requirements for CubeSat platforms

The following information shall be provided in the datasheet either in public domain or upon request for quotation except the ones in 7.7

7.1 Mechanical Interface

- 3D CAD file in a standard format, such as STEP
- Available payload volume and mass
- Volume and mass of the platform
- Physical configuration and outline dimension in drawing
- Payload mounting method

7.2 Electrical Interface

7.3 Software Information

7.4 Operation-related Information

7.5 Safety Information

7.6 Reliability Information

7.7 Assembly, Integration and Testing Information

An example is available at Lean Satellite Website

https://lean-sat.org/download.html

Specific items written for each type of units

8. External Electrical Interface (Umbilical)

- The following items shall be included in the umbilical connector, i.e. access port.
  - Flight pins
  - Software debug and programming. The debugging includes communication (monitoring, commanding, etc.) with the flight computer
  - Battery charging. It is recommended to separate the battery's positive and negative pins at least by one pin, which is either removed or connected to the ground via a high resistance.
  - Battery status monitor
  - Inhibit check

Specific items written for each type of units

Comments?

If you have comments to the standard draft,
write in the comments sheet and send it to me at
cho.mengu801@mail.kyutech.ac.jp
or to NETS mailing list at
nets-project@space-kyutech.net

International Workshop on Lean Satellite 2021 (IWLS-2021)

We will discuss more about CubeSat Interface and various other things
Time: Week of December 6, 2021
Venue: Kitakyushu, Japan