The Evolution of SpaceWire Electrical Interconnect

=Faster, Lighter, smaller

Nigel Kellett
Business Development
Thank you ...!!
Faster, Lighter, smaller

Low Mass SpW
MicroMach®
AxoMach® SpFi
MicroMach® Flat
Low Mass SpaceWire: Where are we?

- ESA TRP in 2012 to develop a lighter version of SpaceWire
  - Successfully completed in 2014
  - Delivered on multiple missions; Solar Orbiter, MTG, ExoMars, Metop-SG, ...
  - Roughly **half the mass** of classic SpaceWire (40g/m v 80g/m)
    - + smaller bend radius, more flexible
    - + improved radiation tolerance

- Upcoming case study: **PLATO payload harness**:
  - around 270 x 4-6m SpW cables:
  - Potential saving of **over 60Kg** using Low Mass instead of classic SpW
    - + LVDS variants
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Low Mass SpW  MicroMach®  AxoMach® SpFi  MicroMach® Flat
New SpW connector purpose: Refresher

- No connectors on the market met the SpaceWire protocol ECSS-E-ST-50-12C
  - Best option until now was the 9 way micro-D (ESCC3401-029)

- ESA TRP launched in 2015 to develop a more adapted connector:
  - Compact (as close as possible as 9 pin micro-D)
  - 100 ohms matched impedance connection
  - Improved EMC performance
  - Higher data rate performance (at least 400Mb/s)
  - Low crosstalk between ways

- Axon’ selected (in consortium with STAR-Dundee)
... and so from the twin heritages of...

Micro-D

AxoMach®
... MicroMach® is born!

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
- Twist pin MicroD contacts → well known, robust technology
- Size → close to a 9pin microD
Guide pin:

→ To secure the mating sequence, two special guide pins are used
→ secures the backshell to the connector.
→ Makes “Blind mating” possible
Connector variants developed

From In-line to equipment variants
1. **Edge panel mount**

- **Compact solution** for card edge variant
- Termination as a SMT
- Matched impedance
2. Wired panel mount

- Easy to integrate
- Flexible
- Matched impedance but without shielding
3. Flex PCB panel mount

- Compact
- Flexible
- 4 x 100Ω differential impedance with a full ground plane
SpaceWire MicroMach® Saver

- Used during AIT phase to save the connector interfaces from too many matings
Improvement features versus Micro-D links

From signal integrity to EMC
MicroMach® Evaluation ongoing with ESA & CNES

- Evaluation Test Plan driven by *Detail Specification for SpaceWire harnesses* currently being written
  - ESCC3409 **xxx**

- **4 Test Groups**
  - 1 - Maximum Data Rate
  - 2 - Mechanical
  - 3 - Thermal
  - 4 - Constructional Analysis

- First results on **Group 1** are available
MicroMach® evaluation first results of Group1

Cross talk:

- -50dB up to 1Ghz
- **MicroMach®** link offers a significant crosstalk improvement
  - (around -20dB less @ 1Ghz).
- Thanks to the 4 independent 100 Ohm cavities, the signal coupling between contacts pairs is reduced to a minimum
... with thanks to Paul Walker from 4Links...

- Part of Paul’s explanation of how crosstalk can cause glitches in signal
  - Presentation made at DASIA, Oxford, May 2018
MicroMach® evaluation first results of Group1

Signal integrity:

• Top view shows overshoot on the signal measured on the Micro-D terminated link

• Significantly better with MicroMach®

• 100 Ohm matched characteristic impedance between the twin signal pins delivers better signal integrity on MicroMach®

Micro-D terminated 1m link @400Mb/s

MicroMach® Terminated 1m link @400Mb/s
MicroMach® evaluation first results of Group1

Shielding effectiveness:

• Compared to Micro-D, the MicroMach® delivers noticeable improvement in shielding effectiveness

• This improvement is possible due to:
  – cable shield inner and outer terminations
  – Low bond resistance between male and female connectors
MicroMach®

• 1st test equipment fitted with MicroMach® from STAR-Dundee

STAR-Dundee
<table>
<thead>
<tr>
<th>TV N°</th>
<th>Cable</th>
<th>Length (m)</th>
<th>Max data rate (Mb/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>ESCC3902.003.02</td>
<td>&gt;3200</td>
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</tr>
<tr>
<td>9</td>
<td>ESCC3902.004.01</td>
<td>&gt;3200</td>
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</tr>
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<td>&quot;Low Mass SpW&quot;</td>
<td>&gt;3200</td>
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<tr>
<td>11</td>
<td>Parallel Pair</td>
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<tr>
<td>12</td>
<td></td>
<td>&gt;3200</td>
<td></td>
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<tr>
<td>13</td>
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</tr>
<tr>
<td>16</td>
<td></td>
<td>&gt;3200</td>
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</tr>
</tbody>
</table>

MicroMach® Group1 max data rate summary
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Low Mass SpW  MicroMach®  AxoMach® SpFi  MicroMach® Flat
AxoMach® SpaceFibre : a refresher

- ESA TRP via University of Dundee in 2013:
  - SpaceFibre Demonstrator

- Cable assembly from AxoMach® heritage:
  - 4 x RF coaxial cables type AX2.4S (R&T evaluation with CNES)
  - 100 Ohm differential Impedance
  - Up to 10Gb/s per way (2 ways - Tx/Rx / 4 coaxials)
  - Low skew (<20ps)
  - Small size
  - EMC optimised
  - Surface mount & parallel gap PCB terminations
AxoMach® SpFi variant: inline male – PCB female
AxoMach® SpFi : New proposition

• New SMD variant coming soon
  – With flexible or semi-rigid cable
AxoMach® and AxoMach® SpFi: NEW!

- ECSS-E-ST-50-11 “SpaceFibre” Standard almost ready for publication

- **ESCC3409-001 Detail Specification Published!!** (last week)
  - Generic 3409 spec plus first Detail spec (001)
  - AxoMach® and AxoMach® SpFi

- Evaluation already performed = Successful

- **Qualification** to come in 2019
  - (to ESCC 3409/001)
## AxoMach® SpFi: Datarate versus Length

<table>
<thead>
<tr>
<th></th>
<th>0.5m</th>
<th>1m</th>
<th>2m</th>
<th>3m</th>
<th>4m</th>
<th>5m</th>
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<tbody>
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<td>OK</td>
<td>OK</td>
<td>OK</td>
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<tr>
<td>5Gb/s</td>
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<td>OK</td>
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<td>OK</td>
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<td>6Gb/s</td>
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<td>OUT</td>
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<td>9Gb/s</td>
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<td>OUT</td>
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<td>10Gb/s</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OUT</td>
<td>OUT</td>
</tr>
</tbody>
</table>

*Links are measured with CML (Current Mode Logic) driver differential signal amplitude of 600mVpp (worst case condition) and +/-100mV CML receiver input threshold.*
MicroMach® for SpaceFibre?

From 400Mb/s to Multiple Gb/s
SpaceFibre: Possible utilization of MicroMach®

• Test jigs for SpaceWire assemblies are already made today with coaxial cable
  – FM variants with 2.5mm coaxial cable to come

• 1 x MicroMach® = 2 x SpaceFibre channels
  – Mixed AxoMach® SpFi and MicroMach® connectors might be possible on the same harness.
    • E.g. one MicroMach® connected to two AxoMach® SpFi connectors
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Flat Flexible MicroMach-Flat® SpaceWire

FFC SpaceWire new development

MicroMach-Flat
Flat MicroMach® Connectors
Size: 40 x 5.85 mm

- Nickel plated aluminum shells
- PEEK dielectrics
- MicroD contacts
- Stainless steel standard microD hardware
First in-line MicroMach-Flat® prototype

Male-Male jumper - 2m
First results - MicroMach-Flat®

- First electrical results on 2m links
- SpaceWire mask
- SpaceWire eye pattern up to 2.5Gb/s: OK
- Skew <5ps/m
First results - MicroMach-Flat® (cable only)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Speed (max)</th>
<th>Impedance</th>
<th>Attenuation @ Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>3m</td>
<td>1400Mb/s max</td>
<td>101-105Ω</td>
<td>-0.4dB/m @0.1Ghz, -1.18dB/m @0.5Ghz, -1.83dB/m @1Ghz</td>
</tr>
<tr>
<td>10m</td>
<td>300Mb/s max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10m @500Mb/s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Very stable differential impedance

Close to the current SpaceWire cable
Conclusions

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axon’ cable & interconnect
AxoMach® & AxoMach® SpFi now ready for EPPL1 QPL entry: ESCC 3409/001
visibility + recognition of performance & reliability by ESA
access to new space projects

Solution meeting customer needs
These will be the first ESCC qualified “HDR harnesses”

Involvement in qualification status and reinforcement of relationship with ESA
New experience of “harness” qualifications
MicroMach® adapted SpaceWire connector evaluation almost complete
Significantly improved performance over classic 9 pin Micro-D
   robust SpW transmission and EMC protection

Versatile connector/harness solution
   Suitable for SpaceWire, EtherSpace, XAUII, SpaceFibre ...

Rapid assimilation possible into new ESA ESCC HDR Harness families
   ESCC3409/xxx and ESCC3401/xxx submissions pending

... But the classic 9way Micro-D will still be with us for some time to come !
A final thought: if we are “feline” lucky …

- For EtherSpace or Ethernet, we can use the MicroMach® connector, of course
- But it would have to be used with a “CAT” 6 cable …
- … in which case the connector could be renamed …

- “MickyMach”

- Micky does not look impressed 😞
Thank you for your attention

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