axon'
cable & interconnect

Reduction of harnessing

October 2017

Flat, high speed, lightweight, small, fast integration

Nigel KELLETT, Bus. Dev. Mgr. Axon' UK
Gilles ROUCHAUD, Space Products Mgr. Axon' France

Reduction of harnessing !

- … a painful subject …

Introduction

- Whose job is it to “reduce” harnesses?
  - Spacecraft manufacturers
    - Electrical architecture optimisation
    - Adapted routing
    - Minimise redundancy
    - Optimisation of AWG sizes / de-rating rules
  - Space Agencies (in collaboration)
    - Harmonisation / standardisation
      - of optimised componentry
      - of standard media and/or “functions”
  - Component & Harness manufacturers
    - Active development of “reduced” (or accelerated) solutions …

Harness Reduction Concepts

By mass and volume reduction

1. **On power and TM/TC signals**
   - **Reduced size of connectors: Sub-D, Micro-D and nano-D**
   - **Flexible PCB, Flat cables**
   - **Use of aluminium wires**
   - **bus bars**
   - **Derating reflexion**

2. **On signals: Multiplexing, High Data Rates**

3. **Faster Integration Time / Versatility**

Harness Reduction Concepts

By mass and volume reduction

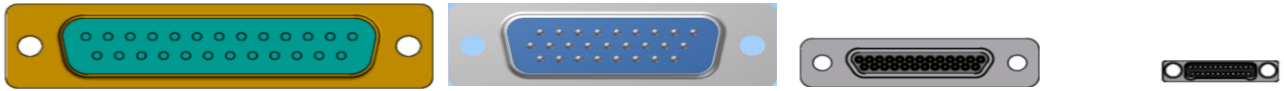
1. **On power and TM/TC signals**
   - **Reduced size of connectors: Sub-D, Micro-D and nano-D**
   - **Flexible PCB, Flat cables**
   - **Use of aluminium**
   - **bus bars**
   - **Derating reflexion**

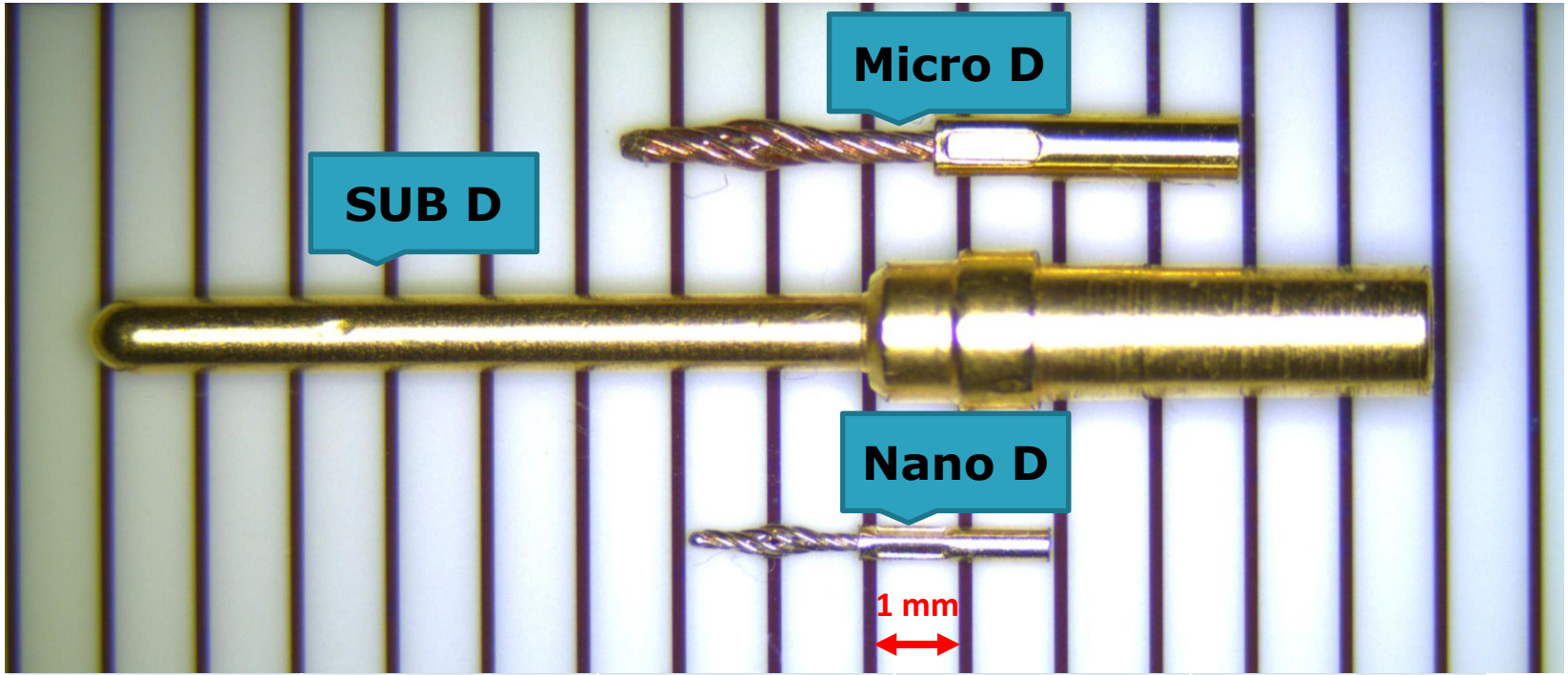
2. **On signals: Multiplexing, Higher Data Rates**

3. **Faster Integration Time / Versatility**

DSUB, DSUB HD, MICRO D & NANO D

Equiv. “25” way …





Volume and mass reductions

- **Surface is reduced:**
  - by a ratio of 2.8 from D-SUB to Micro-D.
  - by a ratio of 5 from Micro-D to Nano-D
  - by a ratio of 14 from D-SUB to Nano-D.
- **Mass is reduced:**
  - by a ratio of 3 from D-SUB to Micro-D.
  - by a ratio of 3 from Micro-D to Nano-D
  - by a ratio of 9 from D-SUB to Nano-D.

Mass and Volume saving

- **High density M** space applications.
- They have bee use.
- **ESCC specific**

CONNECTORS, ELECTRICAL, RECTANGULAR, NANOMINIATURE, NON-REMOVABLE CRIMP CONTACTS AND UNINSULATED SOLID WIRE CONTACTS

BASED ON TYPE NANO-D

ESCC Detail Specification No. 3401/086

Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

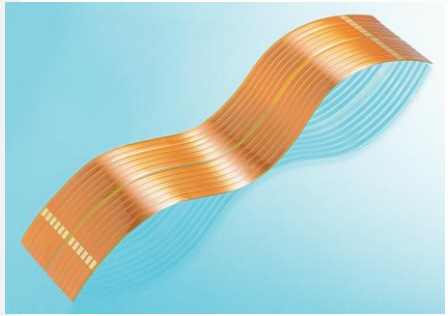
- **Reduced size of connectors: Sub-D, Micro-D and nano-D**
- **Flat cables, Flexible PCB**
- **Use of aluminium**
- **bus bars**
- **Derating reflexion**

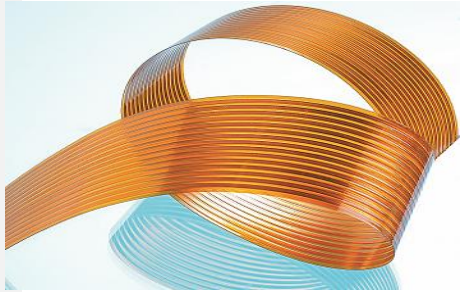
2. On signals: Multiplexing, Higher Data Rates

3. Faster Integration Time / Versatility

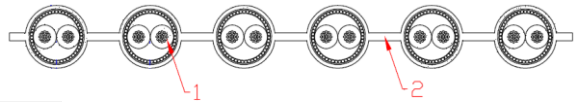
Flat cables

- **Flat cable with flat conductors.**
  - Kapton / acrylic adhesive.
    - Very high temperature delta (-180°C, +180°C, 3000 cycles)
    - Can support 7.5A
    - Can support 1G Rads
    - Limitation: Non continous process: Length <700mm
    - Limitation: Thin conductor(70µm max)
    - ➢ **External use**
  - Kapton / FEP adhesive
    - Temperature range: 90°C / +200°C,
    - Radiations: 30Mrads. Still functional
    - Continuous process: No length limitation.
    - Thin conductor preferred
    - ➢ **Internal use.**





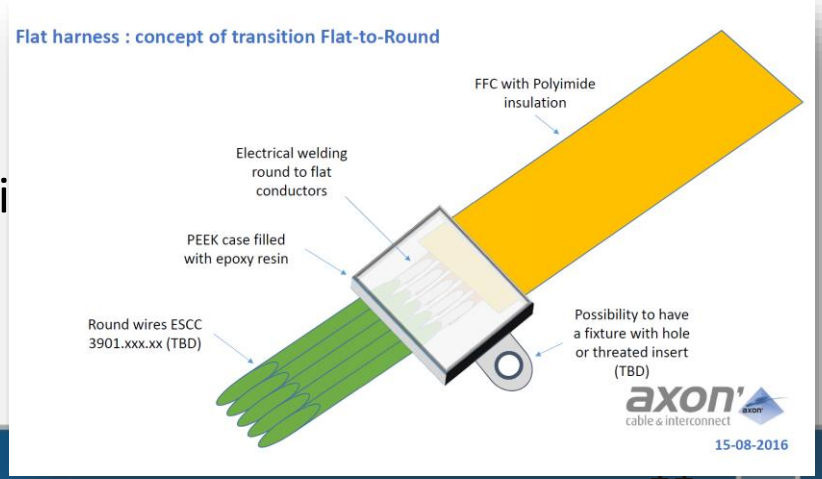
- **Flat cable with round wires.**
  - FEP, ETFE or PFA insulation
  - Radiations up to 30Mrads
  - Possibility to use ESCC qualified base cables.
  - Possibility to include shieldings per wire/pair.
  - Dimensions / materials and feasiblity to be checked on case by case basis.
  - ➢ **Internal use**



Axon' available connection

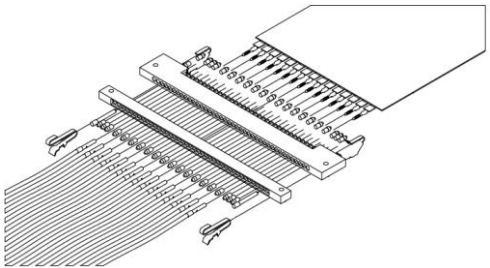
- No dedicated space-environment connector for flat/round connections exists as yet.
- Connection to standard round ESCC wires allows integration with standard connectors (SubDs, 38999, etc.)

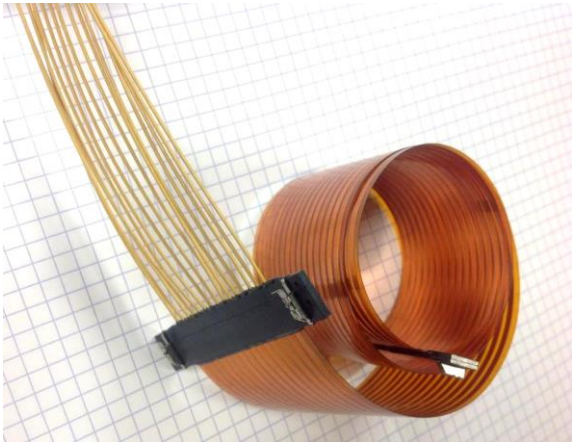
- Axon' proposes
  - Electrical link by solder/welding.
  - Mechanically protected by Epoxy resins i PEEK (or LCP) case.
    - Note : Epoxy resins are widely used in Space microD applications (see 05039-ST-01 "Axon' range of ESCC micro-D connectors")

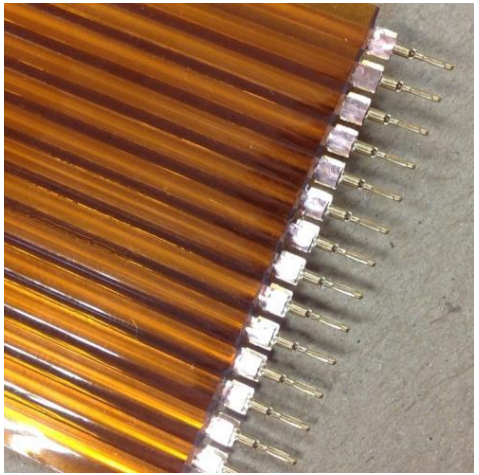


Axon' connection concept

- Axon' is developing flat cable dedicated connector.
- See hereunder one of the concepts (using adapted components from the Microstrip® product family)







Main pros and cons of flat cables

- **Advantages:**
  - Mass, volume
  - Temperature radiations
  - Flexibility (in one axis)
  - Cost
  - Wiring can be automated. Electrical soldering.
  - Can be integrated in the structure
- **Limitations**
  - Line to line connections: Electrical architecture to be modified

Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

- **Reduced size of connectors: Sub-D, Micro-D and nano-D**
- **Flat cables, Flexible PCB**
- **Use of aluminium**
- **bus bars**
- **Derating reflexion**

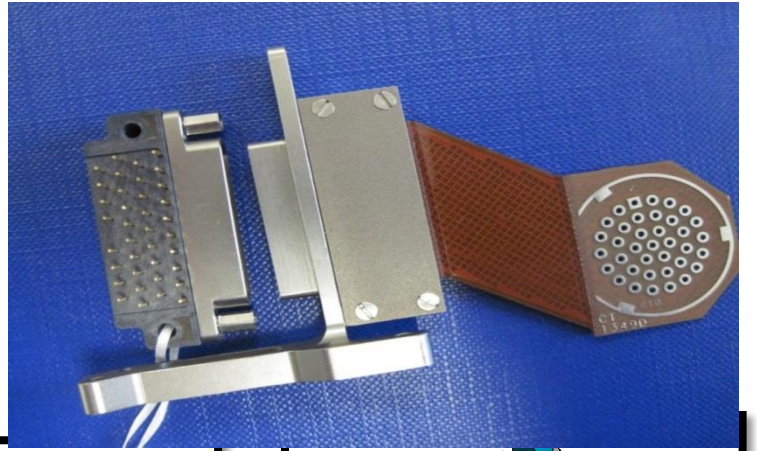
2. On signals: Multiplexing, Higher Data Rates

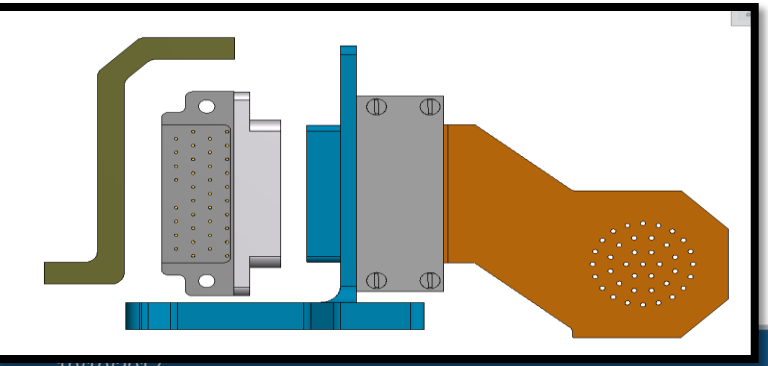
3. Faster Integration Time / Versatility

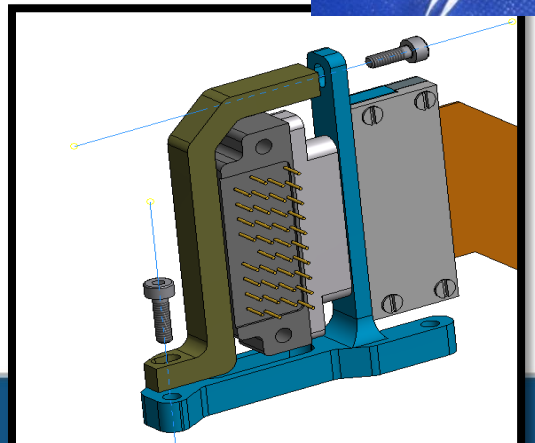
Flex connection to Micro D

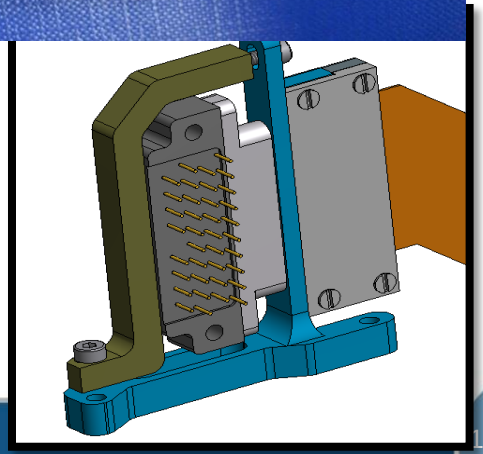
Custom design:

- Adaptation of micro-D or nano-D connectors to flexible PCB
- From single flex to complex shielded flex

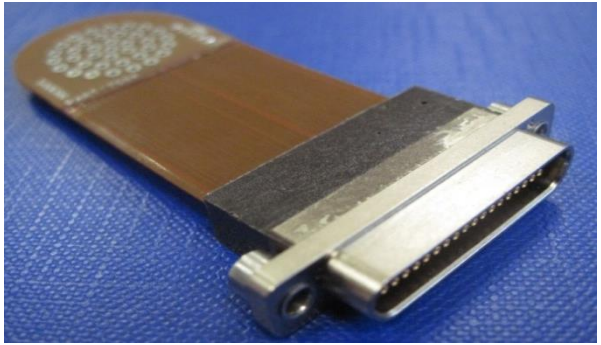


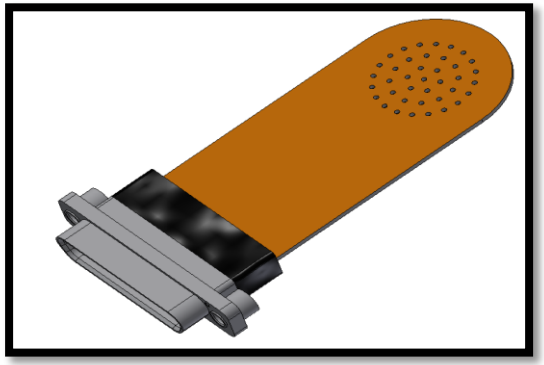


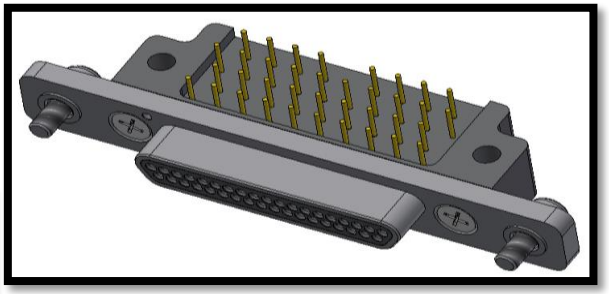


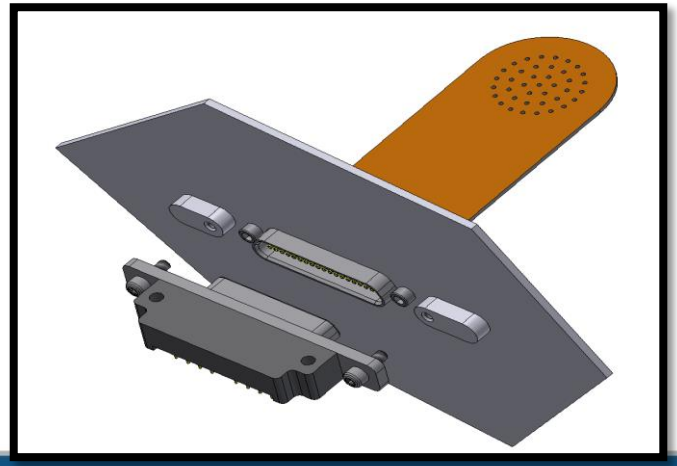


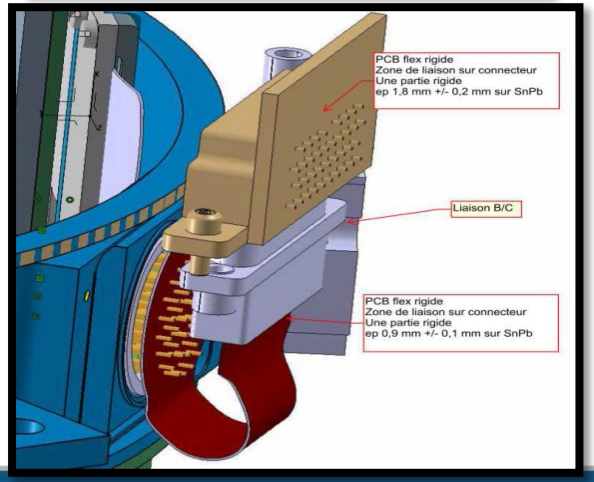
Flex connection to Micro D

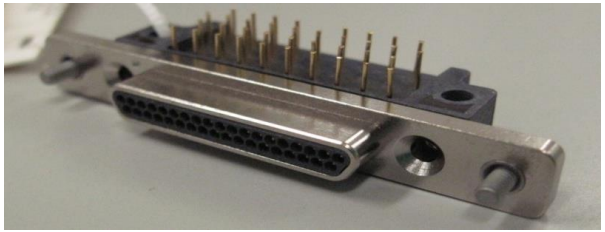




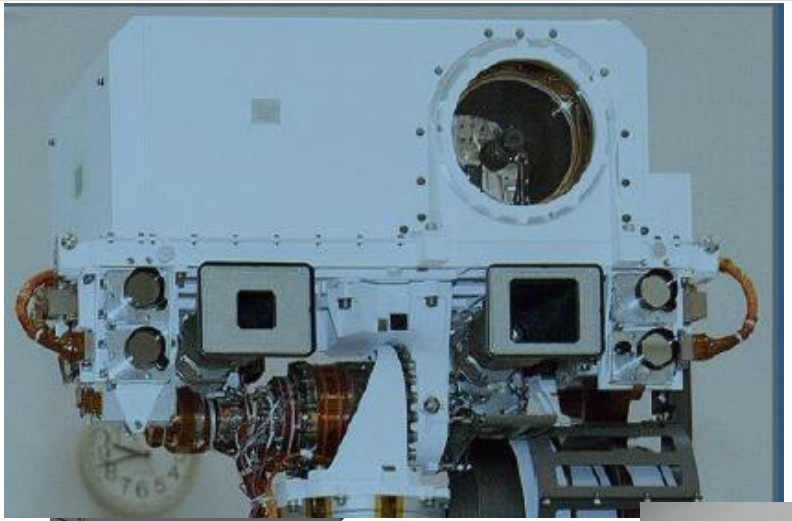


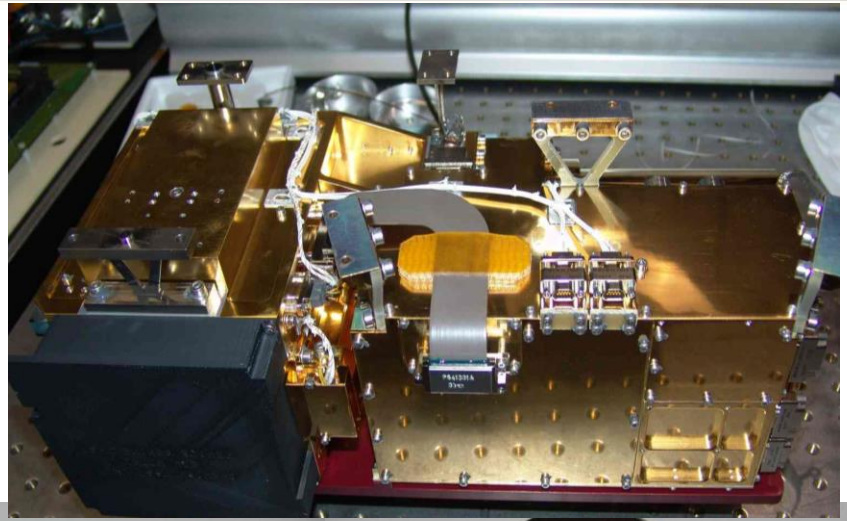


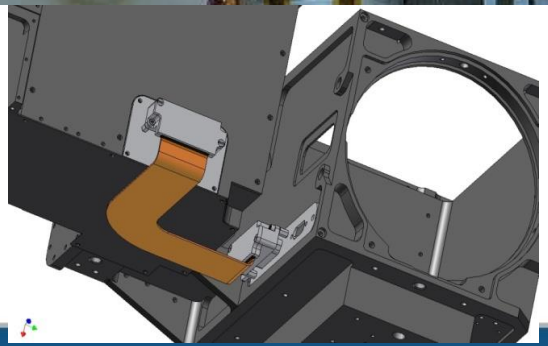




CHEMCAM curiosity







Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

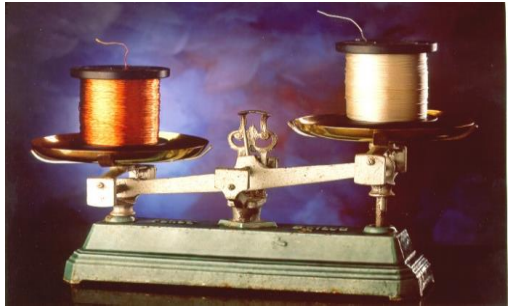
- Reduced size of connectors: Sub-D, Micro-D and nano-D
- Flexible PCB, Flat cables
- **Use of aluminium**
- bus bars
- Derating reflexion

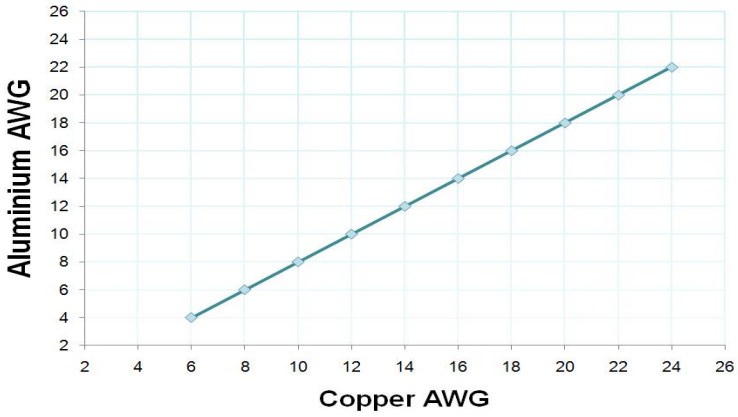
2. On signals: Multiplexing, Higher Data Rates

3. Faster Integration Time / Versatility

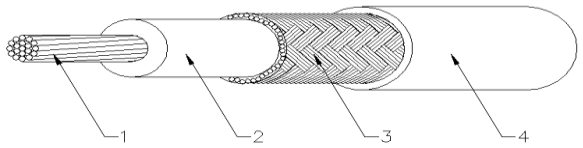
Axalu® Aluminium conductors

- Significant mass saving
- Difficult crimping process to be implemented
- Can be limited on braid shields
  - Used for cable or bundle shielding (Silver plated)





Weight saving using aluminium wires



Calculation based on ESCC 3901.012.45

1. AWG22 Conductor (19x0,15mm) with 2µm silver coating
2. Cross-linked ETFE insulation
3. Shield strand (0,10mm) with 2µm silver coating
4. Cross-linked ETFE jacket

	Material		WEIGHT (g/m)				
	Conductor	Braid	Conductor	Wire	Braid	Cable	
AWG 22	Cu	Cu	3,24	4,05	4,66	10,06	
AWG 22	Al	Cu	1,12	1,93	4,66	7,94	-21%
AWG 22	Cu	Al	3,24	4,05	1,70	7,11	-29%
AWG 22	Al	Al	1,12	1,93	1,70	4,99	-50%
AWG 20	Al	Al	1,91	2,95	2,02	6,52	-35%

Weight reduced = 35 to 50 %

Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

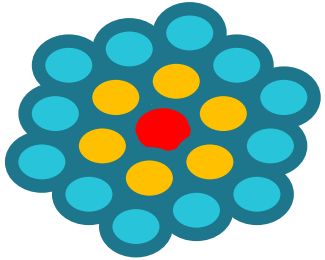
- Reduced size of connectors: Sub-D, Micro-D and nano-D
- Flexible PCB, Flat cables
- Use of aluminium
- **bus bars**
- Derating reflexion

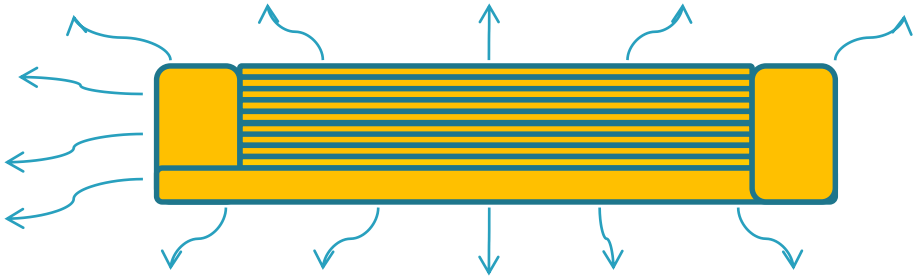
2. On signals: Multiplexing, Higher Data Rates

3. Faster Integration Time / Versatility

Bus bar system advantages

Wire strand versus bar sandwich





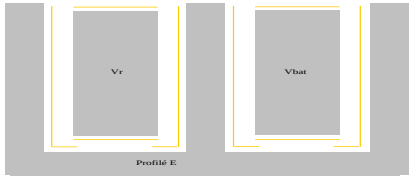
1st effect: Thermal radiation & conduction are more efficient in a bar

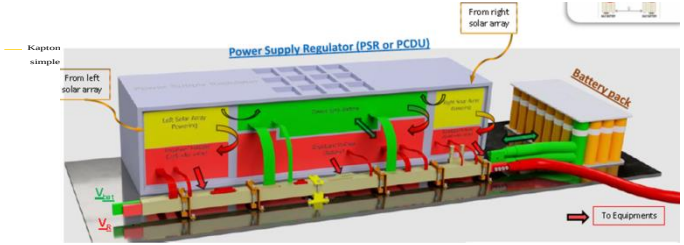
2nd effect: Aluminium: electrical resistivity versus density: At iso resistance 35 % of mass saving

Bus bars are not standard products. They are available in many shapes and for different electrical functions.

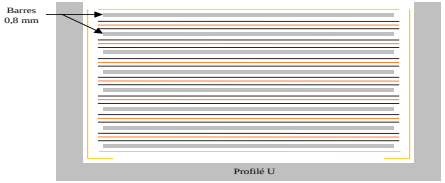
They are customized for each mission

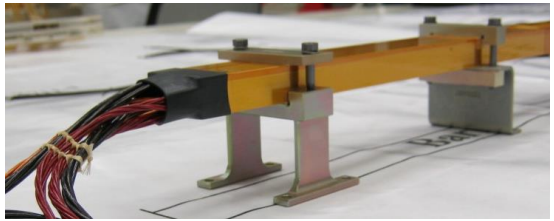
Bus bars



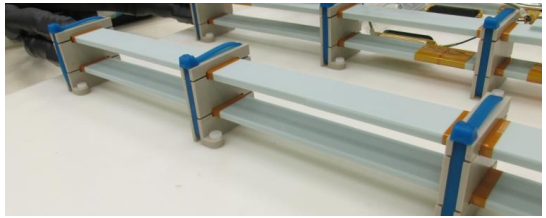


BAR E (V_r , V_{bat} and 0V)





BAR U: 0V U Shape with layers of different potential (X sections of Vgs potted)



BARs I: Silver plated bars (+&-)

Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

- **Reduced size of connectors: Sub-D, Micro-D and nano-D**
- **Flexible PCB, Flat cables**
- **Use of aluminium**
- **bus bars**
- **Derating reflexion:** *ECSS-Q-ST-30-11C margin.*

2. On signals: Multiplexing, Higher Data Rates

3. Faster Integration Time / Versatility

Harness Reduction Concepts

By mass and volume reduction

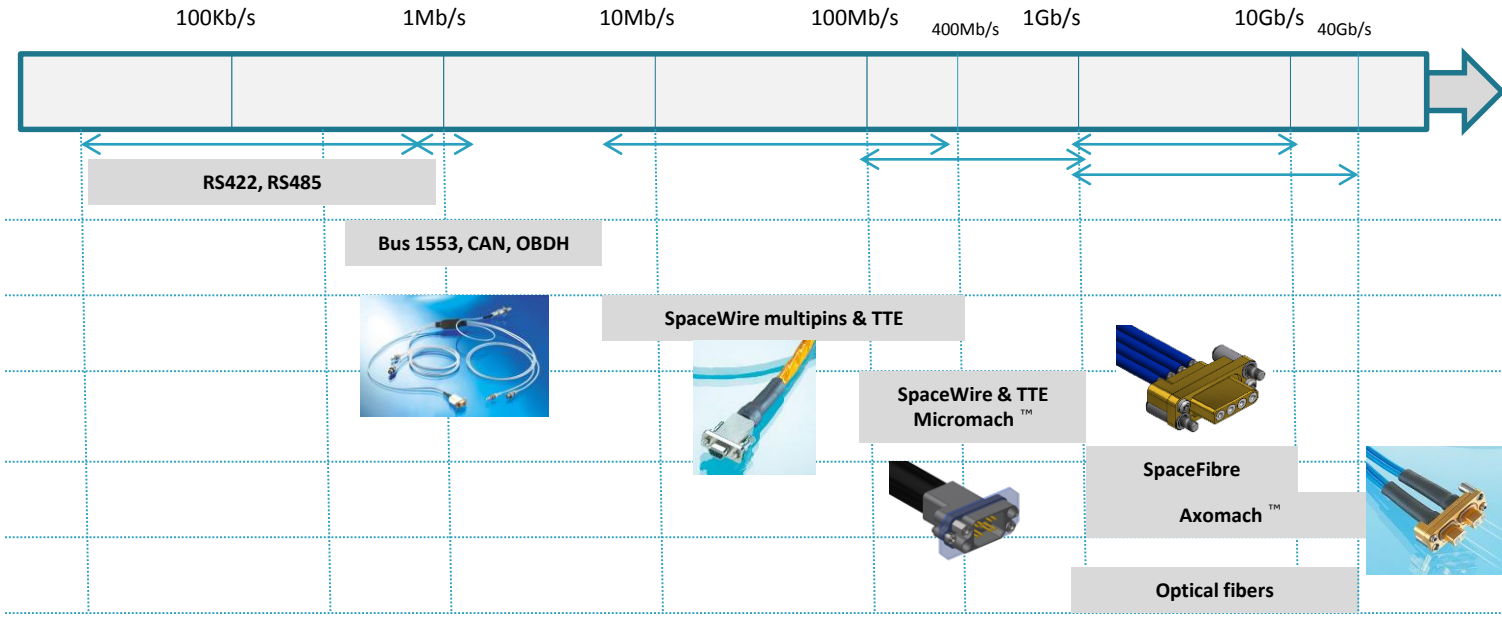
1. **On power and TM/TC signals**
   - Reduced size of connectors: Sub-D, Micro-D and nano-D
   - Flexible PCB, Flat cables
   - Use of aluminium
   - bus bars
   - Derating reflexion:

2. **On signals: Multiplexing, Higher Data Rates**

3. **Faster Integration Time / Versatility**

Axon high data rate range

Cable	Zc	Network
TP, STP	120Ω	
STP	77 Ω 100Ω 120Ω	Bus
STP	100Ω	Direct Link
STP SPP	100Ω 100Ω	Direct link
SPP Coax pair	100Ω 100Ω	Direct link
Optical	-	-



BUS MIL-STD-1553B

Media: Shielded twisted pair 77Ω, differential mode
Protocol: Mil STD 1553B, Manchester
Data rate: 1 Mb/s : Bus network

Main characteristics:

- High reliability, system highly protected by design
- very good EMI performance
- Up to 31 equipments.
- Stub lengh <6m, Bus line <100m
- Very long heritage, since early 90’s

Classic SpW (with 9 pin micro-D)

- **Media:** 4 Shielded twisted pair 100Ω, twisted, shielded and jacketed

- **Data rate:** Up to 400 Mb/s:

- **Main characteristics**
  - Lengh Limitation depends on data rate (4m at 400Mb/s)
  - Heritage: Huge since 1997...
  - Low EMI & crosstalk performances
  - Not matched cavities

Low mass SpaceWire with micro D

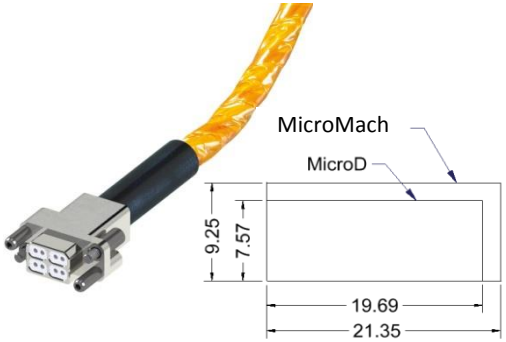
- ESCC3902/004: ESA QPL
- ECCC3401.29 micro D connectors: ESA EEPL2
- Low mass cable
  - Cable mass: 40g/m instead of 80g/m
  - Improved skew
  - Improved radiation behaviour
  - Improved Flexibility and lower bend radius
  - Inner and outer shield connected to the shell
- Heritage: Implemeted in several programs: Exomars, MTG, Solar orbiter…
- Under PID (followed by CNES)

SpaceWire with matched 100Ω connector: MicroMach ™

Main features:

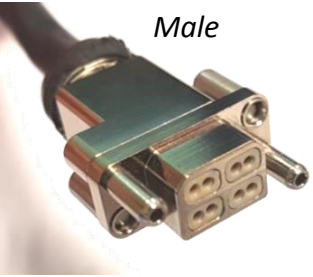
- 1 cavity by transmission line → crosstalk
- Inner and outer shield termination → EMC
- 100Ω differential impedance throughout the line → Data rate
- Integrated guide pin → mechanical robustness
- MicroD contacts → well known technology
- Size → close to a 9pin microD

Male with LowMass cable

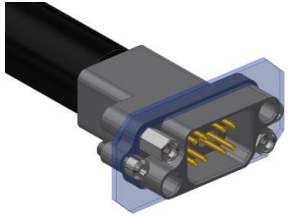


In-line variants

Male

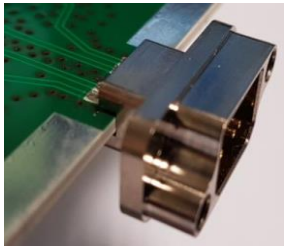


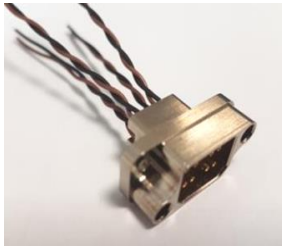
Female panel mount



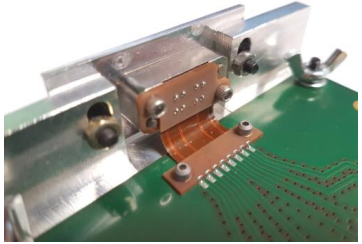
PCB variants

Edge panel mount





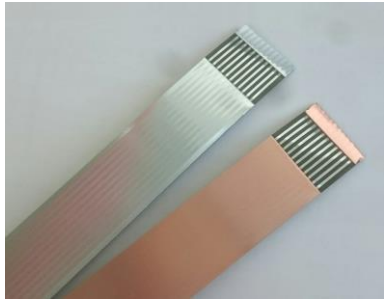
Flex PCB panel mount

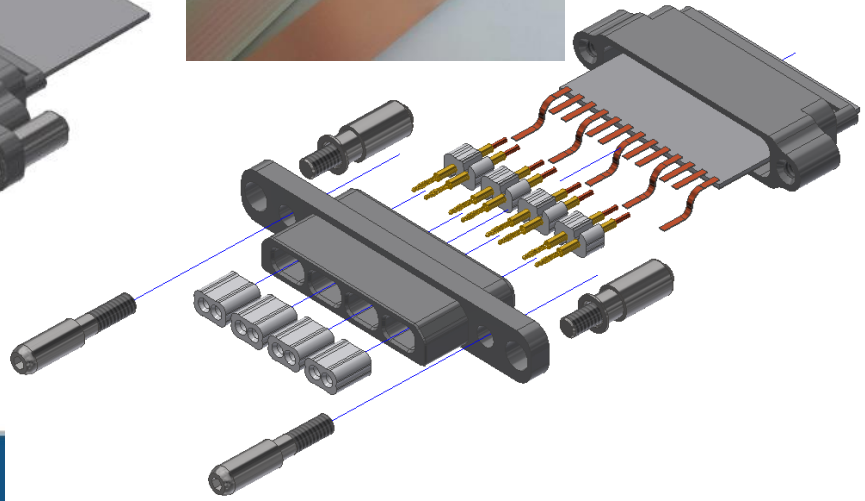


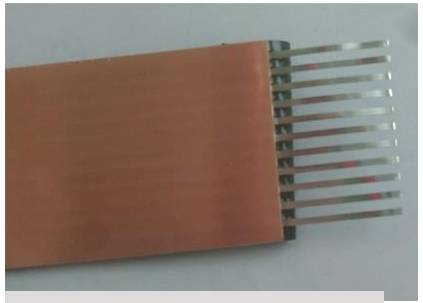
Micromach™ Future extension of the range

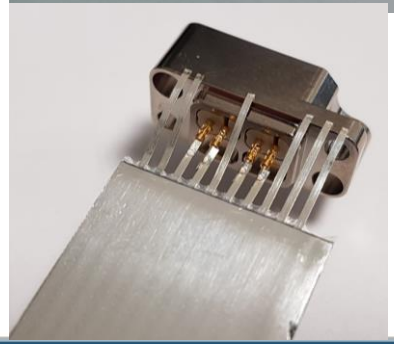
Adaptation to flat cables (SpaceWire Flat cable)

Size: 40 x 5.85 mm





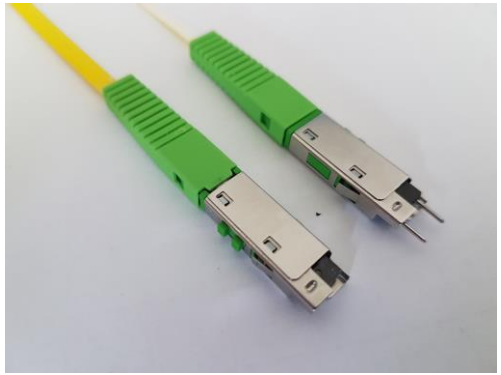




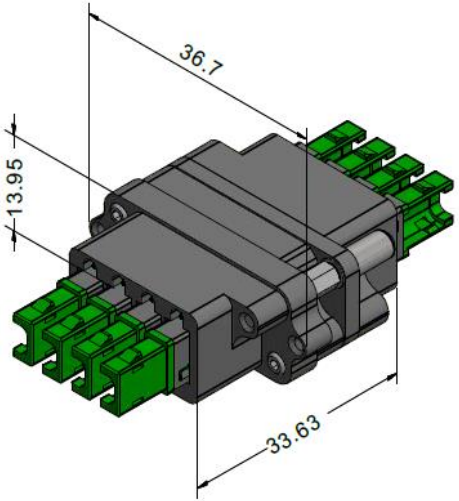
MicroMach™ future extension of the range

Optical MicroMach™

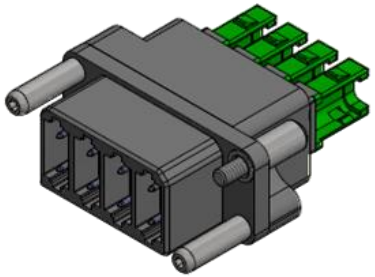
Diamond:
- Fiber optic connections specialist
- Vertically integrated
- Delivering space assemblies



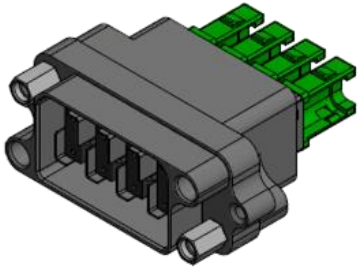
Diamond "MFS contact" with 12 fibers (possibility to go up to 24)



Male



Female



MicroMach with 4 MFS contact:
→ 4 x 12 fibers = 48 fibers !

Micromach™ Extension of the range

Optical MicroMach™

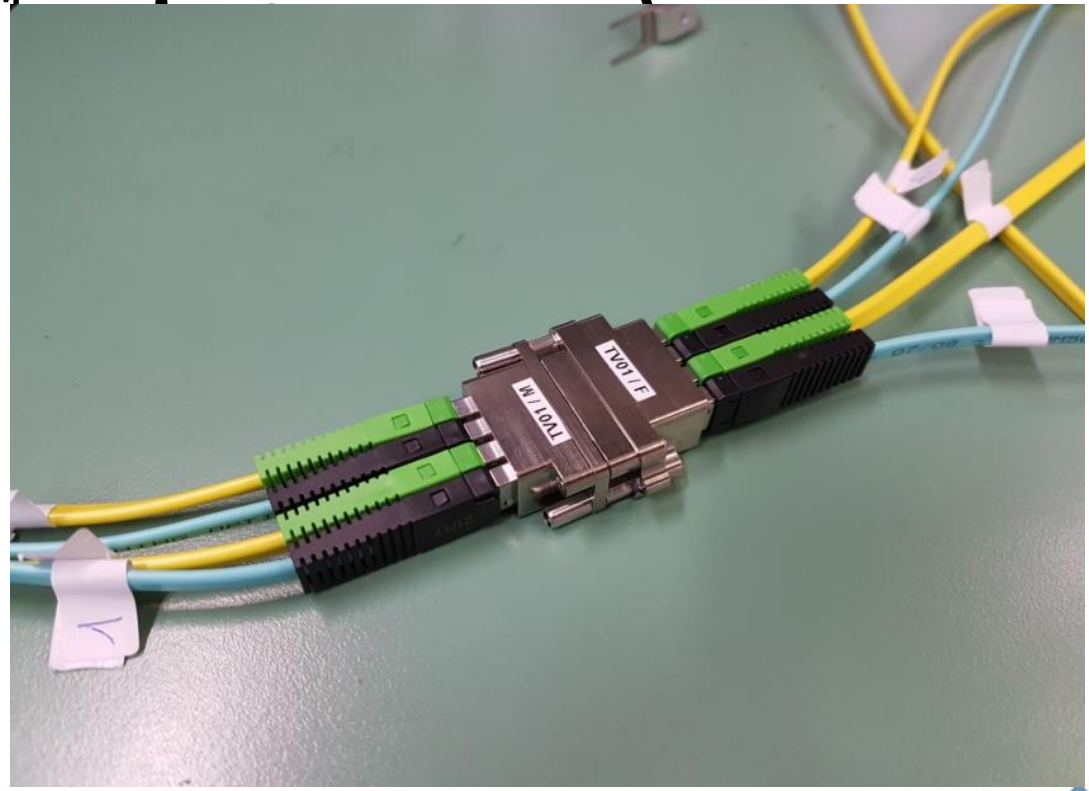
- MFS contacts
- Mono or multi mode fibers.
  - Blue multimode
  - Yelllow monomodes

- Standards
- EN 186310
- TIA/EIA 604-15

SPECIFICATIONS

	MULTIMODE 0° PC	SINGLE MODE 0° PC	SINGLE MODE 8° APC	UNITÉS	CONDITION DE TEST
Pertes d'insertion	typ. 0.35	typ. 0.25 max. 0.75	typ. 0.25 max. 0.75	dB	IEC 61300-3-4; λ = 1300/1550nm
Pertes de réflexion	typ. 30	min. 40	min. 60*	dB	IEC 61300-3-6; λ = 1300/1550nm
Tolérance	max. ±0.2			dB	IEC 61300-2-2; λ = 1300/1550nm
Durée de vie	500 cycles de connexion				
Temp. de service	-40/+85**			°C	
Temp. de stockage	-40/+90**			°C	
Poids de rupture	> 50			N	

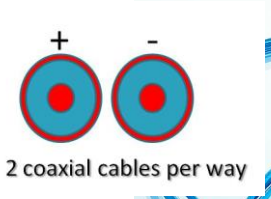
* Mesuré avec un réfléctomètre de précision
** La température de service des câbles employés peut limiter les spécifications du connecteur

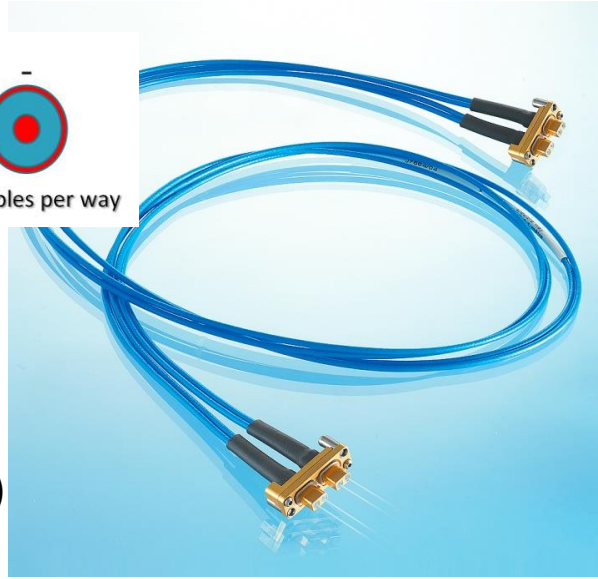


AxoMach ™

Media: Pair of 50Ω coaxials: Differential mode =100Ω

Data rate: Up to **10Gb/s per way** (L<4m)





Main characteristics

- Low Skew <10ps per connector couple
- Low Xtalk between ways <-35dB 0-10GHz
- High shielding effectiveness <-60dB 0-10GHz

Heritage:

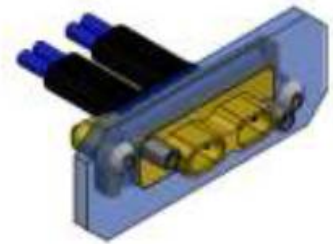
In Mars orbit: Maven (JPL) and Mangalyaan Orbiter Probe (ISRO)

implemented in many military and scientific programs.

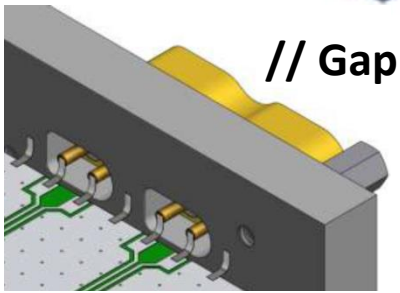
AxoMach™ range of products & SpaceFibre

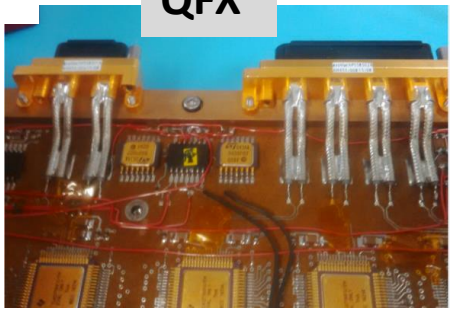
- **In-line versions**

- **Panel mount versions**



- **PCB versions**
  - Paralell gap
  - QFX





Harness Reduction Concepts

By mass and volume reduction

1. On power and TM/TC signals

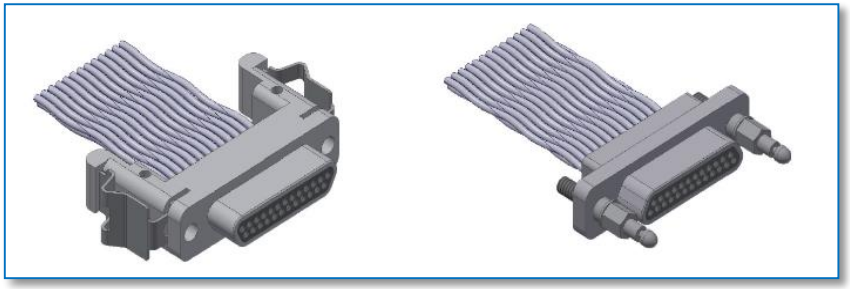
- Reduced size of connectors: Sub-D, Micro-D and nano-D
- Flexible PCB, Flat cables
- Use of aluminium
- bus bars
- Derating reflexion

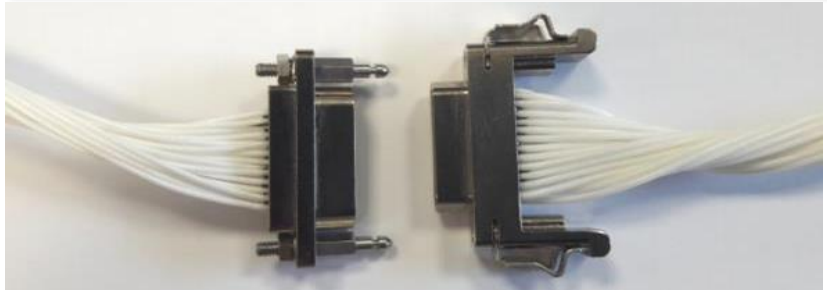
2. On signals: Multiplexing, Higher Data Rates

3. Faster Integration Time / Versatility

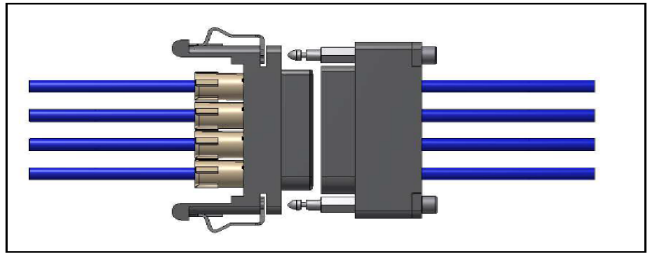
Micro D and MMC fast locking

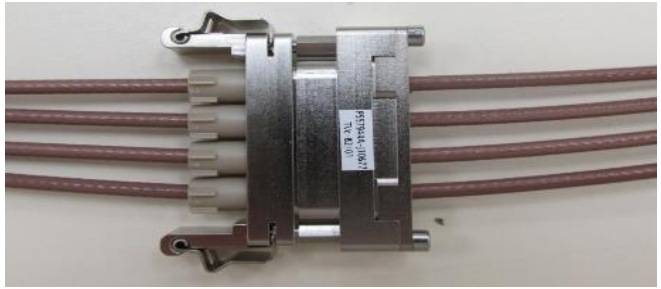
- **D-Click locking on micro D**
  - MDDCA line created
  - From 9 to 37 ways (51 ways not needed, but also not recommended)



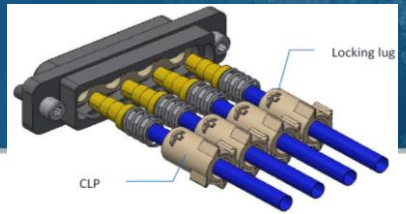


- **D-Click locking on MMC power or coax**
  - MMCA
  - From 4 to 8 size 12 power or coax contacts.



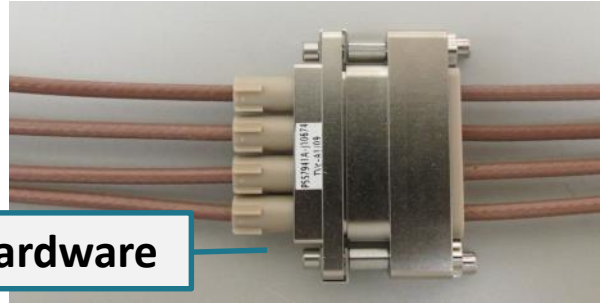


MMC products range



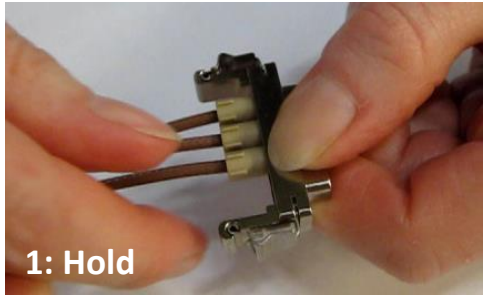
Fast locking

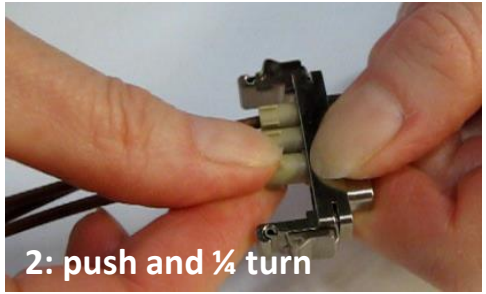
D- click

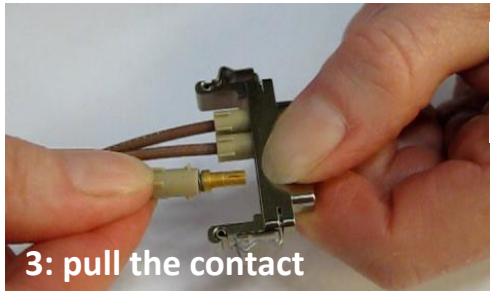


Std hardware

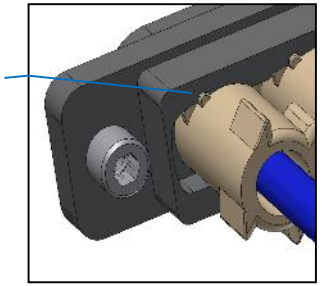
Fast contact removal







Visual check of the locked position



Faster Integration Time / Versatility

(Reduction of overall labour time)

- D-Click mounting/locking hardware for micro D range of connectors + power variants (MMC)
  - Instant push-click to mate and lock
  - No time-consuming alternate screwing
  - No tooling (easier access)
  - Security locking (Locking evidence & no risk of unwanted de-locking)
- Double insulation compliance for MMC
- Fast removeable contacts (MMC)
- Compact power or coax combo (MMC)

Final conclusion

Axon' is constantly striving, together with ESA, to ***reduce space and weight***, to ***increase data throughput***, to ***improve EMC, ESD*** and ***radiation compatibility***, and to ***accelerate cable harness integration times***.

Thank you for your attention

Nigel KELLETT, Bus. Dev. Mgr. Axon' UK
n.kellett@axon-cable.co.uk

Gilles ROUCHAUD, Space Product Mrg, Axon' France
g.Rouchaud@axon-cable.com