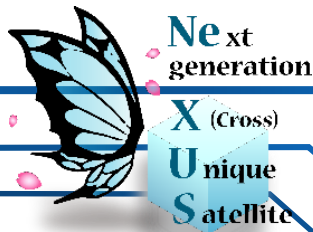
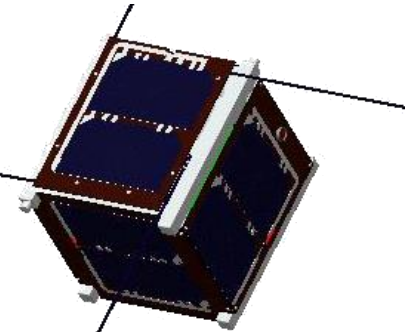


Demonstration of amateur radio technology using a CubeSat “NEXUS”

Tomohiro Suzuki

Nihon university

Miyazaki laboratory



Miyazaki Yamazaki Lab.
宇宙航空システム研究部



JAMSAT



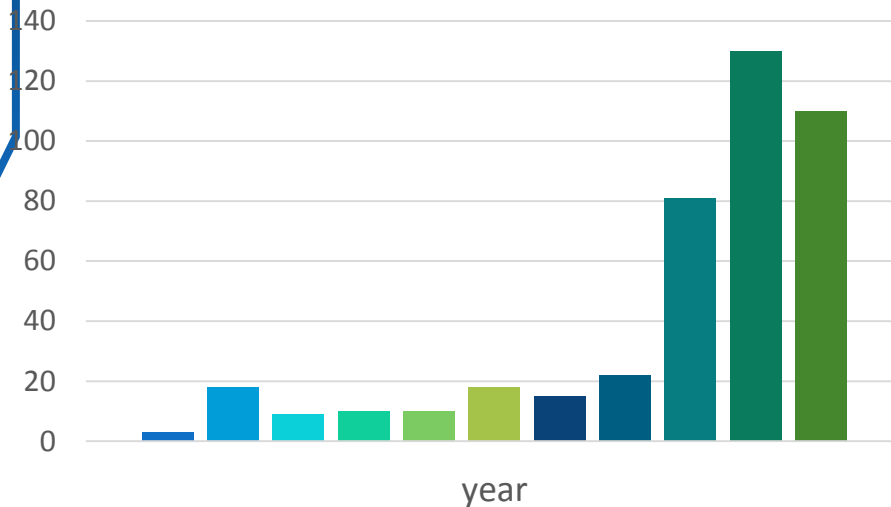
Outline

- Background
- Architecture of satellite
- Mission components
- Development phases
- Future plan
- Conclusion

Background

- In recent years , the increasing of launch of CubeSat are explosively.
- Most of them uses amateur radio band for communication.

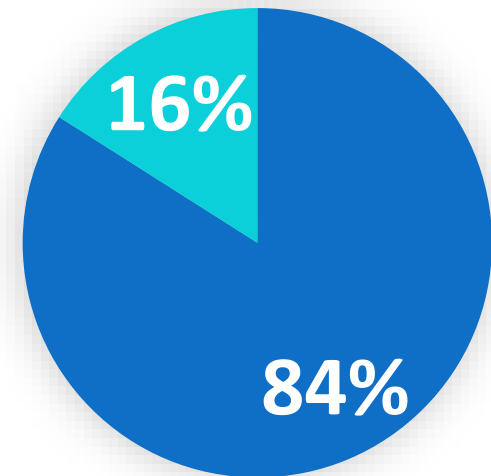
Number of CubeSat
Launched by year



■ 2005 ■ 2006 ■ 2007 ■ 2008 ■ 2009 ■ 2010
■ 2011 ■ 2012 ■ 2013 ■ 2014 ■ 2015

Source: State of the satellite industry report 2016

Frequency breakdown of CubeSat



■ Amateur frequency
■ Experimental frequency

Background



**Mission level
of CubeSat**

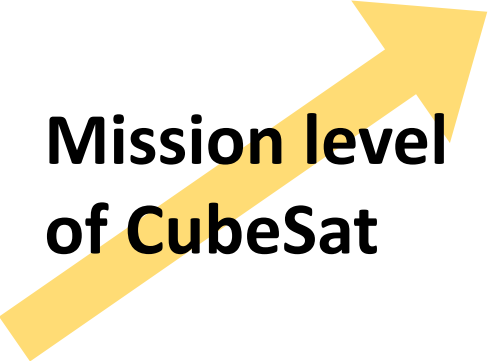


**Quantity of
mission data**



Mission life time

If you have faster transmitter ?



**Mission level
of CubeSat**



**Quantity of
mission data**



Mission life time

Mission objectives

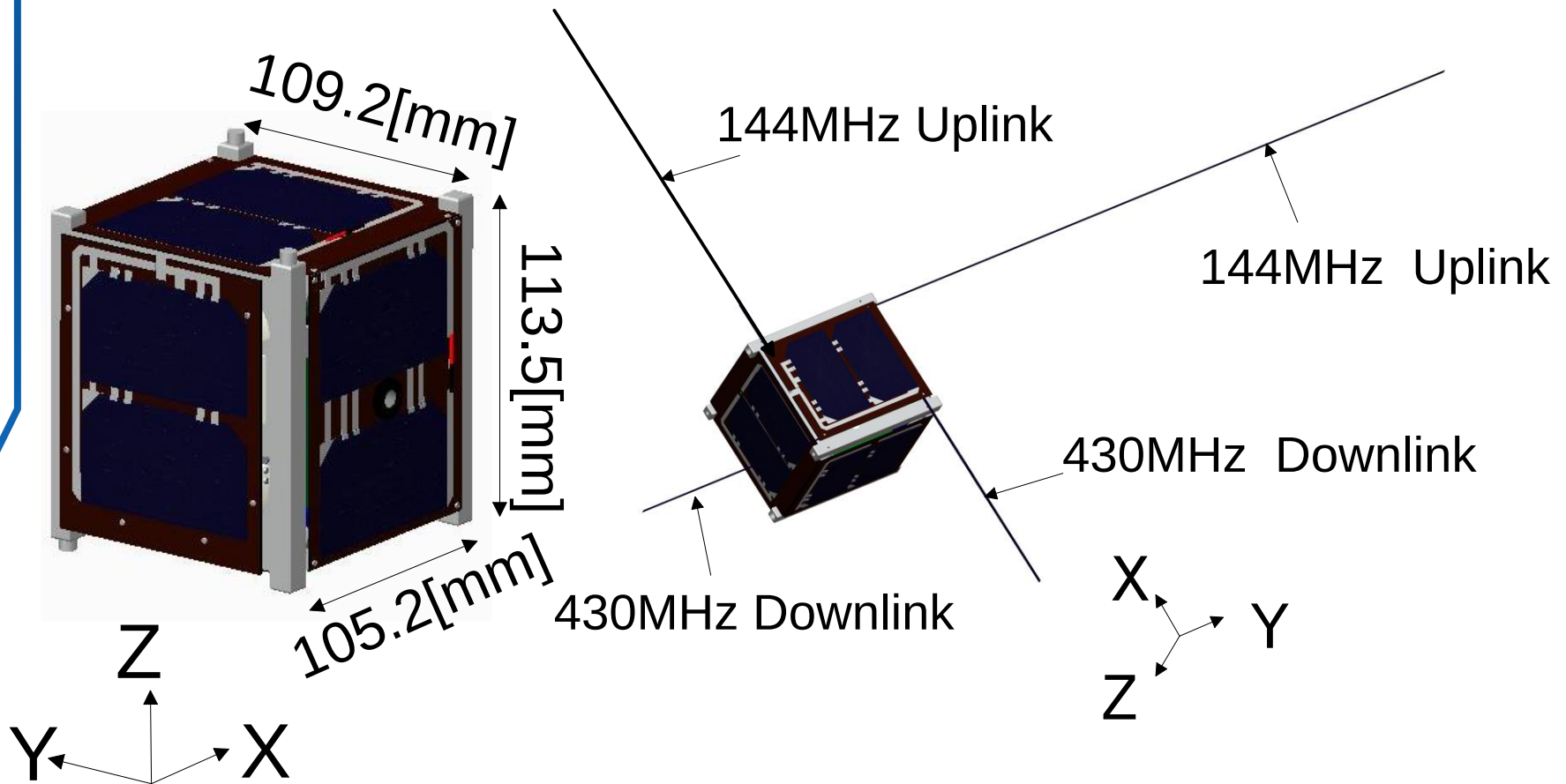
Technology demonstration mission for the following key components.

- $\pi/4$ shift QPSK Transmitter
 - High speed communication device
- FSK Transceiver
 - Multifunctional transceiver
- New CAM system
 - Small and light weight
- Liner Transponder
 - Relay some data for amateur radio operator

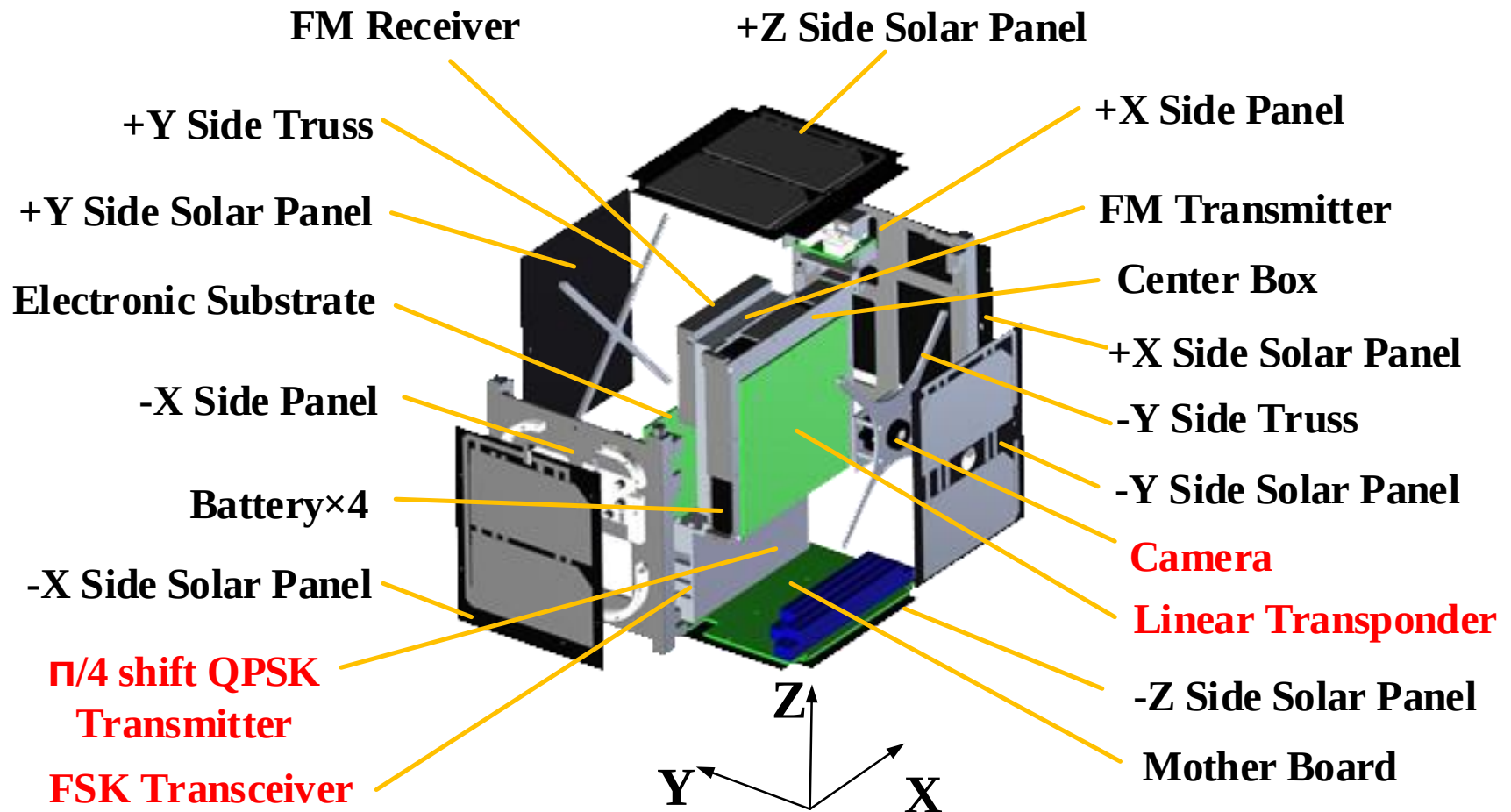


Commercialization off the shelf

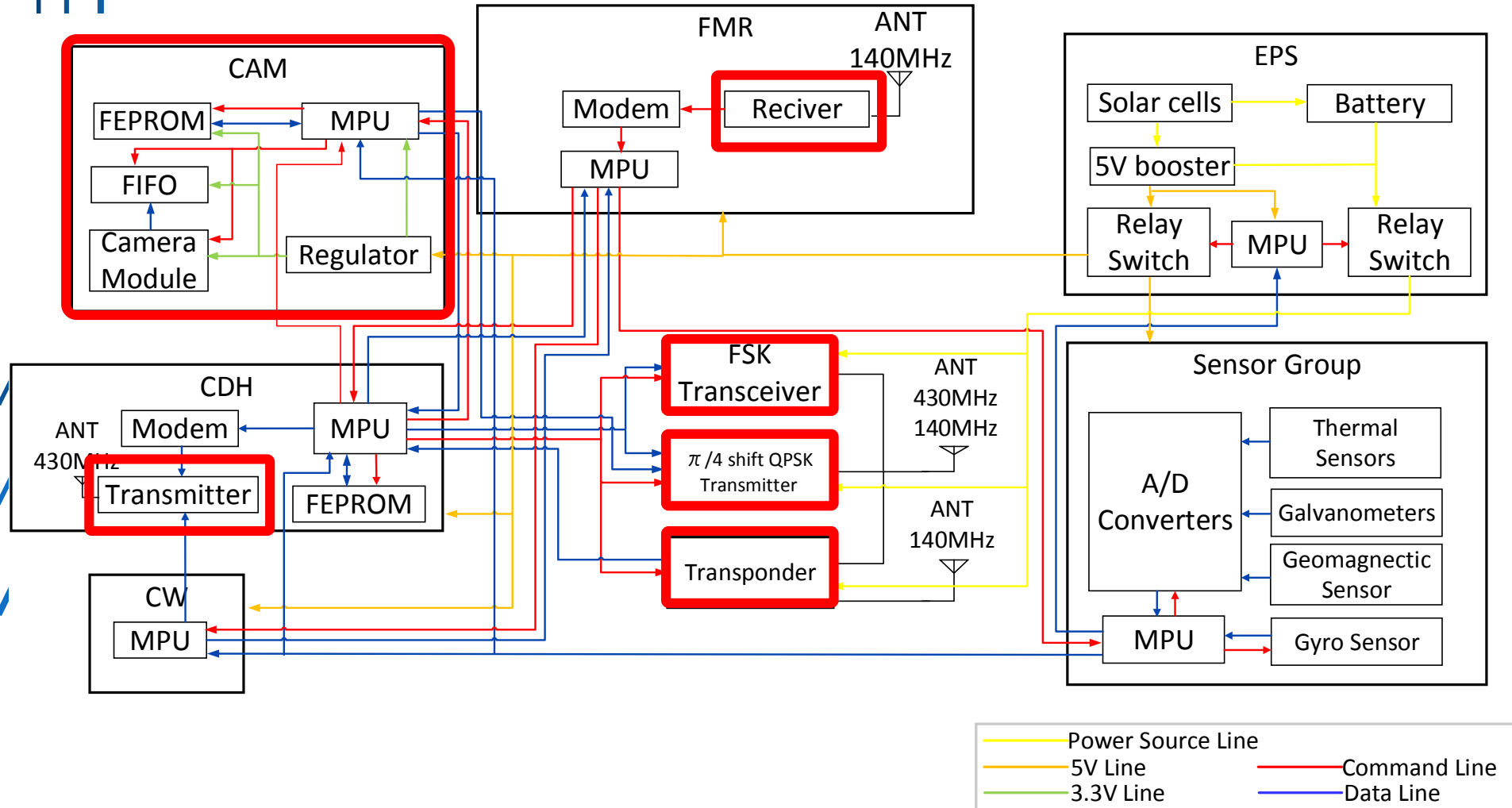
Architecture of “NEXUS”



Architecture of “NEXUS”



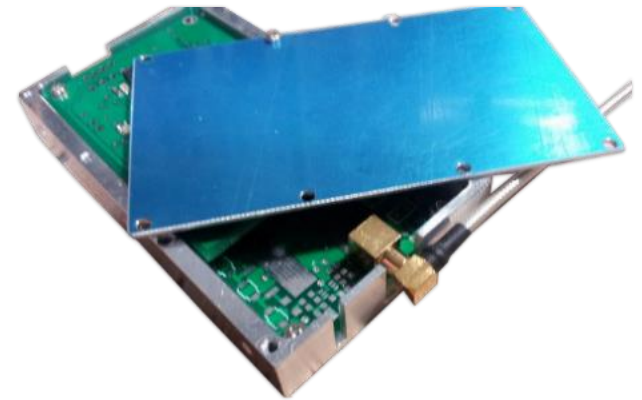
System diagram



$\pi/4$ shift QPSK Transmitter

Mechanical specification

Parameter	Value
Size [mm]	83.5 × 47.5 × 11.5
Mass[g]	74.1
Operation Voltage[V]	3.7~4.2
consumption [W]	0.4



- **38400bps** downlink using 430MHz amateur radio band
 - It is faster than other amateur radio transmitter.
- **FX.25 protocol** communication
 - It is stronger than AX.25 in noise
- Decode by **software defined radio(SDR)**
 - It can reduce the cost of ground station



FSK Transceiver

Mechanical specification

Parameter	Value
Size [mm]	53.8 × 36 × 5
Mass[g]	36
Operation Voltage[V]	3.7~4.2
Transmit Power [W]	0.4



- **600~14400bps** downlink using 430MHz band(FSK modulation)
 - More efficient than conventional communication devices
- AFSK,GMSK modulation
 - Amateur radio operator can decode the data.
- FSK Uplink using 140MHz amateur radio band

Compare of other transceiver

transceiver	Size[mm]	mass [g]	Transmission power[W]	Bit rate[kbps]
NISHI MUSEN FM transmitter	88.5 × 60 × 10.5	60	0.8	1.2 or 9.6
FSK transceiver	53.8 × 36 × 5	36	0.4	0.6 ~ 14.4
$\pi/4$ shift QPSK transmitter	88 × 47.5 × 12.5	74	0.4	38.4
5.8GHzband ¹⁾ FSK transmitter	76 × 70 × 15	-	2	115.2
S-Band ²⁾ transmitter	95 × 46 × 15	75	0.5	1000
S-Band ³⁾ transmitter	200 × 191 × 30	600	0.25	9.6 ~ 38.4

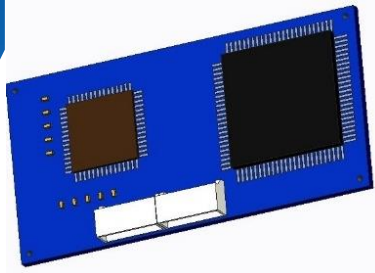
- 1) FITSAT-1 (NIWAKA) Research and development report(written in Japanese)
- 2) CubeSat Shop : S-Band Transmitter for Pico and Nanosatellites
- 3) SSTL : S-Band Downlink Transmitter

New CAM system

➤ NEXUS CAM system

Mechanical specification

Parameter	Value
Size [mm]	80 × 40 × 2 (Board) 30 × 30 × 10(CAM)
Mass[g]	30.4
Operation Voltage[V]	3.3
ROM[GB]	0.032



board image



Camera module

- 5MP(2592×1944pixels)
- JPEG,RGB picture format
- Small size, component

➤ GOM SPACE CAM system

Mechanical specification

Parameter	Value
Size [mm]	96 × 90 × 58
Mass[g]	169
Operation Voltage[V]	3.3
ROM(micro SD)[GB]	2



- 2048×1536 pixels
- JPEG,RGB picture format

Source: GOM SPACE home page
<http://gomspace.com/index.php?p=products-c1u>

Liner Transponder

Mechanical specification

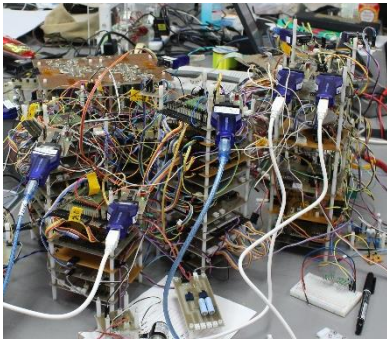
Parameter	Value
Size [mm]	80 × 80 × 10
Mass[g]	150
Operation Voltage[V]	3.7~4.2
Transmit Power [W]	0.8



- Up:140MHz band /Down: 430MHz band Repeater.
 - We can promote the new entry of satellite communication
- Measurement of electrical intensity on the 140MHz band.
 - We can make the map of electrical intensity in the orbit

Development Phases

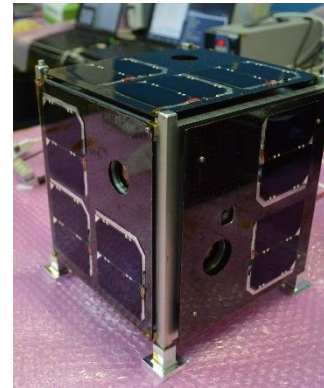
BBM phase



EM phase



FM phase



Launch

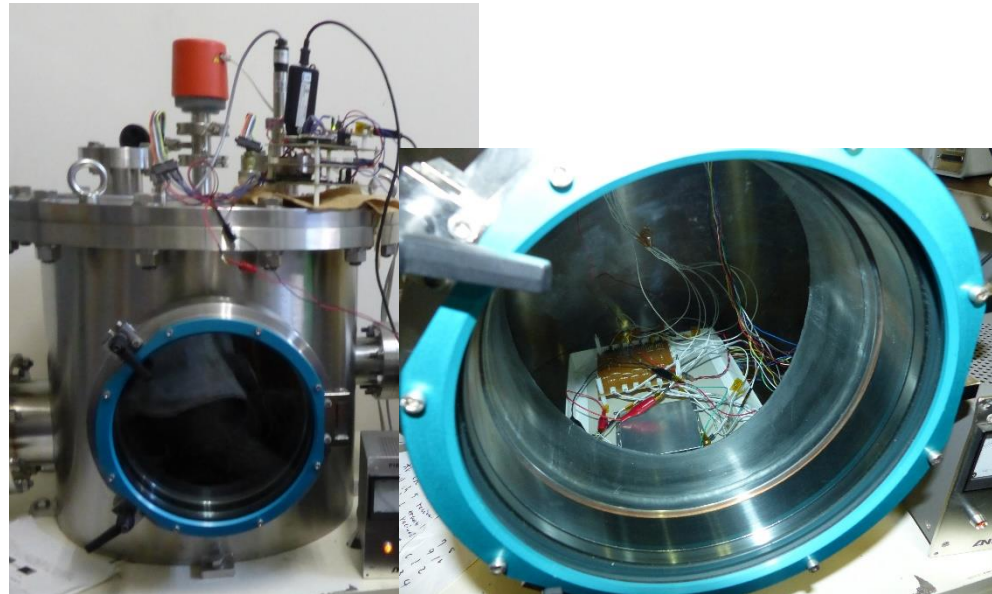
- BBM integration phase
- Key technology are already finish.

Development Phases

- Environmental test (Radiation test, Vacuum test)



Radiation test(total dose)



Vacuum test

- PDR : November 27th
- Try for launching of NEXSU in 2018

No	phases	2016								2017									
		9		10		11		12		1		2		3		4		5	
		1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4
1	BBM																		
2	EM																		
3	FM																		

▼ PDR

▼ CDR

Environment test

No	phases	2017												2018					
		6		7		8		9		10		11		12		1		2	
		1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4	1,2	3,4
1	BBM																		
2	EM																		
3	FM																		

▼ Completion

Conclusion

- QPSK transmitter is high speed and low power communication device.
- QPSK transmitter can reduce the cost of ground station
- FSK transceiver is more multifunction than traditional communication devices.
- CAM system is more small and light weight than traditional camera component.
- The development of key technology of mission devices are already finish.

Thank you for your attention



Ne^{xt}
generation
X^(Cross)
U
nique
S
atellite



Miyazaki Yamazaki Lab.

宮崎山崎システム研究所



JAMSAT

Appendix

Mission Profile

1 month after launch

- Demonstration of $\pi/4$ shift QPSK Transmitter

2 month after launch

- Demonstration of FSK Transceiver

3 month after launch

- Demonstration new CAM system

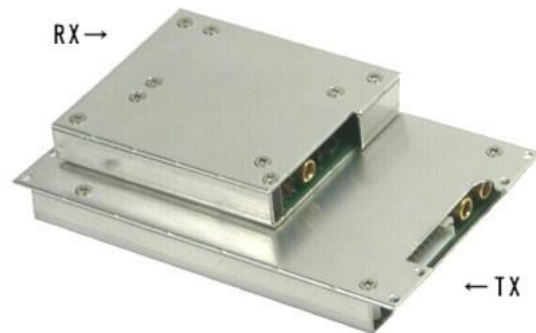
12 month after launch

- Demonstration of Liner Transponder

Appendix

Telemetry transceiver

- CW/FM combined transmitter
- AFSK modulation receiver
- Send HK data and some mission data



Parameter	Value
Size [mm]	88.5 × 60 × 10.5
Mass[g]	99
Operation Voltage[V]	5.0
Transmit Power [W]	0.1 W(CW operation) 0.8 W(FM operation)
Transmission rate[bps]	1200bps,9600bps

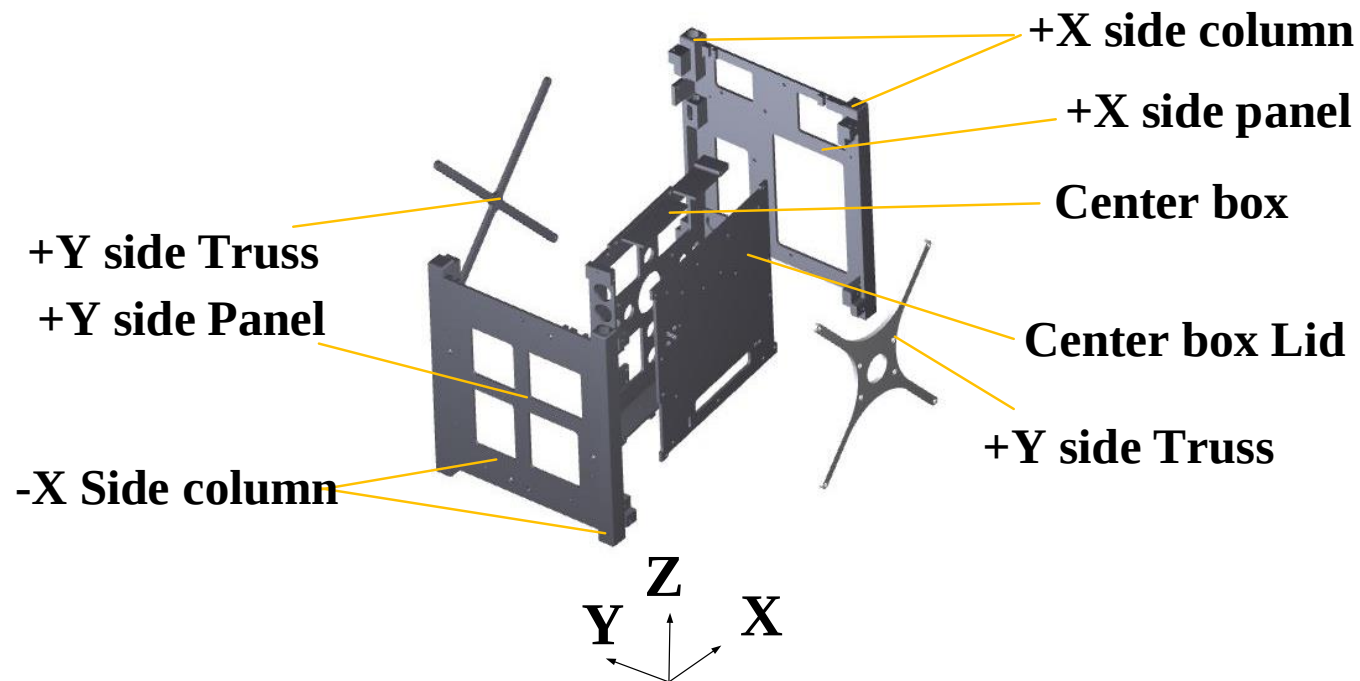
Introduction

Success criteria

mission	Full success	Extra success
Demonstration of $\pi/4$ shift QPSK transmitter	To downlink the data in 38400bps by using the QPSK transmitter	N/A
Demonstration of FSK Transceiver	To downlink data in between 600 and 14400 bps	N/A
Demonstration new CAM system	Shooting the Full HD earth images and downlink those images data.	N/A
Demonstration of Liner Transponder	To relay data by using liner transponder	To make a map of 140MH band electrical intensity of LEO

Appendix

Structure and heat subsystem

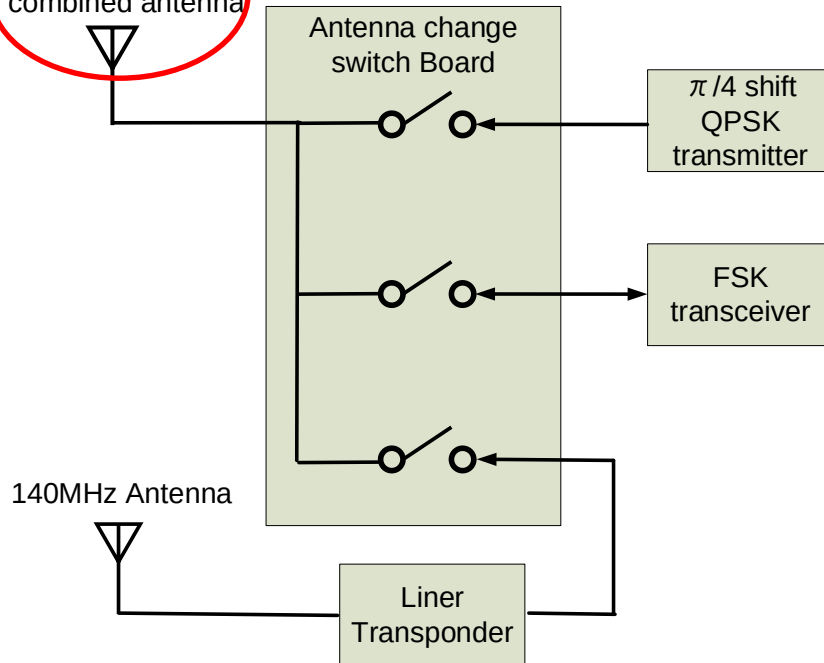


- It has 2panel , 2 truss and central box.
- Each panel has two columns.

Appendix

Breakdown of antenna

140MHz,430MHz
combined antenna



140MHz antenna

430MHz antenna

CW/FM
combined
transceiver

430MHz band

140MHz band

