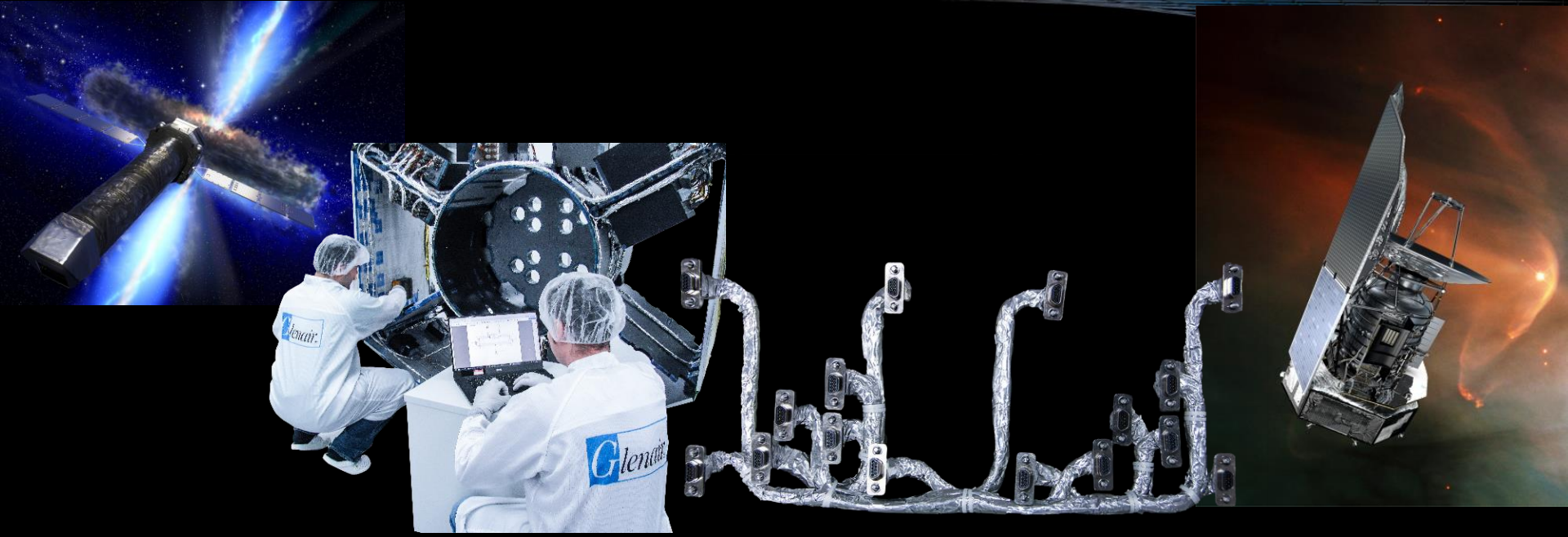
MISSION-CRITICAL
INTERCONNECT
SOLUTIONS

Glenair®

Advancements in

Cryogenic Cable Harness Technology

Enabling connectivity for extreme-temperature environments in space & earthbound missions



29th International Cryogenic Engineering Conference
International Cryogenic Materials Conference 2024

July 22-26 : 2024 : Geneva : Switzerland

Presented by Michael Berens

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Introduction

Cryo applications in space missions like Herschel, Ariel and Athena and earthbound telescopes like ALMA, ELT and VLT

The presentation will introduce the challenges in cryo harnessing and solutions developed by Glenair

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Challenges in Cryogenic Cable Assemblies are mastered with exotic conductor materials, special harness designs, and new processes for creating reliable connections

Why not using standard copper wires, ordinary harness design and well-know processes?

Most cryo applications are limited by their resources like liquid nitrogen, helium, electric power and often by their fundings

Conflicting requirements for conductor materials require extensive thermal engineering and testing

Challenges in Cryogenic Cable Assemblies are mastered with exotic conductor materials, special harness designs, and new processes for creating reliable connections

Why not using standard copper wires, ordinary harness design and well-know processes?

- Low thermal conductivity minimizes heat flux
- Small wire diameter and long transmission path minimizes heat flux
- Strategically placed heat sinks can support the thermal design
- Electrical conductivity is essential for power and signal transmission
- Additional requirements: vibrations, temperature cycles, and vacuum conditions

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Conductor Material Selection must be chosen based on the field of application

Areas with extreme temperature conditions can only be connected by using materials with low thermal and sufficient electrical conductivity:

- ✓ Stainless Steel (SST)*
- ✓ Phosphor bronze
- ✓ Niobium-titanium
- ✓ Brass
- ✓ Manganin
- ✓ Constantan

**SST is the most interesting material since it has the lowest thermal conductivity with still acceptable electrical conductivity*

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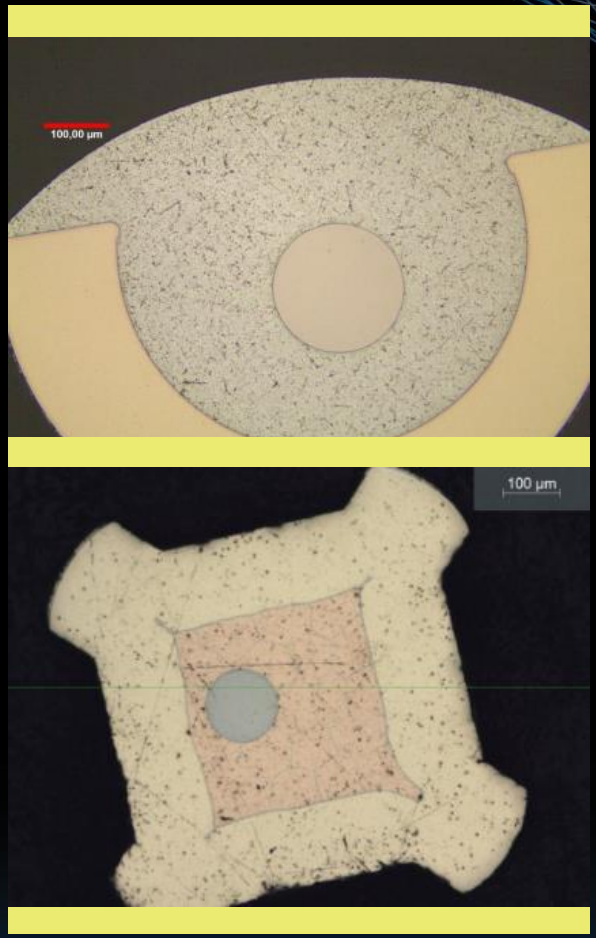
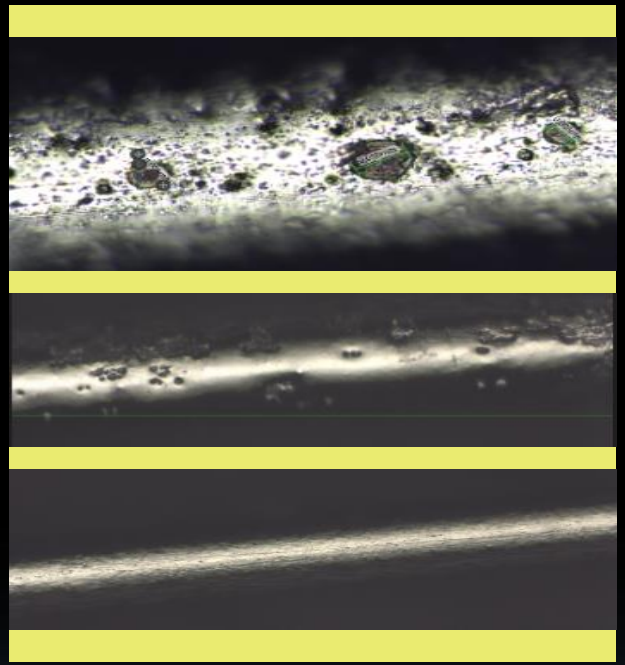
Assembly Design Considerations must be chosen from solder and crimp connections

Through an extensive development program, Glenair has developed a process to make cryo materials like SST solderable and crimp able



Manufacturing Challenges & Solutions Space-Flight Interconnect Component & Harness Manufacturing

- ✓ Thin-gauge SST wires (0.1 mm) offer high thermal resistance, high strength, and low brittleness compared to manganin
- ✓ Brittleness can lead to significant problems in contact crimping and soldering
- ✓ Variations of the flux, the number of immersions and tin temperature led to desired results (top to bottom)
- ✓ High quality standards in production and testing lead to significant improvement of the products life-time



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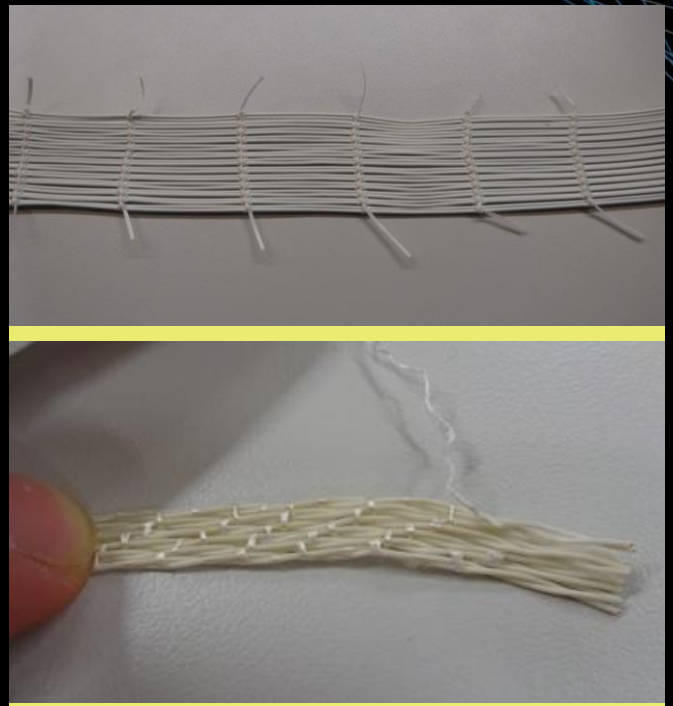
Harness Design Development derives from the thermal systems boundary conditions

There are different Strategies for optimizing thermal and electrical properties with assembly design

- ✓ Choosing the proper conductor material, minimizing wire diameter, maximizing transmission paths, placement of heat sinks
- ✓ Usage of special cryo harness designs with optional EMI shielding:



Harness design with wire stitching

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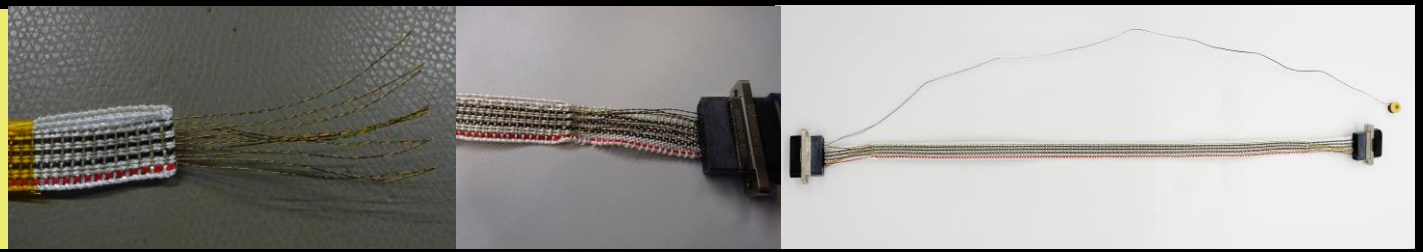
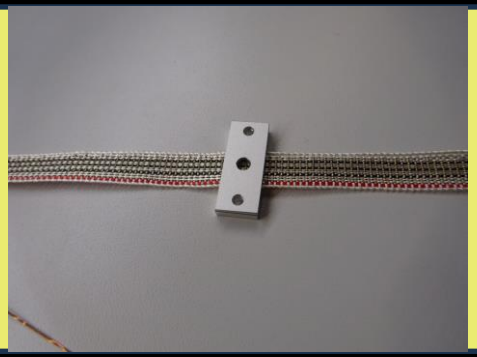
Harness design with wire looms



Heat Dissipation Elements support to facilitate optimal heat flow and conducting heat out of the wiring harness at designated positions

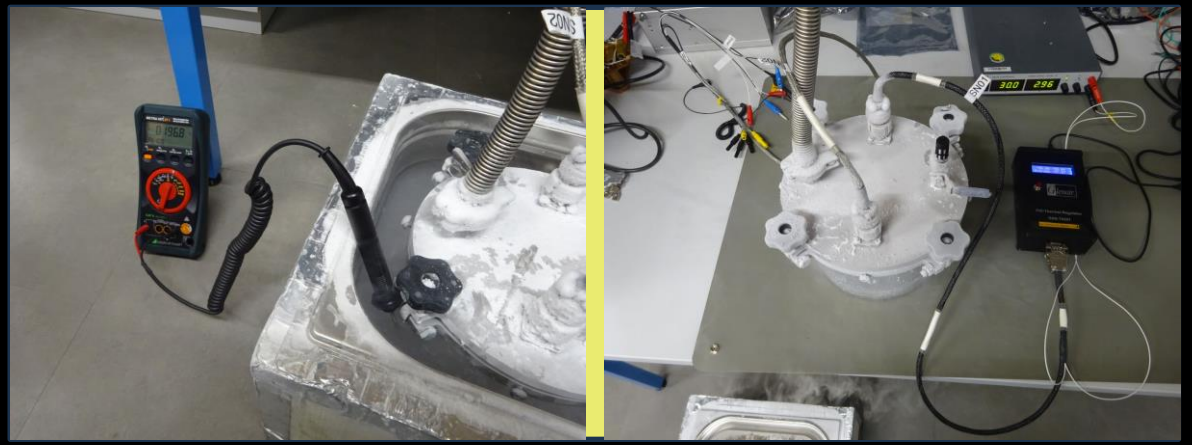
Development and optimization of heat sinks is done at Glenair to optimize the overall harness athermal performance

A simple example is given



Validation and Testing Methods to prove correct workmanship and validity of connection

- ✓ Non-destructive electrical verification: cable resistance and isolation measurements
- ✓ Destructive testing: pull-out tests and micrograph analysis
- ✓ Mechanical resilience and thermal cycle simulation



Qualification Phase is part of the Glenair Cryo-Technology Program

PDR

Development of process concepts for SST, Phosphor Bronze, Niobium-titanium, Brass, Manganin, Constantan

CDR

Detailed development of processes for SST, Phosphor Bronze, Niobium-titanium, Brass, Manganin, Constantan

QR

Full thermal, electrical and mechanical qualification of developed of processes for SST, Phosphor Bronze, Niobium-titanium, Brass, Manganin, Constantan to ensure long-term reliability and absence of degradation

Future Prospects and Conclusion Glenair paves the way for the success of future scientific missions, pushing the boundaries of what is technically feasible in extreme-temperature environments

Cryo harnessing challenges have been introduced

Glenair development process with some milestones has been shown

Next steps on the process road has been presented

Thank You For Listening!

Do you have any further questions?

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