ESCCON
9 - 11 March 2021

esa

Vision and opportunities for Space Harness Technologies

10 / 03 / 2021

DEFENCE AND SPACE

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Vision

Imagine disruptive, extremely flexible electrical architectures for future platforms, allowing:

Highly performant electrical systems,
Quick & easy design,
Full optimization for each mission,
High quality,
Low cost …

… then develop the needed technologies and building-blocs to make it a reality.

How ?

On-Ground Present usually prefigure **in-Space Future**.

Major gaps between Ground and Space technologies for electrical systems are found on :

- **Full digitalization**: processors, microcontrollers, data busses everywhere.
  => This does remove a great part of the harness complexity.
- **Fiber optics is now a standard on ground** and is flying in quite all Airbus aircrafts today.
  Already designed into next generation of AIRBUS telecom payloads
- **Very high integration** of the products: volume effectiveness, co-design between mechanical, electrical and thermal functions.
- More **Generic** approach, solutions to cover multiple roles no longer bespoke.

Beside technology aspects, Space is now an industrial challenge with the same drivers:

- **Short Time-to-Market**: quick design and manufacturing processes.
- **Cost effectiveness**.

Any technical solutions shall take them up.

Last but not least: **reliability and quality** for space products shall be at least maintained… or improved!

Main Long-Term Axes

Digitalization = Generalization of digital data transfer.

All on-board discrete signals shall be replaced by data bus transfers.

- Telemetries shall be natively digital or digitalized as close as possible to the source.
- Commands shall be generated and conveyed as digital signal.

=> This will increase digital data volume and data rates, a new challenge for Harness.
Proposed solution: Photonics.

Integration of electrical, mechanical and thermal functions

=> The volume of harness shall be reduced, the design and assembly of the satellite shall be simplified.
Proposed solutions: Digitalization will remove lots of wires currently used for signals
Electro-structure: power distribution shall be imbedded in the structure.
Electrical connection of units shall be made through mechanical assembly.

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Short-Term Axes

Without loosing focus on the preparation of the long term vision, system evolutions require new harness technologies **right now.**

High voltage

More and more missions require high voltage harness, up to 2000V.

⇒Connector solutions are not very common and mainly US-made. We need to qualify several European alternatives.

New space and Constellations require very short and safe assembly time and low cost.

⇒Cheap but safe fast-locking connectors shall be developed for different applications (e.g. RF harnesses, thermal hardware), without single source as far as possible.

⇒New quick solutions for harness fastening are also needed.

⇒Manufacturing and assembly automation shall be fostered.

On-Board Digitalization

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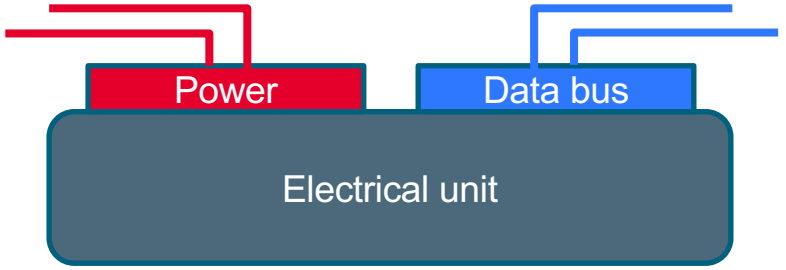
On-Board Digitalization

Speed-up the replacement of all on-board discrete signals by data bus transfers.

Digitalization has been a natural trend since the 90's with the development of processors and data busses, but there is a lot to do yet.

Main gaps to date are:

– To replace remaining relays by solid-state components (Mosfets, LCL shall be generalized).
– To use digital sensors as far as possible.
– To digitalize more signals inside the units.
– To provide small and cheap Remote Interface Units to digitalize signals and generate commands as close as possible to the end-users.



The "DC" electrical interface of most of the units should look like this!

These gaps are not within the Harness domain: they should be driven by the electrical architectures and avionics road maps.

However, **the harness shall provide solutions to support to this evolution**: higher data-rates on data busses, co-engineering with the unit developers to ensure compliant connectives.

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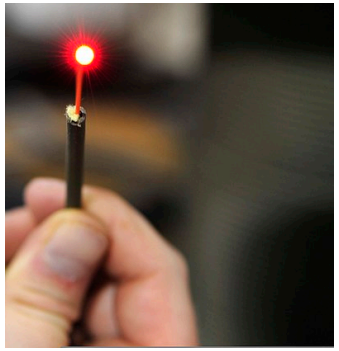
On-Board Digitalization

Increase digital data volume and data rates

Data bus technologies used in Space are based on coper wires.
Main pain points are: EMC emission and susceptibility, mass, low potential for improvement, expensive, different data bus standards...
Increasing the bus performance with this technology will worsen them: more complex, fragile, heavy cables and connectors, as well as expensive procedures for manufacturing and test.

=> **fiber optics shall take the lead** as it does for ground applications.
The main gap is to qualify the photonic technologies for space :

- Optical transceivers
- Fiber Optics
- Interconnection:
  - Connectors
  - Wireless optical solutions can help to transfer data to distant elements, e.g. through mechanisms or between two elements of the structure.



LiFi is one of the optical wireless options for interconnections.

Electrical & Mechanical Integration

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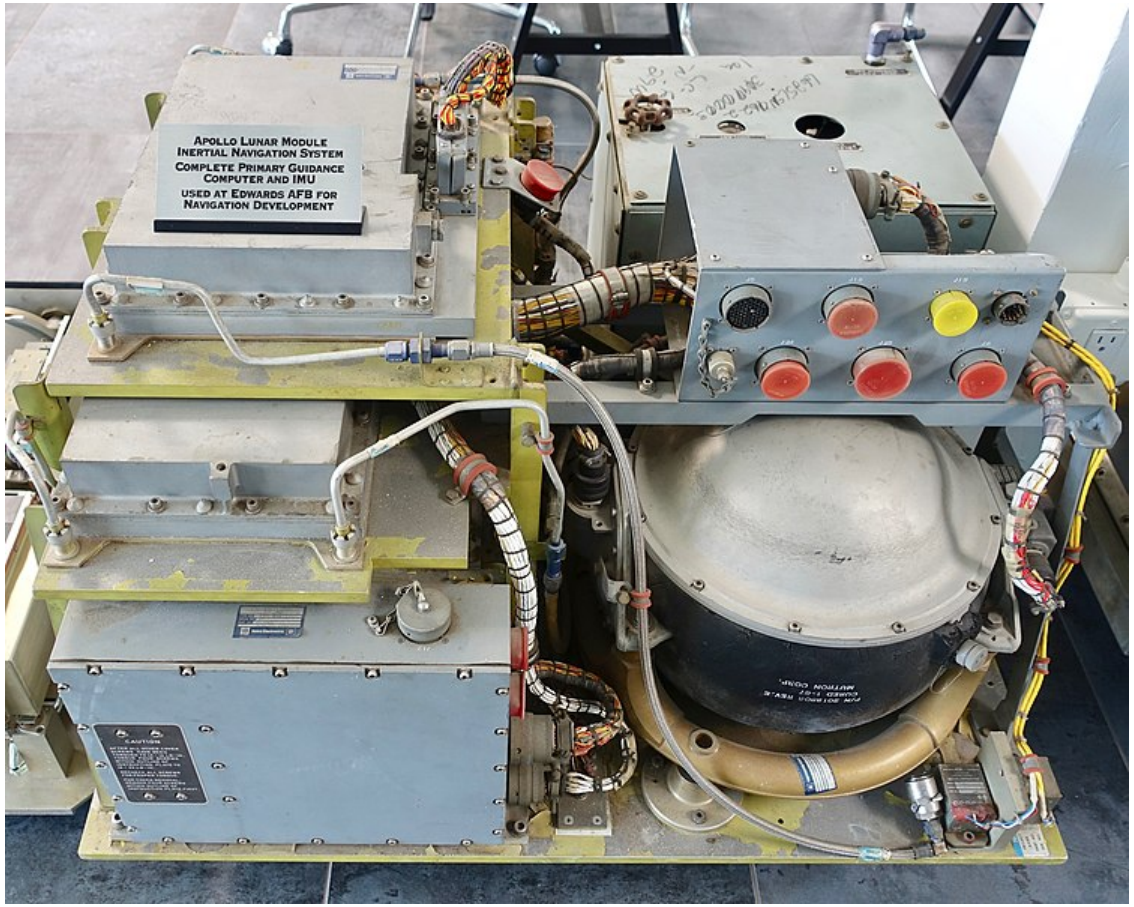
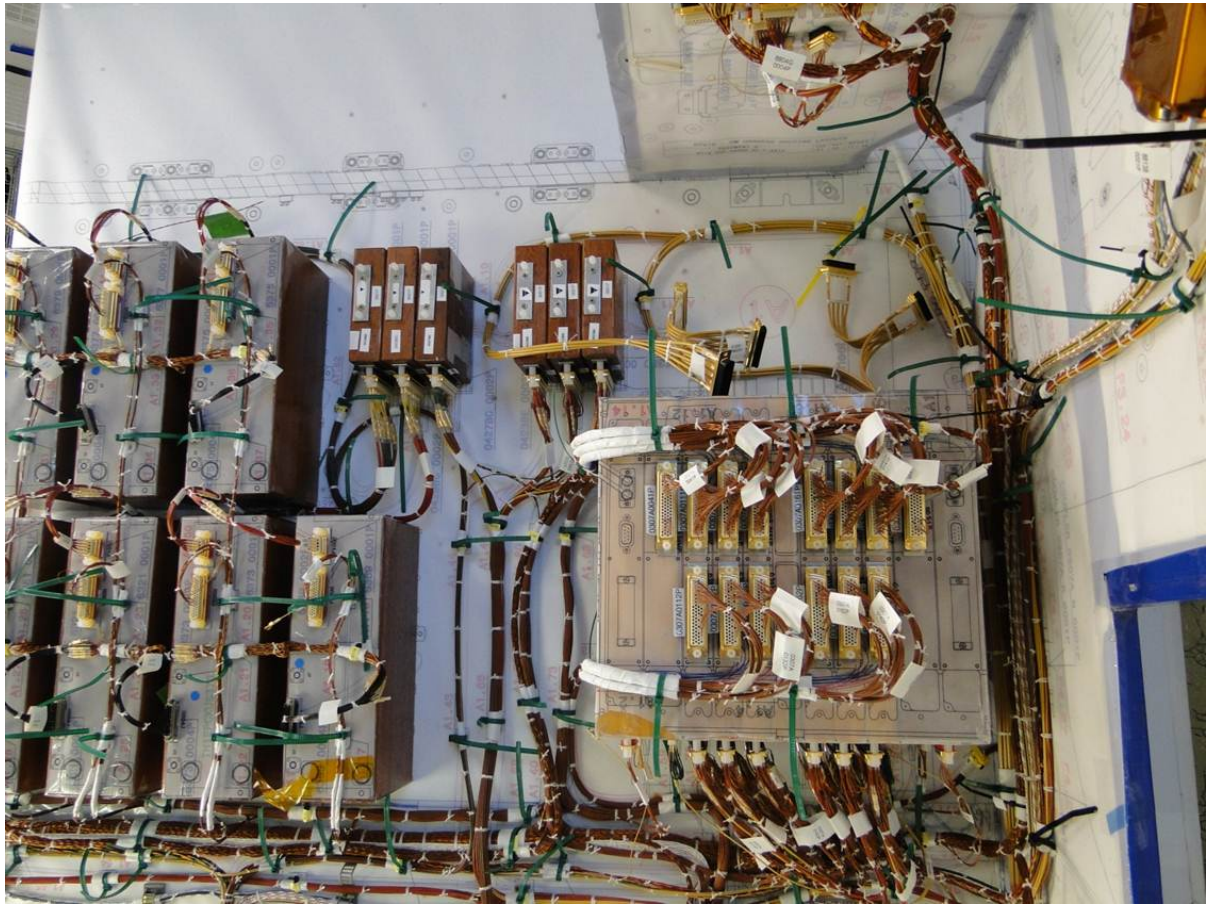
"Evolution" in the past 60 years



Space Harness in the 60's



Space Harness Today

=> Not much change in technology, but a lot more complex

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Meanwhile, on ground…

⇒ No wires, all conductors are flat,
Mechanical and electrical functions are co-optimized and merged.

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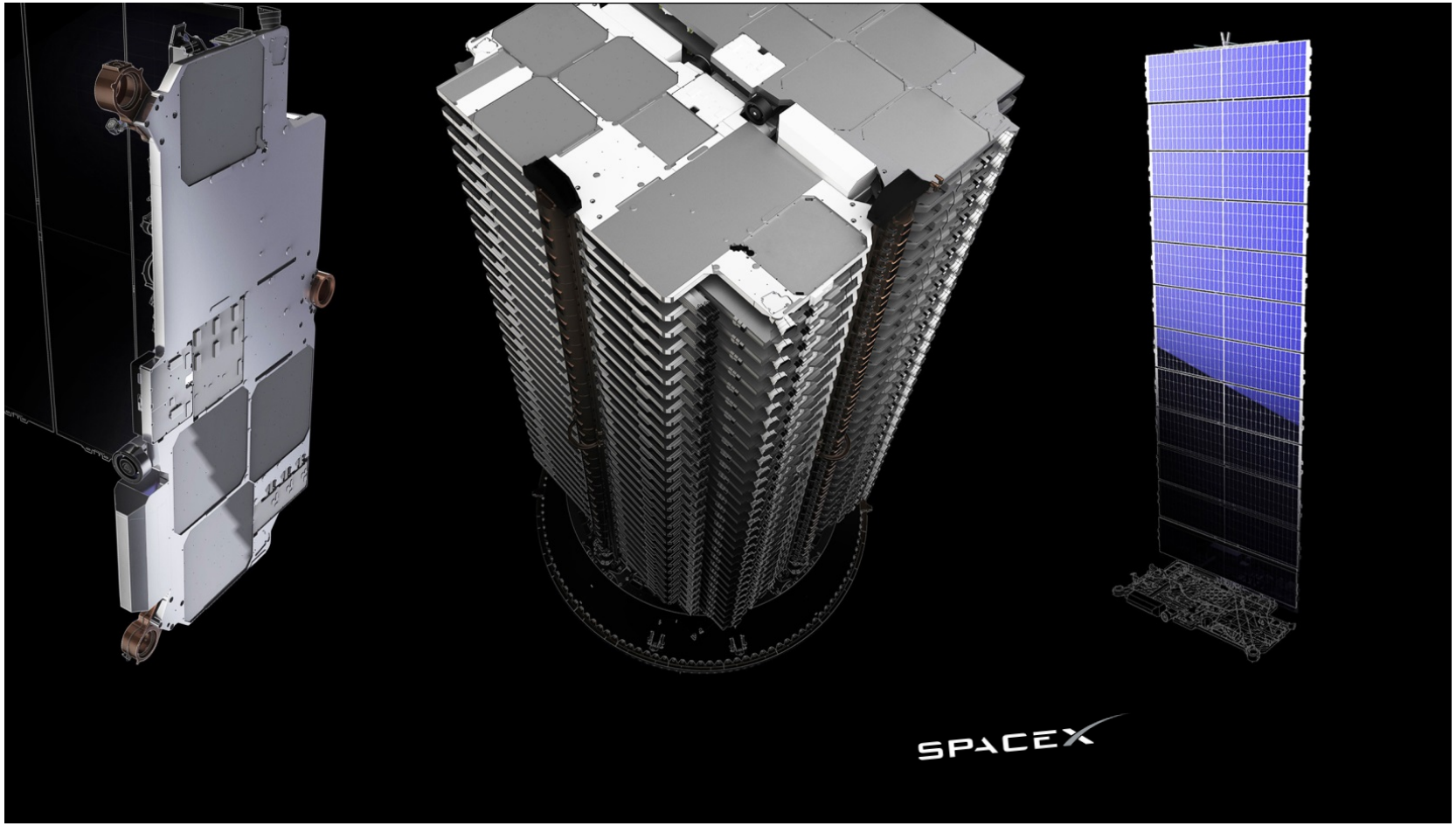
The shift seems to be already taken…



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Electrical & mechanical Integration

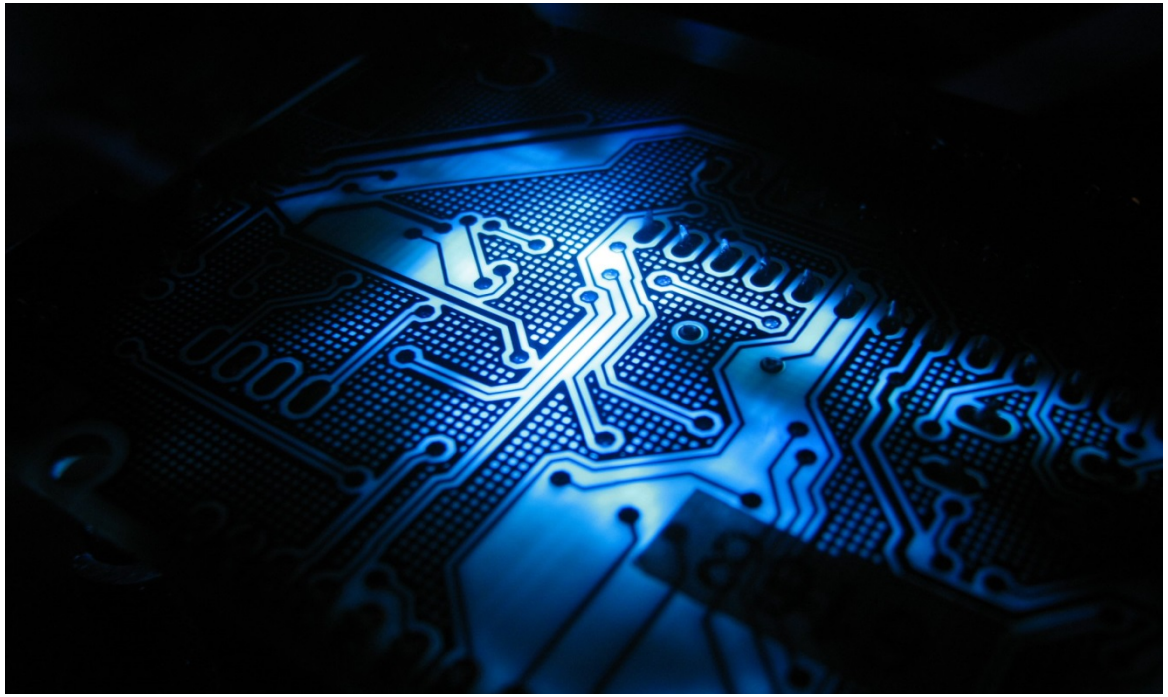
First target: **Merge power electrical conductors with the mechanical structure.**

Why power and not signal ?

- Hopefully, analog signal shall become exceptions thanks to digitalization.
- There is no better alternative than electrical conductors for general DC power distribution as per today.

Some candidate technologies for conductors:

- Conductive printing,
- Embedded flat cables
- Additive manufacturing
- …



From Printed Circuit Board to Printed Circuit Wall

A critical point => Using existing connectors with flat conductors would be a major limiting factor and therefore a killer. Dedicated connector technologies shall be developed and qualified in parallel.

Benefits for industrial challenges

Time to market:

Easier design: sizing and 2D routing could be automated (like PCB's).

The manufacturing processes of the structure & the electrical conductors could be merged.

No need to implement tie-bases on the structure.

No harness installation for power lines. Implicit connections just by mounting units onto the structure.

Cost savings:

Less engineering, less AIT, less harness complexity, significant mass reduction, better performance expected.

=> Savings on harness, fittings, connectors, mechanical structure.

Cost of the technology to be assessed v.s. the Total Cost of Ownership of the harness… which is currently very high!

Generic approach to develop 'one stop' solutions to support a production values.

Harness R&T's and Studies In Progress

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Harness R&T and studies in progress at Airbus DS

Short term:

- Fast locking connectors for thermal and small hardware (2-4 pins, no metallic shell).
- High voltage connectors (up to 2000V) – Applications: plasmic propulsion, some payloads...
- Fiber optics link for high data rate (Space applications are already in progress).
- Non destructive investigation facilities on already installed harness (CNES study).
- Participation to ESA study on Launcher harness improvement (Prime: Ariane Group, sub: ADS & Axon' Cable)
- Completion of Derating study for shielded bundles.
- High power connectors for aircrafts and drones batteries.

For Telecom payloads:

- Fast Locking Multiway RF connector developments for production payloads.
- Harness support solutions aimed at reduced AIT times.
- Harness assemblies built and tested off line then integrated.

Long-term:

Early study on:

- Electro-structures started in 2020 (flat conductors on the mechanical structure, dedicated connectors).
- Photonics.

Conclusion

By nature, any change in harness technology is likely to trigger changes in electrical units and vice versa: this reflects that the Harness is nothing less then the interface between any two avionic elements, but also with the mechanical structure.
As a consequence, evolutions limited to harness technologies without any modification on units and structure are not expected to generate any disruptive benefit.

Therefore, it is important to foster and develop disruptive technologies very early, in parallel with the associated evolutions of the electrical architectures and the mechanical structures.

The support of agencies is crucial to pull the technologies at an acceptable TRL for a first flight application: a space qualification can hardly be fully conducted in the frame of a program.

Agencies are also key to monitor the consistency of the evolution of electronics, harness and possibly structure, making sure that they will be ready at the same time to achieve the vision at system level.

The main evolutions on these three systems presented above would be: digitalization of unit's interfaces, solid-state distribution units, optical transceivers, fiber optics, wireless optical links, flat conductors on structure, connectors for fiber optics and for flat conductors.

Most of these technologies have become commonplace in ground applications and would offer huge opportunities in Space.

Thank you!

… Any Question ?

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