Development and Reliability assesment of High Data Rate cPCI Serial Space Connectors

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14/10/2025

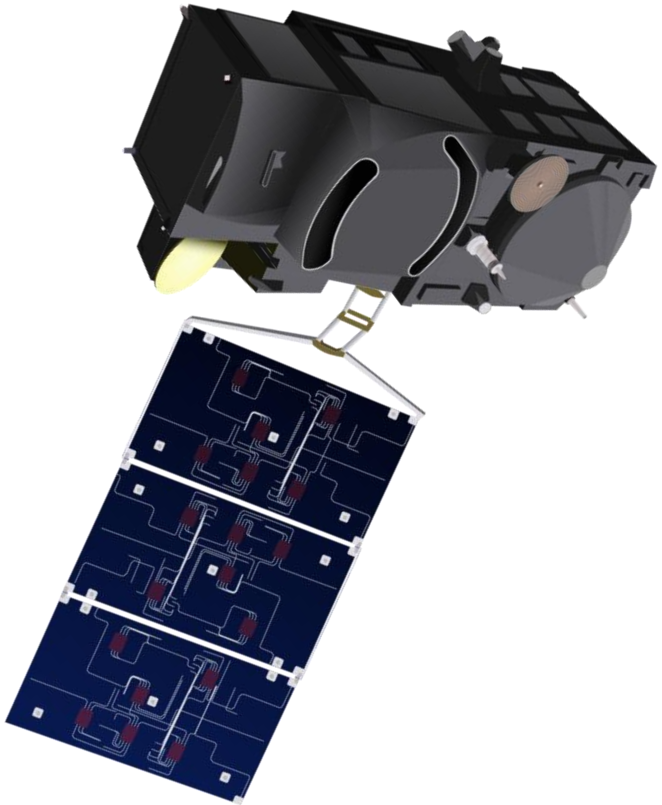
Background & Rationale

Specification & Challenges

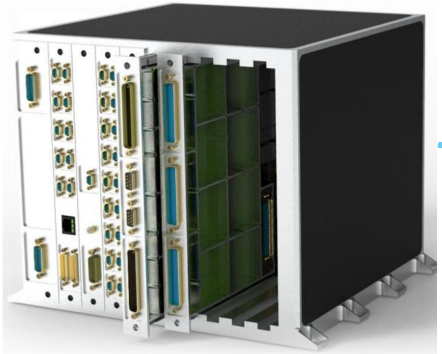
On-going Activities

Conclusion

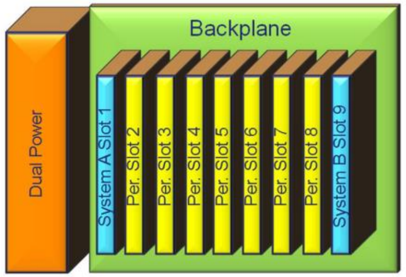
Background and rationale



ADHA Modules



cPCI Serial Space Architecture



cPCI SS Connectors

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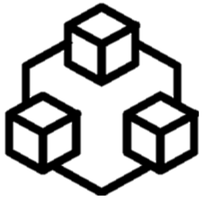
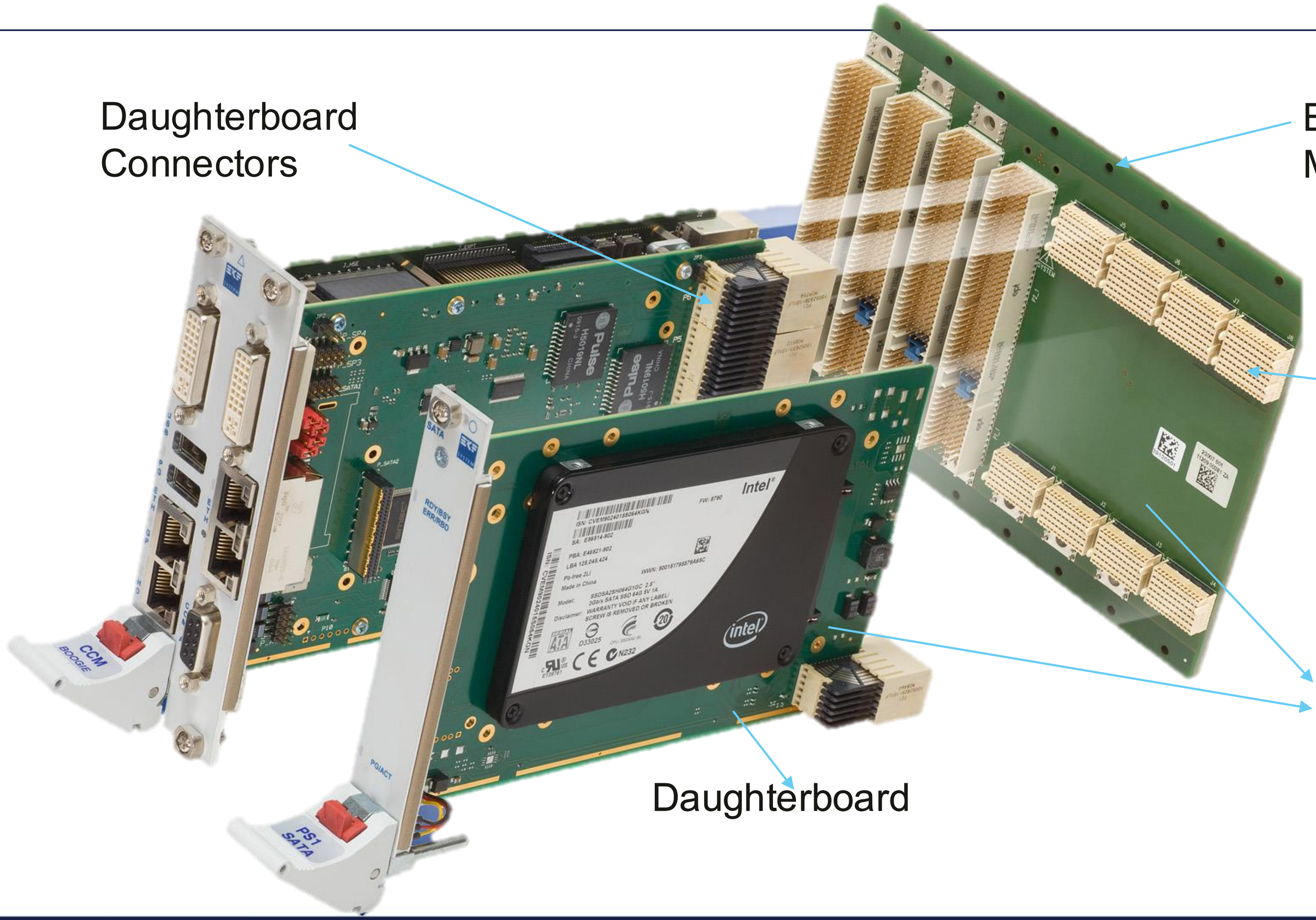


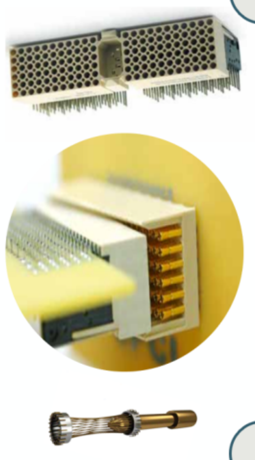
- The cPCI Serial Space (SS) was selected as the standard for ADHA workshop January 2020.

- cPCI SS allows for flexibility, modularity, interoperability and relatively price reduction compared to the level of performances.

Background and rationale

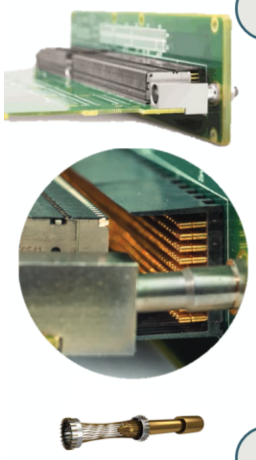


Background and rationale



cPCI

- Manufactured by Smiths Interconnect (Hypertac)
- Compatible with cPCI and NASA DLA Qualified
- Based on the hyperboloid contact technology
- Resistant to Shock & Vibration
- Standard soldering reflow, not solderless!
- High Data Rateup only up to 3.12 Gb/s



KVPX

- Manufactured by Smiths Interconnect (Hypertac)
- Solderless Solution, based on Press-fit
- High Data Rate up to 16Gb/s
- Based on the hyperboloid contact technology
- Resistant to Shock & Vibration
- Compatible with VITA, and not compatible with cPCI SS

Airmax

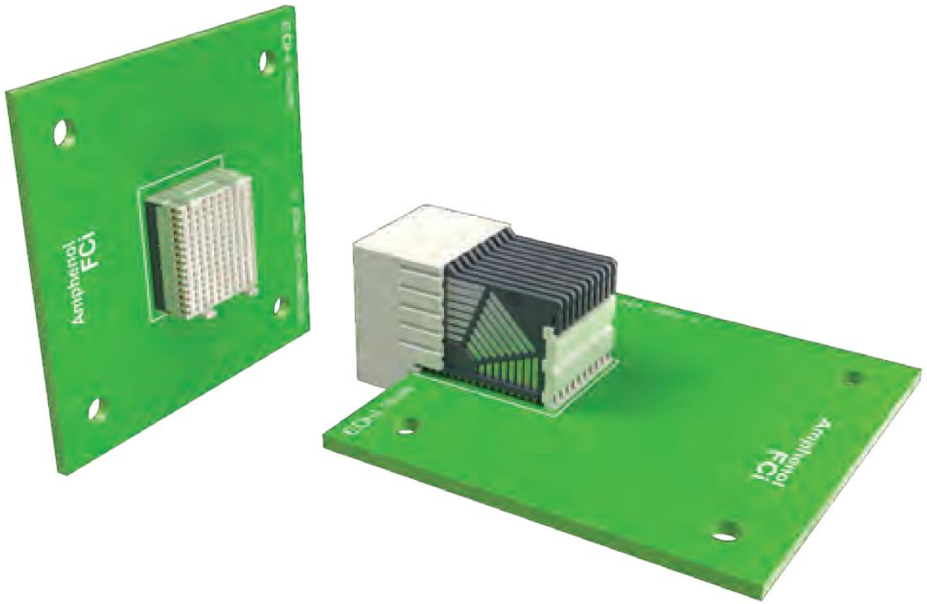
- Manufactured by Amphenol
- Compatible with cPCI SS
- Solderless Solution, based on Press-fit
- Specified up to 25 Gb/s
- Low cost, but not proven in harsh environment
- No available reliability data!

Currently, there is no High Data Rate connectors, compatible with cPCI SS, for space applications!

The current available space solutions are not compatible with cPCI SS (speed rate, layout, etc.).

Background and rationale

The only solution compatible with cPCI SS (and with high data rate) is a commercial solution, manufactured by Amphenol (manufactured in China) with no proper evaluation data!



Need to Develop and Qualify a Space-grade High Data Rate (25 Gb/s) Connectors compatible with cPCI SS for space applications

Background & Rationale

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Specifications & Challenges

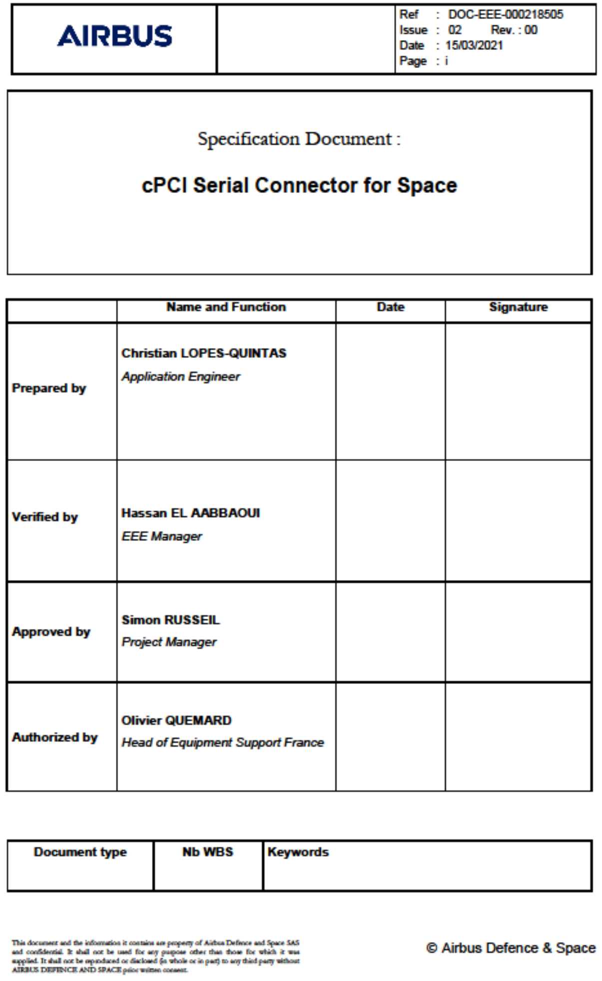
ADHA

esa

AIRBUS

beyond gravity

ThalesAlenia Space
a Thales / Leonardo company



AIRBUS		Ref : DOC-EEE-000218505 Issue : 02 Rev. : 00 Date : 15/03/2021 Page : i

Specification Document :

cPCI Serial Connector for Space

	Name and Function	Date	Signature
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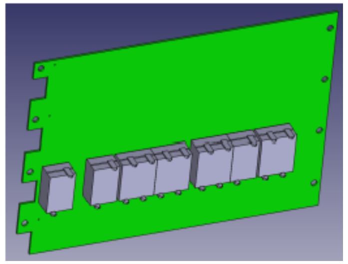
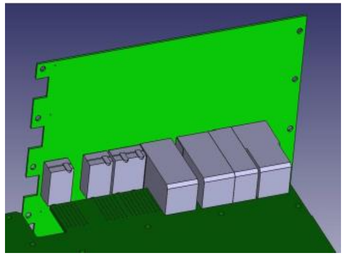
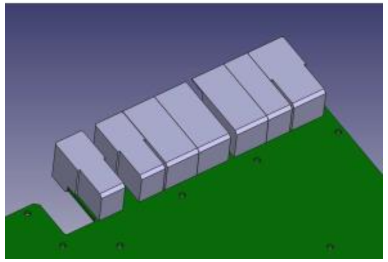
Verified by	Hassan EL AABBAOUI *EEE Manager*		
Approved by	Simon RUSSEIL *Project Manager*		
Authorized by	Olivier QUEMARD *Head of Equipment Support France*		

Document type	Nb WBS	Keywords







Main Challenges w.r.t. ADHA Specification:

- High Speed up to **25 Gb/s**
- **Solderless** solutions (i.e. Press-fit)
- Operating Temperature: **-55°C to 125°C**
- No impedance change or discontinuity of **1ns** or longer duration during mechanical and thermal tests
- Current rating per contact: **2A**

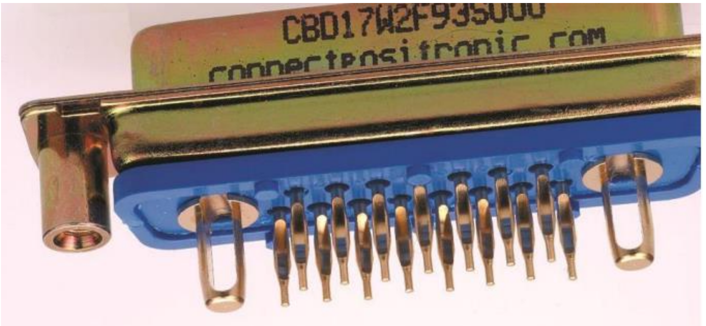
Specification & Challenges

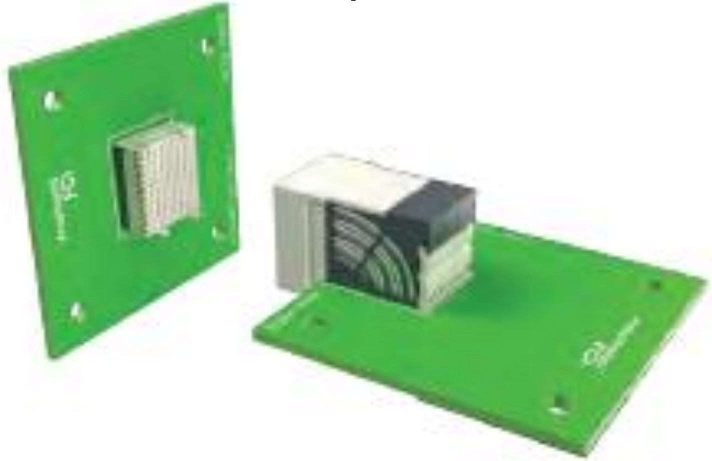
Known reliability issues related to the press-fit technologies:

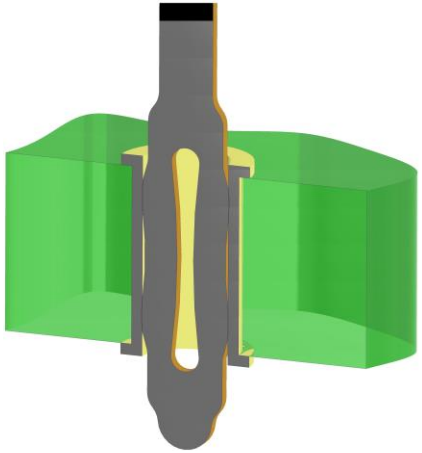
- **Impedance discontinuities during mechanical tests**

Low data press-fit connectors (Positronic) are being ESCC qualified for discontinuities smaller than 10 us during mechanical tests.

ADHA High data rate requires 1ns of discontinuity during mechanical test.



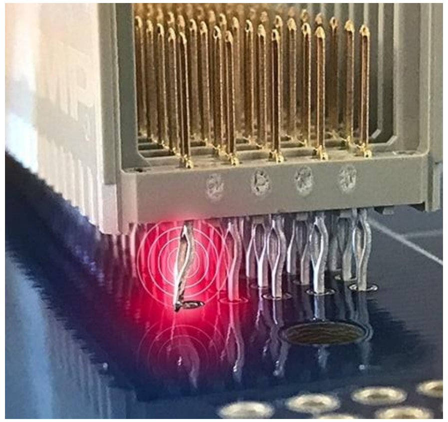




No clamping mechanism (or additional screws) to hold the mated pair together.
All the mechanical stress goes through the press-fit terminations.
This leads to intermittent loss of connectivity during vibration or shock!

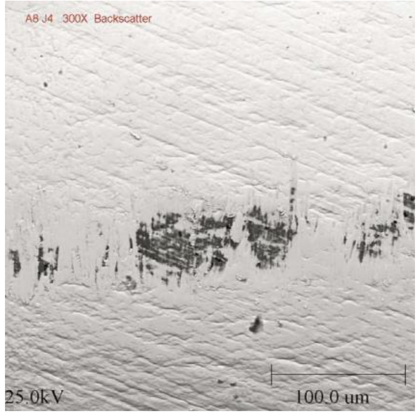
Specification & Challenges

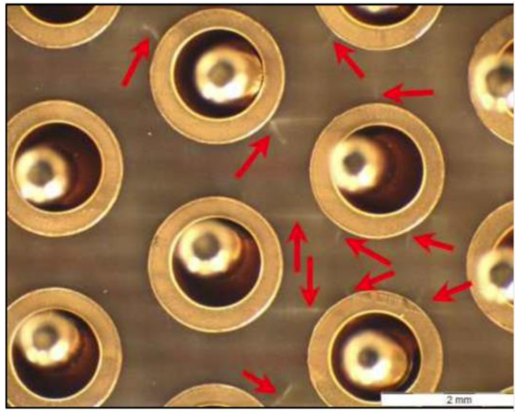
Known reliability issues related to the press-fit technologies:

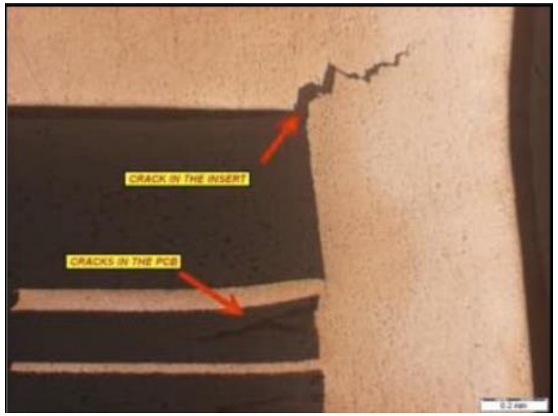


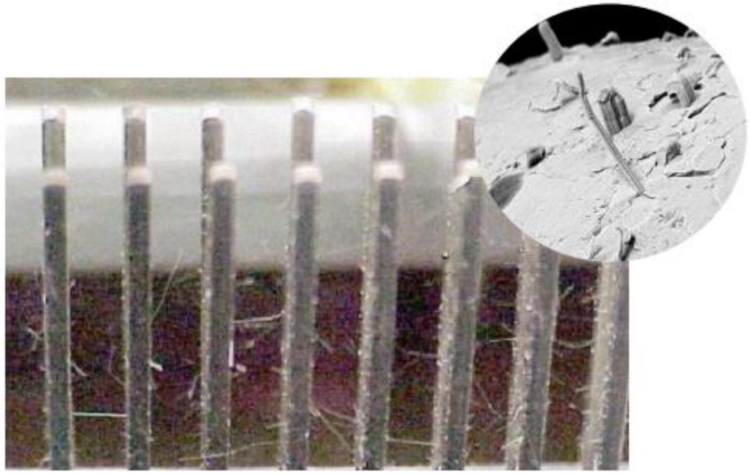
- PCB Damage due to the fretting of the plating materials (corrosion wear) or cracks in PCB and pins materials, due to the relative movement of the press-fit pins inside the PCB.

- Growth of dendrites tin whiskers on pins with pure tin are also considered as delayed failures!









This leads to an increase in contact resistance, thus a drastic decrease of the data rate!

Background & Rationale

Specification & Challenges

On-going Activities

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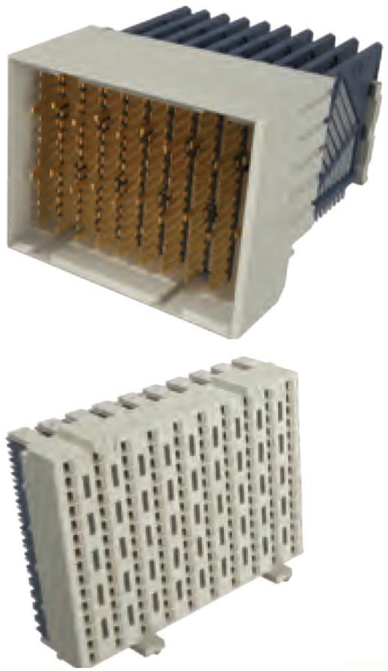
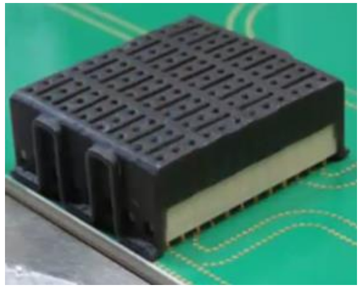
ON-GOING ESA R&D ACTIVITIES

1. **TDE**: Procurement and Reliability Assessment of High Data Rate Press-Fit cPCI SS connectors: AIRMAX VS (Amphenol) and HYPERBITS (Performance Interconnect) (ALTER TECHNOLOGY SPAIN)
2. **TDE**: Board to Board Interconnections for High Data Rate applications (AXON' cable)
3. **ARTES**: High Density Modular Electrical Interconnections for High Data Rate Applications (Performance Interconnect & ALTER TECHNOLOGY FRANCE)

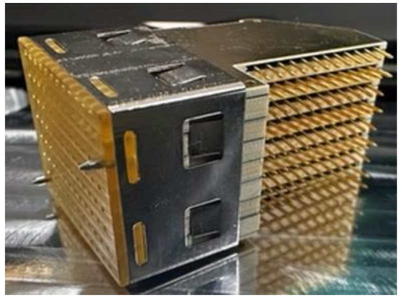
ALTER TECHNOLOGY

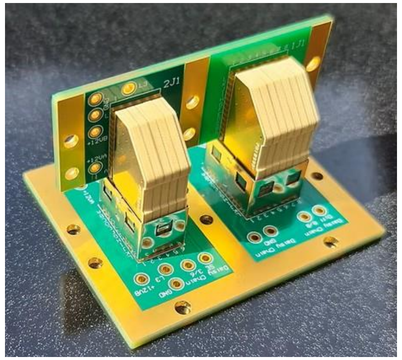
Amphenol





advanced interconnect axon' solutions





ALTER TECHNOLOGY

PERFORMANCE INTERCONNECT

Background & Rationale

Specification & Challenges

On-going Activities (I)

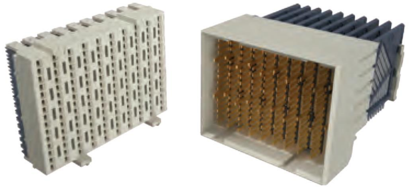
TDE: Procurement and Reliability Assessment of High Data Rate Press-Fit cPCI SS connectors: AIRMAX VS (Amphenol) and HYPERBITS (Performance Interconnect) (ALTER TECHNOLOGY SPAIN)

Conclusion

Procurement and Reliability Assessment of High Data Rate Press-Fit cPCI SS connectors

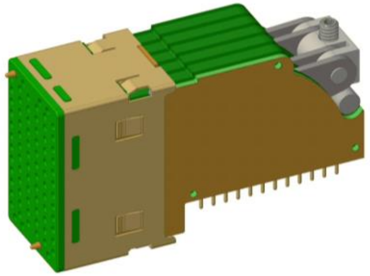
Contractor: ALTER TECHNOLOGY (Spain)				**ESA Budget**	**80 k€ +20k€**
Funding	**TDE**	**Initial TRL: 2**	**Target TRL: 4**	**TO: Léo Farhat Joaquín Jiménez**	
Start of activity: June 2022		**End of Activity: March 2026**			

Background and justification:
The current large increase of data traffic is causing the space sector to push for the development of communication standards that allow for higher data rates. ESA has recently funded a study on Advanced Data Handling Architecture (ADHA) in order to establish a versatile, compact, modular and scalable Data Handling System architecture using standardised building blocks. Unfortunately, there is currently no space grade High Data Rate (HDR) connectors compatible with cPCI SS. The only existing solution is a commercial connector, manufactured by Amphenol (USA), with no reliability assessment data.



Objective(s):
The aim of this activity is double:
1 -to procure and assess the reliability of existing high data rate press-fit connectors compatible with cPCI SS: the commercial AirMax VS® cPCI-s manufactured by Amphenol (USA).
2- to support the development and assess the reliability of the HyperBits™ S-FECT (Performance Interconnect, FR)

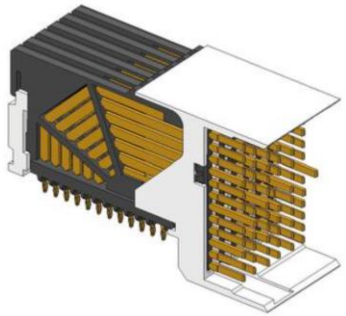
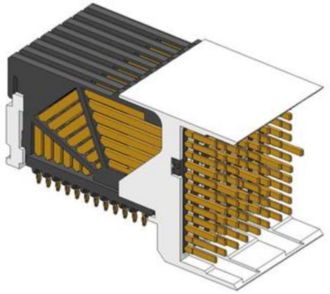
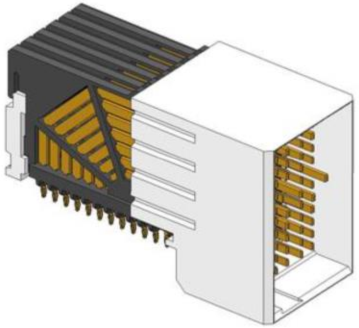
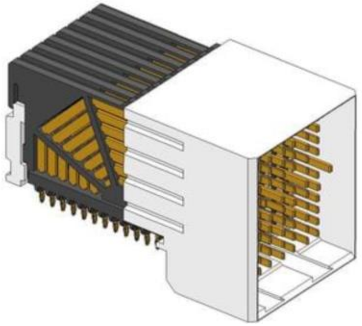
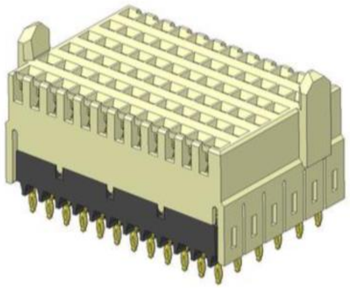
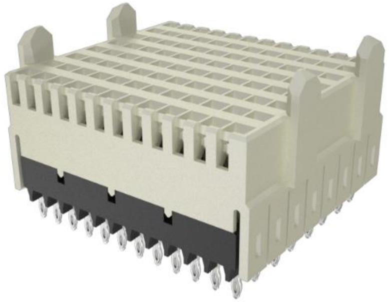
Achievement and status:
- AirMax VS® cPCI-s samples procured. Assembly of Hyperbits gen1: assembled solutions Q2 2023
- Test plan has been defined: DC electrical parameters under mechanical and thermal cycles with electrical continuity monitoring, mating & de-mating, life test (s-parameters, high and low temperature), construction analysis, outgassing.
- Final design and validation of test PCBs for mechanical testing and s-parameters testing.
- DC electrical parameters tested, outgassing performed, mechanical tests on-going (sine vibration).



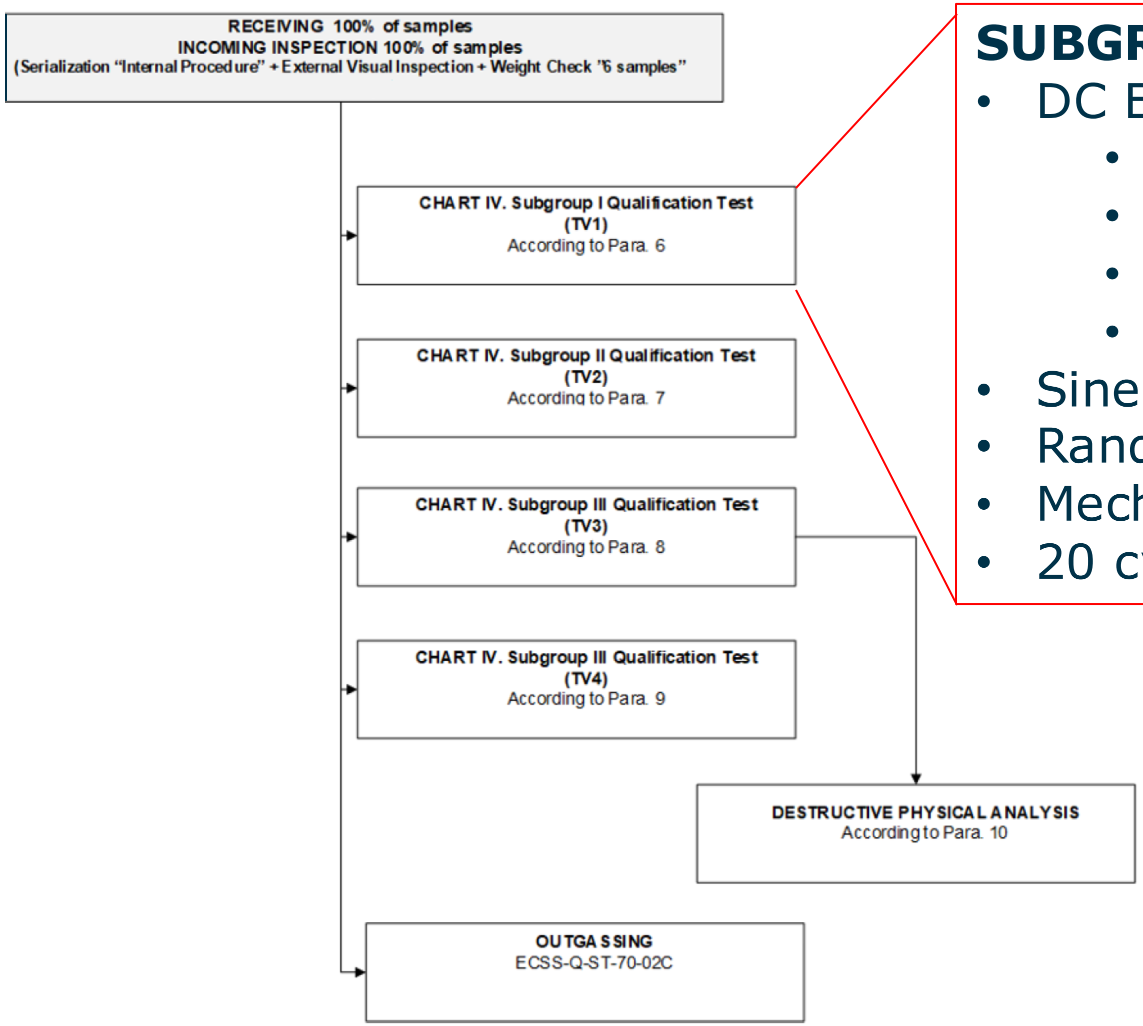
Benefits:
- The advantages offered by solderless technology makes this the perfect baseline to develop High Data Rate connectors.

Next steps:
- S-parameters measurements
- Thermal cycles, mating & de-mating, life test
- Final Report expected in March 2026.

Airmax VS (Amphenol): Assembly & Reliability Tests (Procurement)

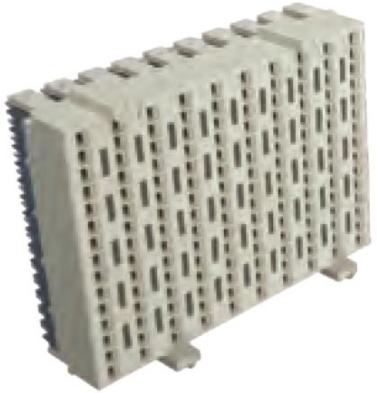
10 samples HDR press-fit AirMax VS® cPCI-s **10052824-101LF** Daughterboard **72**-position, 6 column, 2 Walls, Right Angle		10 samples HDR press-fit AirMax VS® cPCI-s **10052837-101LF** Daughterboard **96**-position, 8 column, 2 Walls, Right Angle Header	
10 samples HDR press-fit AirMax VS® cPCI-s **10052825-101LF** Daughterboard **72**-position,6 column, 4 Walls, Right Angle		10 samples of HDR press-fit AirMax VS® cPCI-s **10052838-101LF** Daughterboard **96**-position, 8 column, 4 walls, Right Angle	
15 samples HDR press-fit AirMax VS® cPCI-s **10052829-101LF** Backplane **72**-position, 6 column, Vertical Receptacle		15 samples HDR press-fit AirMax VS® cPCI-s **10052842-101LF** Backplane, **96**-position, 8 column, Vertical Receptacle	

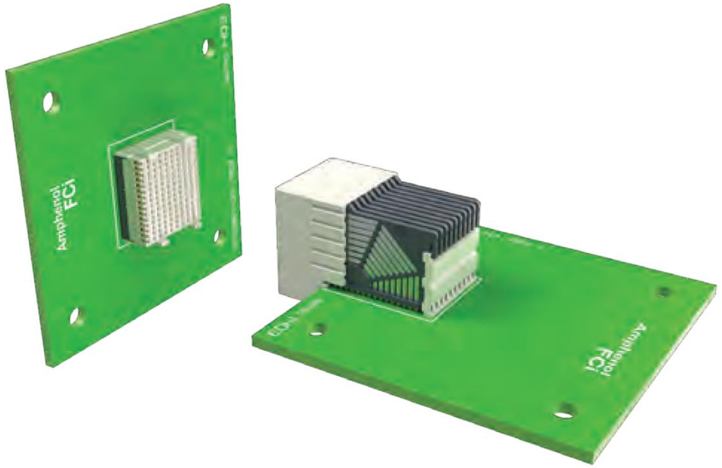
Airmax VS (Amphenol): Assembly & Reliability Tests: Test plan (I)



SUBGROUP I - TV1

- DC Electrical measurements
    - Contact resistance at 10mA
    - Contact resistance at 2A
    - Voltage proof $500V_{rms}$
    - Insulation resistance $500V_{DC}$
- Sine vibration
- Random vibration
- Mechanical Shock
- 20 cycles thermal shock





Airmax VS (Amphenol): Assembly & Reliability Tests: Test plan (II)

RECEIVING 100% of samples
INCOMING INSPECTION 100% of samples
(Serialization "Internal Procedure" + External Visual Inspection + Weight Check "6 samples"

CHART IV. Subgroup I Qualification Test
(TV1)
According to Para. 6

CHART IV. Subgroup II Qualification Test
(TV2)
According to Para. 7

CHART IV. Subgroup III Qualification Test
(TV3)
According to Para. 8

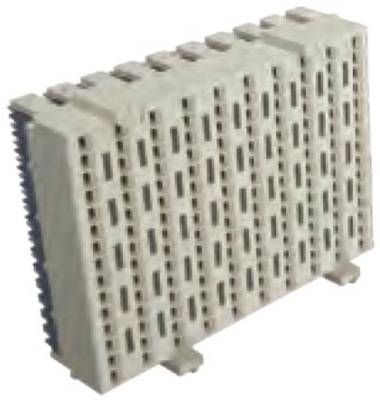
CHART IV. Subgroup III Qualification Test
(TV4)
According to Para. 9

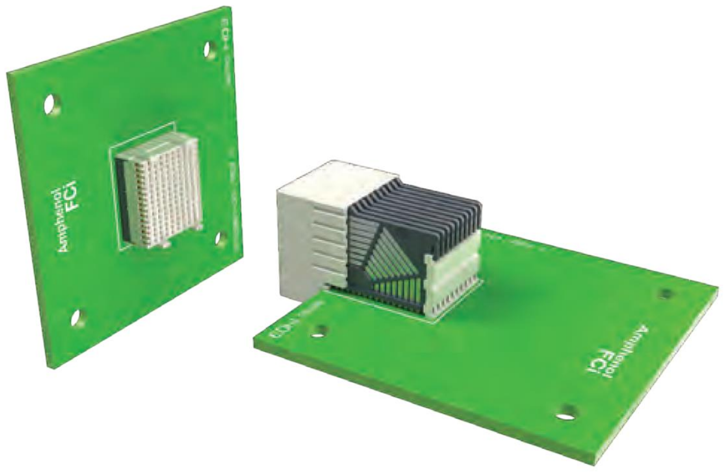
DESTRUCTIVE PHYSICAL ANALYSIS
According to Para. 10

OUTGASSING
ECSS-Q-ST-70-02C

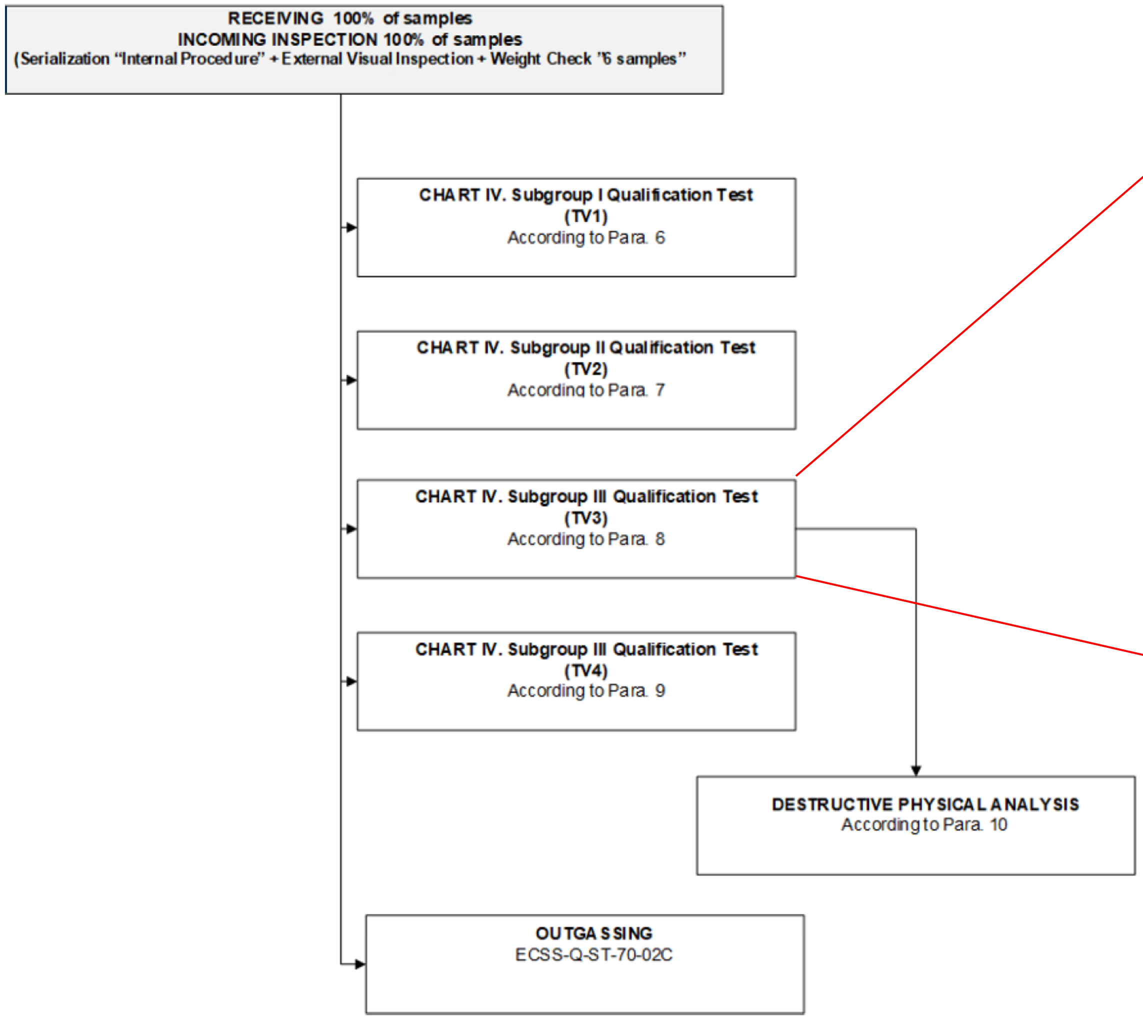
SUBGROUP II – TV2

- Mating and de-mating
- DC Electrical measurements



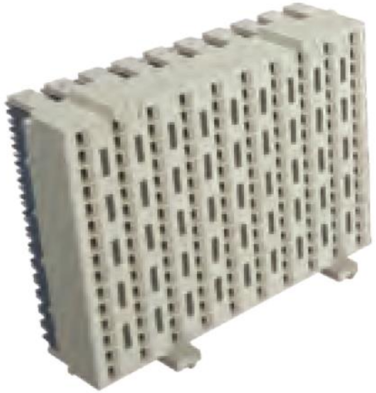


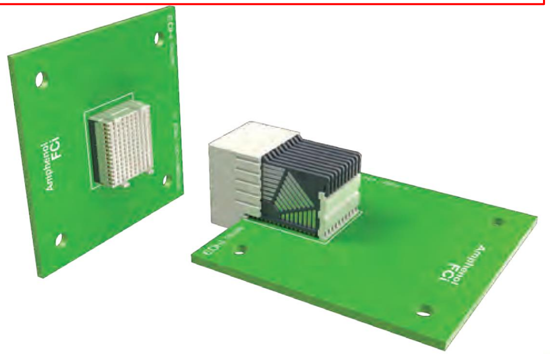
Airmax VS (Amphenol): Assembly & Reliability Tests: Test plan (III)



SUBGROUP III – TV3

- RF measurements
(at 25°C, -55°C, +125°C):
  - Insertion loss
  - Near-end cross talk
  - Far-end cross talk
  - Differential impedance
- Life test until 500h
  until 1000h
  until 2000h





Airmax VS (Amphenol): Assembly & Reliability Tests: Test plan (IV)

RECEIVING 100% of samples
INCOMING INSPECTION 100% of samples
(Serialization "Internal Procedure" + External Visual Inspection + Weight Check "6 samples"

CHART IV. Subgroup I Qualification Test (TV1)
According to Para. 6

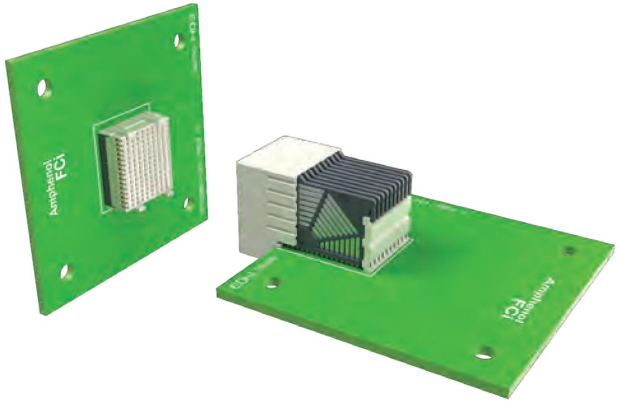
CHART IV. Subgroup II Qualification Test (TV2)
According to Para. 7

CHART IV. Subgroup III Qualification Test (TV3)
According to Para. 8

CHART IV. Subgroup III Qualification Test (TV4)
According to Para. 9

DESTRUCTIVE PHYSICAL ANALYSIS
According to Para. 10

OUTGASSING
ECSS-Q-ST-70-02C



SUBGROUP IV – TV4

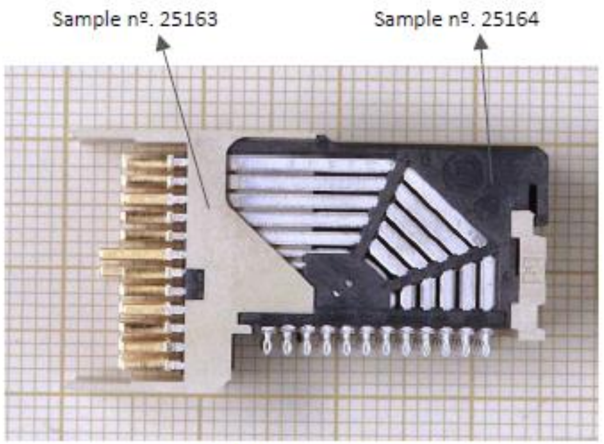
- DC Electrical measurements
- RF measurement (+125°C)
- 5 cycles overload test (1,5xrated current)

Airmax VS(Amphenol): Assembly & Reliability Tests: Test results (I)

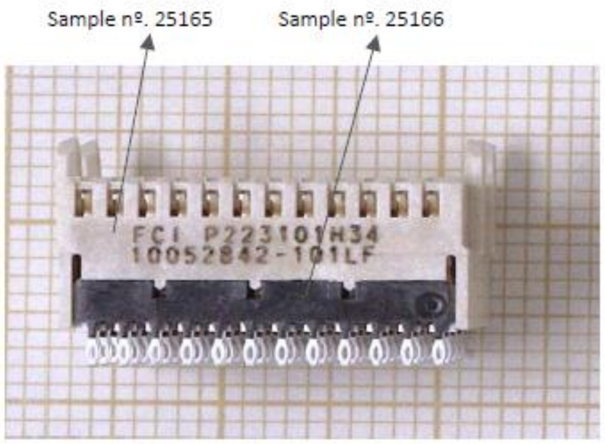
1. Outgassing ECSS-Q-ST-70-02C

Samples	Description	TML (%)	RML (%)	CVCM (%)
25163	White plastic housing - Header	0,069	0,053	0,001
25164	Black plastic housing - Header	0,074	0,058	0,003
25165	White plastic housing - Receptacle	0,072	0,047	0,001
25166	Black plastic housing - Receptacle	0,052	0,041	0,002

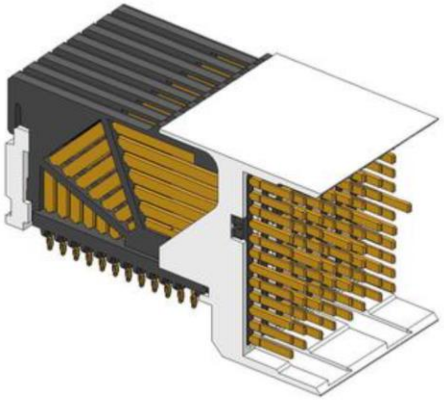
*The samples tested are **compliant** with general limits of acceptance for material selection according to ECSS-Q-ST-70-02C: RML < 1,00% , CVCM < 0,10%.*



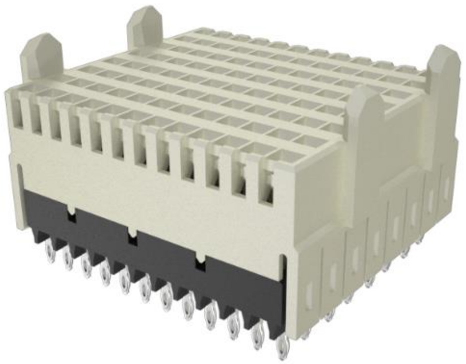
S/N 25 . PT:10052837-101LF



S/N 64 . PT:10052842-101LF



10052837-101LF



10052842-101LF

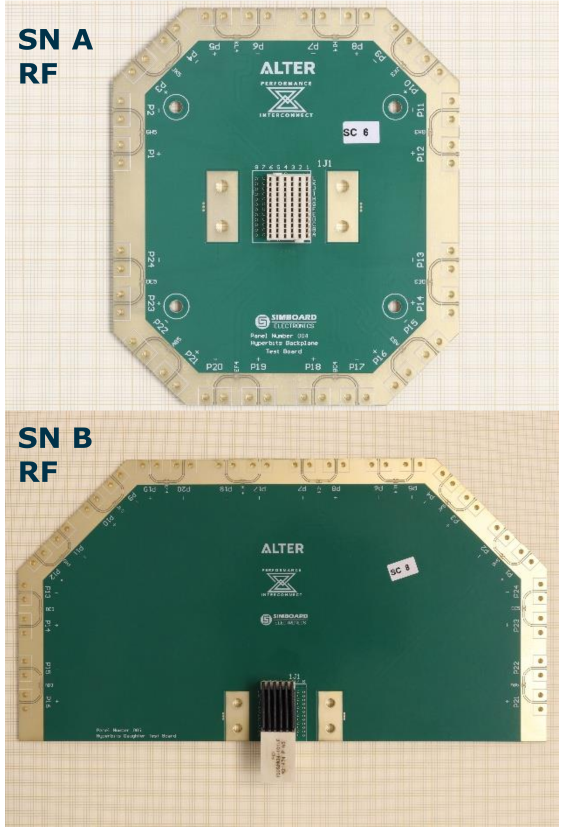
Airmax VS(Amphenol): Assembly & Reliability Tests: Test results (II)

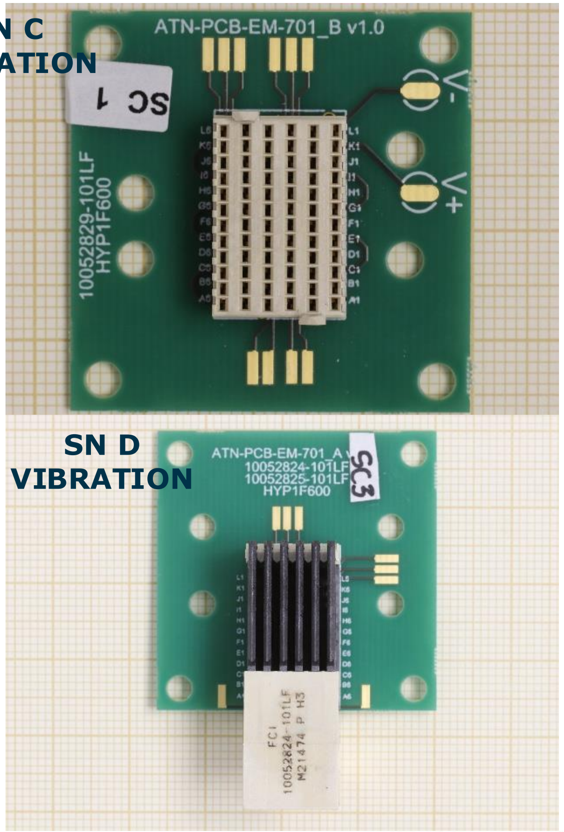
RF characterisation PCB, Mechanical characterisation PCB, Airmax connectors insertion

Connector SN	Connector-PCB SN	Type of connector	Nº of Pins	PCB
54	A	10052829-101LF Receptacle.	72	RF PCB (Back plane)
4	B	10052824-101LF Header.	72	RF PCB (Daughter)
53	C	10052829-101LF Receptacle.	72	Vibration PCB 10052829-101LF
34	D	10052824-101LF Header.	72	Vibration PCB 10052824-101LF & 10052825-101LF
66	E	10052842-101LF Receptacle.	96	Vibration PCB10052842-101LF
36	F	10052838-101LF Header.	96	Vibration PCB 10052837-101LF & 10052838-101LF
61	G	10052842-101LF Receptacle.	96	RF PCB (Back plane)
24	H	10052838-101LF Header.	96	RF PCB (Daughter)

Successful insertion of 8 Airmax connectors:

- *Four inserted in PCBs for vibration characterisation (SN C,D,E,F), plus other 4 connectors.*
- *Four inserted in PCBs for RF characterisation (SN A,B,G,H), plus other 4 connectors*



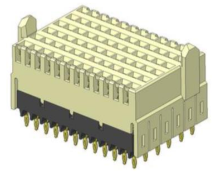


AirmaxVS (Amphenol): Assembly & Reliability Tests: Test results (III)

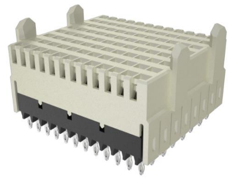
3. DC electrical measurements at room temperature: continuity verification, contact resistance, voltage proof, insulation resistance

Samples to be submitted to mechanical testing

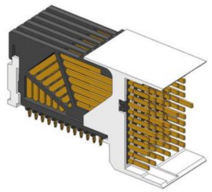
Connector SN	Connector-PCB SN	Type of connector	Nº of Pins	PCB
53	C	100528**29**-101LF Receptacle.	72	Vibration PCB 10052829-101LF
34	D	100528**24**-101LF Header.	72	Vibration PCB 10052824-101LF & 10052825-101LF
66	E	100528**42**-101LF Receptacle.	96	Vibration PCB10052842-101LF
36	F	100528**38**-101LF Header.	96	Vibration PCB 10052837-101LF & 10052838-101LF



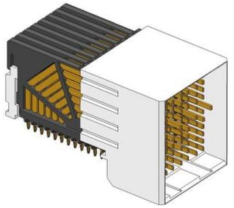
SN **C**: 100528**29**-101LF Receptacle (72)



SN **E**: 100528**42**-101LF Receptacle (96)



SN **D**: 100528**24**-101LF Header (72)



SN **F**: 100528**38**-101LF Header (96)

DC Electrical measurements test results:

Nº	TEST		CONDITIONS	LIMITS		UNIT	PASS	FAIL
				MIN	MAX			
1	Contact Resistance	RCL	Imeas = **10mA**	--	35	mΩ	4	0
2	Contact Resistance	RCR	Imeas = **2A**	--	20	mΩ	4	0
3	Voltage Proof	IL	Vmeas = 500Vrms, t = 5s (Note 3)	Note 3		--	4	0
4	Insultaon Resistance	Ri	Vmeas = 500VDC, t = 60s (Note 4)	1000	--	MΩ	4	0

Note 3: No evidence of breakdown, flashover or excessive leakage current >0.5mA.

Electrical measurements performed in **4** mated connector pairs (C mated with D / E mated with F)

Continuity verification: **Successful results.**

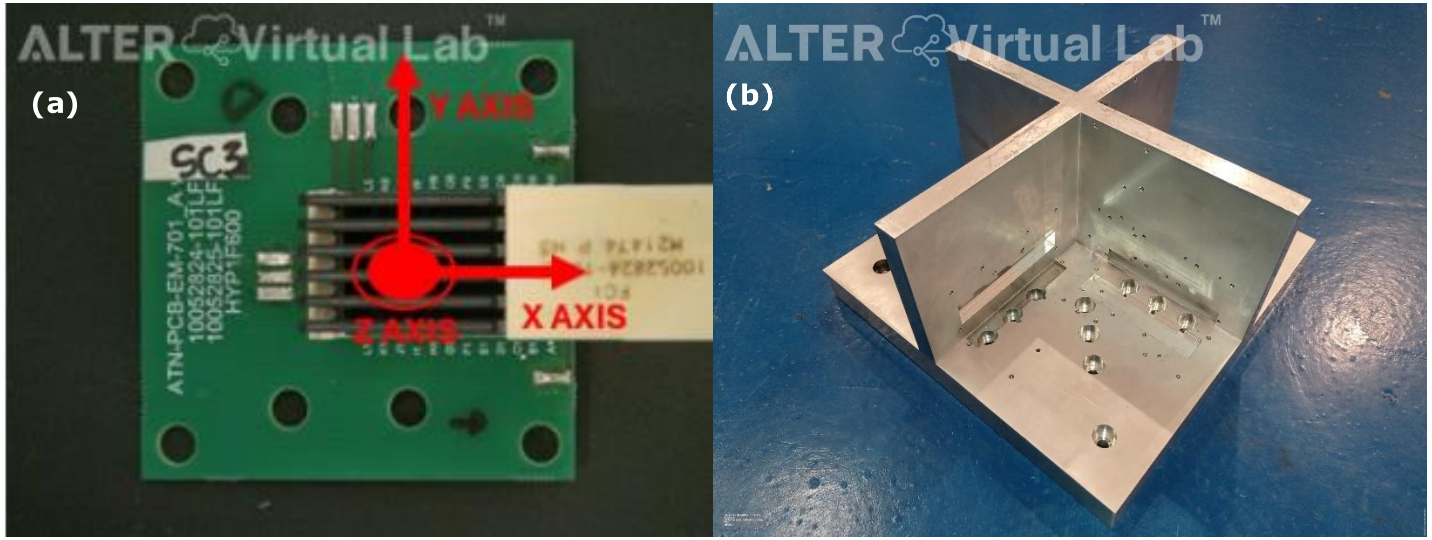
Contact resistance, voltage proof, insulation resistance: **Successful results.**

No anomalies were detected.

AirmaxVS(Amphenol): Assembly & Reliability Tests: Test results (IV)

4. Sine vibration test: Axis definition, vibration tool & measurement conditions

Axis definition & vibration tool

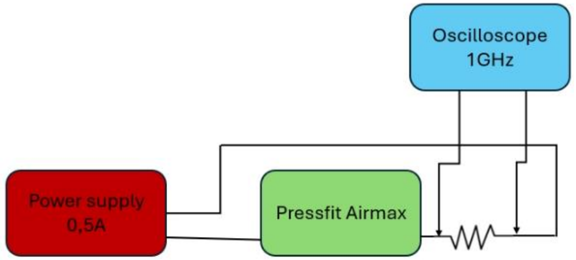


(a) Axis identification (SN D) and (b) vibration tool.

EUT set up & Measurement conditions

- ✓ Detection of 1 ns or longer duration discontinuity.
- ✓ Constant DC signal maintained through the contacts under test and + External resistor with magnitude significantly higher than the contacts resistance of the device under test.

  Singal monitored with a digital scope with a minimum bandwidth of 1.0 GHz
- ✓ Threshold level and time period configured to be triggered if limits are exceeded.

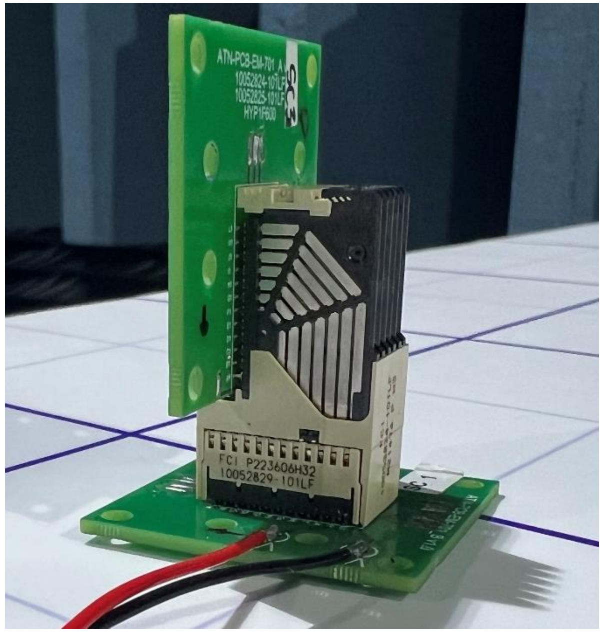


Voltage	Frequency	Number of wires
10 V	DC	2

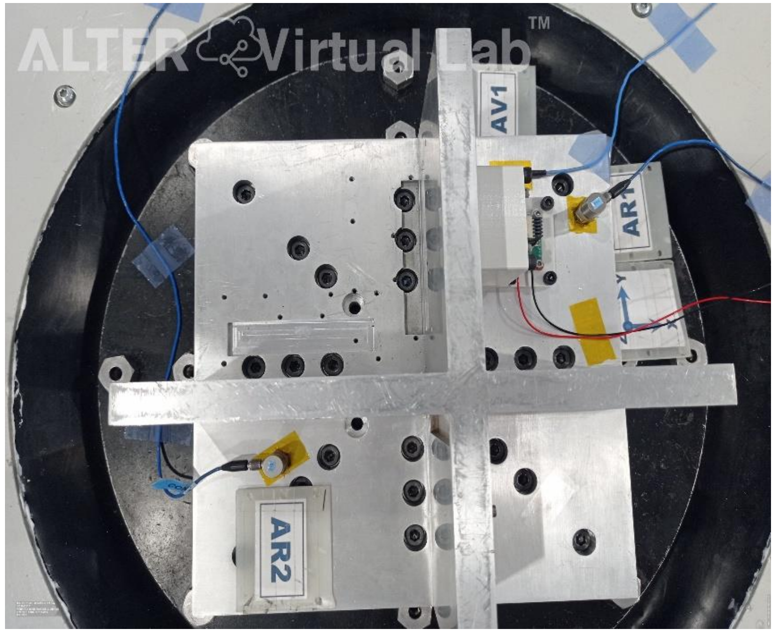
Airmax VS(Amphenol): Assembly & Reliability Tests: Test results (V)

4. Sine vibration test: Set up

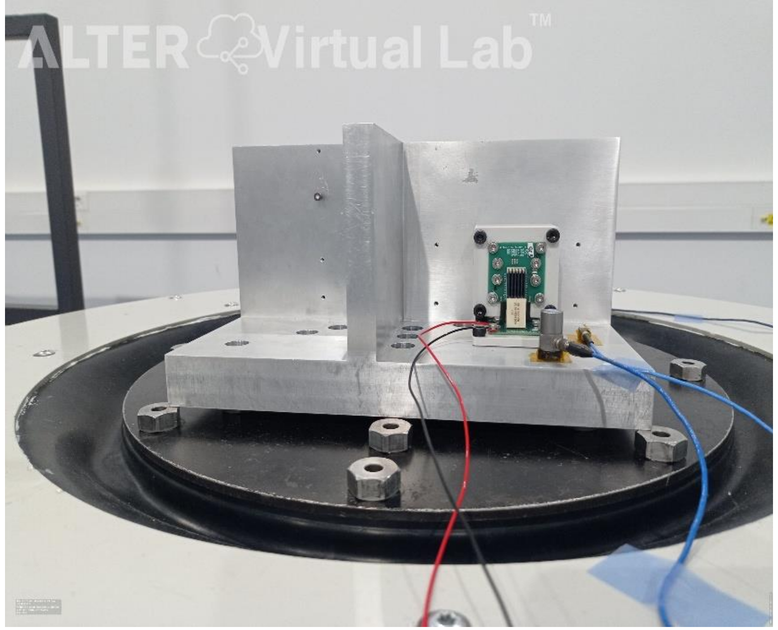
Set up



C-D mated connectors before assembly on the vibration test jig



Top view of the connectors assembled on the vibration test jig



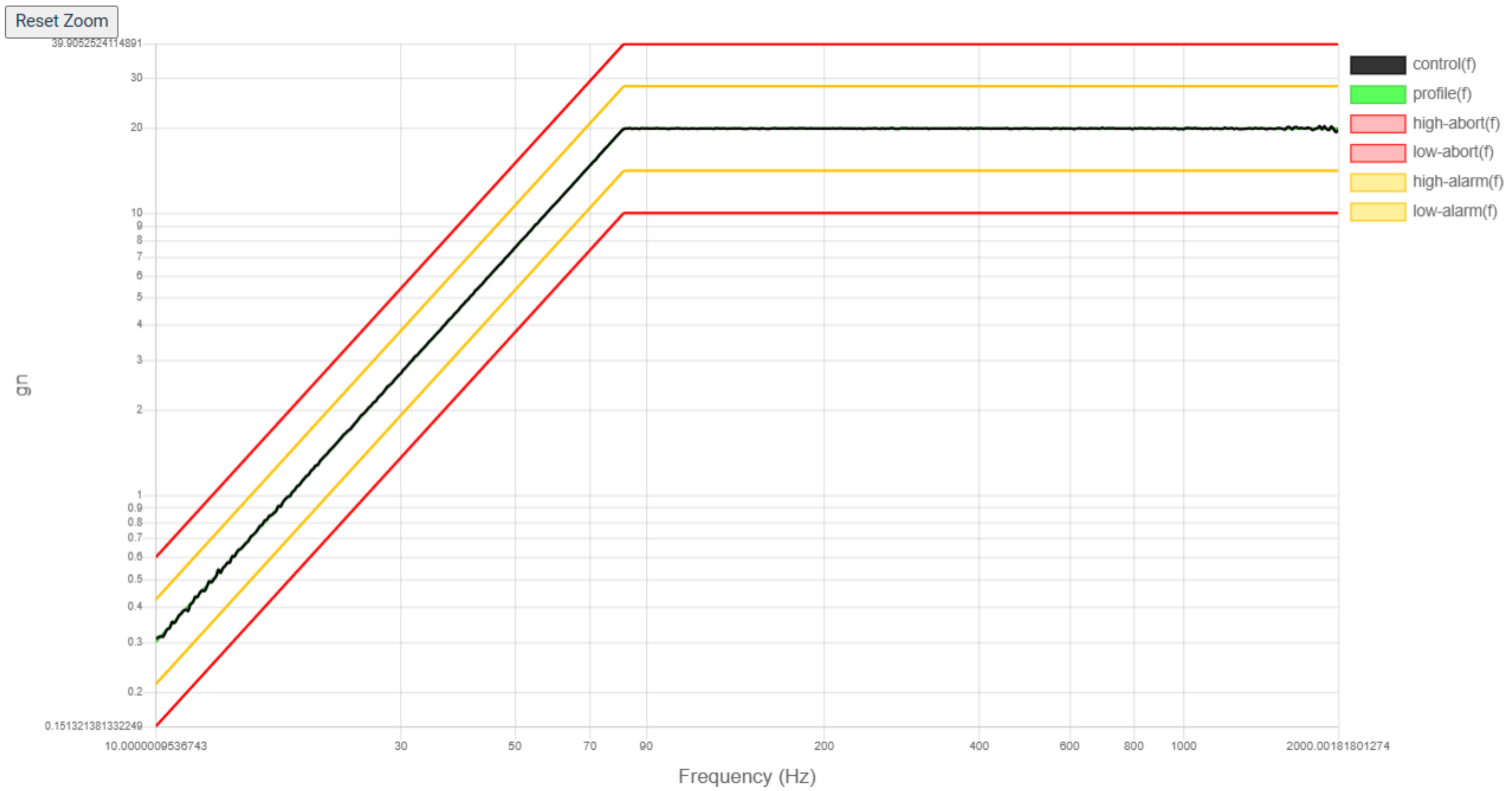
Front view of the connectors assembled on the vibration test jig

Airmax (Amphenol): Assembly & Reliability Tests: Test results (VI)

4. Sine vibration test: Vibration conditions check (empty tooling)

Vibration conditions check (empty tooling)

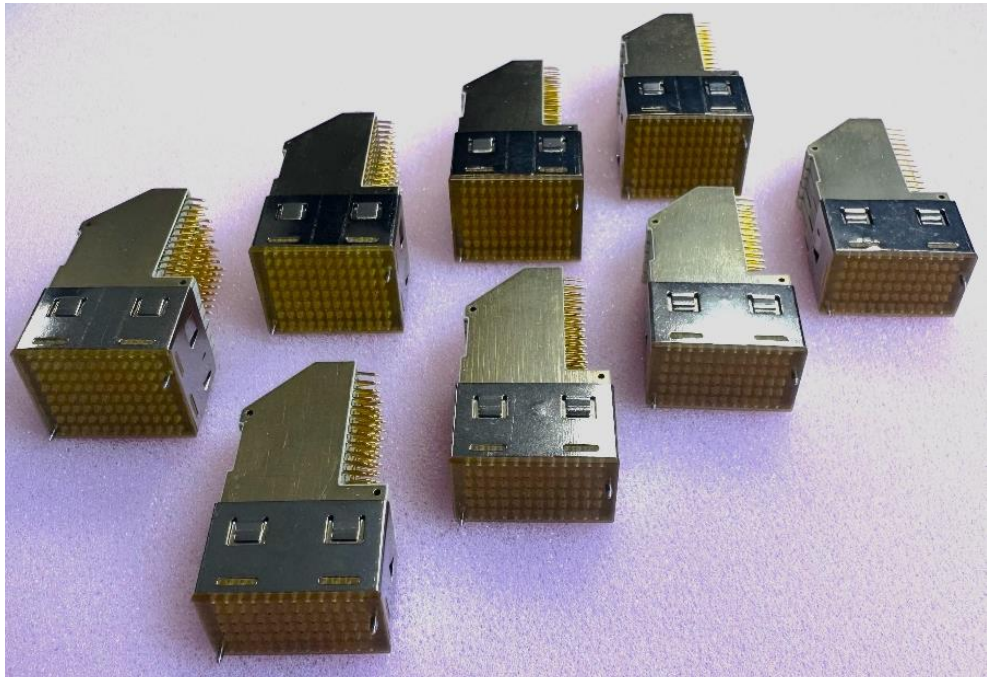
SINE VIBRATION - X AXIS - TEST FIXTURE - GRAPH - CONTROL



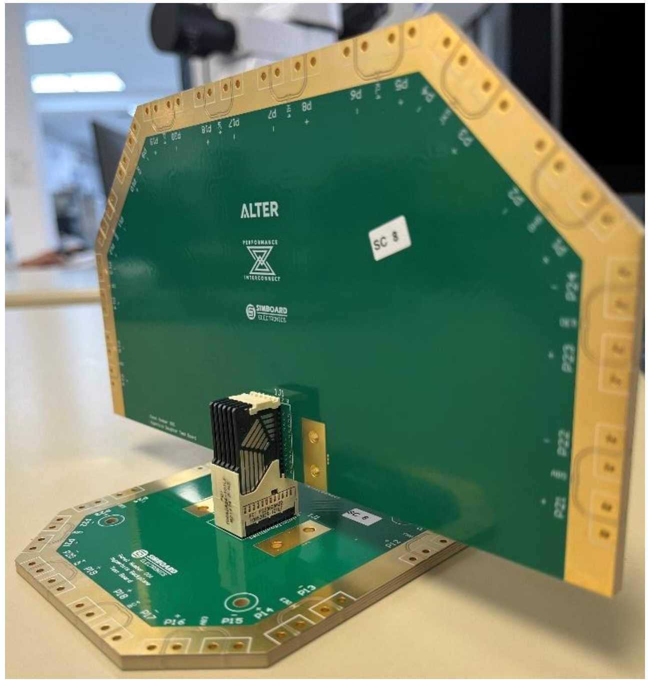
Airmax (Amphenol): Assembly & Reliability Tests: Next steps (I)

Next steps:

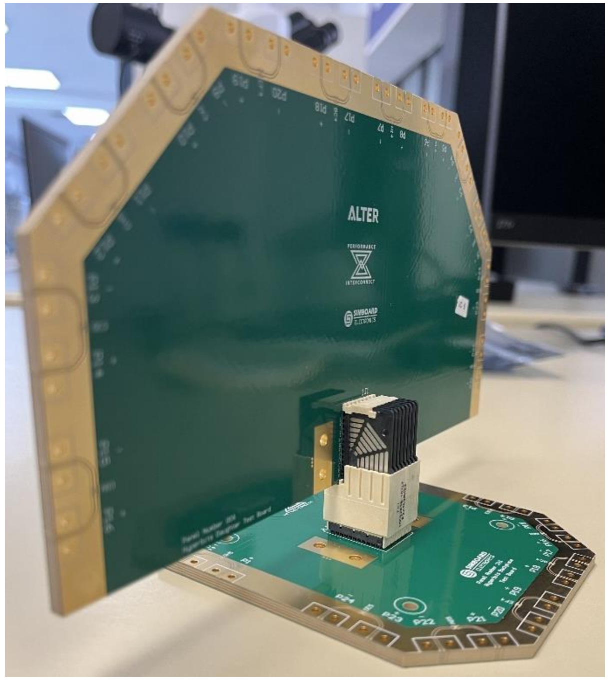
- S-parameters measurements and life test



Hyperbits (Performance Interconnect)



AIRMAX VS A-B (72 pins)



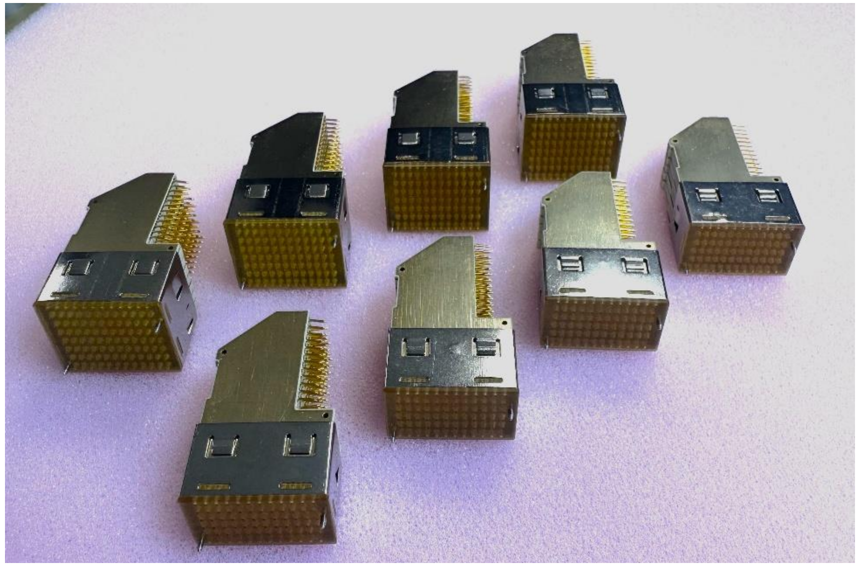
AIRMAX VS G-H (96 pins)

Inserted on RF PCB's for S-measurements

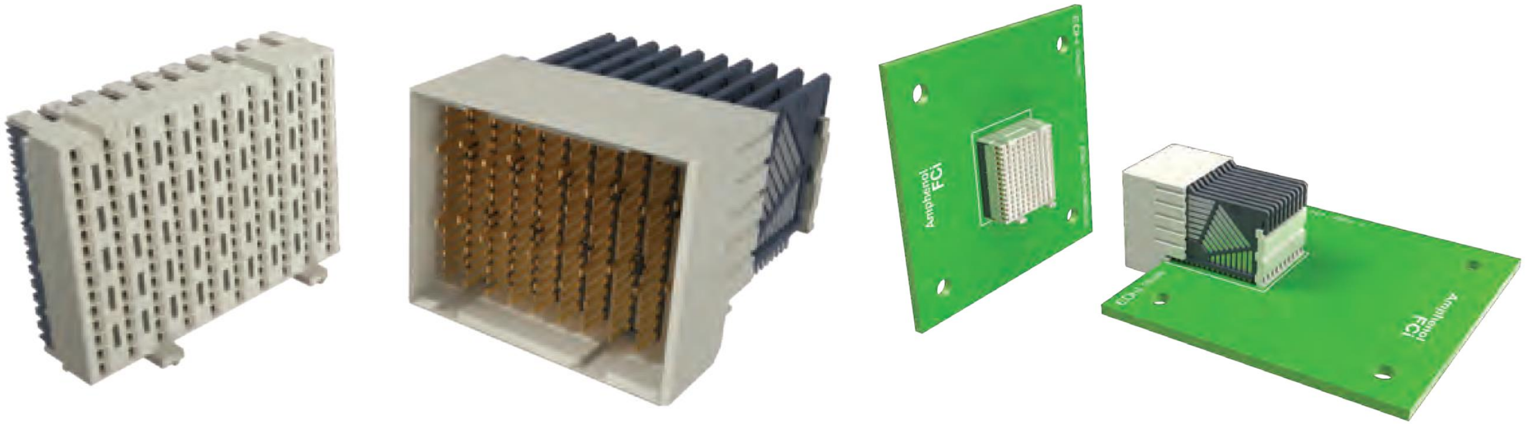
Airmax (Amphenol): Assembly & Reliability Tests: Next steps (II)

Next steps:

- Finish mechanical testing (random vibration, mechanical shock)
- Thermal shock test
- Mating & de-mating (endurance) test flow



Hyperbits (Performance Interconnect)



AIRMAX VS (Amphenol)

Background & Rationale

Specification & Challenges

On-going Activities (II)

TDE: Board to Board Interconnections for High Data Rate applications (AXON' cable)

Conclusion

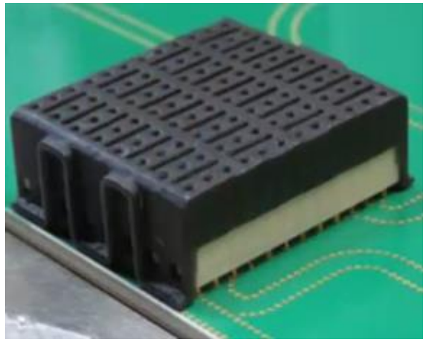
Board to Board Interconnections for High Data Rate applications

Contractor: AXON' CABLE (FR)				ESA Budget	250 k€ + 275k€
Funding	TDE	Initial TRL: 2	Target TRL: 4	TO: Léo Farhat - Joaquín Jiménez	
Start of activity: August 2023		End of Activity: 12 2026			

advanced interconnect solutions axon'

Background and justification:
To fulfil future Telecommunication payload mission needs, satellite manufacturers are fabricating digital and high power processing equipment with high speed signal performance, high speed and complex digital processing technologies. These are based on digital printed circuit boards (PCB) and new high density and high data interconnection technologies.

Solderless solutions based on press fit connectors, spring probes or S-FECT (Slide-Fit Electrical Contact Termination) technology, are being developed in order to validate reliability issues, especially the signal continuity during mechanical tests. These solutions are not designed for high data rate applications yet. This justifies the need for next-generation interconnect solutions capable to withstand space environment for high data rates.



Objective(s):
- To develop interconnection solutions based on innovative solderless technologies, that need to withstand future requirements in terms of High Data Rate (HDR), up to 56Gbps.

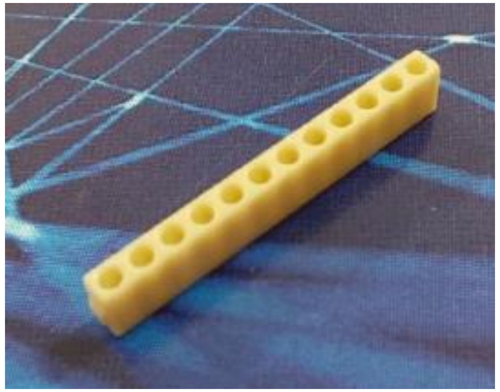
Achievement and status:
- Kick-off Aug 2023
- Literature review and user survey: identify customers' needs and confirm the performance levels to be specified in the technical specification. Critical assessment of existing connectors.
- Consolidated preference for connector design: HDR and power with few Mbit/s.
- Patent survey. Technical specification based on survey results updated. Back-up procurement to guarantee EM models manufactured. PDR Dec 2024, production of prototypes (including 3D printed housing), with two different materials and two variants: shielded and unshielded, due to customer urgent need.

Benefits: Availability of European connector for HDR for space applications.

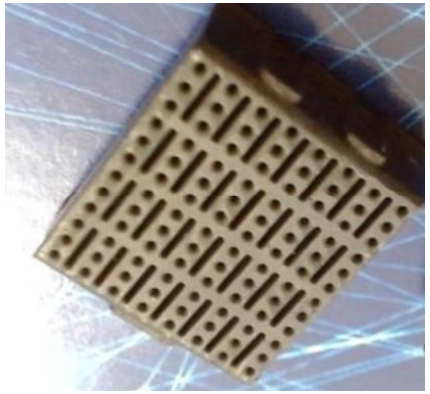
Next steps
- Improved molded samples production for mechanical tests.
- Evaluation Test Plan to be defined: test sequence on contacts, test set-up definition, tool-machining.

AXON’ CABLE: CONNECTOR PROTOTYPE MANUFACTURING (I)

Backplane connector



Machined frame



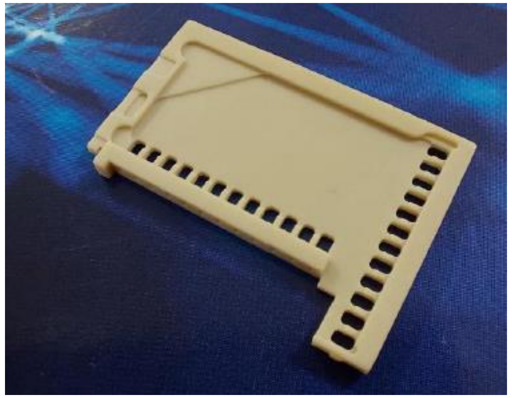
3D printed housing

4-slot socket contact – closed press-fit

AXON’ P/N: CONTACT130255B

Daughter board connector

PCBs



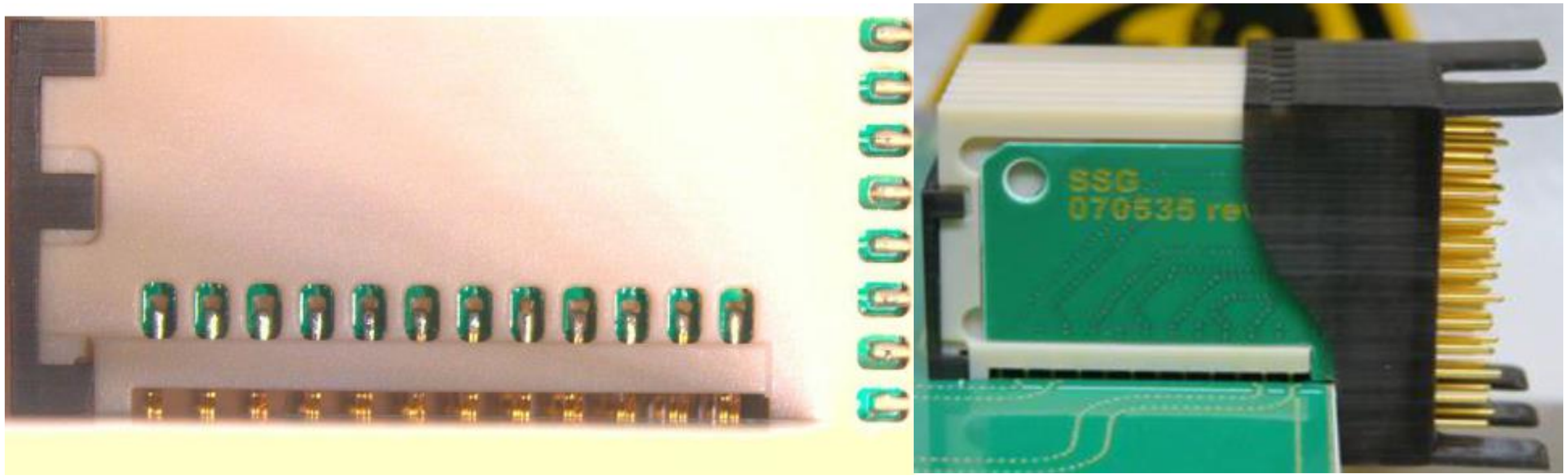
Machined frame

3D printed housing

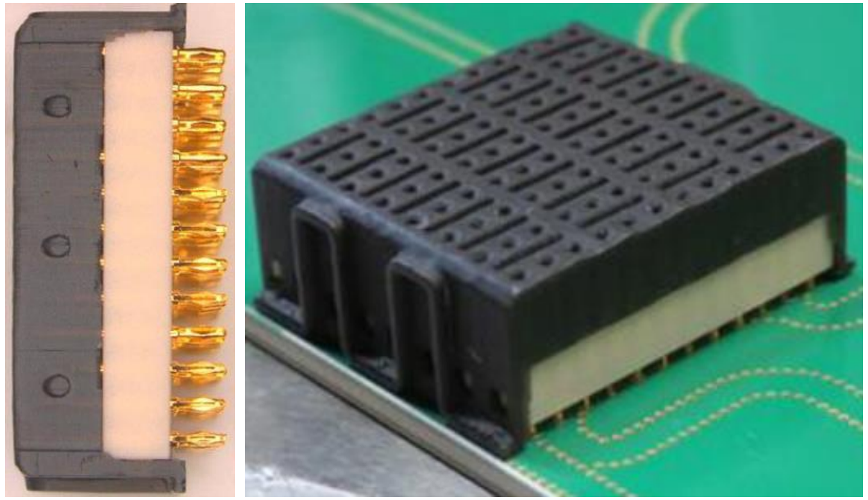
Machined pin contacts

Metal sheet press-fit

AXON' CABLE: CONNECTOR PROTOTYPE MANUFACTURING (II)



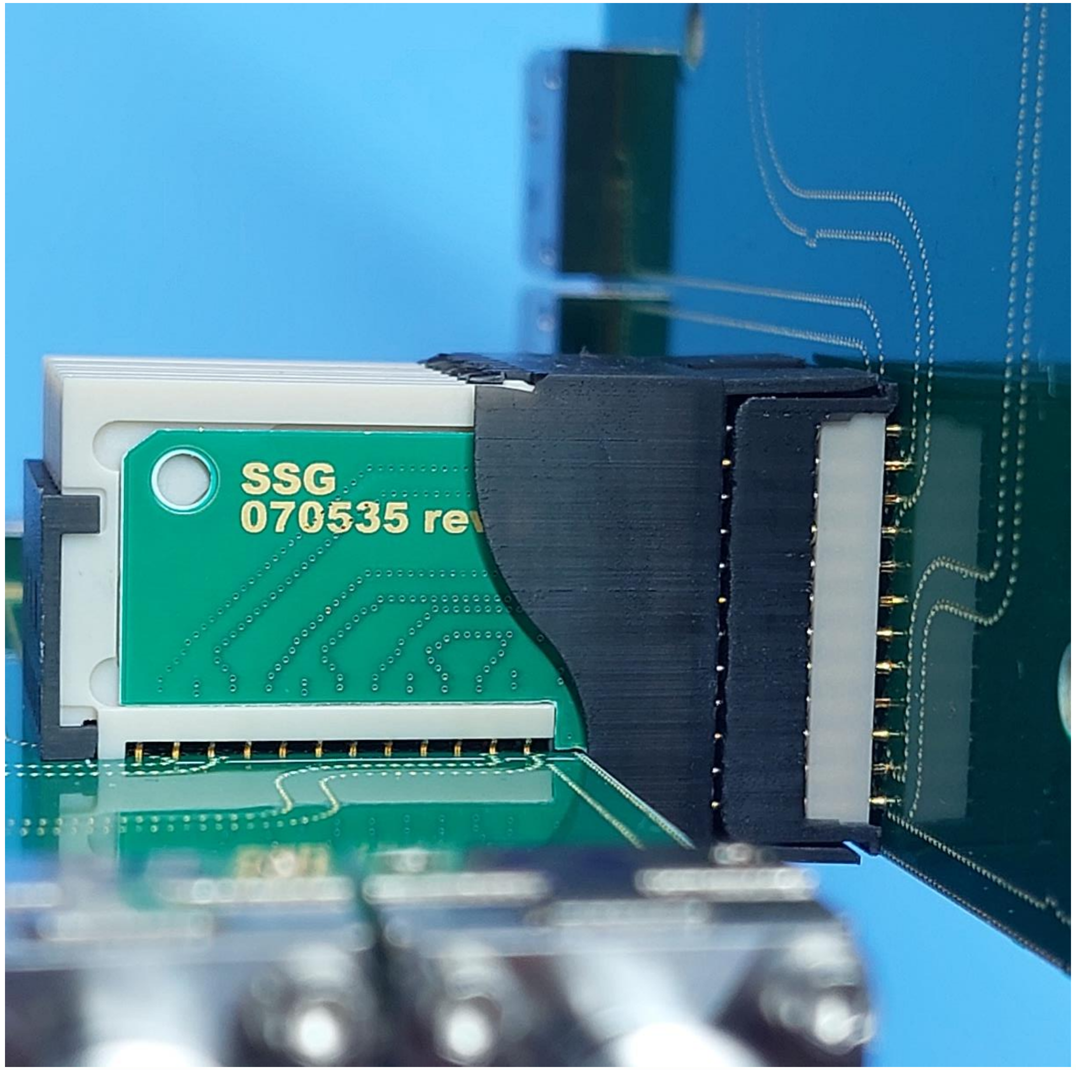
Daugther board connector prototype



Back-plane connector prototype

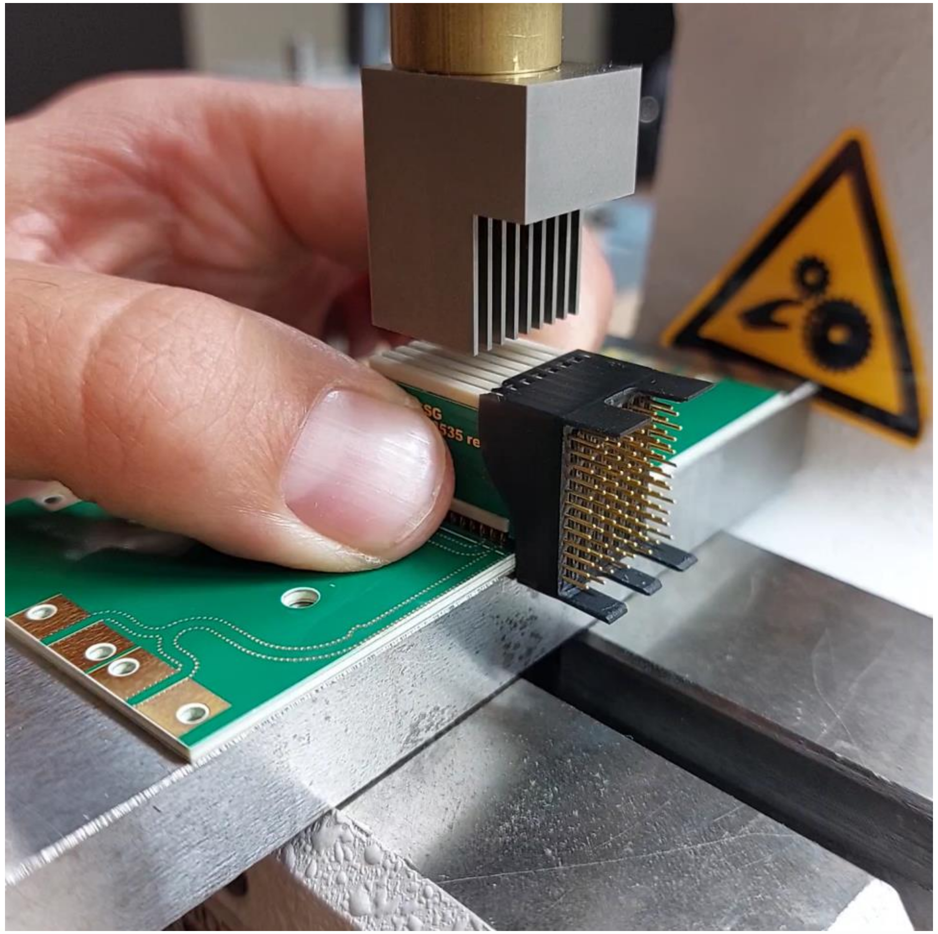
- These are the first prototypes manufactured, due to customer urgent need.
- Two types of materials used due to time constraint: one material for machined frames (white colour), one different material for housing (3D printed, black colour)
- Systematical improvement of these connector prototypes is already planned.

AXON’ CABLE: PROTOTYPE CONNECTOR MANUFACTURING (III)



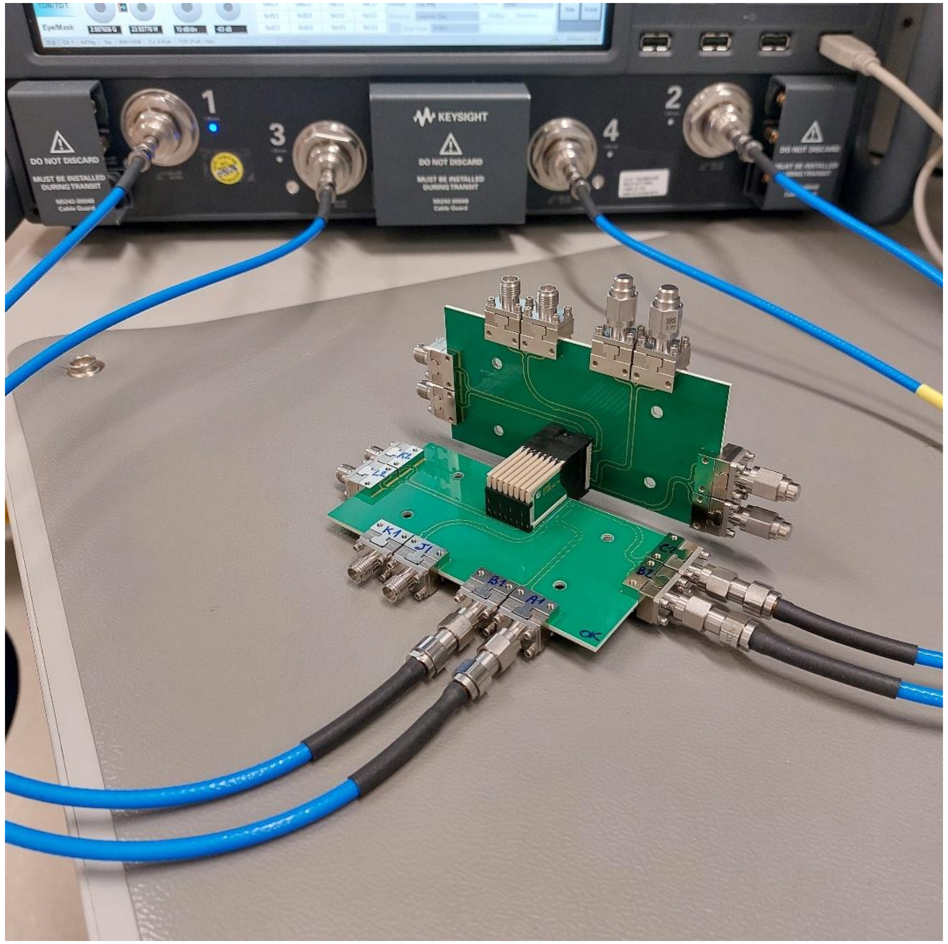
Insertion tool manufactured by AXON (manual press)

No damage on connector prototype frames or PCB



AXON’: CONNECTOR PROTOTYPE ELECTRICAL CHARACTERISATION (I)

- Two types of connector prototypes characterised:
  - Unshielded prototype connector
  - Shielded prototype connector daughter board (to try improve crosstalk, and decrease impedance)
- Two types of test results:
  - Contribution of connector prototype and PCB (“embedded”)
  - Connector prototype contribution only (“de-embedded”)
- DC tests performed: line resistance, insulation, voltage proof
- RF tests performed:
  - high data rate
  - insertion loss
  - near-end cross talk
  - far-end, cross-talk
  - differential impedance



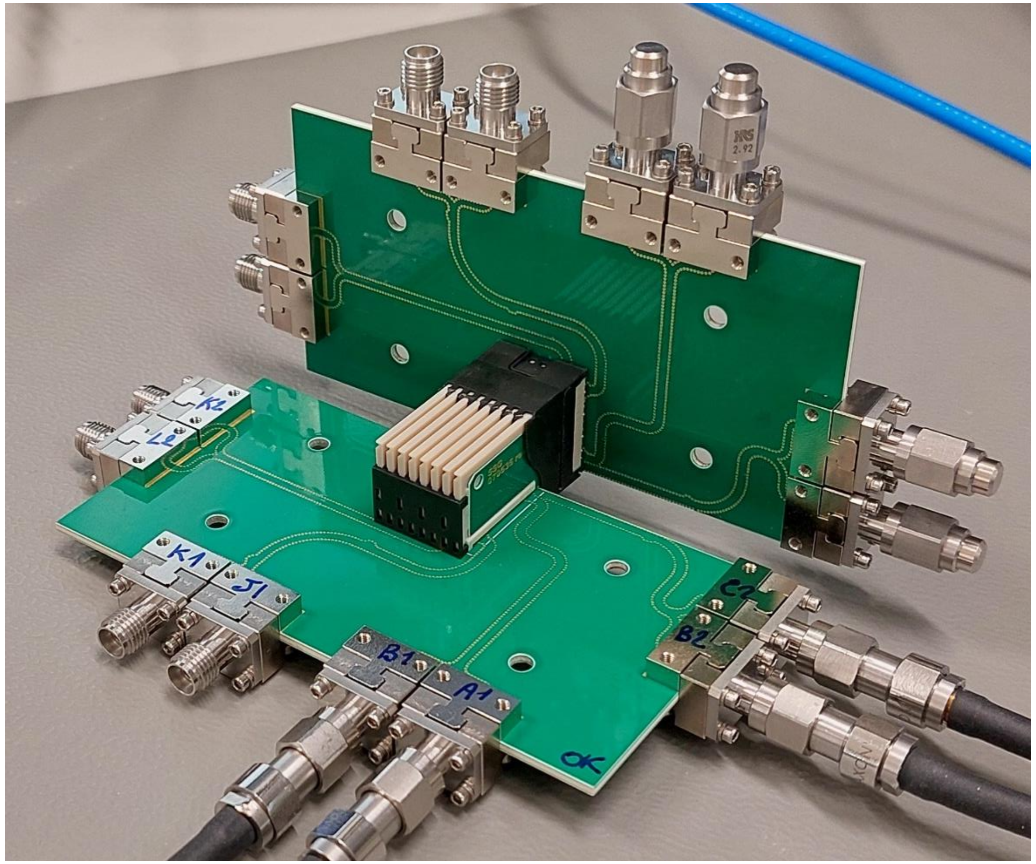
AXON’: CONNECTOR PROTOTYPE ELECTRICAL CHARACTERISATION (II)

***Table 1**: Connector cabling*

	A	B	C	D	E	F	G	H	I	J	K	L
08	GND	+	-	GND	+	-	GND	+	-	GND	+	-
07	+	-	GND	+	-	GND	+	-	GND	+	-	GND
06	GND	+	-	GND	+	-	GND	+	-	GND	+	-
05	+	-	GND	+	-	GND	+	-	GND	+	-	GND
04	GND	+	-	GND	+	-	GND	+	-	GND	+	-
03	+	-	GND	+	-	GND	+	-	GND	+	-	GND
02	GND	+	-	GND	+	-	GND	+	-	GND	+	-
01	+	-	GND	+	-	GND	+	-	GND	+	-	GND

***Table 2**: Connector cabling versus VNA ports 1,2,3,4*

VNA Port	PCB Daughter	PCB Backplane
1	J1 / L2 / A1 / C2	
2		K2 / B1 / B2 / K1
3	K1 / K2 / B1 / B2	
4		L2 / J1 / A1 / C2



Test PCBs:
Lines J1, K1, K2, and L2 are *longest* lines on PCB connector.

Lines A1, B1, B2 and C2 are the *shortest* lines on PCB connector.

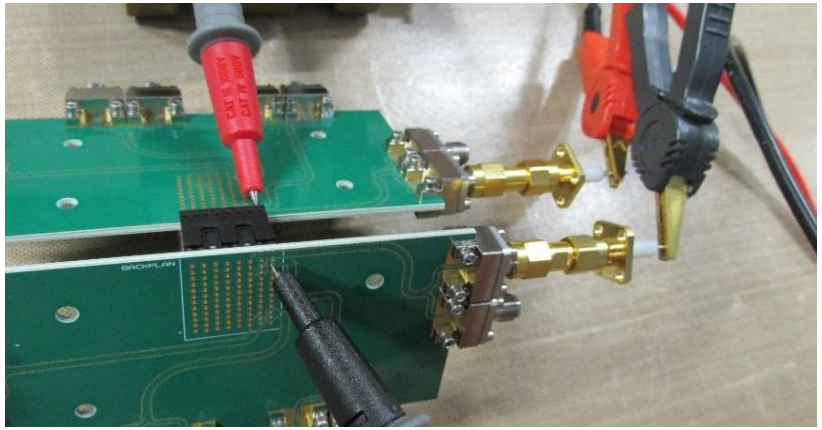
AXON': ELECTRICAL CHARACTERISATION (III) DC LINE RESISTANCE

Table 1: results for the unshielded connector

PCB Daughter	PCB Backplane	R0 (mOhms)
A1	A1	63.3
B1	B1	61.8
B2	B2	52.4
C2	C2	52.7
J1	J1	107
K1	K1	109
K2	K2	119
L2	L2	121

Table 2: results for the shielded connector

PCB Daughter	PCB Backplane	R0 (mOhms)
A1	A1	66.2
B1	B1	63.5
B2	B2	63.8
C2	C2	63.9
J1	J1	106
K1	K1	108
K2	K2	139
L2	L2	141



-B2 & C2 close to 52mΩ and A1 & B1 close to 63mΩ: Δ= 21%

-J1 & K1 close to 108mΩ and K2 & L2 close to 120 mΩ: Δ= 11%

-B1, B2 & B3 close to 63mΩ and A1 close to 66mΩ: Δ= 5%

-J1 & K1 close to 107mΩ and K2 & L2 close to 140m Ω : Δ= 31%

Variability on DC-resistance probably caused by irregular thickness of the line PCB layers

AXON': ELECTRICAL CHARACTERISATION (IV) VOLTAGE PROOF, INSULATION

Measured poles	DWV under 600Vrms	Insulation under 500Vdc
A1 & B1	<2mA	>1000MΩ
A1+B1 & GND	<2mA	>1000MΩ
B2 & C2	<2mA	>1000MΩ
B2+C2 & GND	<2mA	>1000MΩ
J1 & K1	<2mA	>1000MΩ
J1+K1 & GND	<2mA	>1000MΩ
K2 & L2	<2mA	>1000MΩ
K2+L2 & GND	<2mA	>1000MΩ

unshielded connector

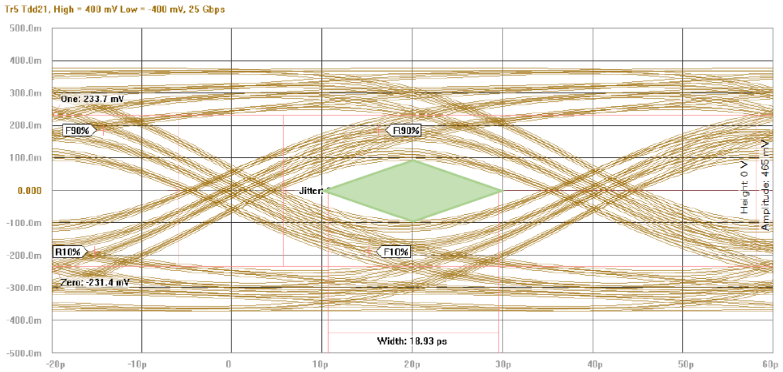
Measured poles	DWV under 600Vrms	Insulation under 500Vdc
A1 & B1	<2mA	>1000MΩ
A1+B1 & GND	<2mA	>1000MΩ
B2 & C2	<2mA	>1000MΩ
B2+C2 & GND	<2mA	>1000MΩ
J1 & K1	<2mA	>1000MΩ
J1+K1 & GND	<2mA	>1000MΩ
K2 & L2	<2mA	>1000MΩ
K2+L2 & GND	<2mA	>1000MΩ

shielded connector

Tests results are successful!

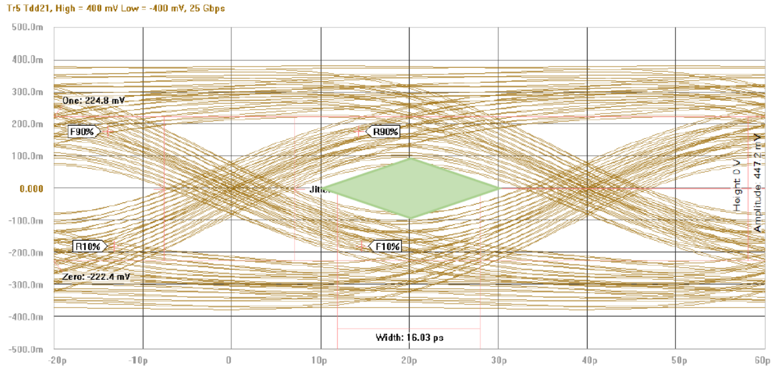
AXON': RF PARAMETERS (I) DATA RATE

Connector&PCB contribution ("embedded")



NOK

Figure 10: K1-J1 Daughter & K1-J1 Backplane 25 Gb/s



NOK

Figure 12: K2-L2 Daughter & K2-L2 Backplane 25 Gb/s

- All configurations at 12.5 Gb/s pass the test
- For configurations at 25 Gb/s the signal fails

Connector contribution only ("de-embedded")

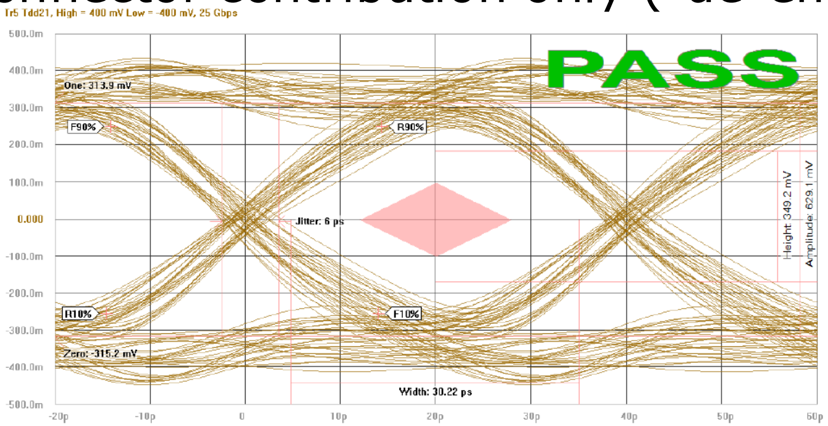


Figure 37: K2-L2 25 Gb/s for de-embeded CPCI

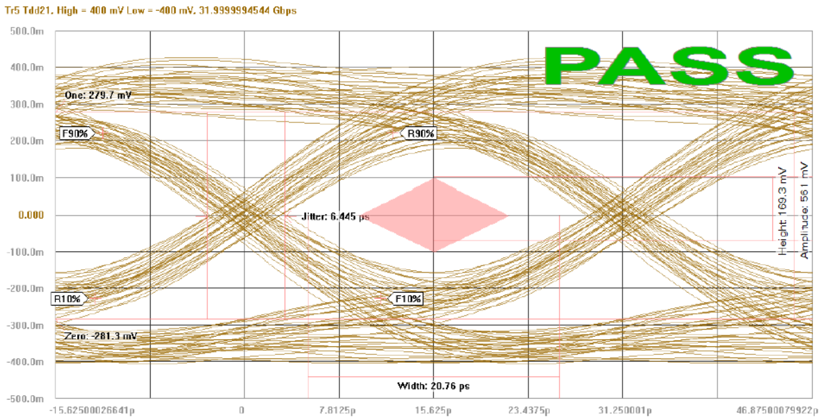


Figure 38: K2-L2 32 Gb/s for de-embeded CPCI

12.5, 25 and 32Gb/s pass the test!

Similar results for shielded or unshielded variants

AXON’: RF PARAMETERS (II) INSERTION LOSS

Connector&PCB contribution

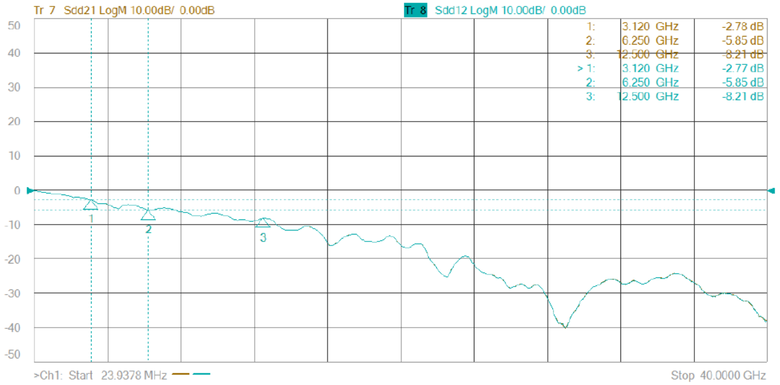


Figure 16*: K2-L2 Daughter & K2-L2 Backplane*

For each configuration, the insertion losses:

- 2 dB for 3.125 GHz
- 5 dB for 6.25 GHz
- 8 dB for 12.5 GHz

Connector contribution only (“de-embedded”)

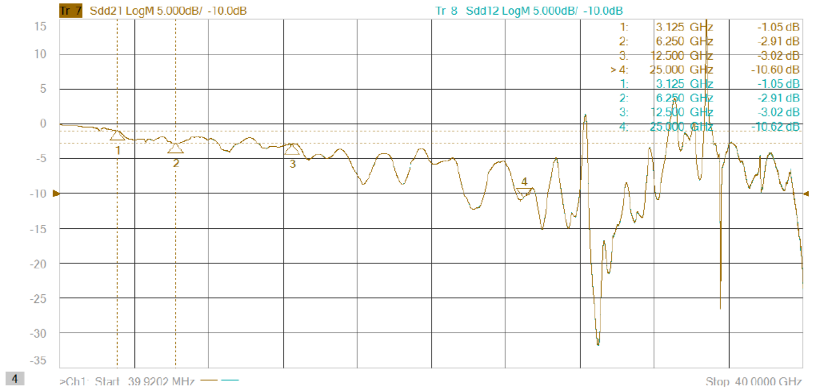


Figure 42*: insertion losses K2-L2 for de-embeded CPCI*

For each configuration, the insertion losses:

- 0.7 dB for 3.125 GHz
- 2 dB for 6.25 GHz
- 3 dB for 12.5 GHz

Similar results for shielded or unshielded variants

For 3.125GHz, results are PASS

AXON': RF PARAMETERS (III) NEAR/FAR END X-TALK

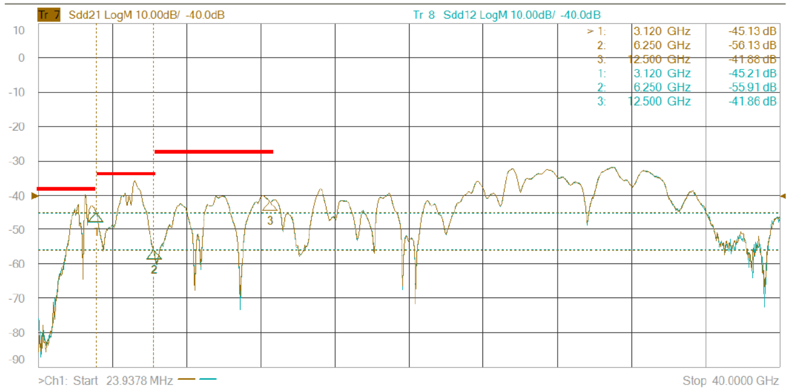


***Figure 18**: K1-J1 Daughter with K1-J1 Backplane loaded & K2-L2 Daughter with K2-L2 Backplane loaded*

PASS

Near-end unshielded

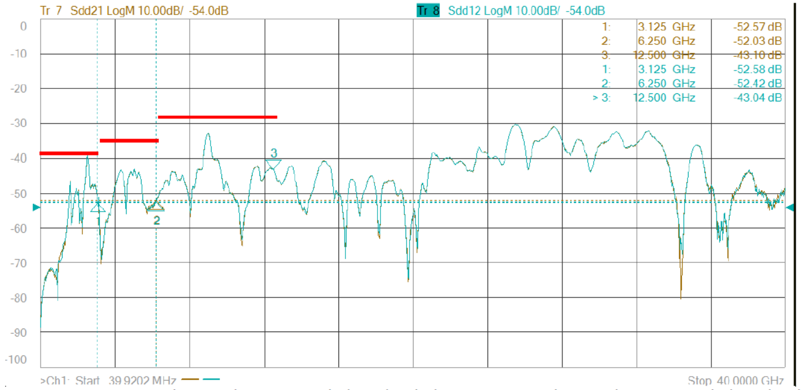


***Figure 56**: K1-J1 Daughter with K1-J1 Backplane loaded & K2-L2 Daughter with K2-L2 Backplane loaded for shielded CPCI*

PASS

Near-end shielded

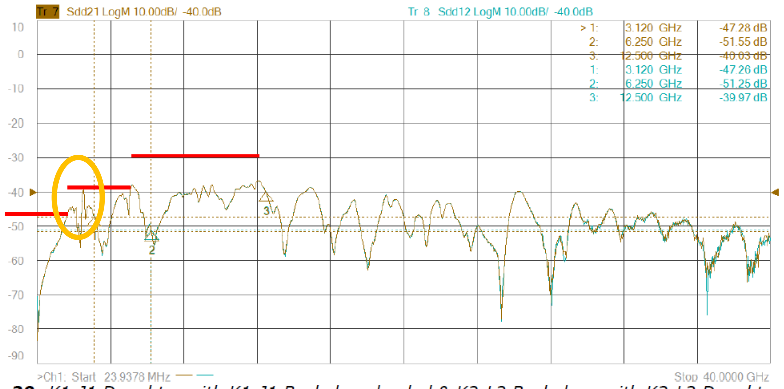


***Figure 20**: K1-J1 Daughter with K1-J1 Backplane loaded & K2-L2 Backplane with K2-L2 Daughter loaded*

Far-end unshielded

Only one peak NOK. The rest is PASS

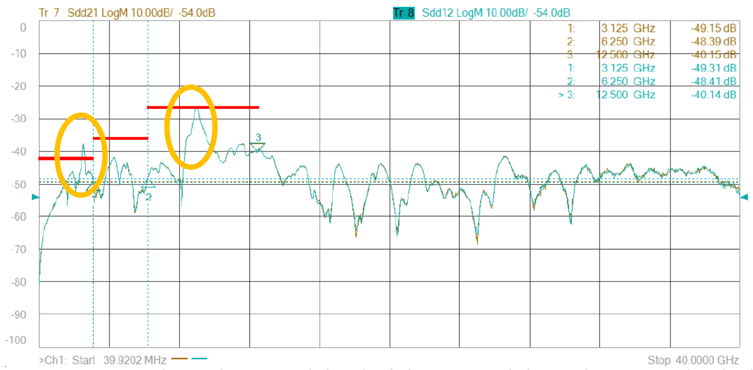


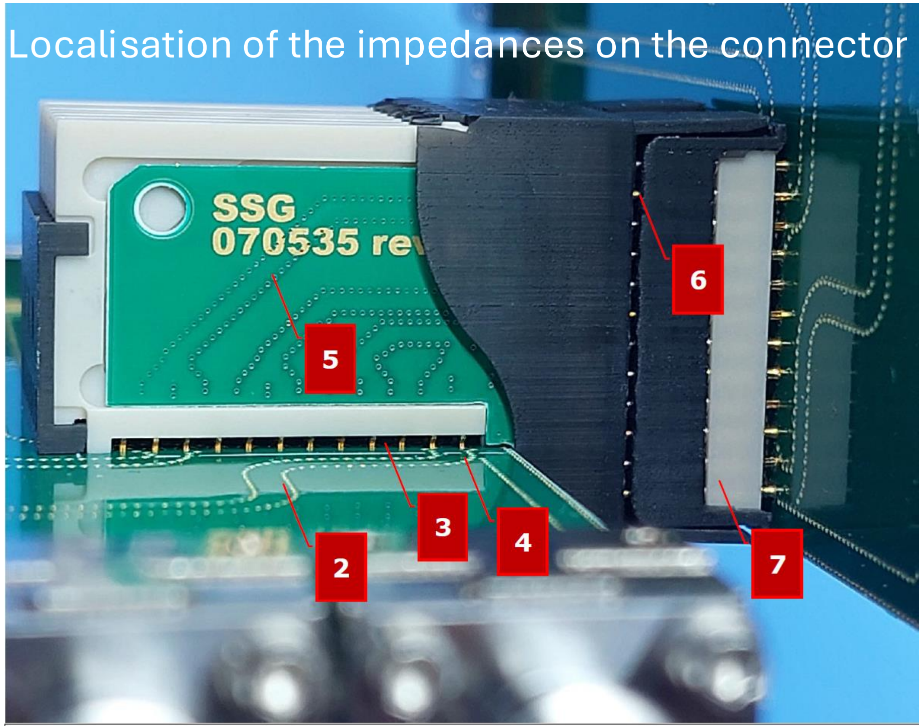
***Figure 58**: K1-J1 Daughter with K1-J1 Backplane loaded & K2-L2 Backplane with K2-L2 Daughter loaded for shielded CPCI*

Only two peaks NOK. The rest is PASS

Far-end shielded

Similar results for shielded or unshielded variants

AXON': RF PARAMETERS (V) DIFFERENTIAL IMPEDANCE



Corresponding areas:

1-2.92mm PCB connector connection

2-Test PCB transmission line (skew compensation)

3-Bonding PCB-PCB

4- Daughter connector pressfit / through hole

5-Daughter connector internal PCB transmission line

6- Daughter connector male contact

7- Female contact + Backplane connector pressfit / through hole

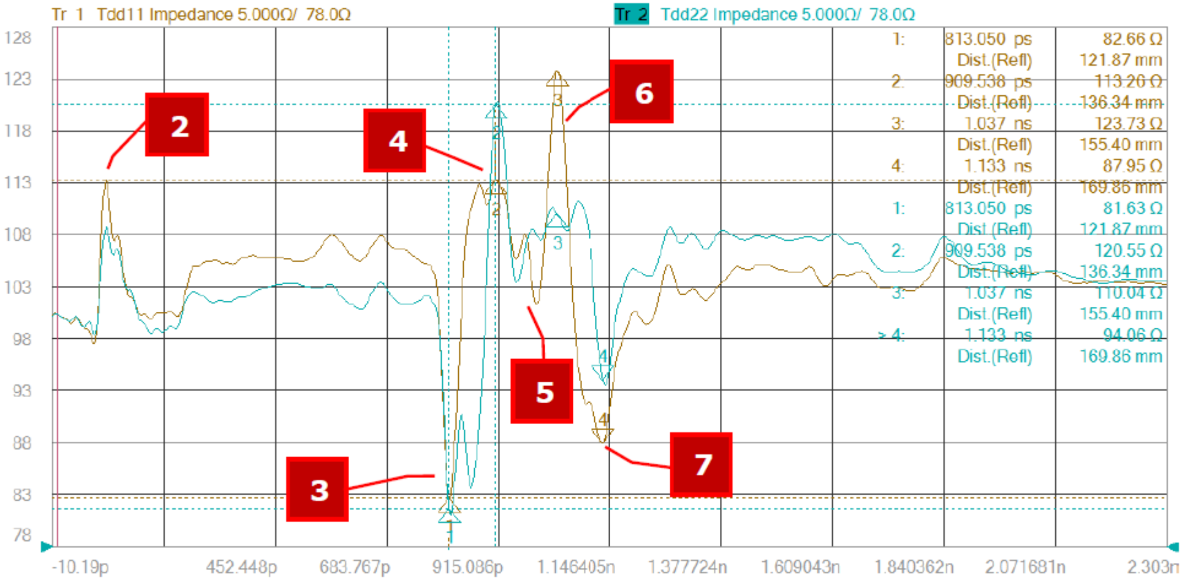


***Figure 21**: A1 & B1 Daughter & A1 & B1 Backplane*

NOK

Similar results for shielded or unshielded variants

AXON’: RF PARAMETERS (VI) SUMMARY

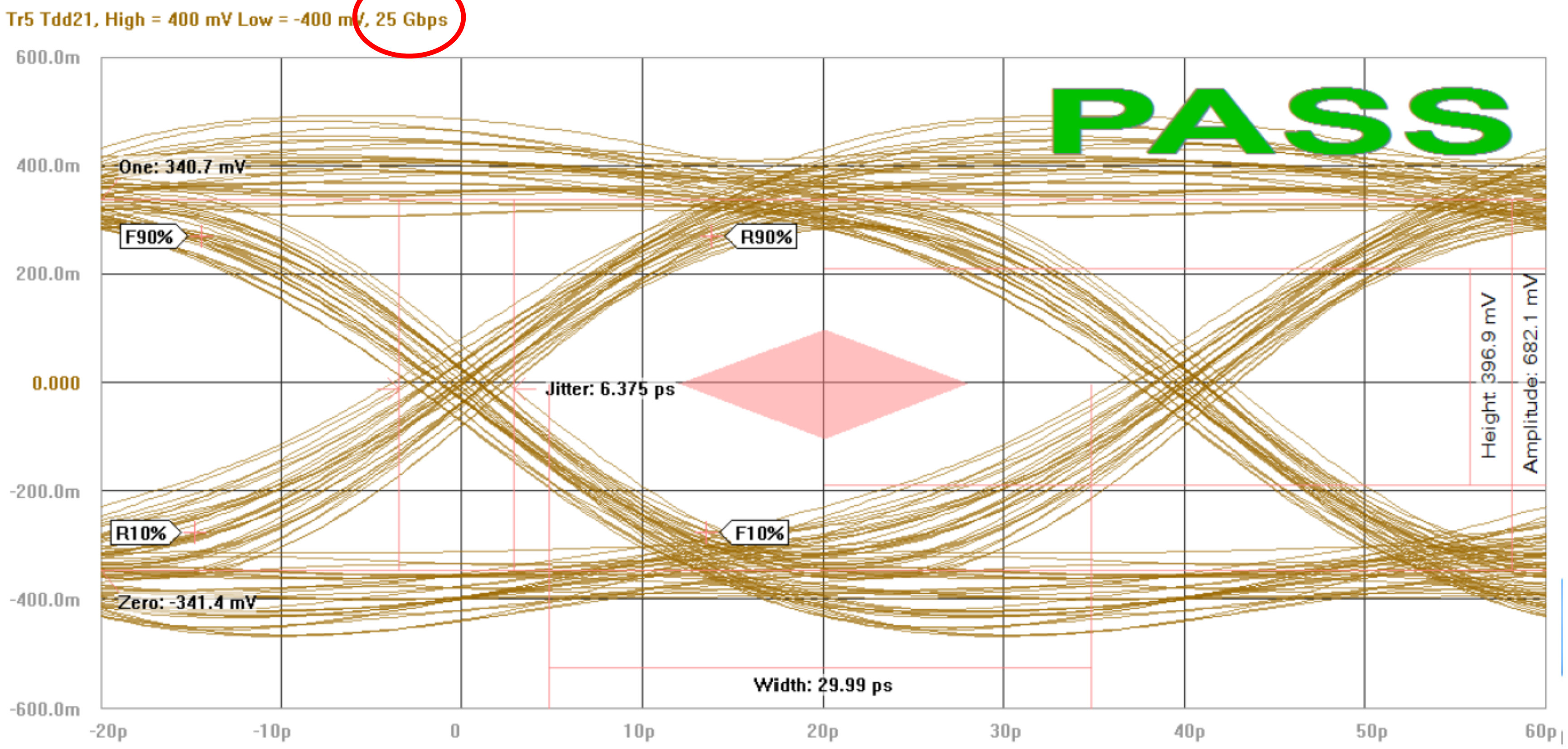
Tests	Targets			Results		
High speed data rate unshielded variant (input signal 800 mVpp)	SpaceFibre mask 200 mV diff peak-peak			12.5 Gb/s		25 Gb/s
				OK		NOK
High speed data rate de-embedded unshielded variant (input signal 800 mVpp)				12.5 Gb/s		25 Gb/s
				OK		OK
High speed data rate shielded variant (input signal 800 mVpp)				12.5 Gb/s		25 Gb/s
				OK		NOK
High speed data rate shielded variant and de-embedded (input signal 800 mVpp)				12.5 Gb/s		25 Gb/s
				OK		OK
Insertion losses	3.125 GHz	6.25 GHz	12.5 GHz	3.125 GHz	6.25 GHz	12.5 GHz
A1-B1 unshielded variant	-1 dB	-1.5 dB	-2 dB	-2.42 dB	-5.89 dB	-8.87 dB
A1-B1 de-embedded unshielded variant				-0.71	-2.74	-3.37
A1-B1 shielded variant				-2.46	-5.5	-8.12
A1-B1 shielded and de-embedded				-0.86	-2.78	-2.32
K1-J1 unshielded variant				-2.34	-4.97	-8.3
K1-J1 de-embedded unshielded variant				-0.73	-2	-3.88
K1-J1 shielded variant				-2.59	-5.19	-10.09
K1-J1 shielded and de-embedded				-1	-2.1	-4.18
B2-C2 unshielded variant				-2.37	-4.95	-9.13
B2-C2 de-embedded unshielded variant				-0.68	-2.09	-3.81
B2-C2 shielded variant				-2.49	-4.55	-8.9
B2-C2 shielded and de-embedded				-0.97	-1.64	-2.32
K2-L2 unshielded variant				-2.78	-5.85	-8.21
K2-L2 de-embedded unshielded variant				-1.05	-2.91	-3.02
K2-L2 shielded variant				-2.51	-5.24	-8.22
K2-L2 shielded and de-embedded				-0.91	-2.31	-2.38

Tests	Targets			Results		
Near end signal crosstalk	3.125 GHz	6.25 GHz	G12.5 Hz	3.125 Hz	6.25 Hz	12.5 Hz
A1-B1 / B2-C2 unshielded variant	-39 dB	-34 dB	-29 dB	- 45.3	- 52.9	- 38.7
A1-B1 / B2-C2 shielded variant				-44.8	-36.8	-36.5
K1-J1 / K2-L2 unshielded variant				-45.2	-56.1	-41.9
K1-J1 / K2-L2 shielded variant				-39	-43.2	-32.9
Far end signal crosstalk	3.125 Hz	6.25 Hz	12.5 Hz	3.125 Hz	6.25 Hz	12.5 Hz
A1-B1 / B2-C2 unshielded variant	-42 dB	-34 dB	-26 dB	- 45	- 49.3	- 39
A1-B1 / B2-C2 shielded variant				-41.4	-36.6	-32.3
K1-J1 / K2-L2 unshielded variant				-47.3	-51.3	-39
K1-J1 / K2-L2 shielded variant				-38.5	-41.8	-26.4
Differential impedance unshielded variant TDR (40GHz BW, rise/fall time ≤ 17.5 ps)	min	max		min	max	
	90 Ω	110 Ω		82 Ω	130 Ω	
Differential impedance shielded variant TDR (40GHz BW, rise/fall time ≤ 17.5 ps)	min	max		min	max	
	90 Ω	110 Ω		80 Ω	119 Ω	

- Data rate: PASS
- Insertion loss: PASS at 3.125GHz
- Near-end cross-talk: PASS
- Far-end cross-talk: PASS unshielded variant
- Differential impedence: NOK
- **Very promising results for prototypes!**

AXON': RF PARAMETERS (VII) COMPARISON WITH AIRMAX VS

Pistes K2L2



AXON': CONCLUSIONS / NEXT STEPS

CONCLUSIONS

- Decision to manufacture these two-material prototypes only to fulfil urgent customer needs.
- Digital transmission is ensured with margin a bit more over 12.5GHz (equivalent to 25Gb/s) with a NRZ baseband signal, which exceeds ADHA needs.
- These are very promising results. It is planned to systematically improve these prototype connectors.
- The few non-conformances concern mainly the insertion losses above 3.125GHz and differential impedance.
- Shield between the frames => light impedance improvement but not big changes.

NEXT STEPS:

- Prototype connector planned improvements:
    - Manufacturing process upgraded to have molded connectors, with one material only.
    - Improve internal PCBs.
    - Pin surface treatment.
- TRR estimated for June 2026, with evaluation test plan.
- Production of samples for mechanical testing, test set-up definition and test flow performance.

Background & Rationale

Specification & Challenges

On-going Activities (III)

ARTES:High Density Modular Electrical Interconnections for High Data Rate Applications (Performance Interconnect & ALTER TECHNOLOGY FRANCE)

Conclusion

Development of High Density Modular Electrical Interconnections for High Data Rate Applications

Contractor: ALTER TECHNOLOGY (FR), PERFORMANCE INTERCONNECT (FR)				ESA Budget	500 k€
Funding	ARTES AT	Initial TRL: 3	Target TRL: 6	TO: Léo Farhat Joaquín Jiménez	
Start of activity: 12 2023		End of Activity: 07 2026			

Background and justification:
Urgent need to develop backplane high data rate interconnections compatible with compact PCI Serial Space (cPCI SS) standard. This is capable of routing data between processing modules of on-board computers. Backplane connectors are critical components to enable high speed interconnections.

Currently, there are no European solutions able to reach 25 Gbit/s to 50 Gbit/s. Engineering models of modular backplane high density connectors compatible with cPCI serial space standards will be designed, manufactured and tested for use in high data rate space applications. Additionally, the focus of the activity will be to achieve at least 25 Gbit/s data rate.

Objective(s):
The objective of this activity is to design, develop and test engineering models of modular backplane high density connectors for high data rate space applications, compatible with cPCI serial space standard.
- enabling routing of more than 120 channels
- achieve an interface bit rate of at least 25 Gbit/s, with a goal of 56Gb/s for long-term missions.

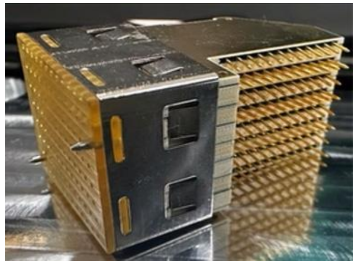
Achievement and status:
- ITT was issued in Q3 2022. No support from delegation. ITT re-issued to get support from National Delegation.
- Contract signed with ALTER (FR) and Performance Interconnect (FR) on 12/12/2023.
- Kick-off held in January 2024, finalized technical specification.
- Version 2 of the connectors created (Gen2HYP) to have EM models available:prototypes manufactured and characterisation done.

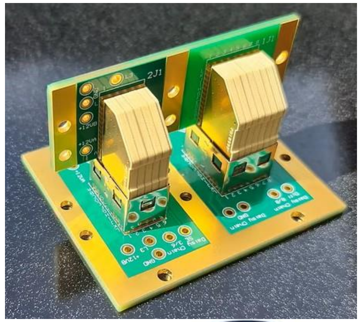
Benefits:
- European provider of interconnections for High Data Rate applications for space applications.

Next steps:
- CDR+MRR Nov 2025
- Reliability tests: electrical validation (high frequency measurements), mechanical validation (vibration, shock), thermal cycles.

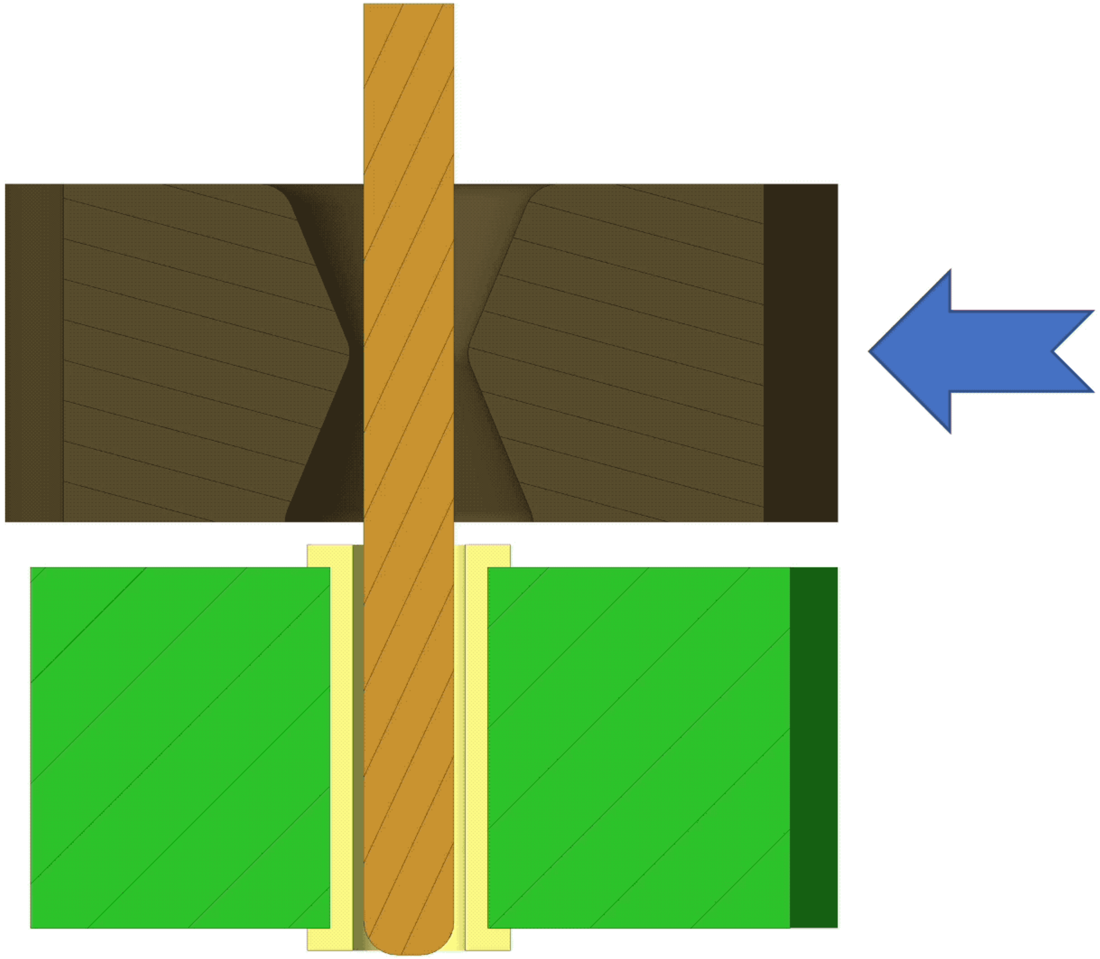
ALTER TECHNOLOGY

PERFORMANCE INTERCONNECT





HYPERBITS: S-FECT (I)



S-FECT:

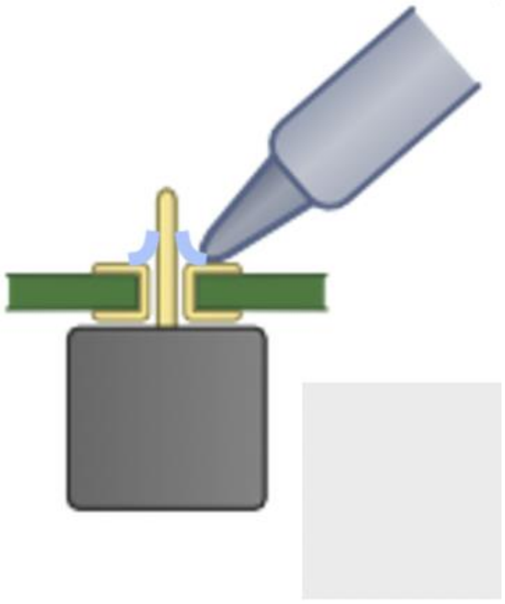
SLIDE-FIT

ELECTRICAL

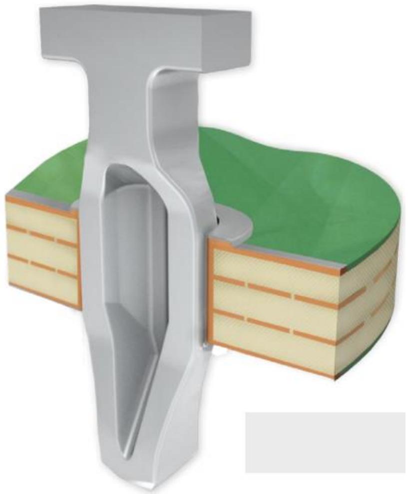
CONTACT

TERMINATION

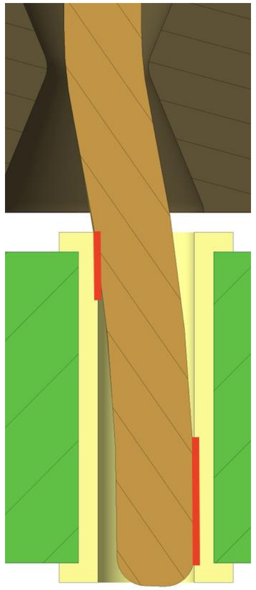
HYPERBITS: S-FECT (II)



NO SOLDERING



NO PRESS-FIT



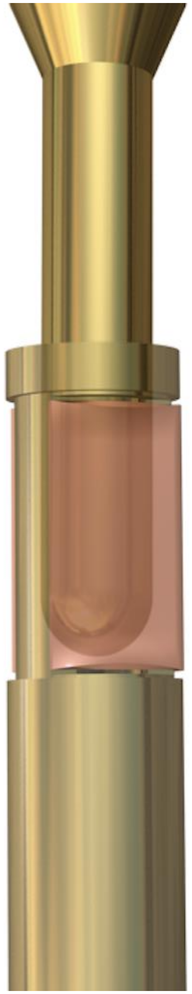
<Higher normal Force

>Lower resistance

Based on **S-FECT** Technology

Contacts slide and operate in elastic deformation

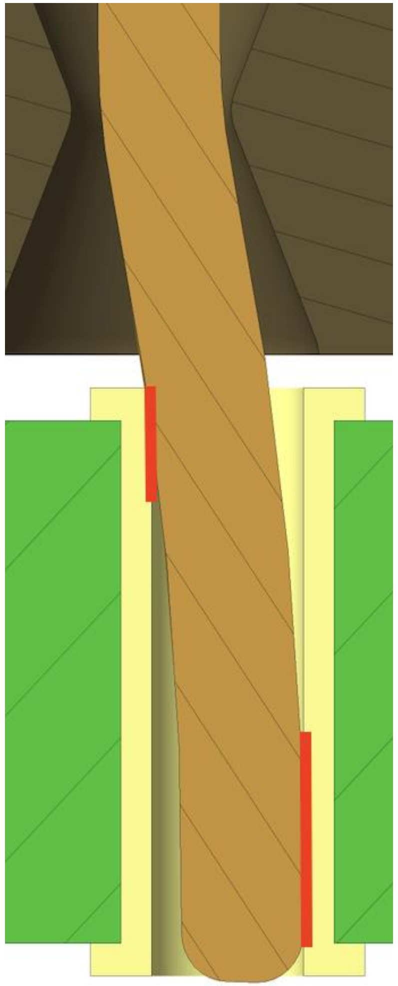
HYPERBITS: S-FECT (III)



External Pressure Element
Technology

Already qualified to

Mil - 39029
GSFC-311
ESCC-3401



S-FECT
Technology

Similar mechanism of operation BUT…

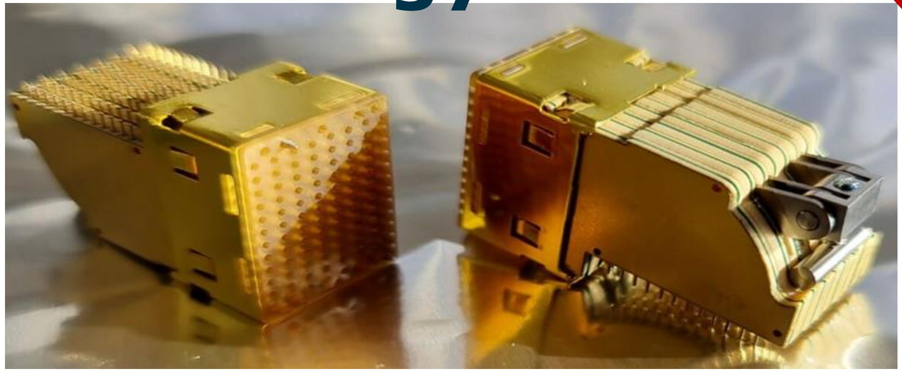
< Higher normal Force
and
> Lower resistance

Connects directly to PCB

HYPERBITS: ADVANTAGES (I)

Press-fit versus S-FECT

S-FECT™ Technology



1-part connector system

- **reduced cost**
- **simple installation**

$

No special assembly tooling required

NO Deformation of contacts +
NO Damage to PCB =

- Reusable PCB +
- Reusable Connector

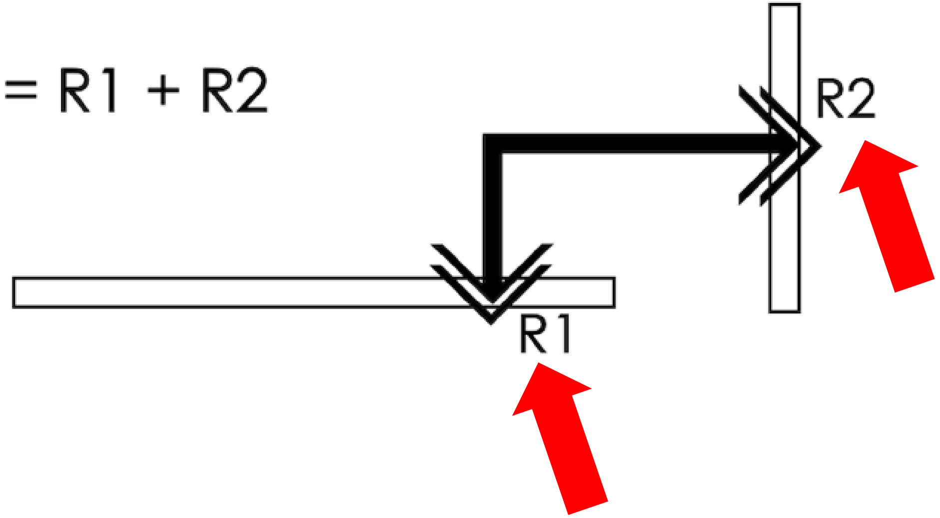
HYPERBITS: ADVANTAGES (II)

Press-fit versus S-FECT

S-FECT™ Technology

Total resistance PCB to PCB:

Rt = R1 + R2

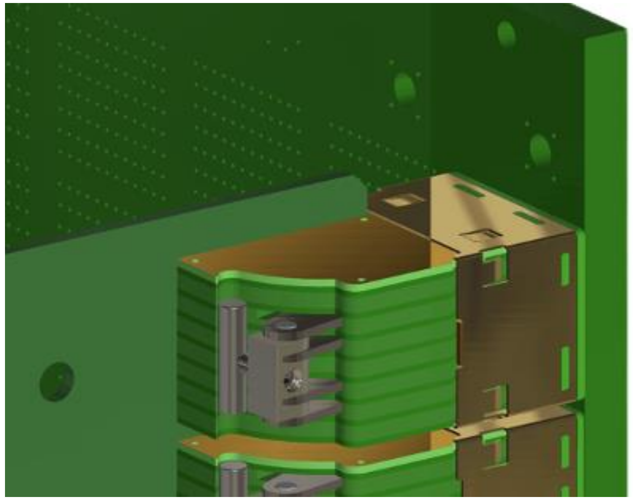


1-part connector system

- reduced cost
- simple installation

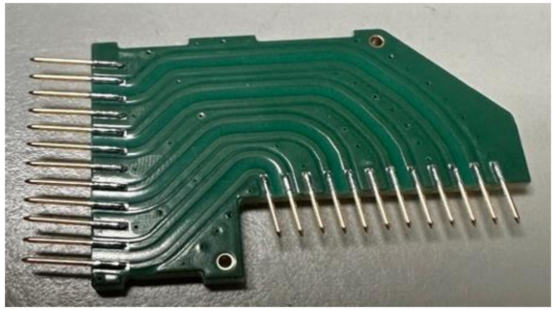
HYPERBITS™

R1 = R2 ≤ 5mΩ

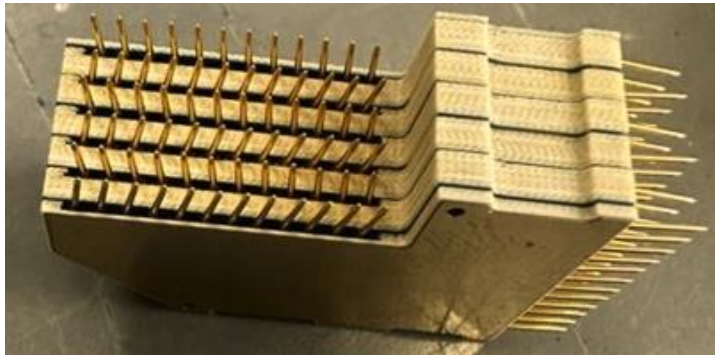


HYPERBITS Gen 2.0: CONNECTOR MANUFACTURING

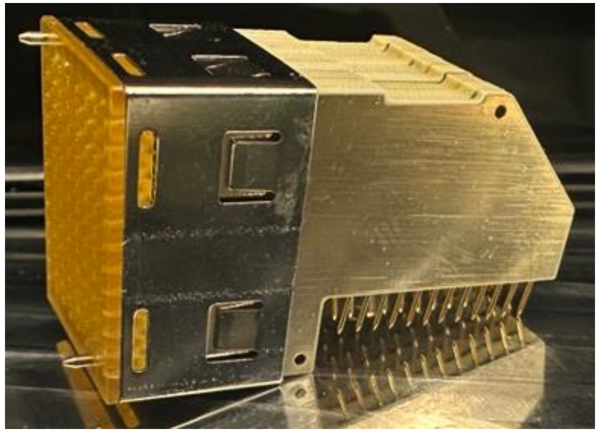
A- Pin soldered on wafer

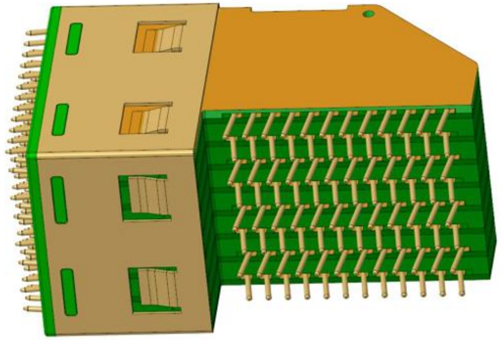


B- PCB Connector Assembly



C- Slide Shield Assembly





Hyperbits
Gen 2.0

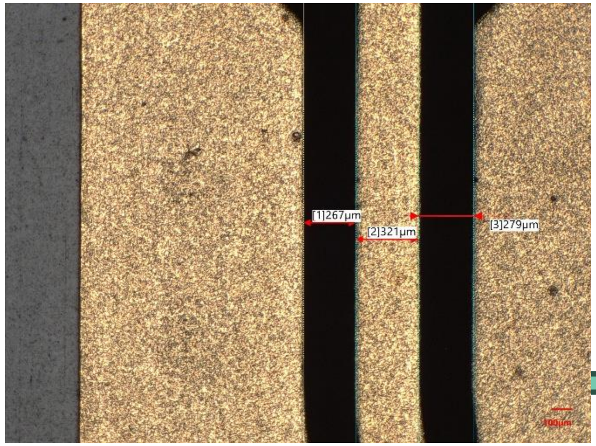
HYPERBITS Gen 2.0: TEST PCBs

- V1: on test boards for RF measurements (Backplane and Daughter Card), tracks and insulation were not respected

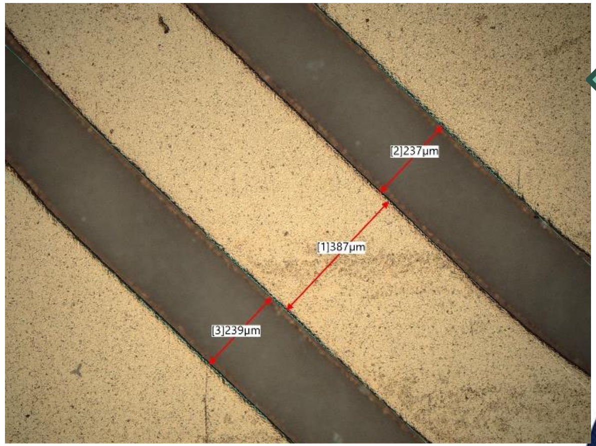
→ RF impedance not respected.

→ V2: new RF boards were manufactured; Tracks dimensions and isolation requirements are now respected.

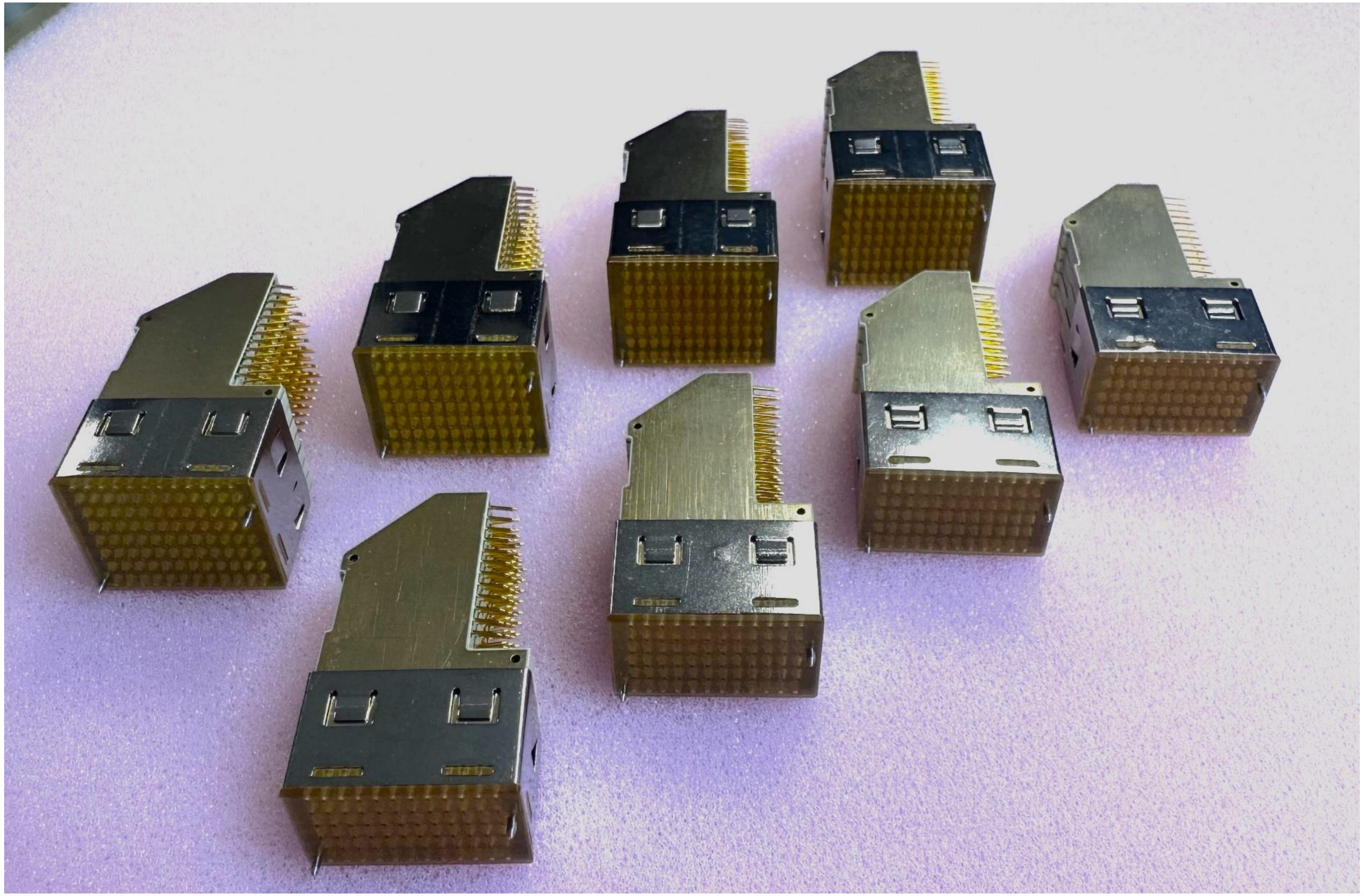
RF boards V1

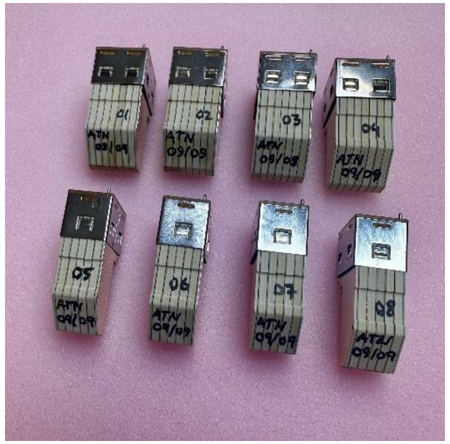


RF boards V2

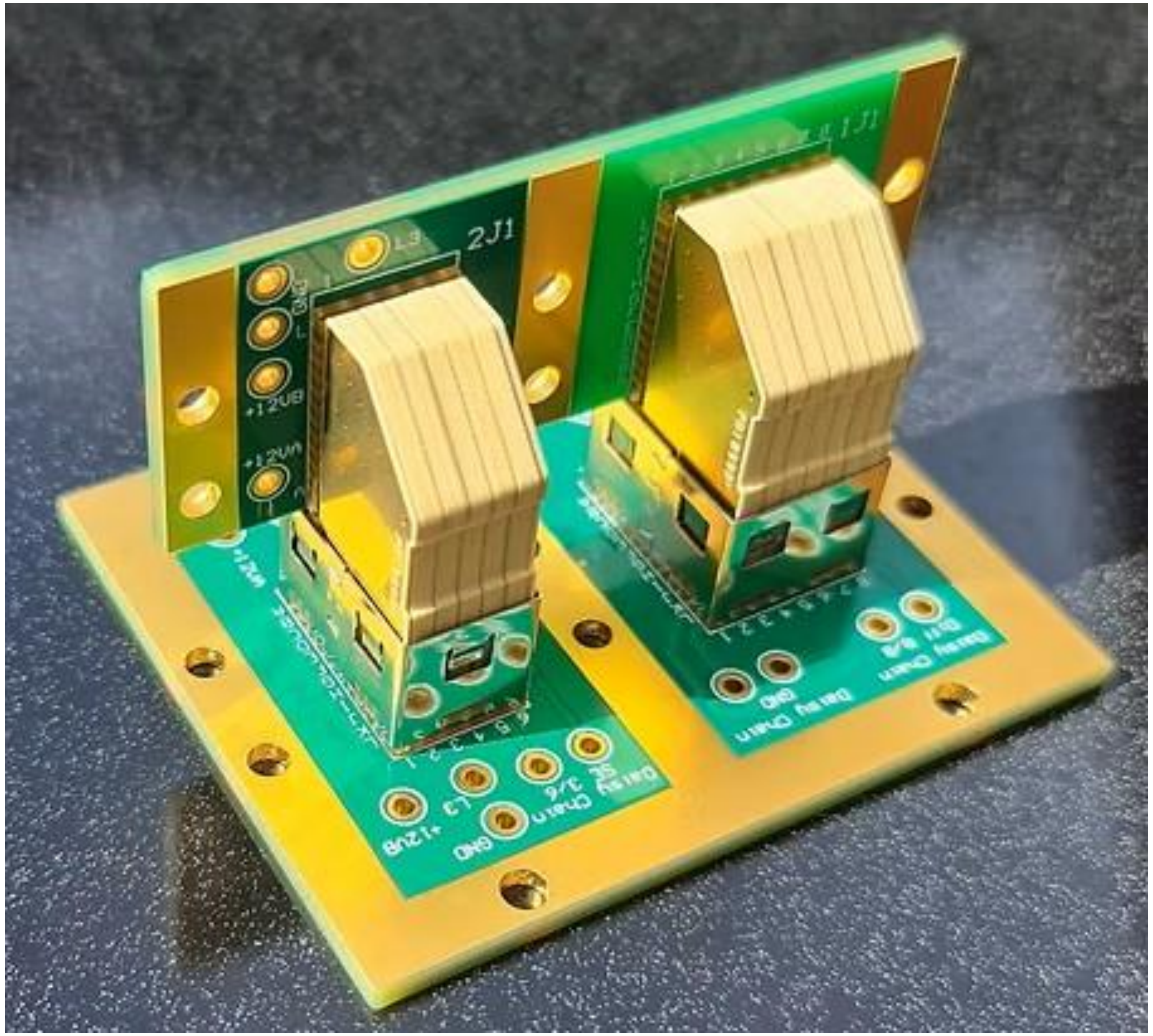


HYPERBITS Gen 2.0





HYPERBITS Gen 2.0: CONNECTOR ASSEMBLY

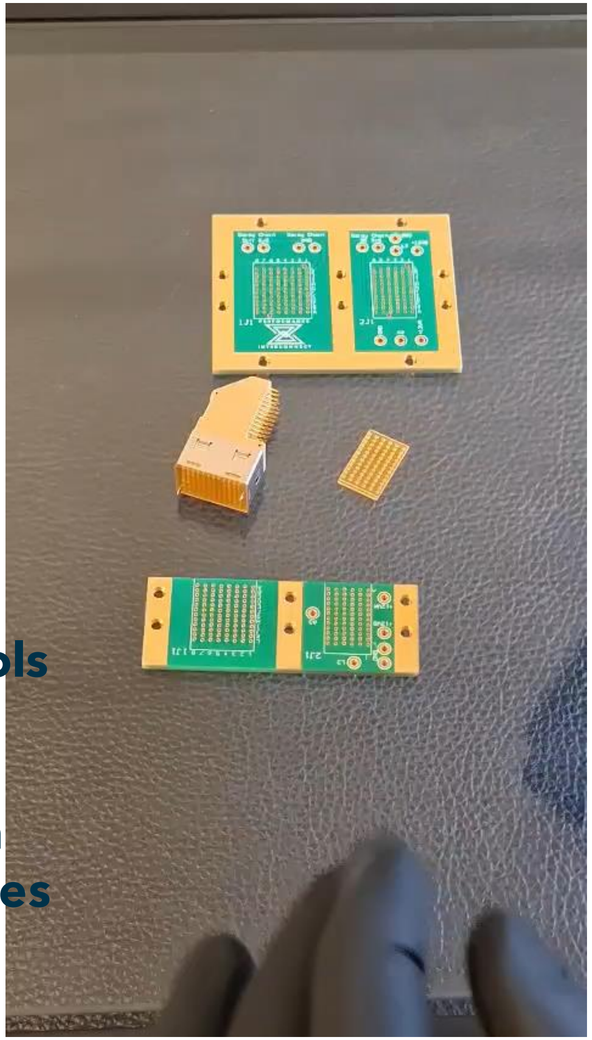


Repairability:

PCB reusable
Connector reusable

Blindmating:

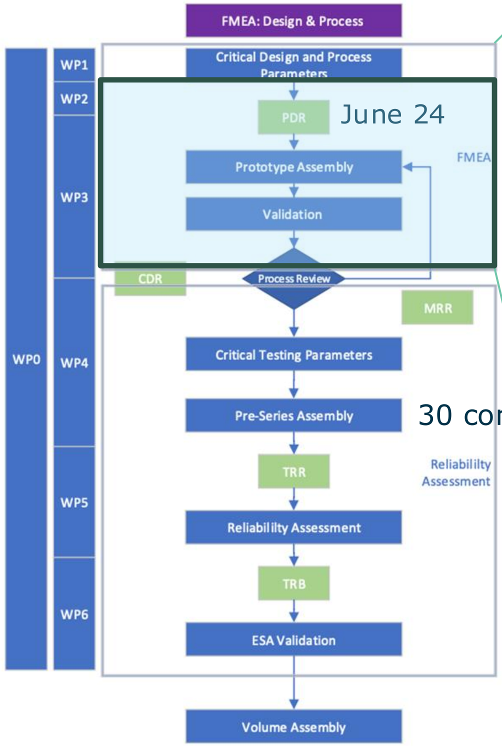
Directly into the backplane



Zero specialty tools

Zero jet effect
Zero deformation
Zero loose particles
Zero inspection

CHARACTERISATION HYPERBITS Gen 2.0 (I)



30 connecteurs - 8 range

- Design FMEA and Process FMEA to define critical parameters for reliability testing (Electrical, Mechanical, Temperature, Insertions etc.)
- Internal Alter Technology and Performance Interconnect prototypes assembly 5x parts + 5x parts

- Mechanical validation ~~5x~~ 2x parts
  - External Visual Inspection
  - PCB Insertion
  - External Visual Inspection
  - Contact resistance (RCL – PCB to PCB)
  - Daisy-chain measurements.
  - Sine Vibration (no random vibration)
    - Sweep frequency: 10 – 2000 -10Hz
    - Cycle Period: 30 minutes
    - Amplitude: 1,5mm / 20g whichever is less.
    - Axis per Cycle: 3 mutual perpendicular direction
    - contact disturbance detection (1µs)
  - External Visual Inspection to check any crack or Failure
  - Daisy-chain measurements
  - Mechanical Shock
    - Shape of Shock: Half Sine
    - Acceleration: 50 g
    - Pulse duration: 11 ms
    - Nº of Shock per test: 3
    - Axis per Test: 3 (mutual perpendicular direction)
    - contact disturbance detection (1µs)
  - External Visual Inspection
  - Daisy-chain measurements
  - Contact resistance (RCL - PCB to PCB)
  - 5x Thermal Shock
    - -55 ºC (+0, -10) ≥10 min
    - 125 ºC (+15, -0) ≥10 min
  - External Visual Inspection
  - Daisy-chain measurements
  - Contact resistance (RCL - PCB to PCB)
  - Insulation Resistance – 500Vdc
  - ~~Voltage Proof Withstanding voltage 750 Vrms~~

- Electrical validation 5x parts
  - External Visual Inspection
  - PCB Insertion
  - External Visual Inspection
  - High Frequency measurements

N.º	TEST		CONDITIONS	LIMITS MIN.	LIMITS MAX.	UNIT
1	Z_{diff}	Differential impedance	Between two adjacent pins.	95	105	Ohm
2	IL	Insertion loss	Up to 3.12 GHz	--	1	dB
			Up to 6.25 GHz	--	1.5	dB
			Up to 12.5 GHz	--	2	dB
3	$Xtalk_{near}$	Cross talk (Near end pins)	Up to 3.12 GHz	--	-39	dB
			Up to 6.25 GHz	--	-34	dB
			Up to 12.5 GHz	--	-29	dB
4	$Xtalk_{far}$	Cross talk (Far end pins)	Up to 3.12 GHz	--	-42	dB
			Up to 6.25 GHz	--	-34	dB
			Up to 12.5 GHz	--	-26	dB

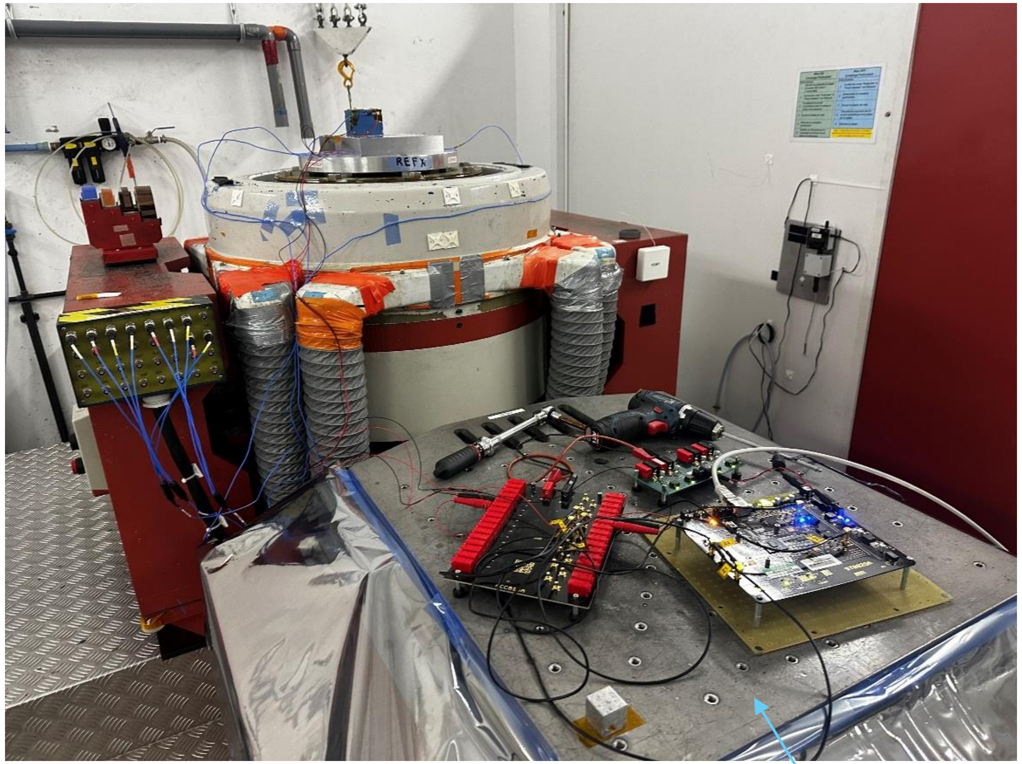
TABLE III: ELECTRICAL MEASUREMENTS AT ROOM TEMPERATURE.

N.º	DESCRIPTION	SYMBOL	TEST METHOD	CONDITIONS (TAMB=23 ±3 ºC)	LIMITS MIN.	LIMITS MAX	UNIT
1	Low Level Contact Resistance (Note 1)	R_{CL}	ESCC 3401, Para. 9.1.1.3	±10mA	20 (Note 2)		mΩ
2	Rated Current Contact Resistance (Note 1)	R_{CR}	ESCC 3401, Para. 9.1.1.3	2A	20 (Note 2)		mΩ
3	Voltage Proof Leakage Current	I_L	MIL-DTL-28748 Para. 4.7.5 (Note 4)	Rated Voltage: 750V RMS	-- (Note 3)	-- (Note 3)	--
4	Insulation Resistance	Ri	MIL-DTL-28748 Para. 4.7.4 (Note 4)	500 V ± 50 V (60 seconds)	1000	--	MΩ

Pass No-Pass status
- Pass – Go to WP4
- No-pass – Explore PCB design, BOM sub parts, material, connector mounting process. Start again prototypes assembly prior to ESA qual.

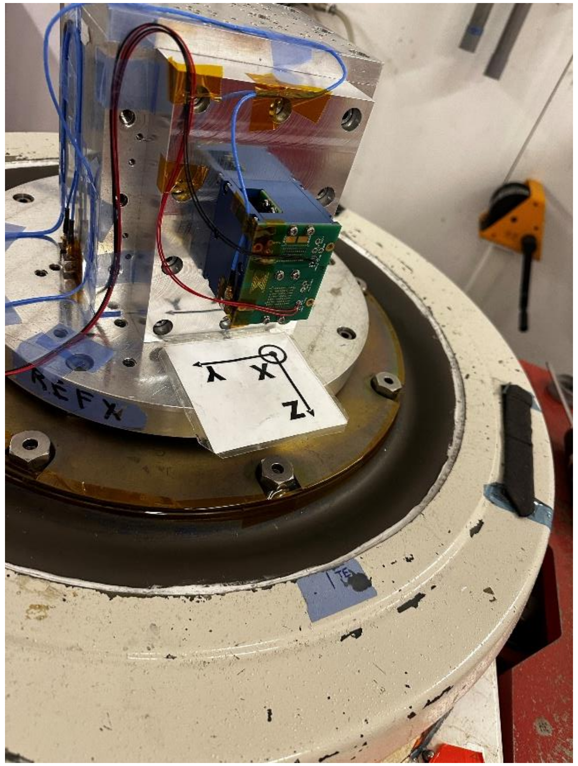
CHARACTERISATION HYPERBITS Gen 2.0 (II)

Shocks and Vibrations environment



General view of vibration test set-up

Shocks and Vibrations X position example



Close-up view of contact disturbance detection system

Results: No contact disturbance detected during shocks and vibrations sequence

CHARACTERISATION HYPERBITS Gen 2.0 (III)

Rdaisy-Chain 8-Rows = 1.66 Ohm all along testing (including 2 x 1.5 m cable)
Rdaisy-Chain 6-Rows (only 2 rows) = 0.41 Ohm all along testing (including 2 x 1.5 m cable)

RCL PCB to PCB before and after Vib and shocks [mOhm]

	1	2	3	4	5	6	7	8
A	25	19	25	17	25	19	24	16
B	27	28	26	25	28	26	26	25
C	20	28	24	27	22	27	18	26
D	30	23	28	25	29	22	28	18
E	31	29	31	32	32	32	28	28
F	21	30	24	33	20	31	18	28
G	33	20	33	22	30	22	31	18
H	30	35	32	36	34	32	32	28
I	17	37	21	37	20	34	18	30
J	31	20	33	19	34	20	32	19
K	33	37	33	36	35	38	32	31
L	16	37	18	45	17	37	16	31

	1	2	3	4	5	6
A	26	19	25	11	25	19
B	14	11	12	12	12	11
C	16	25	11	28	19	26
D	15	18	11	21	20	19
E	15	29	11	30	21	21
F	13	12	11	35	17	21
G	17	20	11	67	22	19
H	16	31	11	28	22	22
I	15	33	12	28	17	23
J	15	16	11	27	33	26
K	17	11	12	14	13	13
L	22	33	19	15	17	42

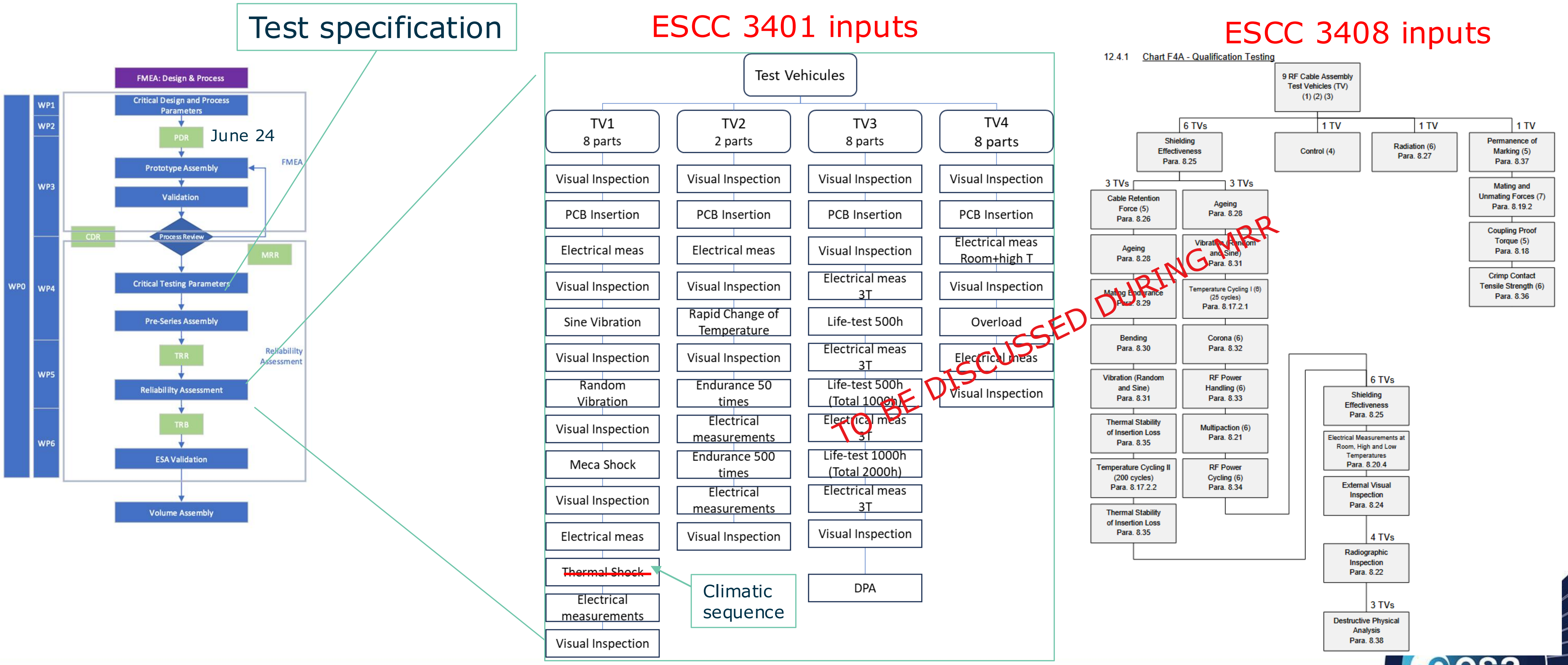
- Very good contact resistance values
- No significant drift observed all along test sequence

RCL PCB to PCB after TC [mOhm]

	1	2	3	4	5	6	7	8
A	25	17	24	17	23	17	22	17
B	25	25	24	24	28	24	22	30
C	17	25	21	27	20	25	15	34
D	28	23	25	25	28	17	25	16
E	27	29	27	30	29	24	25	30
F	20	29	17	27	17	27	16	31
G	33	19	27	17	28	20	26	19
H	32	29	28	31	30	27	30	27
I	18	21	17	33	18	29	16	29
J	33	18	30	17	30	18	29	17
K	33	32	31	33	31	33	29	30
L	16	35	17	33	15	27	15	31

	1	2	3	4	5	6
A	24	15	23	9	23	17
B	8	9	9	10	10	10
C	11	23	9	27	17	25
D	11	15	9	19	18	18
E	11	24	10	21	19	19
F	10	9	9	21	16	20
G	11	15	9	21	21	18
H	10	28	9	23	20	21
I	11	28	9	24	17	23
J	11	16	9	22	31	23
K	8	9	9	10	10	11
L	15	31	16	10	17	38

NEXT STEPS: RELIABILITY ASSESSMENT TEST FLOW (TBD)



Background & Rationale

Specification & Challenges

On-going Activities

Conclusion

CONCLUSIONS

1. **TDE**: Procurement and Reliability Assessment of High Data Rate Press-Fit cPCI SS connectors, ALTER TECHNOLOGY SPAIN: :
    - Existing commercial solution Airmax, Amphenol (China).
    - New and **innovative** solution Hyperbits, Performance Interconnect (France).

   -Mechanical testing and RF measurements about to start.

2. **TDE**: Board to Board Interconnections for High Data Rate applications (AXON' cable)
    - Prototypes manufactured, electrical characterisation done, data rate values exceed customer needs.
    - Molded EMs to be manufactured by June 2026, mechanical tests to be performed.
3. **ARTES**:High Density Modular Electrical Interconnections for High Data Rate Applications (Performance Interconnect & ALTER TECHNOLOGY FRANCE)
    - Prototypes manufactured, DC-electrical characterisation and mechanical testing done.
    - RF measurements to be done, full reliability assessment to be defined and performed.

- Lessons learned already identified in the three activities: assembly process, manufacturing steps, test PCBs procurement.

Space Passive Component Days (SPCD)

First announcement: SAVE THE DATE!

6TH SPACE PASSIVE COMPONENT DAYS - SPCD 2026

13-16 October 2026 | ESA/ESTEC

Noordwijk, The Netherlands

SPCD

SPACE PASSIVE COMPONENT DAYS

www.spcd.space