European Experience using FO for ISS Modules

1St ESA – NASA Working Meeting Optoelectronics : Fiber Optic System Technologies in Space

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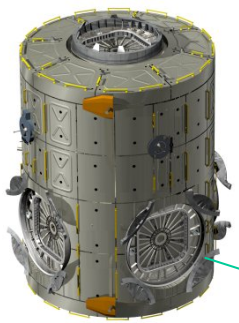
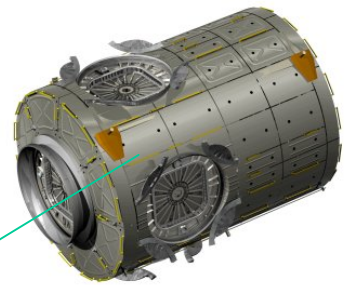
European Involvement in ISS

- HME – MC has been involved with the following ISS Modules :
  - Columbus
  - Node 2 and Node 3
  - Cupola
- For all these elements Fiber Optics connections have been used for :
  - High Rate Data Links
  - Video Links
  - Audio Links
- The reason for having FO links are :
  - Commonality with the rest of the ISS modules
  - EMC harsh environment (total station power is about 80kW)
  - Long distance for inter-module communications
  - High bandwidth needed for Video and HRDL(late 80's, 125 Mbps was considered high bandwidth)

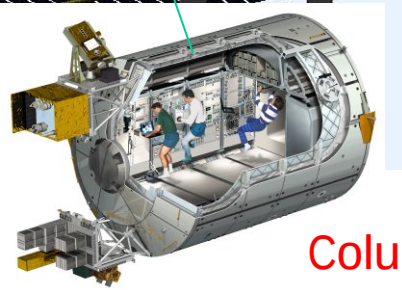
Node 3

Node 2





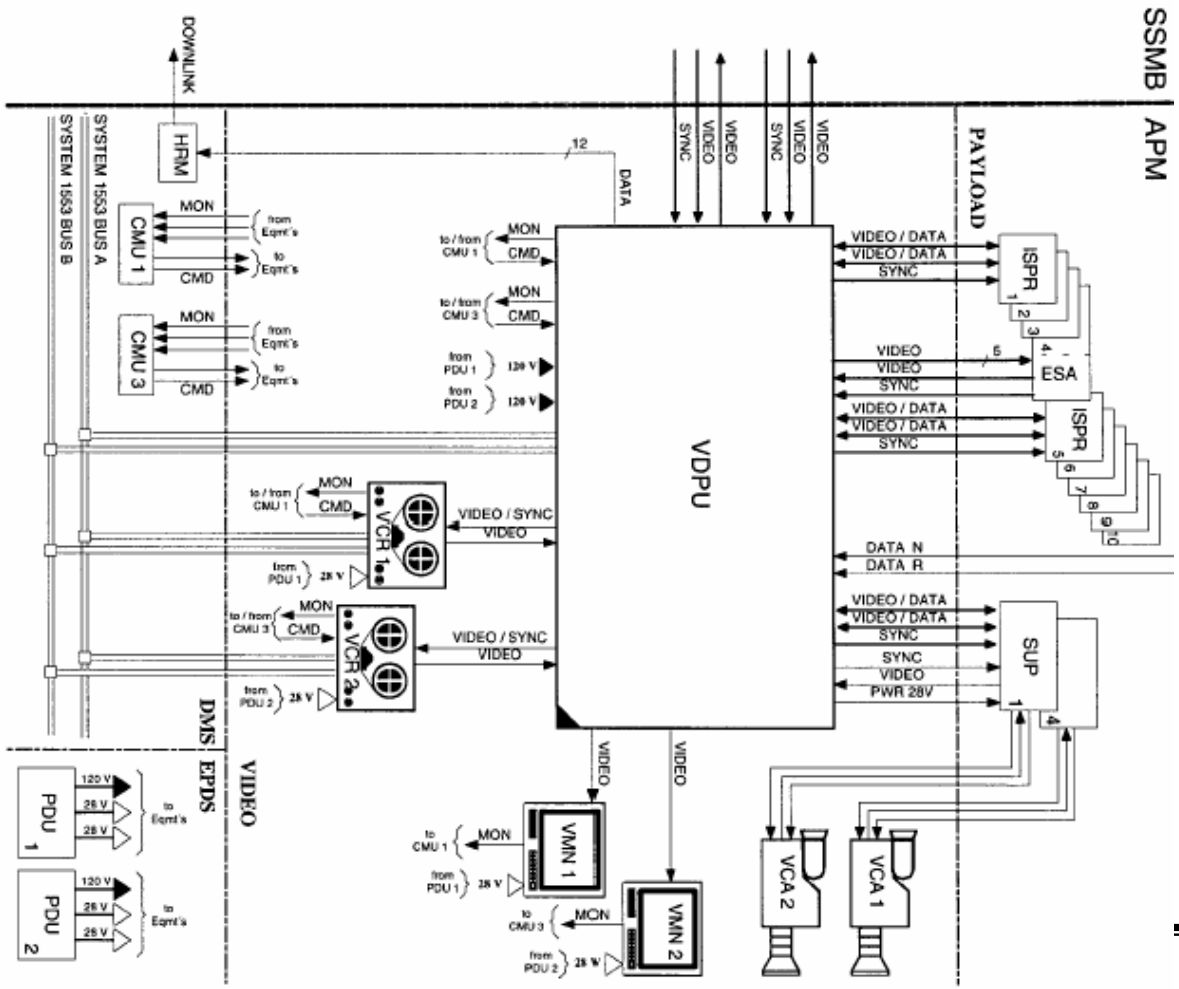
Cupola

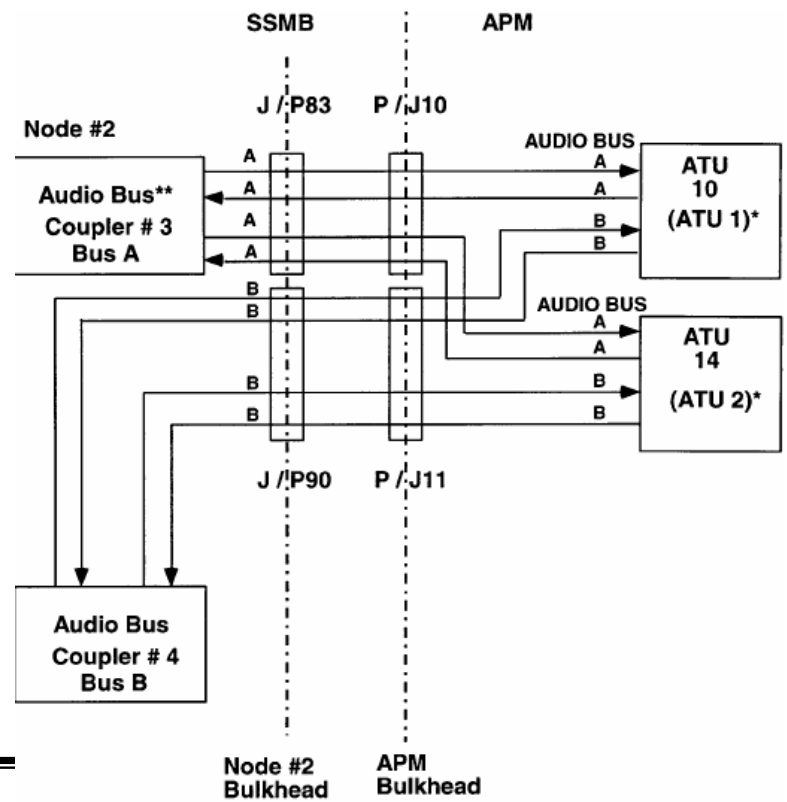


Columbus

Columbus Architecture

Columbus has 68 FO cables (HRDL, Video, Audio)





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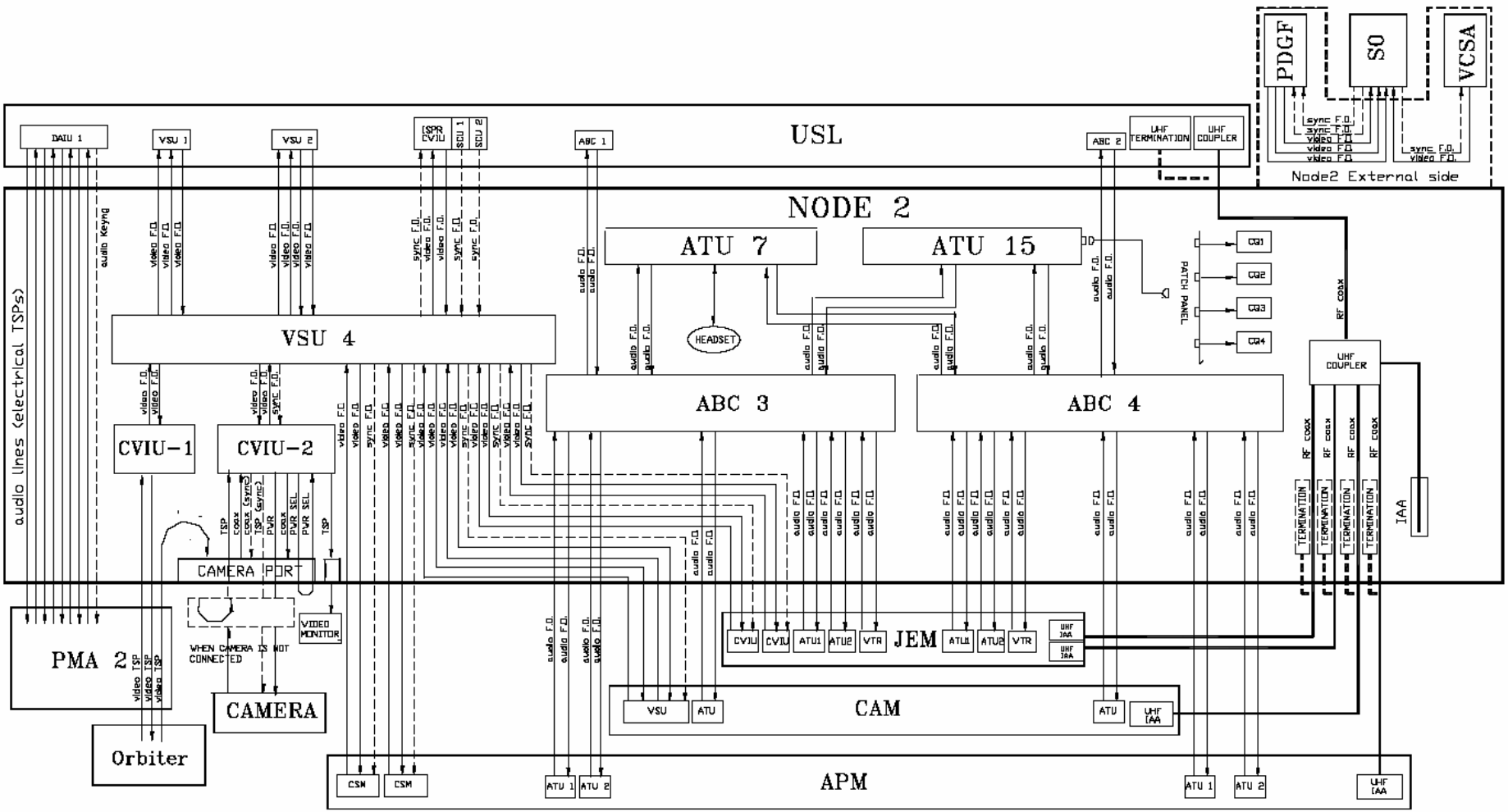
Node 2 Architecture

Node 2 has 56 FO Connectors containing 1200 (HRDL, Video, Audio)



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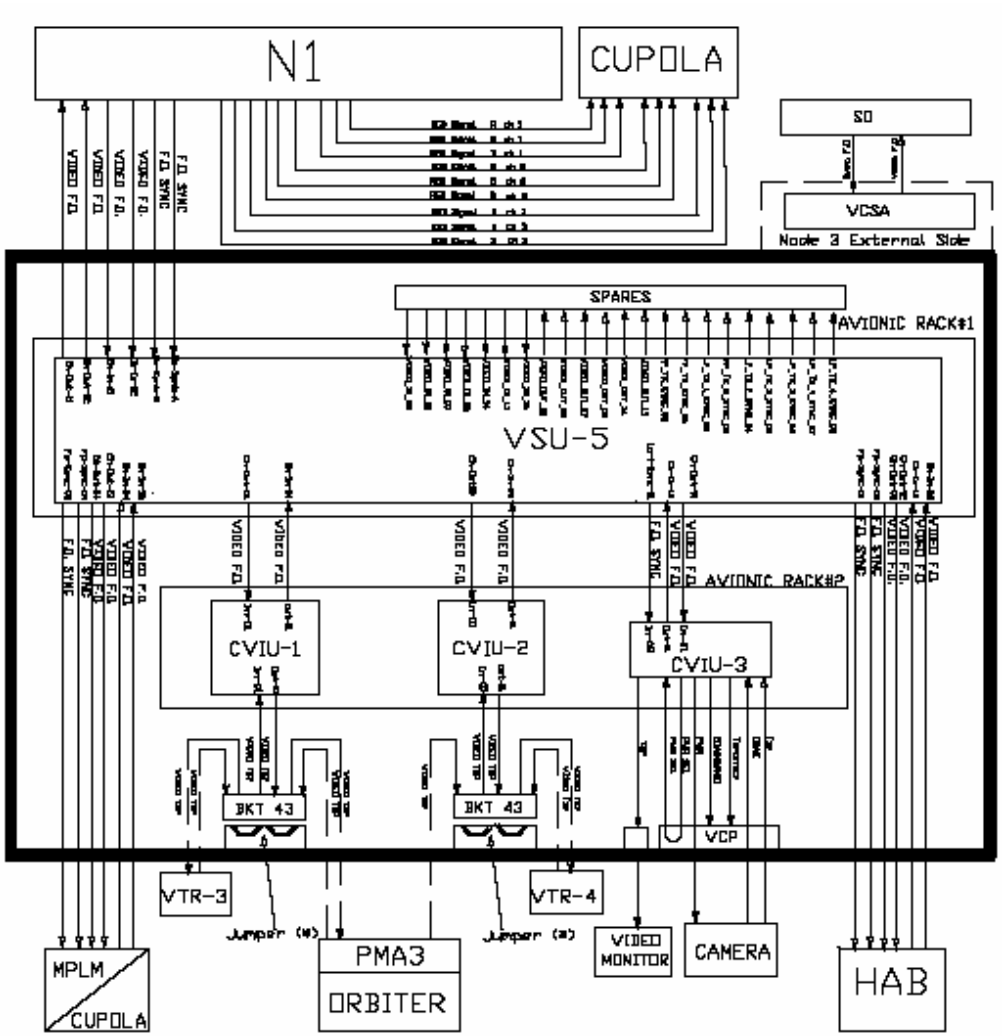
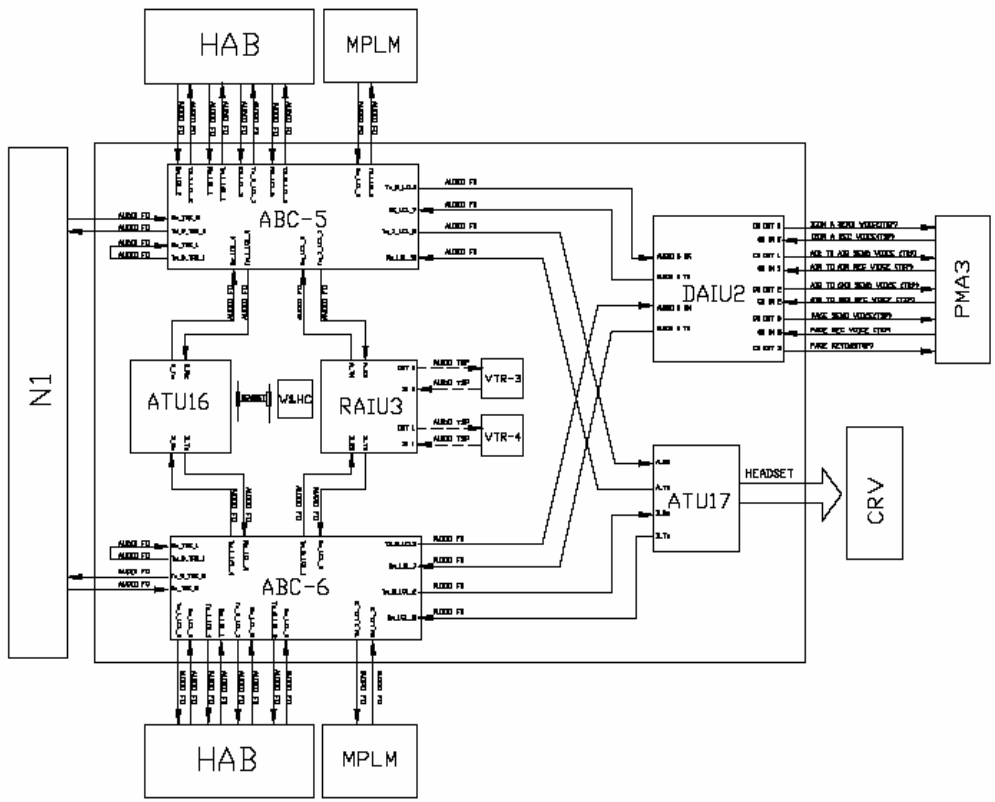
Node 3 Architecture

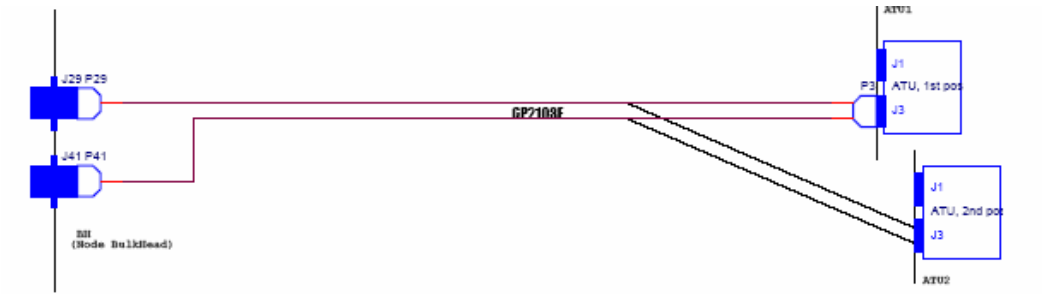
Node 3 has 35 FO Connectors containing 326 termini (HRDL, Video, Audio)

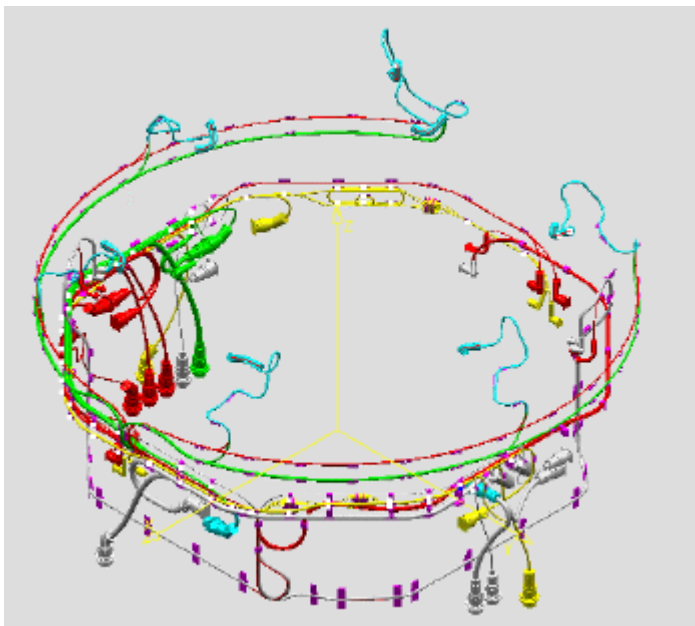




Cupola Architecture

Cupola has 8 FO cables (Audio only)





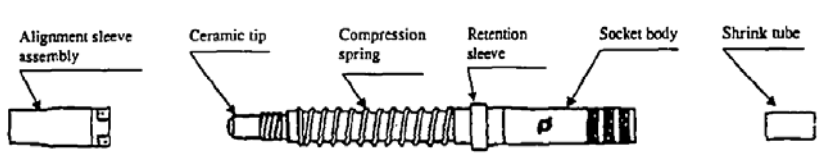
FO Material Source (1)

- **ISS Fiber Characteristics:**
  - All FO equipment used for the ISS has followed a NASA qualification.:
  - NASA standard for ISS is covered by SSQ 21654 :
    - General Specification for Cable, Single Fiber, Multimode, Space Quality,
  - ESA has adapted the NASA standard for material selection and building process.

Parameter	Dim.	Medium Characteristics
Fiber Type	-	graded index, Multimode
Operating Wave length (min/max)	nm	1270/1380
Fiber Core Diameter (min/max)	µm	98/102
Fiber Cladding Diameter (min/max)	µm	138/142
Numerical Aperture (min/max)	-	0.28/0.32
Attenuation max @ 1290 ± 10 nm	dB/Km	≤ 4
Modal Bandwidth @ 1290 ± 10 nm	MHz x Km	200
Minimum Bend Radius	mm	50

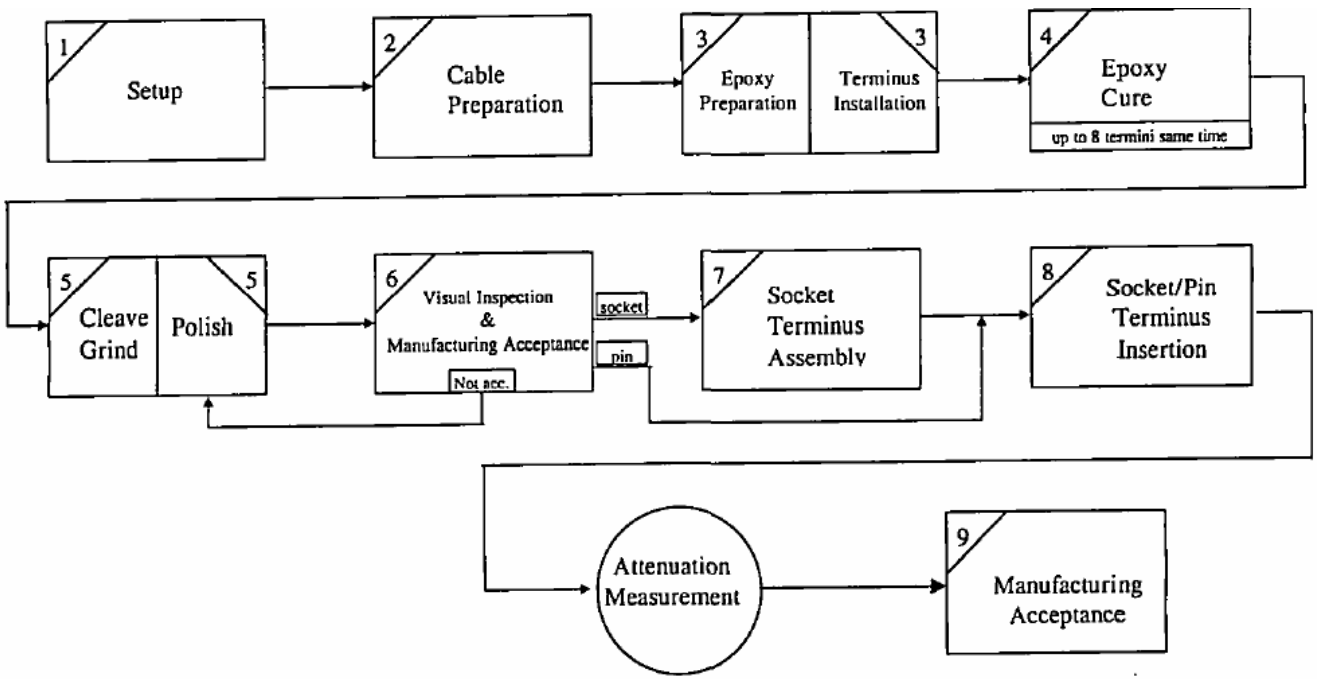
FO Material Source (2)

- Fiber Cable
  - It has been qualified (mechanical and radiation aspects) by Boeing
  - The procurement centralised for all ISS Modules
  - Manufacturer Brand Rex Co.
- Termini / Connectors
  - Termini have been developed and Qualified for ISS by ITT Canon
  - Termini are fitted into Size 16 contacts of multi-contacts round Mil-C-38999 connectors



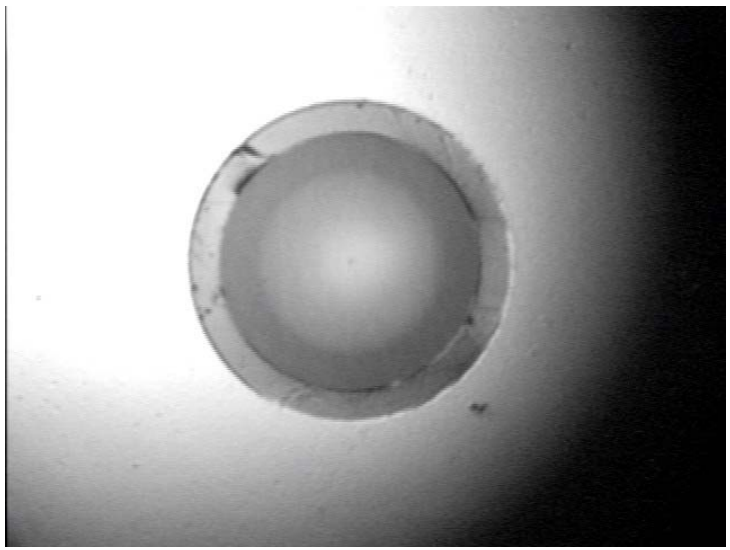
Manufacturing Process

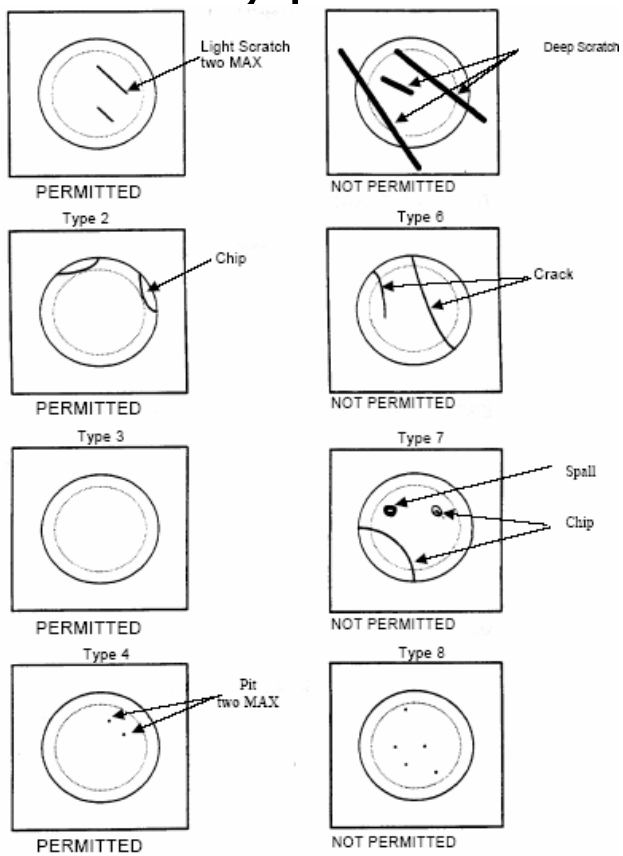
- European Industry working for ISS has followed manufacturing process developed by ITT Canon,
- Specific training was needed at US for qualification operators and inspectors
- Manufacturing Process Flow:



Fiber Acceptance Criteria

- Under Magnification of 200 during assembly process:





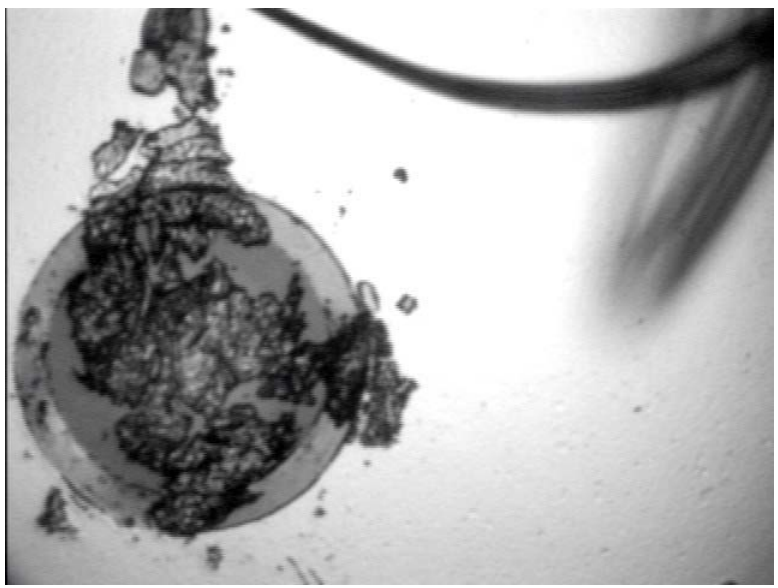
- Under Magnification of 10 for acceptance

Encountered Problems (1)

- Material Defects
  - FO cable has presented cracks and bubbles from the supplier
  - → loss of transmission power and risk of connection breaking during ORU replacement. (ORU = On-Orbit Replaceable Unit).
  - → Re-qualification process needed and inspection process improved
- Connectors Alignment
  - Due to the large number of fibers to pass through modules, multi-pole connectors used for feed through connectors.
  - → Very difficult to achieve good alignment for all termini in a connector simultaneously.
  - Due the large number of interconnection (between modules), link budget were under strict controls by NASA.

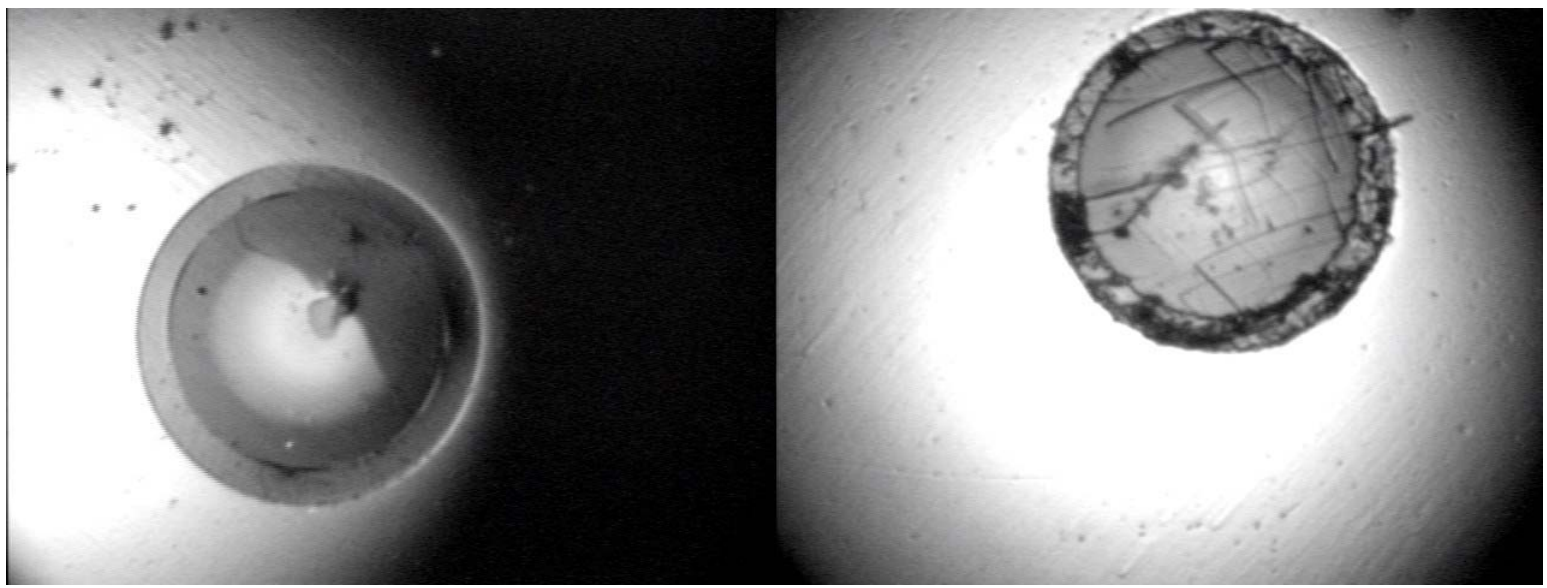
Encountered Problems (2)

- Cleanliness:
  - Due to cleanliness issue discovered during production and integration, an ad-hoc tool and procedure were developed (camera capable for termini inspection up to 200x see picture)



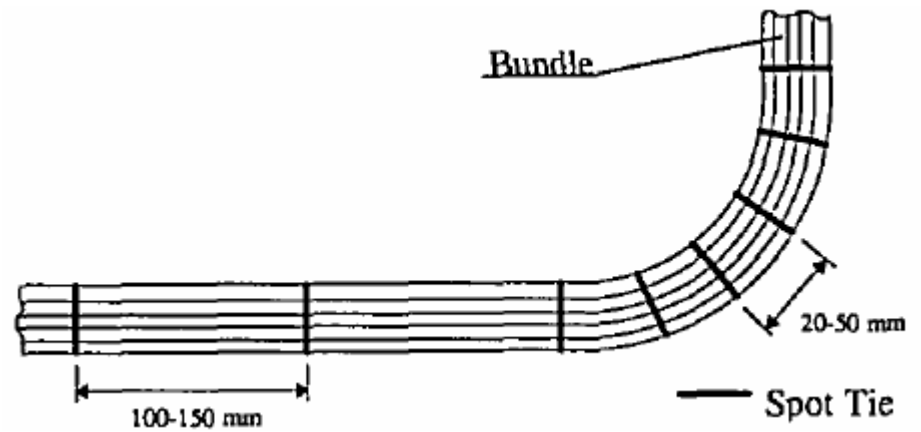
Encountered Problems (3)

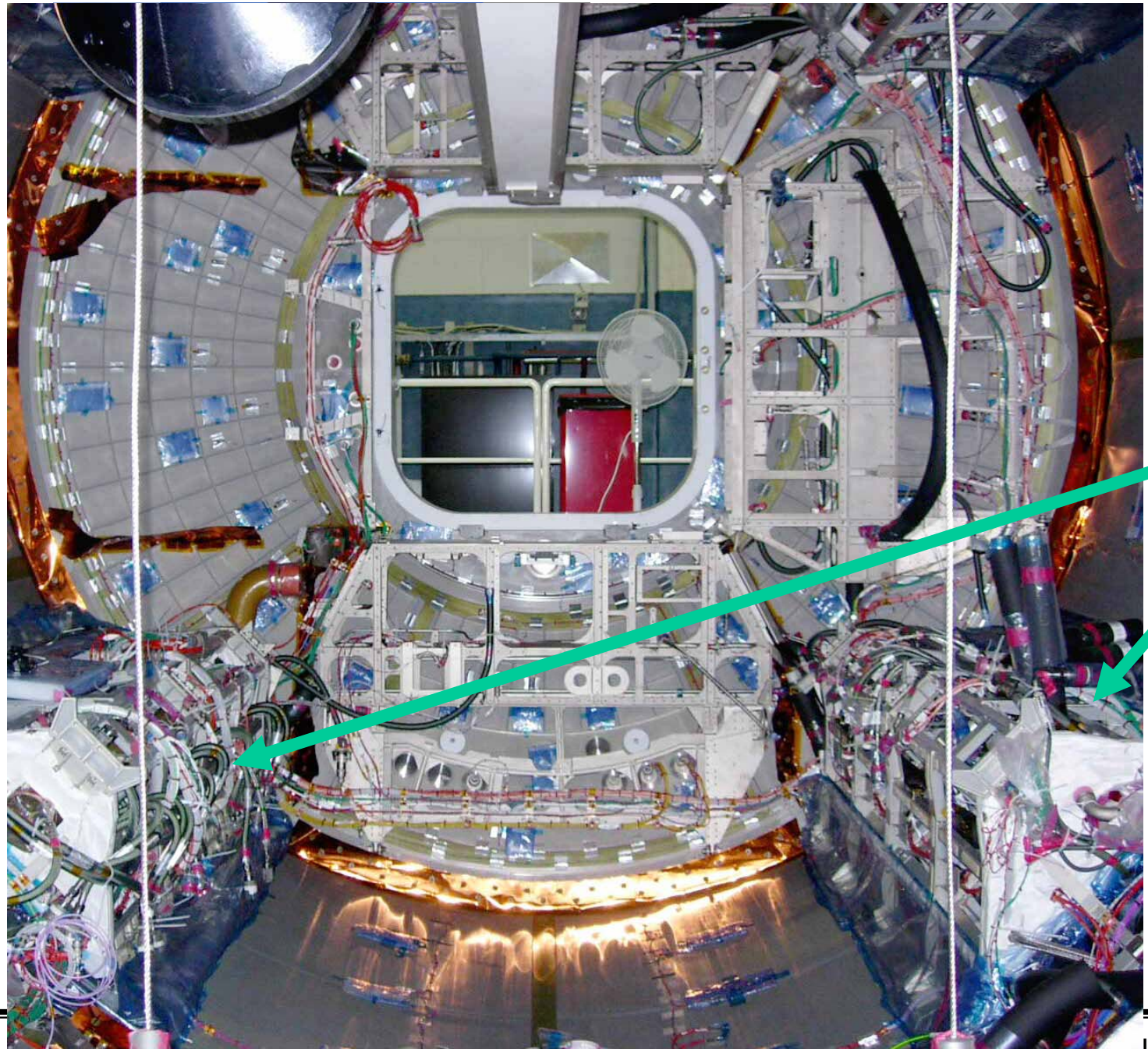
- Termini Damaged and Repair
  - Similar problem was encountered for termini damage.
  - Un-suitable acceptance method was used (10X magnification)
  - Improved of acceptance procedure using 200X magnification



Installation Specificity (1)

- Dedicated precautions to be taken into account for Harness installation :
  - Bending radius
  - Bundles rigidity
  - Mating / Demating





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Harness installation in Stand-offs very Crowded.

Conclusions

- ISS for Europe, was the first large experience with operational FO links.
- European Industry succeeded to gain expertise in the field of manufacturing and installing FO harness on a large scale.
- Evolution of acceptance/installation procedures thanks to inspection technology improvement.
- At the time of the technology selection (late 80s) FO was the best possible solution to cope with long distance, high bandwidth and EMC environment.

→For a performance point of view FO was the best choice for ISS, however strict and controlled qualification methods are necessary based on gained experience.