



ACCEDE | ESCCON

ALTER



2025

Seville - Spain
25 to 27th March



COTS Components in CSS's Space Utilization System

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Space Components Mission Assurance

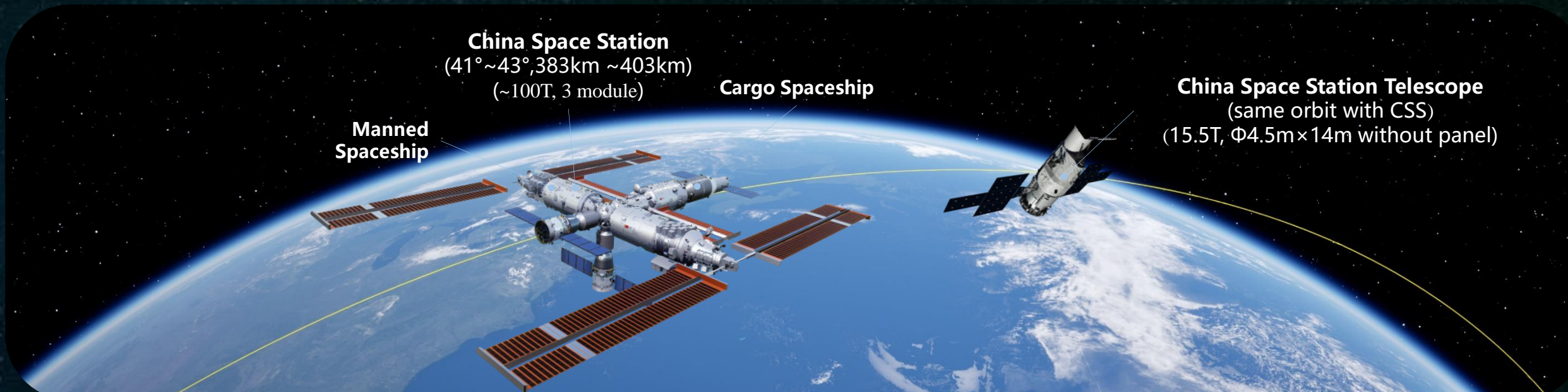
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Technology and Engineering Center for Space Utilization(CSU)

Chinese Academy of Sciences

<http://english.csu.cas.cn>



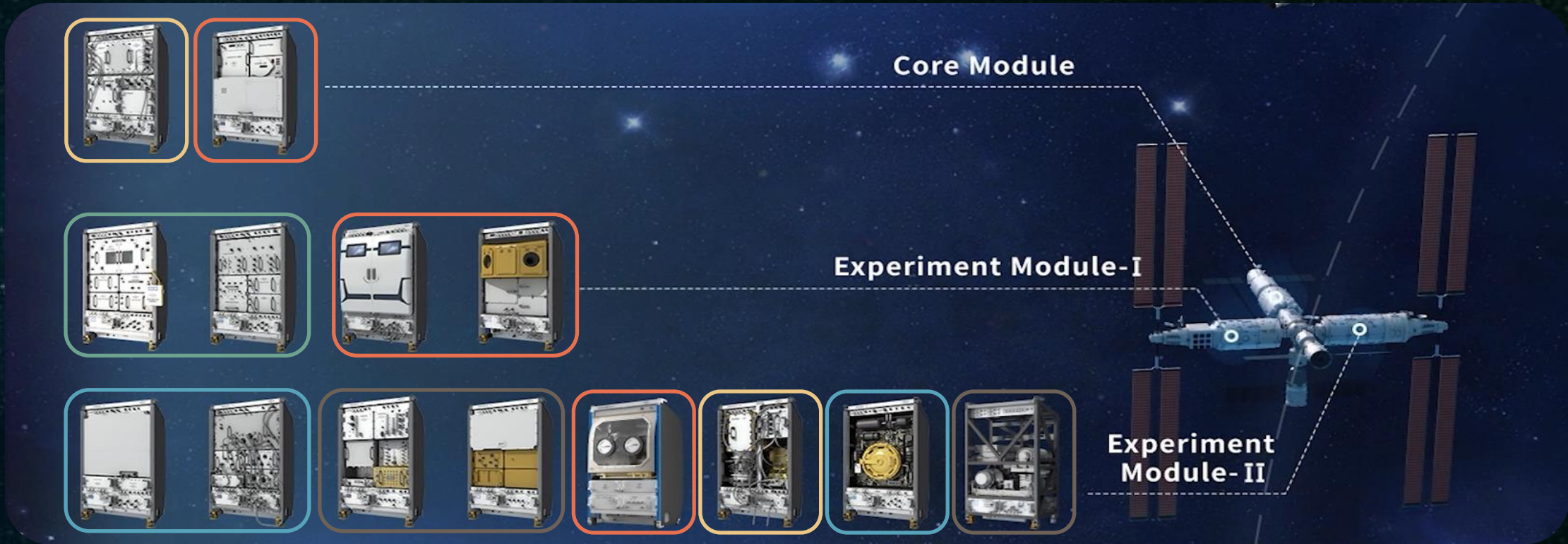


China Space Station (CSS)

Expected lifetime	≥10 years, try to reach 20 years +
Power for payload	12kW
Scientific experiment facility	Pressurized facility: 14 experiment racks, 5 express racks Exposed facility: 50+ payload adaptors
Minimum Crew	3
Cargo ship	1 launch/6 ~ 9 months, > 6500kg cargo
Manned ship	2 launch/year, >300kg Upload cargo, >50kg return cargo
Data transmission	Uplink: 3 ~ 9Mbps Downlink: 1.2Gbps

China Space Station Telescope (CSST)

Expected lifetime	≥ 10+ years
Power for payload	3kW
Main performance metrics	Aperture: 2m; FOV: 1.7sqdeg; Angular resolution: 0.13" spectrum: 255nm ~ 2.5μm
Scientific instrument	5 payload
Data transmission	Uplink: 3 ~ 9Mbps Downlink: 1.2Gbps



Space life science and biotechnology

- Ecology Science Experiment Rack (ESER)
- Biotechnology Experiment Rack (BER)
- Space Radiation Biology Exposed Payload

B

Material science in space

- Material Furnace Experiment Rack (MFER)
- Electrostatic Levitation Experiment Rack (ELER)
- Material Science Exposed Payload

M

Fundamental physics in microgravity

- Cold Atom Experiment Rack (CAER)
- High-precision Time-Frequency Rack (HTFR)

P

F

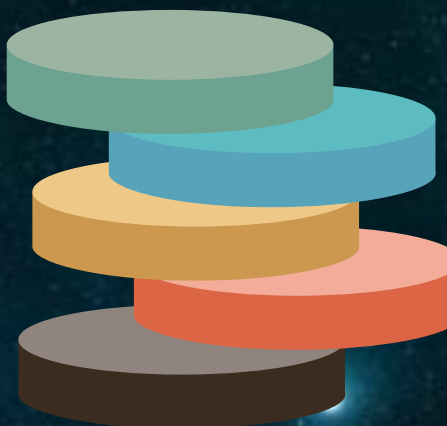
Microgravity fluid physics & combustion

- Fluids Physics Experiment Rack (FPER)
- Two-phase System Experiment Rack (TSER)
- Combustion Experiment Rack (CER)

Multipurpose

- High Micro-gravity Level Rack (HMGR)
- Varying-Gravity Experiment Rack (VGER)
- Science Glove-box and Refrigerator Rack (SGRR)
- Online Maintenance and adjustment Operation Rack (OMOR)

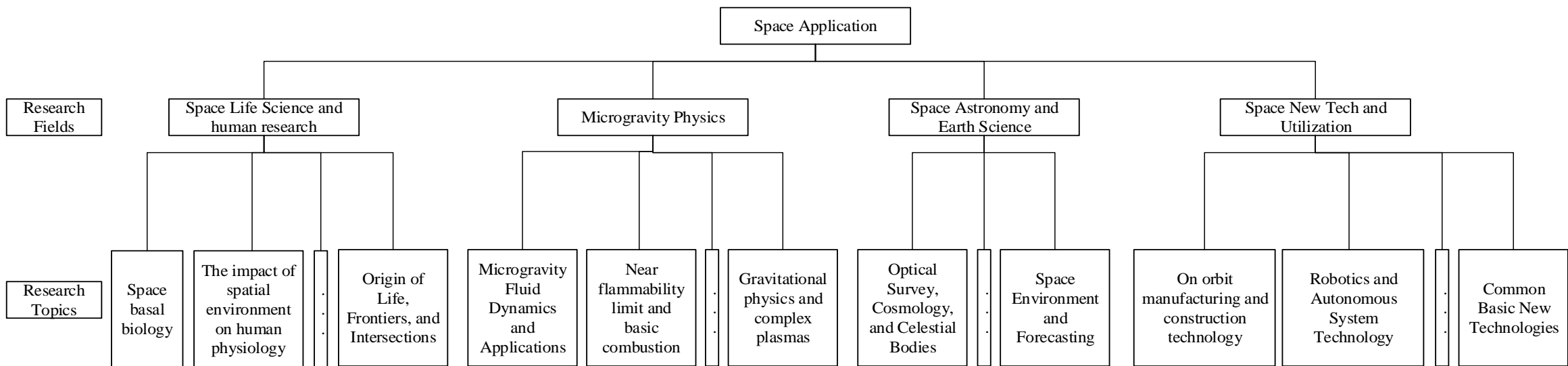
U



China National Space Laboratory

Largest space comprehensive research and experimental platform in China

Carrying out systematic and internationally frontier space science and application research and new technology demonstration, continuously producing major scientific and technological achievements, and continuously obtaining comprehensive application benefits.



The First Report on Scientific Research in China Space Station (2024)
<https://www.cmse.gov.cn/xwzx/202412/W020241231661310955564.pdf>

COTS & Customized Components @ CSU

- **CSU has been undertaking the development of China Manned Space Program since 1992.**
- **Neither as conservative as traditional practice nor as open as the commercial aerospace companies.**
- **Total 91184 pcs of 949 types of COTS components in CSS, including IC , connector , optoelectronic devices, and BME MLCC, etc.**
- **Customized components based on commercially mature technologies, such as radiation-hardened fiber, PLC splitters, and optical transceiver modules.**

CSU EEE Selection Policy

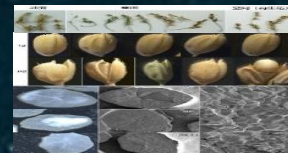
		Payload Risk Level			
		I	II	III	IV
Selection Requirements	Minimum Requirements	Space Grade	Mil Grade	Mil and Mil complaint	Automobile
	Policy about COTS	COTS not recommended	COTS not recommended	Auto, Commercial +board screening	Auto, Commercial +board screening

◆ **24/7 Operational Level I Payload :**

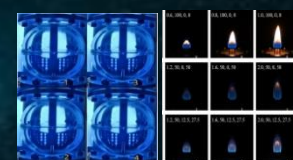
- ✓ Information System: 24% COTS, incl. 20 kinds of IC
- ✓ Solid-State Power Controller(SSPC): 21% COTS, 38 kinds COTS
- ✓ Including total about 50,000 pcs of COTS BME MLCC in orbit

◆ **Zero component failures in nearly four years in orbit, with 107 research projects implemented**

Space Life Science and human research



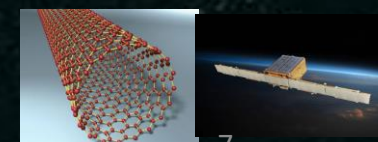
Microgravity Physics



Space Astronomy and Earth Science



Space New Tech and Utilization





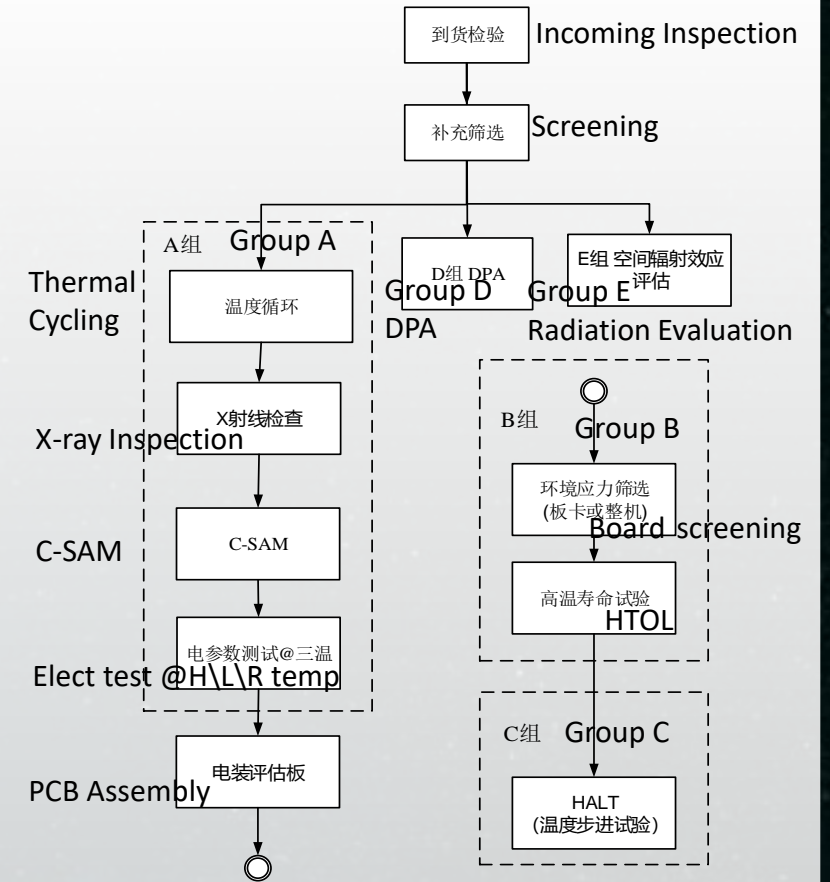
CSU EEE Screening and Evaluation

	Mono IC	Screening*	LAT	DPA	Radiation
Level I	Automobile	✓	✓	✓	✓
	Commercial	✓	✓	✓	✓
Level II	Automobile	✓	✓	✓	✓
	Commercial	✓	✓	✓	✓
Level III	Automobile			✓	
	Commercial	✓		✓	
Level IV	Automobile			✓	
	Commercial			✓	

- ✓ *Board screening is implemented to effectively address cost pressures.
- ✓ Case-by-case principle: dedicated quality assurance plan for each individual payload and for each individual component

Evaluation: Trust the power of commercialization and Focus on Necessary Verification

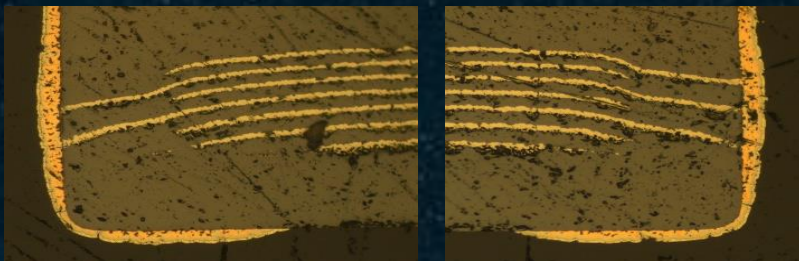
LAT for Monolithic IC			
Group	Item	Method	Samples
A	Thermal Cycle	GJB548 method 1010 I: 200cys ; II: 100cys	4
	X ray	GJB 548 Method 2012	
	C-SAM	GJB 548 Method 2030	
	Electrical test	datasheet	
B	PCB assembly	soldering	Board with 4 samples from Group A
	Board screening	12.5TC@-40~+85°C, Min4h@high-temp phase	
	HTOL	Min240h@125°C Tj (hottest point)	
C	Temperature Step Test (not as criteria)	5°C each step from RT until abnormal	
D	DPA	GJB4027	3
E	Radiation Evaluation	Test and FMEA	2



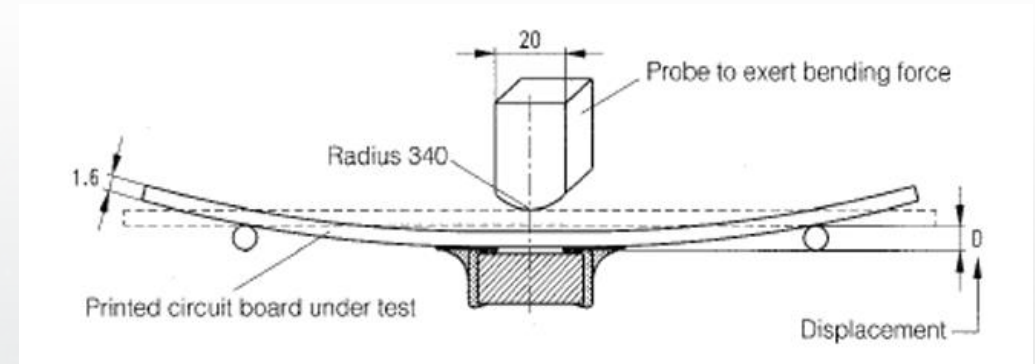
An example of COTS BME MLCC Evaluation

Make technical judgments to maintain the cost-efficiency and ensure reliability.

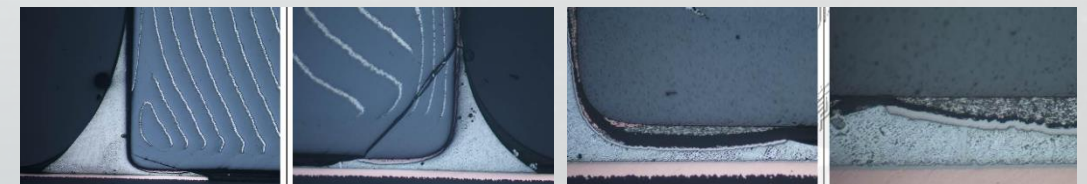
- ✓ Most of qualification tests based on military standards are redundant.
- ✓ Some screening is necessary based on critical weak points



A Counterexample: 217/2400 failed burn-in , & failed the 2mm board flex test



Critical Item	Method	Criteria
BOARD FLEX TEST	AEC-Q200-005A	2mm



MLCC failed the 2mm board flex test

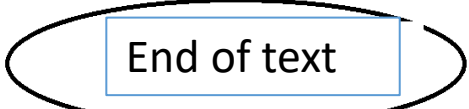


A Lesson from a COTS Failure

- A payload failed twice, with the digital isolator ISOW7841 being a contributing factor In 2019
- Short time into the market for massive product since 2017, with frequent datasheet revisions.
- Reliable use of the product depends on stringent user design criteria

11 Power Supply Recommendations **Revision E** (November 2017)

To help ensure reliable operation at data rates and supply voltages, adequate decoupling capacitors must be located as close to supply pins as possible. The input supply must have an appropriate current rating to support output load and switching at the maximum data rate required by the end application. For more information, refer to the [Detailed Design Procedure](#) section.



11 Power Supply Recommendations **Revision F** (March 2019)

To help make sure that operation is reliable at data rates and supply voltages, adequate decoupling capacitors must be located as close to supply pins as possible. The input supply (V_{CC}) must have an appropriate current rating to support output load and switching at the maximum data rate required by the end application. For more information, refer to the [Detailed Design Procedure](#) section.

ISOW784x integrates a synchronous, isolated DC/DC converter along with isolated data channels. Due to finite efficiency of the integrated micro-transformer, for any given output load current, the input current will be proportionally higher. Thus, the input supply (V_{CC}) decoupling capacitor also needs to be sufficiently larger than the output supply (V_{ISO}) decoupling capacitor. It is recommended to have an input capacitor that is larger than the output capacitor by at least 100 μF . It is also recommended to have an input power supply to ISOW784x with sufficient current limit to support output load current requirements. For an output load current of 130 mA, it is recommended to have >600 mA of input current limit and for lower output load currents, the input current limit can be proportionally lower. When the input supply is lower than 2.7 V, the device can go into a protected under-voltage lock out (UVLO) state per the UVLO thresholds specified in datasheet. Under UVLO state, it is recommended that the output voltage also be discharged to less than 2.1 V. This can be accomplished by having an input capacitor that is 100 μF larger compared to the output capacitor. It also helps to have a small load (~10 mA) at the output capacitor to bleed off any unwanted, residual charge. To make sure ISOW784x quickly transitions from UVLO state to powered state, it is recommended to have an input supply rise time of less than 10 ms.

If it is not possible to follow the aforementioned recommendations and frequent brownouts are expected on the input supply, then simple secondary side monitoring, protection and reset components can help improve the robustness of overall system and power-up or reset mechanisms. More details on output monitoring, protection and an example of reset mechanism can be found in [Overvoltage protection for isolated DC/DC converter](#)

Changes from Revision F (April 2016) to Revision G (March 2017)	Page
• Changed part numbers in the <i>Power Ratings</i> table (previously <i>Power Dissipation Characteristics</i>)	4
• Changed the input-to-output test voltage parameter to apparent charge in the <i>Insulation Specifications</i>	5
• Added the <i>Receiving Notification of Documentation Updates</i> section.....	26

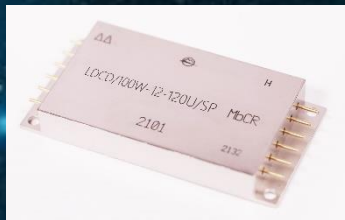
Changes from Revision E (March 2016) to Revision F (April 2016)	Page
• Changed the number of years for the isolation barrier life in the <i>Features</i> section	1
• VDE certification is now complete	1

Revision last updated in 2024 where revision F was released in 2016, actually previous revision F released in 2019

Datasheet in 2017 and 2019

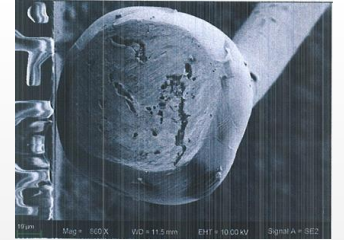
High Grade ≠ High Reliability

- Ball lifted on three consecutive batches of H-grade DC/DC converters from a foreign manufacturer.
- High-grade ≠ Zero risk
- DPA is necessary
- Space-grade DC/DC converters are now available from at least three Chinese manufacturers.(100V input, 100W output with 5V, 12V, ±12V, 28V)



检验结果						
样品编号	引线材料	引线直径 (μm)	试验引线根数	合格判据 (gf)	实测值范围 (gf)	检验结果
3-1	Al	125	6	≥20.0	126.5~184.6	合格
	Au	25	188	≥2.5	10.0~18.1	合格
	Au	25	1	≥2.5	1.6	F不合格

1710 batch



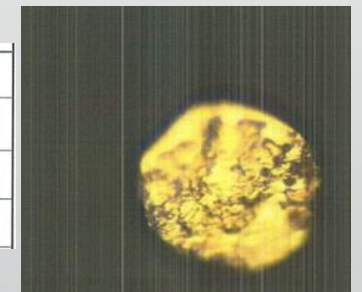
检验结果						
样品编号	引线材料	引线直径 (μm)	试验引线根数	合格判据 (gf)	实测值范围 (gf)	检验结果
5-1	Au	25	183	≥2.5	5.0~17.5	P合格
	Al	125	6	≥20.0	162.7~182.6	合格
	Au	25	1	≥2.5	0.9	F不合格

1738 batch



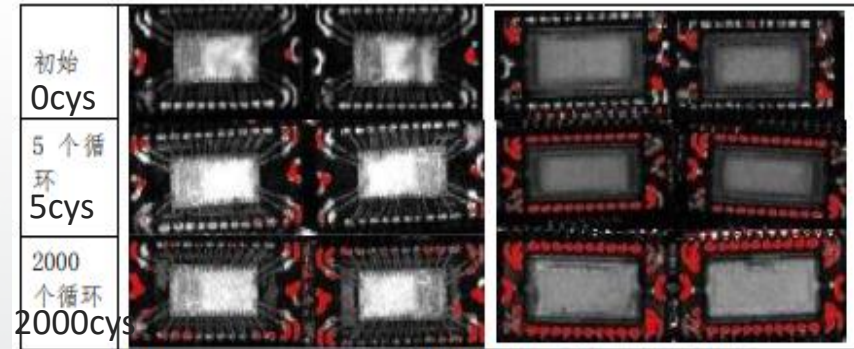
检验结果						
样品编号	引线材料	引线直径 (μm)	试验引线根数	合格判据 (gf)	实测值范围 (gf)	检验结果
2-1	Au	25	185	≥2.5	10.4~17.2	P合格
	Au	25	1	≥2.5	1.6	F不合格

1802 batch



High Reliability Standard Test Method Issues for COTS

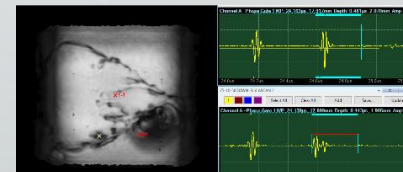
- Delamination is a particularly common issue
- Which to depend on, C-SAM or electrical test and burn-in?
- Effectiveness is worth further study
 - ✓ C-SAM is costly
 - ✓ Immersion in water followed by heat drying may bring oxidation of pins, especially for small size COTS
 - ✓ Not applied to some plastic packages



Delamination expanded after 2000TC (-65--+125°C) , still well performed



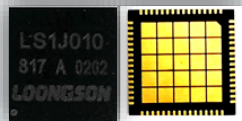
Delamination, failed to elec test after 5cycles TC on poor-quality PEM



MLCC Delamination, screened out by burn-in

Customized Components

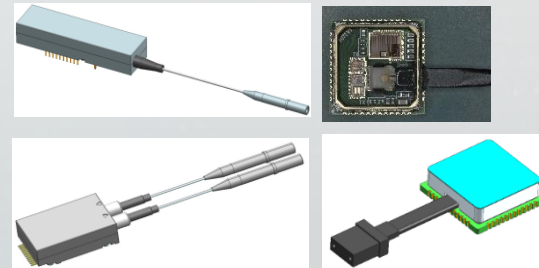
- ◆ Some components originate from commercial technologies and manufacturing processes
 - Optical fiber drawing, coating, on-line tensile strength
 - Fully Automated Process of Plastic Encapsulation for Integrated Circuits
 - the typical manufacturing processes used for optical transceiver modulesIn the communications industry
- ◆ Actually, we are transitioning from traditional high-reliability processes to a large-scale commercial system



8*8mm small-size plastic encapsulated Rad-tolerant MCU,32bit,LS132R,8/10MHz



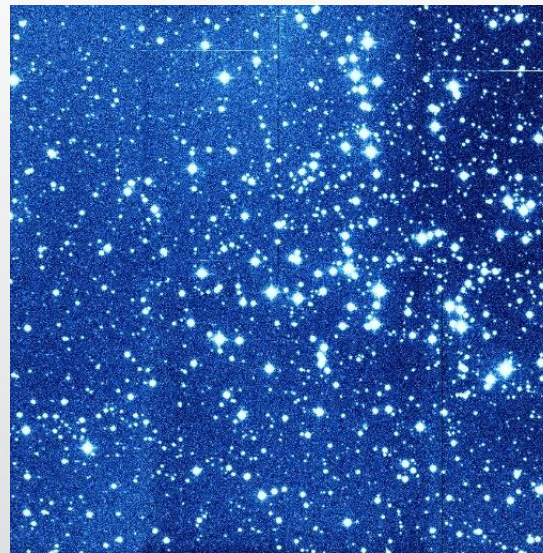
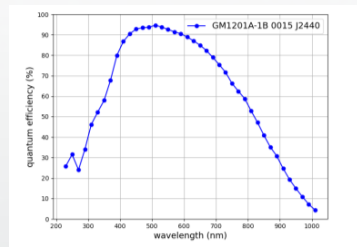
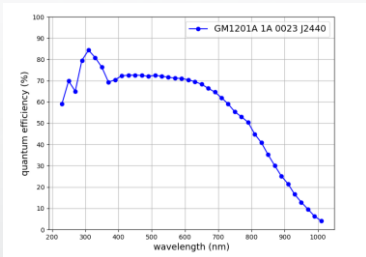
18Mrad(Si) G652 Rad-hard Optical Fibre



4.25Gbps water-sealed high-reliability optical transceiver module with bare die inside

Space-Grade Components

◆ Core and scientific-grade components are essential and irreplaceable.



M38 star cluster



LS1E300 CPU

32bit GS232,200MHz
Supports 128-bit vector operations.
300Krad (Si)
SEL \geq 75 MeV/mg/cm²



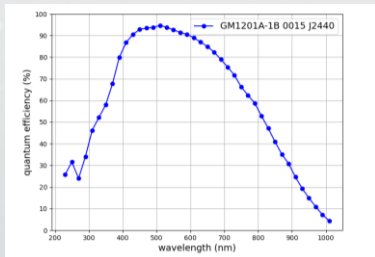
LS1F300 CPU

32bit GS132E,66MHz
Bus: EMI , PCI, ISA , 1553B , CAN , UART , SPI , I2C , SpaceWire;
Interface: AD , OC , PWM , PCM , PPC , GPIO
300Krad (Si)
SEL \geq 75 MeV/mg/cm²

Total more than 500 LOONGSON CPUs in orbit

UV-enhanced
Quantum Efficiency @-85°C

Visible-enhanced
Quantum Efficiency@-85°C



Dark Current
Full array @-85°C

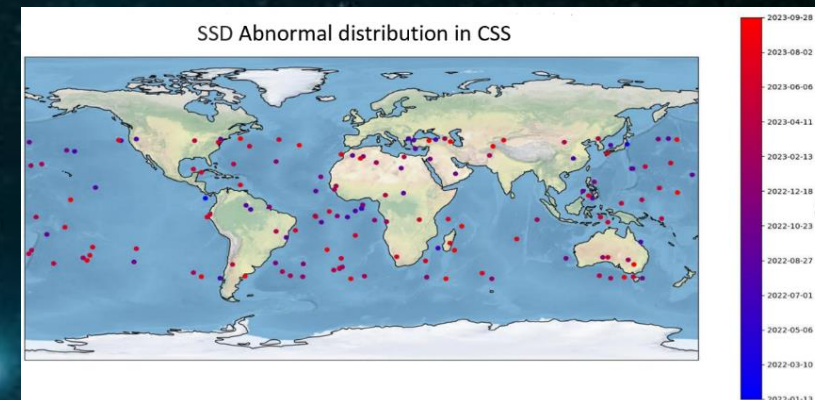


GM1201A-1 astronomical CCD Qualified for CSST
(9220 (H) × 9240 (V) Pixel size: 10 μ m × 10 μ m
Readout Noise@ \leq 40s readout: \leq 5e⁻/pix)
China electronics Technology Group Corp.No.44 Research Institute

Challenge from COTS Radiation Effect

- 48 Solid State Drives(SSD) from 3 different manufactures 24/7 running in orbit
- 300TB scientific data stored and downloaded
- Some SSD are extremely sensitive to SEE and TID (even below 5Krad)
- Neutrons can effectively be used to select SSDs
- Abnormal is normal in space for COTS as long as predicted
- RAID redundant is necessary and Firmware Refresh is effective

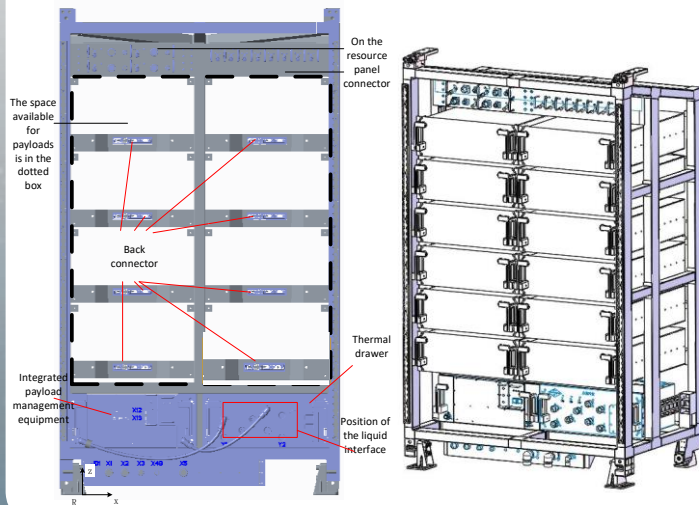
SSD Model	Number In orbit	Abnormal Avg Period (Individuals,days)
Type I	32	83.6
Type II	8	17.9
Type III	8	211.7



Rich Resources for New Facilities

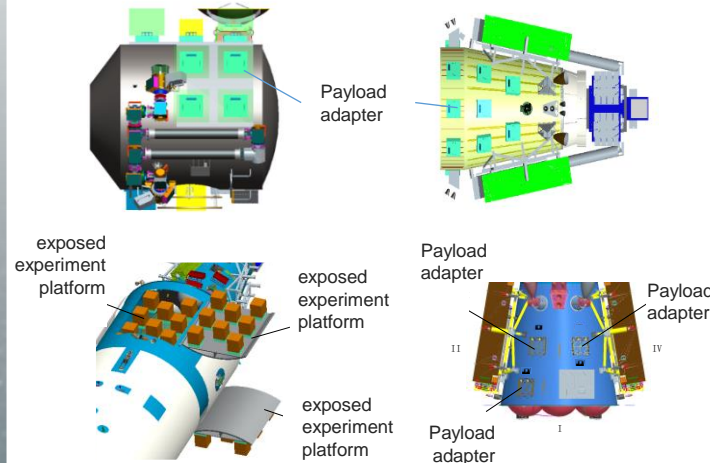
5 Express Racks

Express sub rack payloads:
12 SDU, or 8 SPU



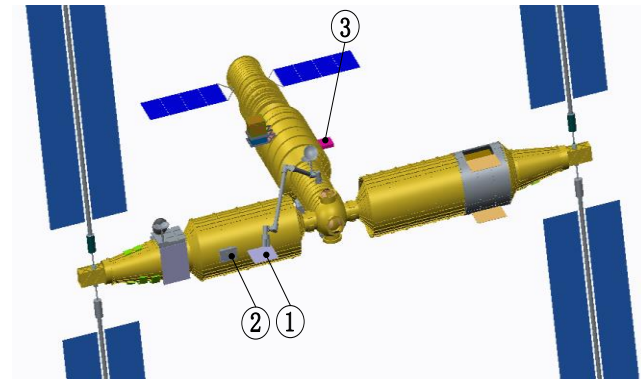
50+ Exposed Standard Payload Adaptors

Standard Adaptor payload:
up to 160kg



3 Exposed Large Payload Adaptors

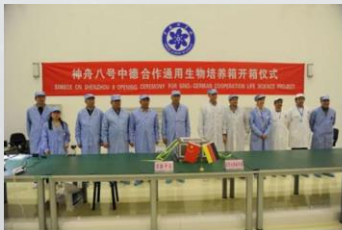
Large adaptor payload:
500kg~2000kg



SiC MOSFET, with 400V SEE immunity, is currently undergoing in-orbit verification, along with 260 COTS supercapacitors supporting this verification

International Collaborations

Previous Activity —Joint Experiments



2010-2011 SIMBOX
China-Germany Cooperation on SZ-8



2018-2019 POLAR
China-Switzerland Cooperation on TG-2

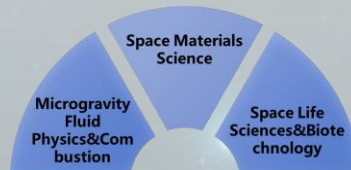
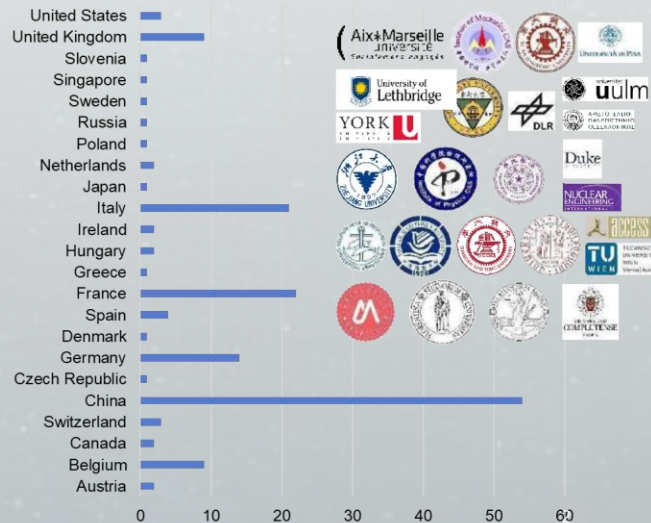


2015-now: Cooperation on Parabolic Flight



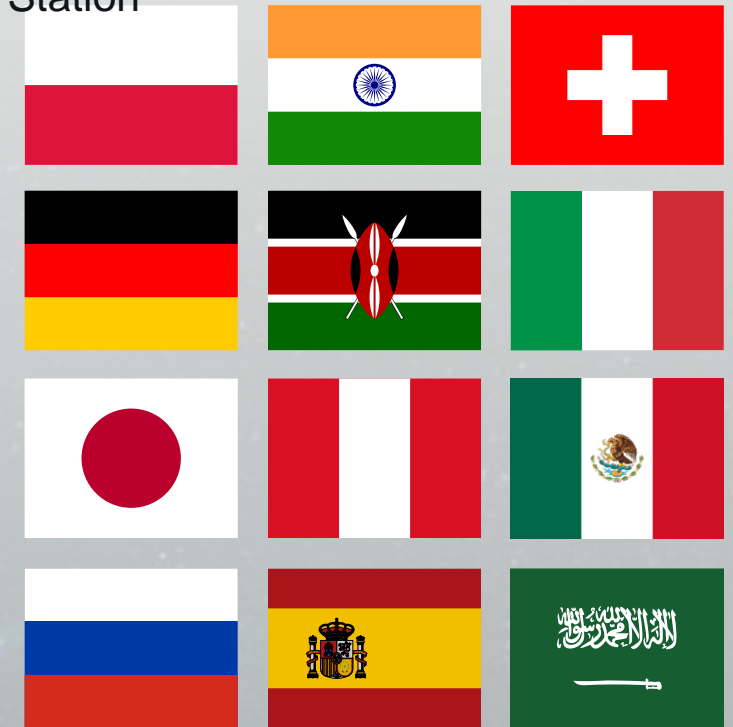
Current Activity with ESA

10 undergoing cooperative projects for the first round, 158 labs from 95 organizations of 23 countries



Current Activity with UNOOSA

7 projects from 12 countries will be launched on board the China Space Station



Our Lab is Open!



Welcome international partners to join our missions in advancing life on Earth, enabling future space exploration, and deepening our understanding of the universe!

Technology and Engineering Center for Space Utilization(CSU), CAS
<http://english.csu.cas.cn>

China Manned Space
[http:// en.cmse.gov.cn](http://en.cmse.gov.cn)