

CubeSat Electrical Interface Standardization for Faster Delivery and More Mission Success



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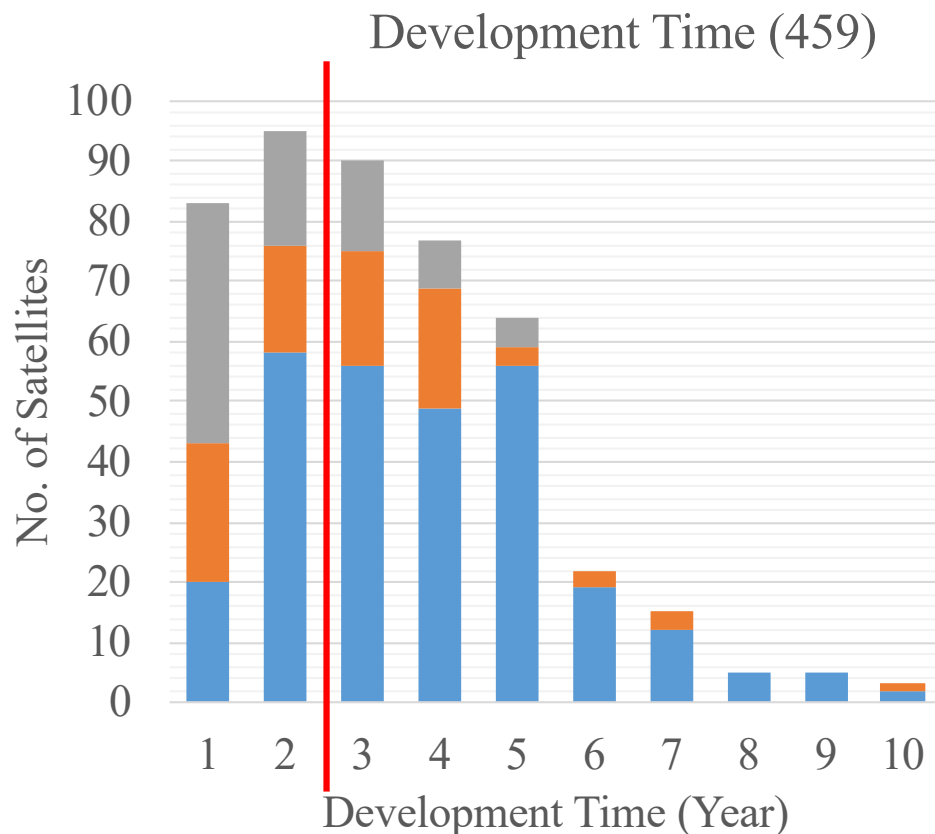
Small Satellite Conference (virtual), Utah, USA

Are CubeSats delivered fast?

- 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?

Survey on delivery time

Statistics of delivery time of 1-10kg satellites since 2003, excluding Spire and Planet



Development time	% of satellites in two categories		
	University	Government	Private
1-2 years	27.7	45.6	67.8
3-10 years	72.3	54.4	32.2

■ Private
 ■ Government
 ■ University

University projects take longer time

CubeSats are not necessarily delivered fast

Delivery time

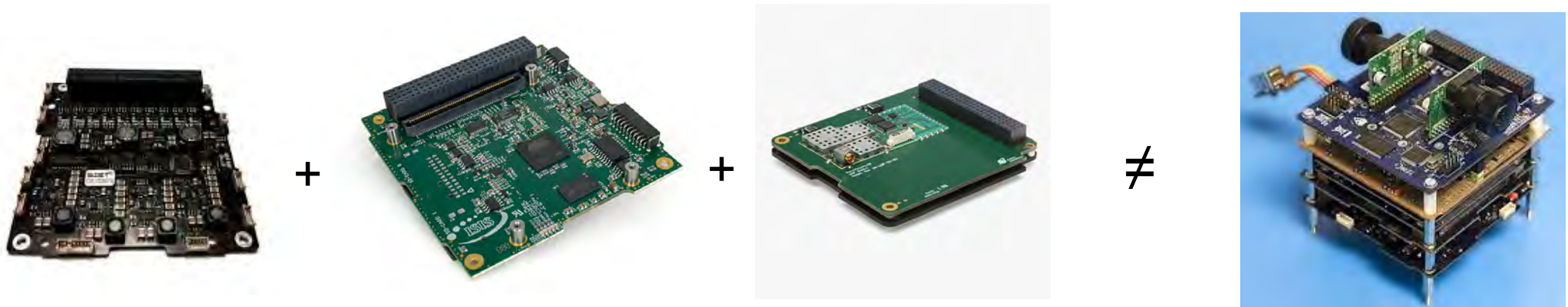
- Delivering the satellite value fast to the end-users/customers/stake-holders is important
- For commercial programs
 - More time means more salary
 - For lean satellites, salary (personnel) is the biggest expenditure
 - Loss of business opportunities
 - Competition with others (satellites, aerial, terrestrial applications)
- For university programs
 - Decrease of mission success rate
 - Academic competition with others
 - Being the first to do in-orbit demonstration is important

Effects of interface incompatibility

- Not directly, decrease of satellite reliability directly
 - Interface incompatibility is 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**

Interface

- Nowadays we can build a CubeSat by buying all the components in Internet
- **International trading** of CubeSat components
- Combining components from various vendors is risky



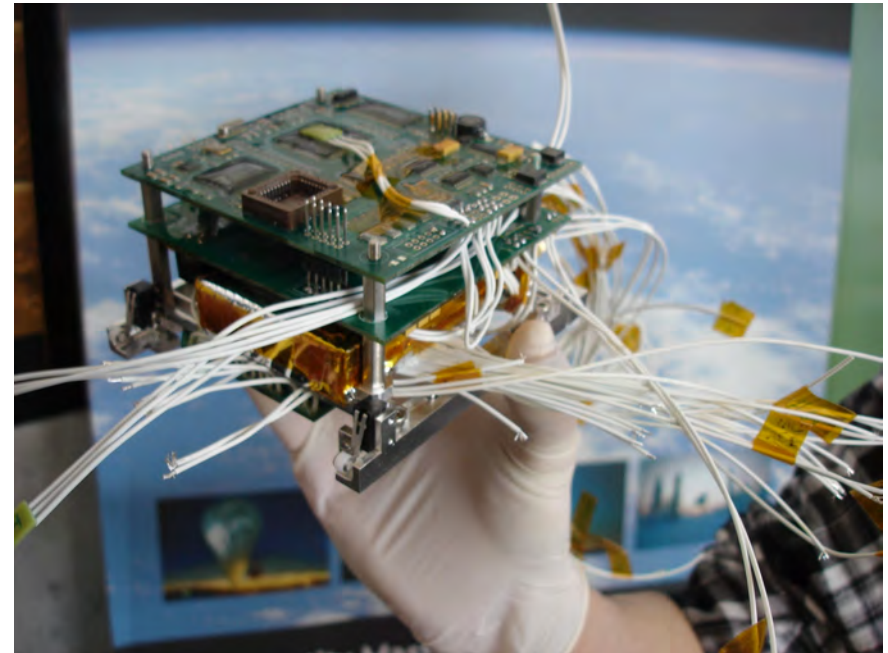
Indeed, many CubeSat developers now tend to buy components from a single vendor

Interface

The legacy PC-104 CubeSat interface is facing the limits



Credit: MIT



Credit: University of Wurzburg

- Too much flexibility (104 pins)
 - Interface incompatibility
- Stacked connection makes disassembly difficult
- But, it is *defacto-standard*

Current status

- According to the survey conducted in 2014-15,
 - 35% of already launched satellites used PC/104
 - 59% of to-be-launched satellites used PC/104
- *J. Bouwmesster et al., “**Survey on the implementation and reliability of CubeSat electrical bus interfaces**”, CEAS Space J (2017) 9:163–173

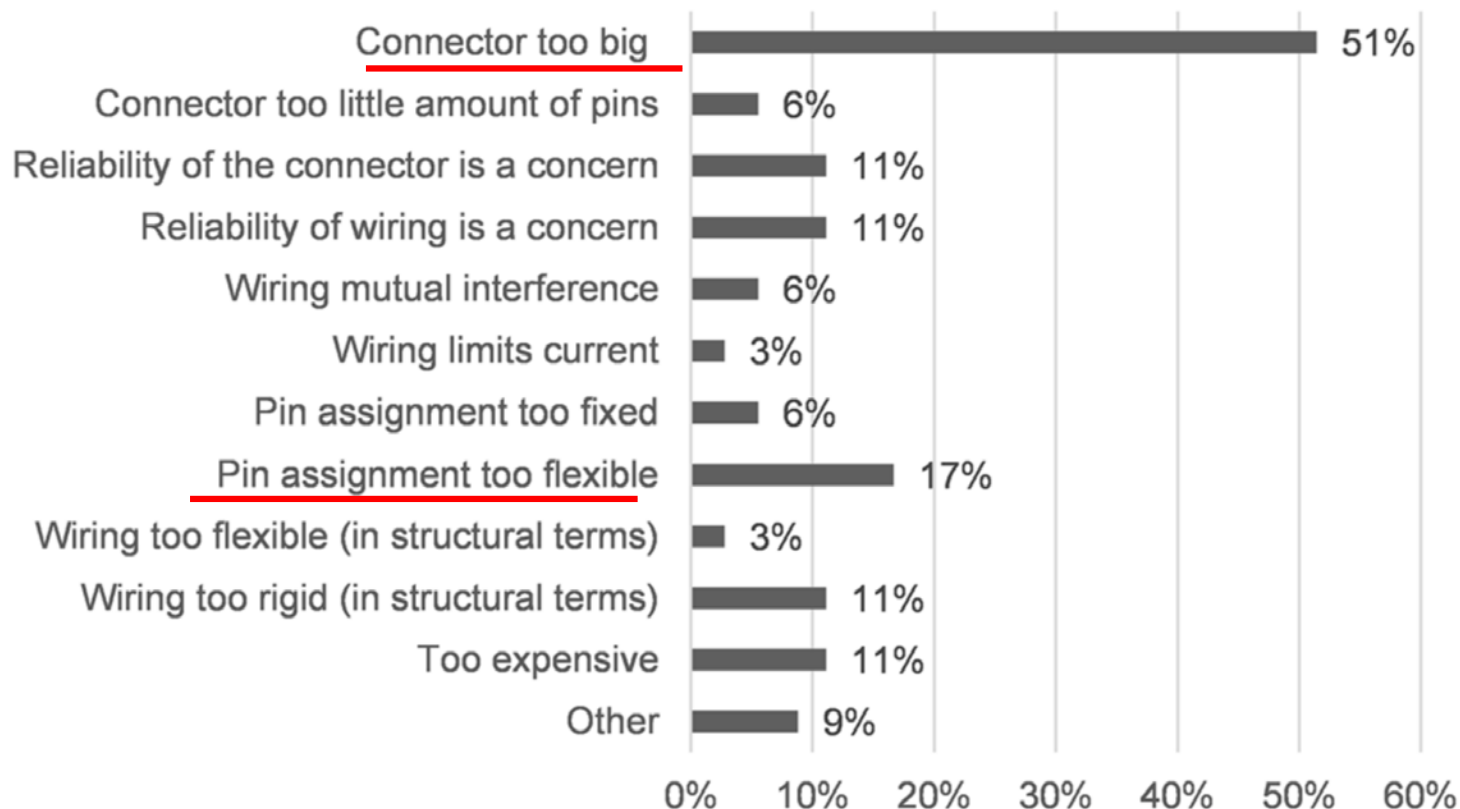
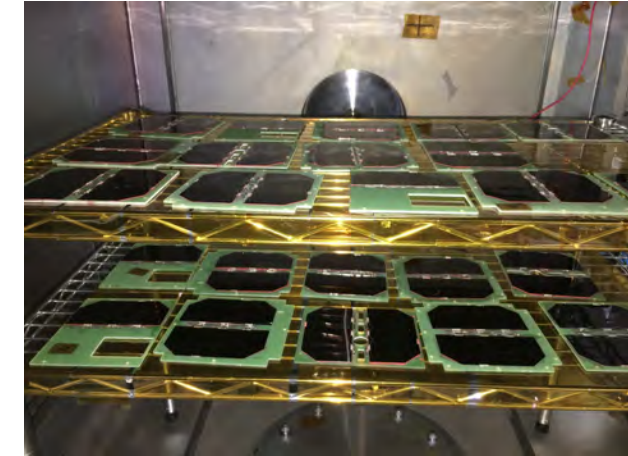


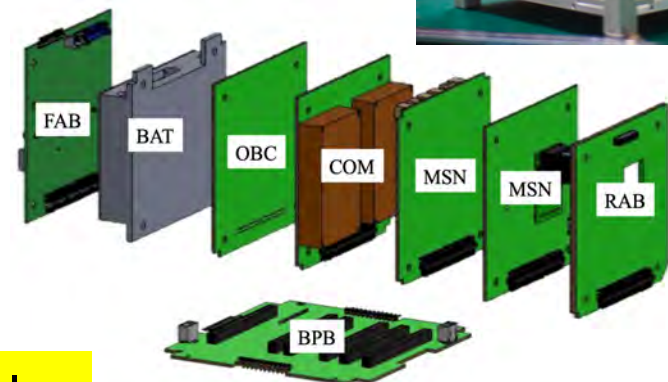
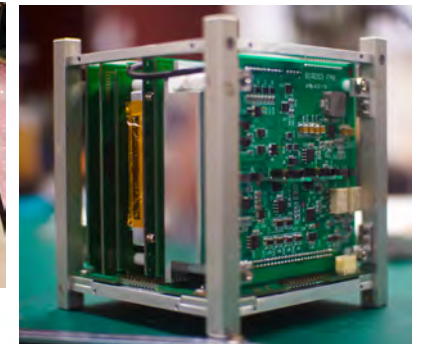
Fig. 12 Design issues reported on PC/104 connector ($n = 36$)

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 Standardization Project

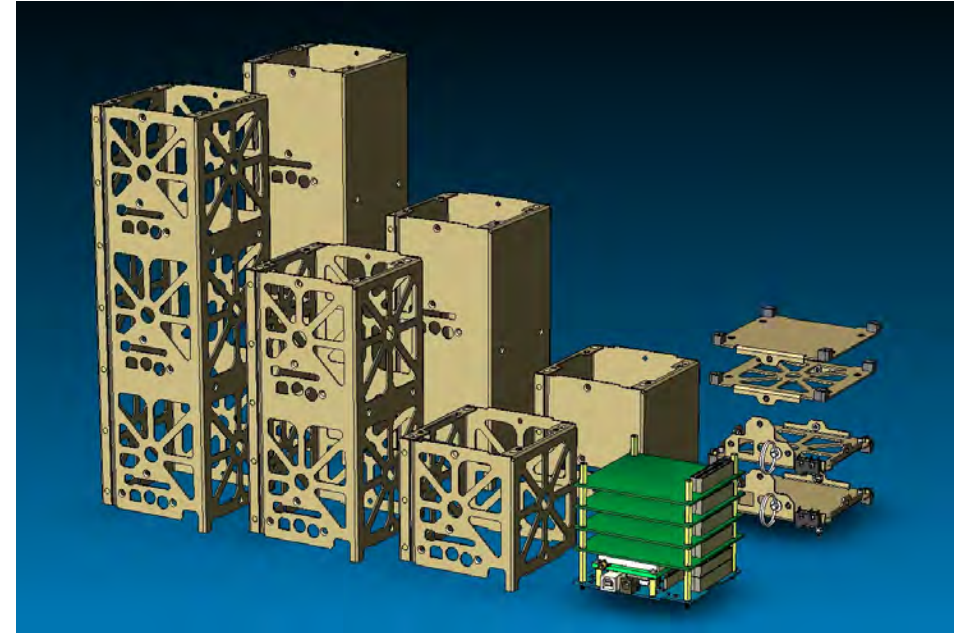
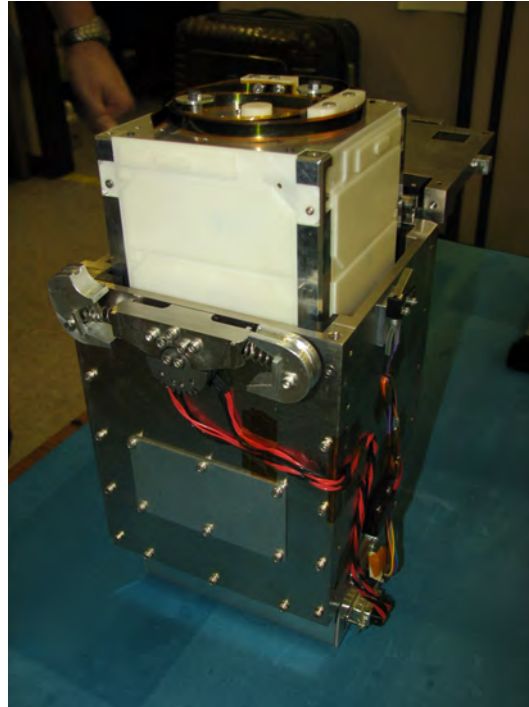
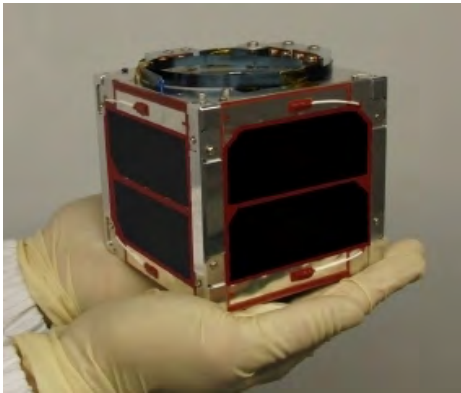


- Funded by Japanese Ministry of Economy, Trade and Industry (METI)
 - 3 years (April 2019 ~ March 2022)
- Goal
 - Make an ISO standard to define electrical interface of CubeSat
 - Submission of NWIP (New Work Item Proposal)
 - 2021 Summer
 - Target date of publication
 - 2024

International Standard

- Standard is not a regulation nor a law
- Law
 - If you violate, you may go to a jail
- Regulation
 - If you violate, you may be punished (but not physically)
- Standard
 - It is up to you whether you follow or not
 - If a contract says “follow ISO***”, then you have to comply. Otherwise, you may be sanctioned financially
- Standard
 - Make the life better and easier
 - Promote international trade and collaboration
 - Can serve as the basis of regulation and law

Benefits of standard



Credit: Pumpkin, Inc.

CubeSat standard (Interface between POD and CubeSat)

It is now ISO-17770

ISO standard related to small satellites (incl. CubeSats)

No.	Title	Content	Published
IS-17770	Cube Satellites (CubeSats)	<ul style="list-style-type: none">• General requirements• Deployer interface	2017.6
IS-19683	Design Qualification and Acceptance Tests of Small Spacecraft and Units	<ul style="list-style-type: none">• Testing	2017.7
TS-20991	Requirements for Small Spacecraft	<ul style="list-style-type: none">• Minimum requirements	2018.7

Benefits of interface standard

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

What we do

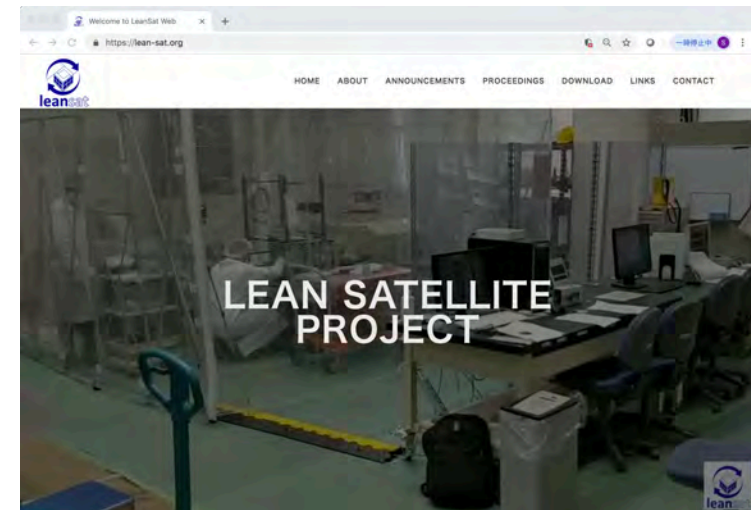
- Making and revising the standard draft
- Coordinating with ISO/TC20/SC14
- Investigating compatibilities among CubeSat components in the market
- Collecting inputs from the worldwide experts and stakeholders through IAA (International Academy of Astronautics) SG-26
- Organizing international workshops 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@ele.kyutech.ac.jp



<https://lean-sat.org/>



Workshop in 2019

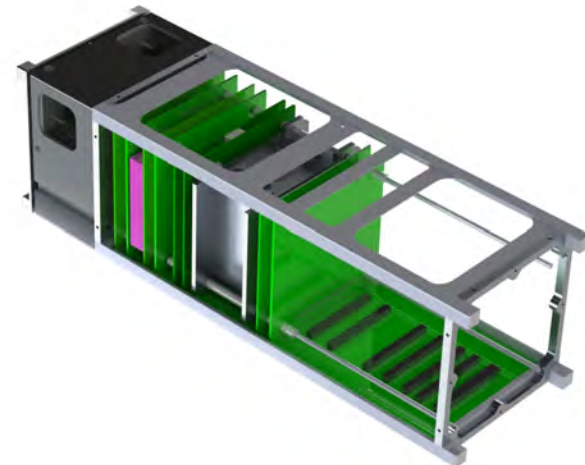
- Side meeting @Small Satellite Conference, Utah
- IAA SG kick-off meeting @IAC, Washington DC
- Presentations at
 - 12th Pico- and Nano-Satellite Workshop, Wurzburg
 - 5th IAA Conference on University Satellite Missions and CubeSat Workshop, Rome
- International Workshop on Lean Satellite 2019, Tokyo



Total 88 people including 33 from abroad

What to be included in the standard

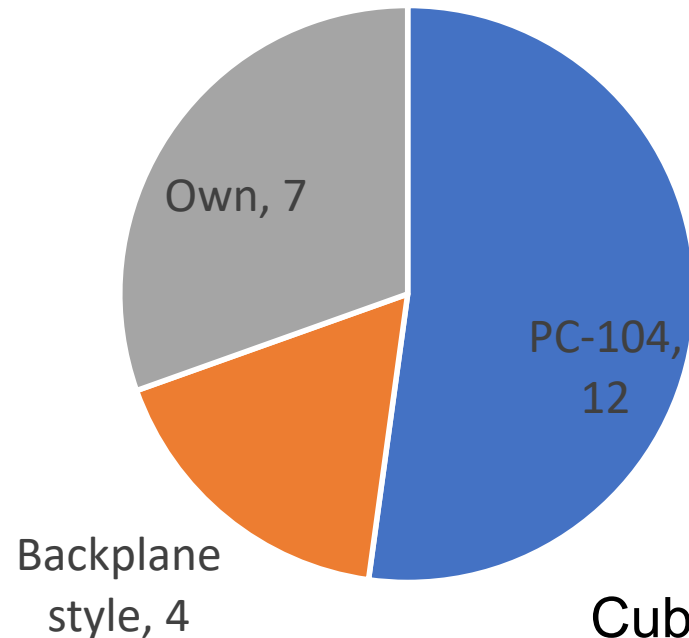
- Interface among components
- Interface between platform (satellite bus) and mission payload
- Document specification to describe the component interface
- Document specification to describe the platform interface



CubeSat Interface Survey

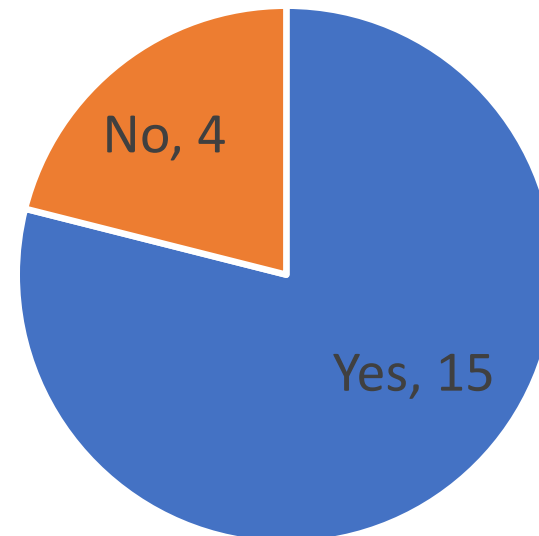
- A survey was conducted in December 2019
- 50 answers have been collected.
 - 21 CubeSat developers
 - 9 CubeSat vendors
 - 20 others

What interface did you use?



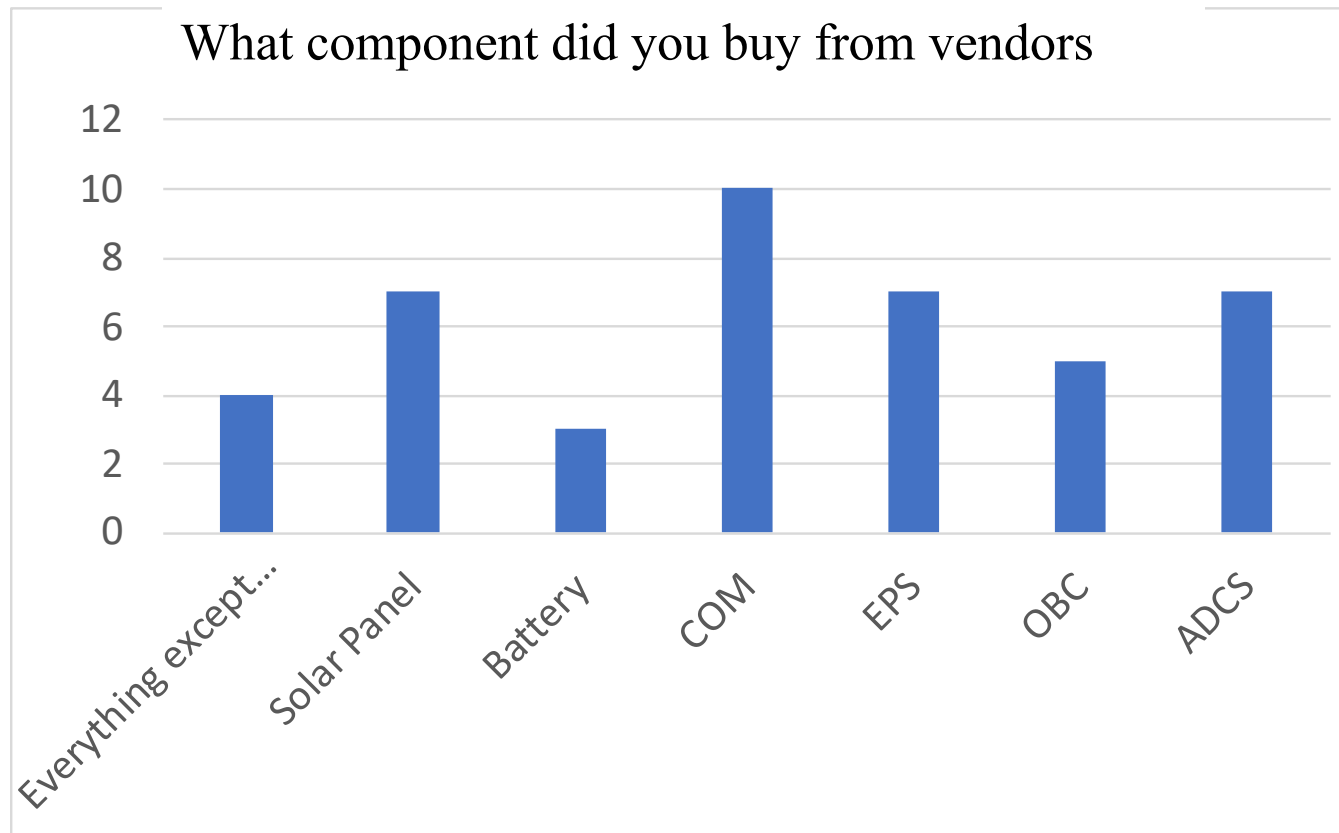
CubeSat developers

Did you buy any component?

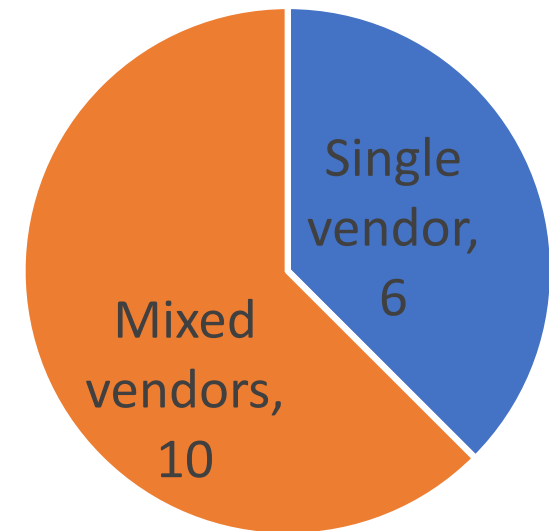


CubeSat Interface Survey

Single vendor vs mixed vendors



Where did you buy?



CubeSat developers

CubeSat Interface Survey

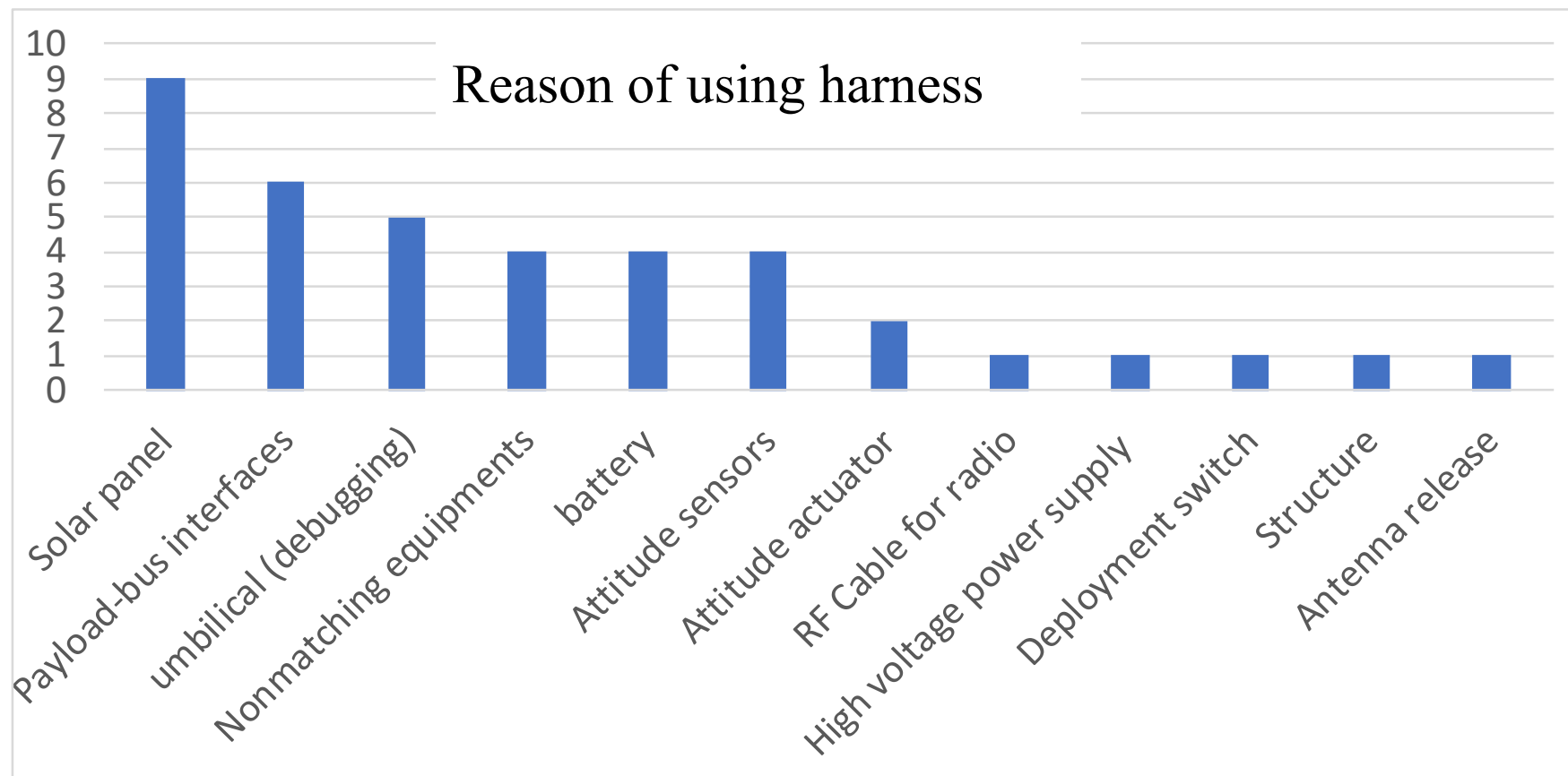
Reason of choosing single vendor or multiple vendor solutions (CubeSat developers)

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 range of options	1
Bought only one component	2	Price	2
		Depending on requirements and performance, functionality	8

CubeSat Interface survey

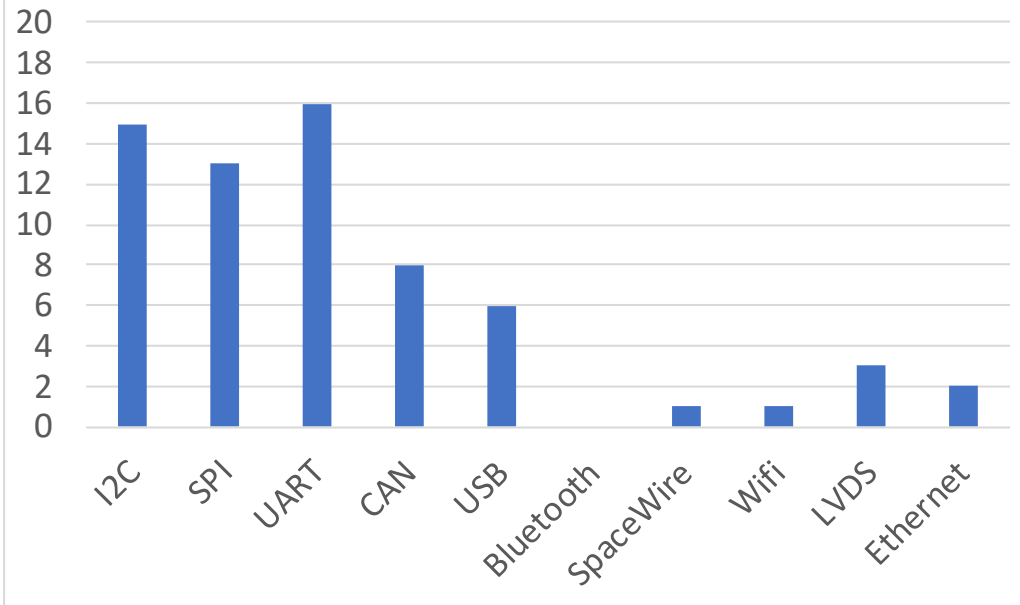
Number of harness lines used in the flight model (CubeSat developers).

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

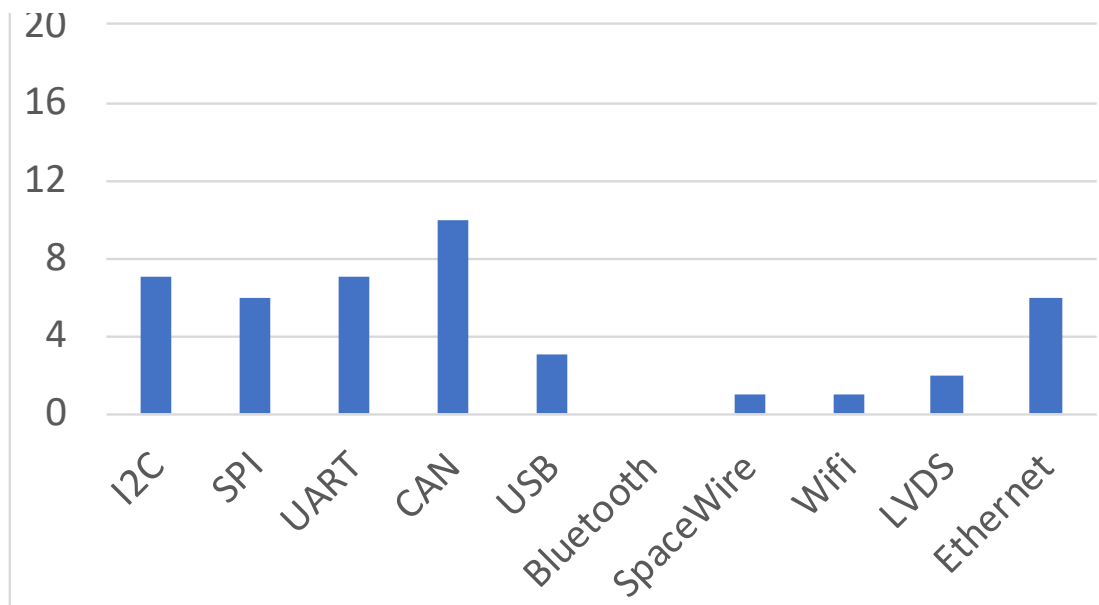


CubeSat Interface survey

Digital communications used



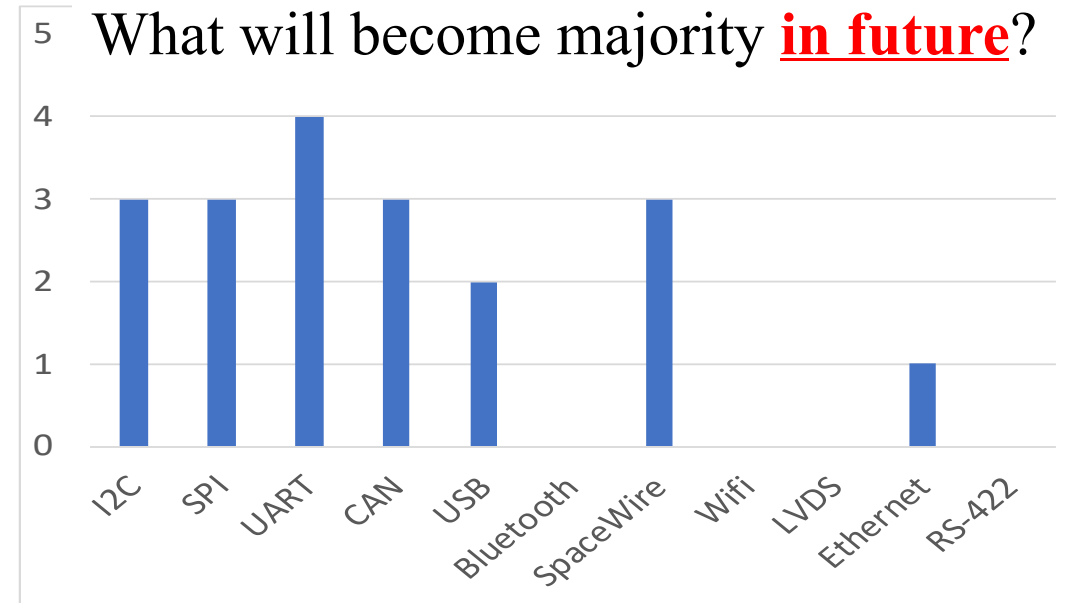
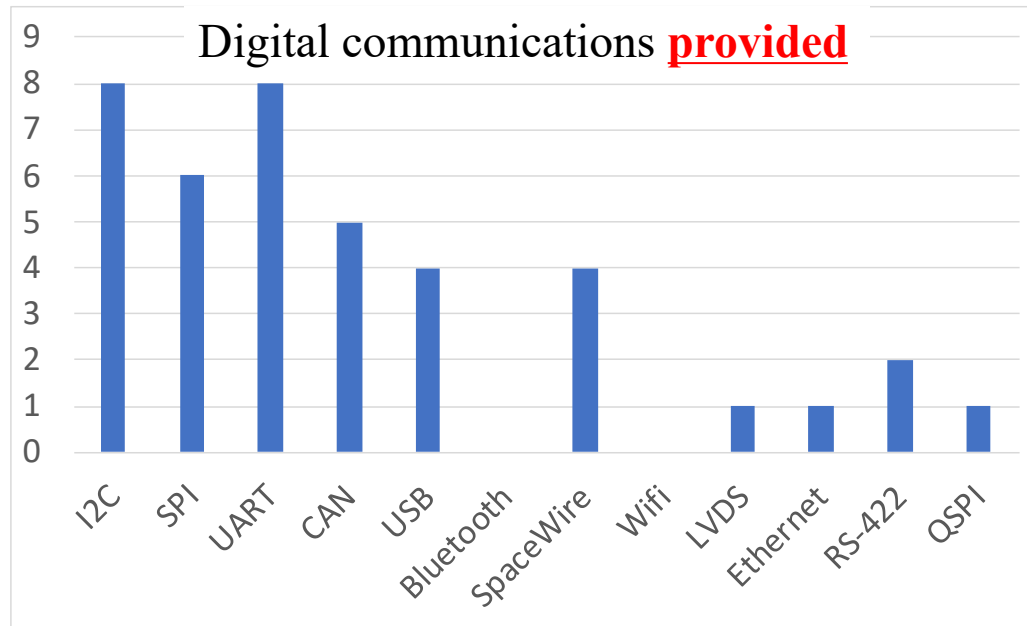
What will become majority in future?



CubSat developers

Developers favor CAN and Ethernet for future

CubeSat Interface survey



CubSat vendors

Vendors favor Spacewire

CubeSat Interface survey

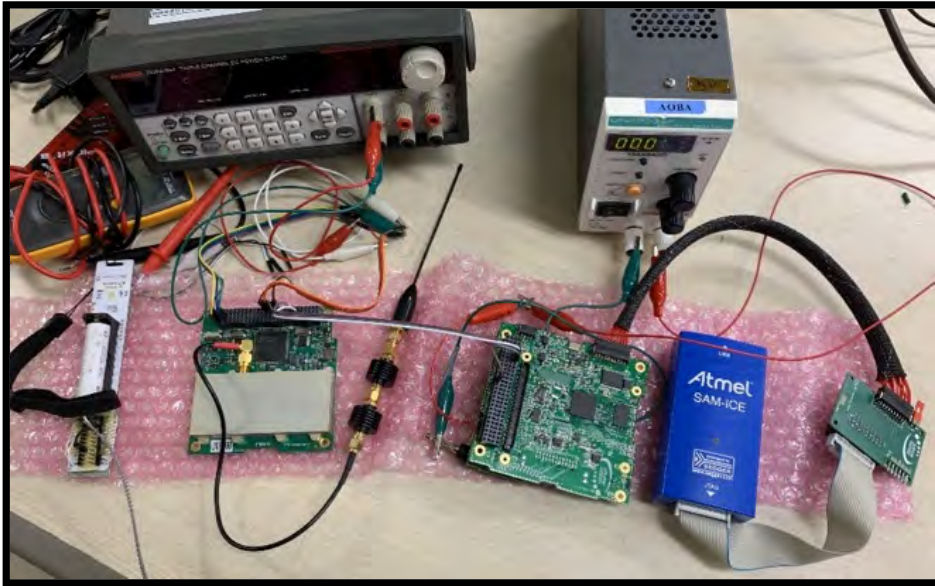
Answers to how to improve the CubeSat delivery time
(multiple choices)

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

TEST OF PC-104 COMPONENT INTEGRATION

- Study how really difficult it is to combine CubeSat components from different vendors.
- Selected three vendors
 - Onboard computer (OBC) from ISIS
 - UHF transceiver (COM) from Clyde Space
 - Electrical power system (EPS) with battery from GomSpace
- The delivery time was from 3 months to 4.5 months.
- Similar to the case when we buy from Japanese domestic vendors

TEST OF PC-104 COMPONENT INTEGRATION



Problems of OBC-COM integration were difficult but manageable
Software needs improvement



OBC-EPS integration was OK for analogue power transmission. But many problems for digital communications

Conclusion

- A new project to standardize the CubeSat electrical interface
 - Aiming at ISO standard toward 2024
 - Open to anybody who are involved in CubeSats
 - Coordinated through <https://lean-sat.org/> along with IAA study group activity
- Research activities to accelerate the satellite delivery time and promote the satellite mass production.
- Contents of standard draft will be discussed more in the Side Meeting
 - Please check the conference schedule