Optical harnesses for space

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Abstract: Procuring optical harness for space applications requires a good understanding of optical harness components. This white paper describes the components of such a harness and proposes a systematic approach for procuring parts depending on the requirements of individual space projects. As a valued player on this market, Diamond will carry out this approach by showcasing the high-quality of its products and processes, such as connectors and the termination process.

1 Introduction

Optical harnesses are used in space craft to transmit digital or analogue information for data or sensory functions. The reliability of the components and the harsh environment to which they are submitted require a systematic and careful approach when planning and procuring such a harness.

This white paper aims to help you understand the various components that make up such a harness.

Due to Diamond specialities, the paper will focus on connectors and the termination process.

2 Optical harness

An optical harness consists of a series of patch cords and pigtails carrying optical signals from a source to a target, including adapters, free space half-adapters (KST) and optical modules (isolators, couplers, etc.).

We will not cover optical modules within this white paper and will instead focus on the basic components : fibre-optics, cables, connectors and adapter.

2.1 Telecom approach

The telecommunications industry has edited the standards for each of these components as described below. The aim is to make sure every manufacturer produces in line with the same requirements.

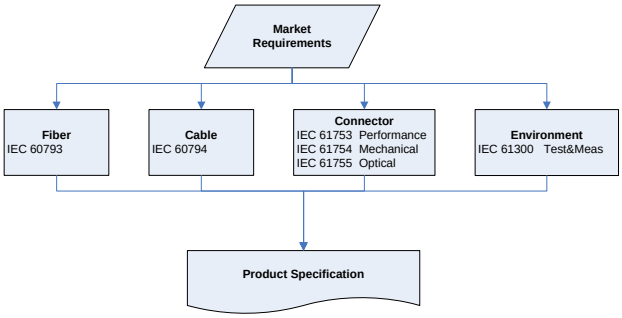

Fig. 1 Telecom standards

2.2 ESA ECSS approach

The approach carried out by ESA has a somewhat different goal. In the ECSS approach, there are three types of specifications: generic, basic and detailed.

The aim is to describe how a device (patch cord) is qualified for space applications and standardized where necessary (detailed specification).

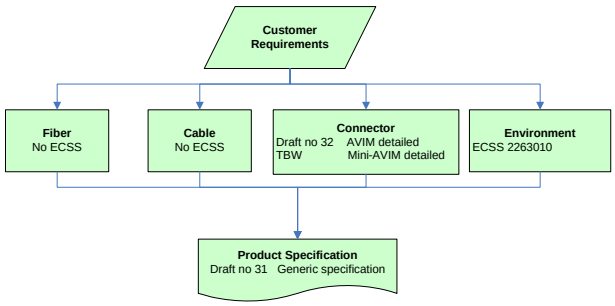

Fig. 2 ESCC specifications and standardization approach

2.3 Optical harness components

2.3.1 Fiber

The fiber is the element that transmits the light and its type depends on the user's application. Various types exists, however the most common are the multimode (MM), singlemode (SM) and polarization maintaining (PM).

Space applications increase the complexity of issues faced by the fiber, due to the temperature, but more importantly, irradiation. Irradiation increases glass absorption, which induces increased losses.

The user alone is responsible for picking the right fiber for a particular application. Diamond is not qualified to make this decision, but the company should be involved in selecting the fiber in order to assert its influence on the termination procedure.

A good source of information here is the NASA GSFC Photonics group website at

http://photonics.gsfc.nasa.gov .

2.3.2 Cable

The cable is normally used to mechanically protect the fiber. This mechanical protection usually interferes with the thermal behavior and normally involves a trade-off between these two effects.

So far, besides using unprotected fibers, we found the use of an ePTFE covered fiber with an aramid-strength Kevlar® member and fluoropolymer jacket to be the most successful solution. Other solutions using PEEK loose tubes have been successfully implemented too.

The cable structure usually has a large effect on the termination procedure and final performance. Diamond should thus be involved in the definition of the cable.

2.3.3 Connectors

The connectors must be physically aligned and there must be good contact between two fibers in order for there to be no discontinuity in the glass light guide.

Their capacity to be resistant to environmental conditions (surviving launch, the space environment and sometimes planetary landing) is important.

Diamond products are presented below.

Two connectors are proposed for evaluation and qualification under ECSS standards: the Mini-AVIM and AVIM connectors. The end of the program, anticipated by Q1 2012, should see the finalization of two detailed specifications.

3 Procurement procedure

Diamond has identified three principal phases and thus proposes three types of quality grades.

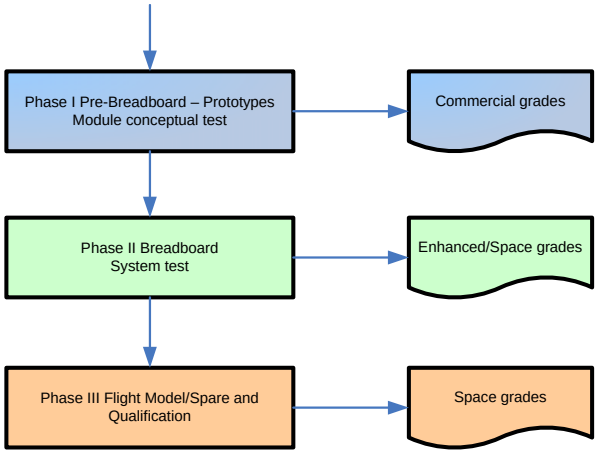

Fig. 3 Project phases

At this point in time, there are no standards for optical harness components. Some are in preparation but are due at the earliest in Q1 2012.

Therefore the harness must be qualified each time.

Diamond currently offers termination services, testing/qualification services and consulting services which correspond to its expertise.

Thanks to our efforts in the evalutation and qualification work carried out under the ESTEC contract, we expect to simplify the requirements for procurement.

4 Diamond products

Diamond is a well known developer and producer of optical connectors. The company was established in 1958 and has been the market leader in high quality optical connectors since the 1980s.

Information on the past projects can be found on our website.

4.1 AVIM

The AVIM connector was developed for an avionics application in the early 90's and has since survived several space missions. It is used on the space shuttle and included in various space missions.

This connector has been used in other harsh environment applications.

Fig. 4 AVIM connector and mating adapter

The full specification can be found on the Diamond website at:

http://www.diamond-fo.com/en/markets_space_avim.asp

4.2 Mini-AVIM

The Mini-AVIM is a recent addition to our space catalogue and has been developed as a lighter and smaller version of the AVIM. It contains the same ferrule and locking mechanism principle with a smaller package made entirely of titanium

Fig. 5 Mini-AVIM connector and mating adapter

The full specification can be found on the Diamond website at:

http://www.diamond-fo.com/en/markets_space_miniavim.asp

4.3 DMI-Space (Q1 2011)

The DMI-Space is a recent addition to our space catalogue. It has been partially tested by NASA and will be released by Q1 2011. It is a more robust version of the DMI connector, with all mechanical parts made from titanium, except the spring clip which is made from coated CuBe. It has by far the smallest and lightest proposed footprint.

Fig. 6 DMI-Space connection (two connectors and a mating adapter)

The full specification will be published by Q1 2011

5 Quality grades

To respond to the various phases, different grades have been defined. Each corresponds to a different quality process and has a different price.

The difference in prices between commercial → enhanced → and space grades are 1x, → 5x, and → 10x. This applies to termination services only.

5.1 Commercial grade

This process applies to telecom performance and optical performance, which are guaranteed through use in similar conditions. The telecom industry has thoroughly standardized the performance / environment and our datasheet corresponds to these established qualities.

5.2 Enhanced grade

- Custom-ageing through cycling during production
- Laser-engraved connectors
- 25% additional quantity to cover batch rejects
- Batch travel card

5.3 Space grade

- Product Identification Document (PID) containing
  - Bill of Materials
  - Optical performance
  - Screening test adapted to configuration
  - Non-conformance table for qualified product (if available) or customer specification (if provided) and batch acceptance test suggestion with offer (delta qualification).
- Production and Test Schedule (PTS)
- Certificate of Compliance
- Batch Screening Test report containing
  - Interferometric report for each connector
  - Parameter values before and after test with pass/fail criteria

6 Conclusion

We have presented the various components that comprise an optical harness and how they are standardized in the telecommuncation and space industry.

A procurement procedure has been presented and should be used to request the proper grade for termination.

This white paper is published on our website and will be updated continuously with new information on this subject. Please note the version number in the bottom left of every page.

Resources

1. *Optical Fiber Assemblies for Space Flight from the NASA Goddard Space Flight Center, Photonics Group,* Melanie N. Ott et al., ISROS 2009
2. *Evaluation test programme for optical fiber connector sets,* ECSS Basic Specification No. 2263010
3. *Gore Flexlite™ 1.2mm* datasheet