QwikConnect

GLENAIR ■ OCTOBER 2012 VOLUME 16 ■ NUMBER 4

DESIGNING INTERCONNECTS FOR Space

Glenair®

Designing Interconnects for Space

Glenair has been providing Space-Grade Interconnect Solutions since the earliest manned space flights. We understand the highly specialized mechanical, electrical and optical performance requirements for data, video and communications in exoatmospheric vehicles. Space-rated interconnect systems require specialized materials and processing and precise and reliable mating interfaces. Size and weight reduction are additional key requirements. All are Glenair strengths.

Space is one of the most severe environments imaginable. During launch, spacecraft and their payloads are shaken violently and battered with intense sound waves. Earth's atmosphere has an insulating property, but spacecraft operating beyond this layer of protection are subjected to shock, vibration, and acoustic stress factors which can damage interconnect systems—particularly if material strength, mating retention forces, contact retention technologies or other design elements of connector/cable components are inadequate for peak and/or sustained levels of mechanical stress.

Temperatures in space can range from extremely cold—hundreds of degrees below freezing—to many hundreds of degrees above, especially if a spacecraft ventures close to the sun. Temperature extremes can generate stress in metal, glass and polymer materials and potentially lead to cracking or other failures.

Meteor showers can damage spacecraft and equipment. Even small dust particles—that appear from Earth as 'shooting stars'—can damage exposed equipment travelling through space at extremely high speeds. Damage can range from a sort of 'sand blasting' effect on solar panels to even more severe forms of harm we would normally associate with a gun shot or bomb blast.

Corrosion is a serious factor, even in space craft designed to operate in environments where resistance to environmental (dust, water and fluid ingress) or electrolytic hazards is not a requirement. In the first case, interconnect systems may be subjected to environmental damage during construction and storage on earth. Launch vehicles, rockets and ground test equipment are often challenged by environmental conditions. In low earth orbit, satellites and stations may be damaged by atomic oxygen, if material choices and other amelioration efforts are not carefully made.

Finally, space places a wide range of demands on design and packaging of interconnect components. These unique packaging challenges include the elimination of sharp surfaces that might damage a space suit, unique coupling technologies for automated de-mating of staged modules, ultra-low profile or reduced weight connectors for weight and space reduction and so on.

The general requirements of designing interconnect systems for space can be summarized as follows:

- The overriding concern for space-grade interconnects is reliability. When millions of dollars

worth of equipment is at stake—not to mention invaluable human cargo when brave and talented women and men take flight—interconnect components have to work with assured reliability and safety every time.

- Minimizing weight and package size of components, while maintaining strength and durability for space-grade operation.
- Systematic processing and screening of non-metallic materials to prevent the outgassing of condensable material.
- Utilization of materials and platings that withstand atomic oxygen corrosion in the space environment.
- Building systems able to withstand the extreme hot and cold temperatures experienced in space.
- Avoiding use of materials with undesirable ferromagnetic properties that could interfere with sensitive instruments on spacecraft.
- Adhering to prohibitions on certain materials and finishes deemed unsafe for space-grade applications.
- Qualifying to standards set forth by NASA, the European Space Agency, and other agencies governing space flight applications.

We'll cover these requirements and more in this special Space edition of QwikConnect.

Dozens of robotic spacecraft, including orbiters, landers, and rovers, have been launched to Mars since the 1960s. Glenair cables have ridden along on several, including the recent Curiosity rover program, helping to fulfill navigation, data and communication requirements.

Reliability is Job One

When a spacecraft is launched, it might carry costly precision scientific experiments, mission-critical equipment for military communications, or astronauts bound for the International Space Station. The cost of failure is too high to employ anything but the highest quality materials and precision fabrication.

That's where Glenair comes in. Vertically integrated, we directly manage all connector, cable and accessory fabrication at our facilities in Glendale, California; Mansfield, England and Bologna, Italy—including precision machining, hermetic firing, component assembly, contact termination, potting and electrical testing. Glenair can assure the highest quality by maintaining direct control over all manufacturing processes.

Glenair is registered in conformance with ISO 9001:2008 and AS9100:2009 Rev. C. We manufacture several connector lines qualified to rigorous military specifications. We operate one of the most extensive product testing laboratories in the interconnect industry, approved to perform corrosion, shock, vibration, pull and the complete range of other performance tests required for interconnect components and harnesses. Additionally, Glenair maintains ongoing relationships with a number of local and national DSCC- and NAVAIR-approved full service testing laboratories.

However, we've found it's never enough to just say that a design "meets the spec." Our goal is to design and manufacture solutions that solve the challenges inherent in space-grade interconnect systems and address the need for fail-safe reliability.

Glenair's devotion to reliability encompasses our controlled domestic manufacturing, our conformance and qualification to specifications, and our rigorous internal and external testing of components. This dedication to reliability informs all of our design and manufacturing of space grade interconnect systems.

Space-Grade KNOWLEDGE

Cryogenic Conditions in Space

Deep space probes and planetary exploration missions require electrical power management and control systems that are capable of efficient and reliable operation in very cold temperature environments. Typically, in deep space probes, heating elements are used to keep the spacecraft electronics near room temperature. Electronic components and systems capable of operation at cryogenic temperatures are anticipated in many future NASA space missions such as deep space probes and planetary surface exploration. For example, an unheated interplanetary probe launched to explore the rings of Saturn would reach an average temperature near Saturn of about -183 °C. In addition to surviving the deep space harsh environment, electronics capable of low temperature operation would contribute to improving circuit performance, increasing system efficiency, and reducing payload development and launch costs. Additional applications where space components and systems must operate in low temperature environments include "Dewar's Flask" type cryogenic cooling of thermal sensor focal planes and infrared vision systems.

Job Two: Reducing Weight in Launch Vehicles and Payloads

100% Metal Clad AmberStrand® Weight vs. Nickel Copper					
Size	Diameter (in)	AmberStrand® (Lbs./cft)	36 AWG Cu (Lbs./cft)	Lbs. Difference	% Lighter
002	.062	.1322	.40	.2678	67.5%
004	.125	.2205	1.03	.8095	78.6%
008	.250	.3968	3.45	3.053	88.5%
012	.375	.5071	3.95	3.443	87.1%
016	.500	.8175	4.77	3.954	82.9%
020	.625	.9700	5.94	4.970	83.6
024	.750	1.146	7.35	5.154	84.4%
032	1.000	1.7637	7.50	5.736	76.4

With weight saving bounties valued at $1000 a pound and more, interconnect materials and technologies that reduce launch vehicle and payload weights is a cost-effective design regimen. Replacing standard metal braid, for example, with AmberStrand® (the Glenair metal-clad composite EMI/RFI braid) is like buying dollar bills for 50 cents. 100 Feet of 5/8" AmberStrand® vs. Nickel Copper Shield Saves 5+ Pounds.

Additional weight savings is readily accomplished through the miniaturization of connector circuits and packages, particularly given the reduced voltage requirements in digital electronic systems. The Glenair Series 79 (Micro-Crimp) and Series 80 (Mighty Mouse) ultraminiature rectangular and circular connector families are ideally suited for high-performance space-based applications and can reduce size and weight up to 70% compared to standard aerospace connectors.

AmberStrand® ultra-lightweight microfilament metal-clad EMI/RFI composite braiding

Size and weight comparison of Series 801 Mighty Mouse (7 Contacts)…

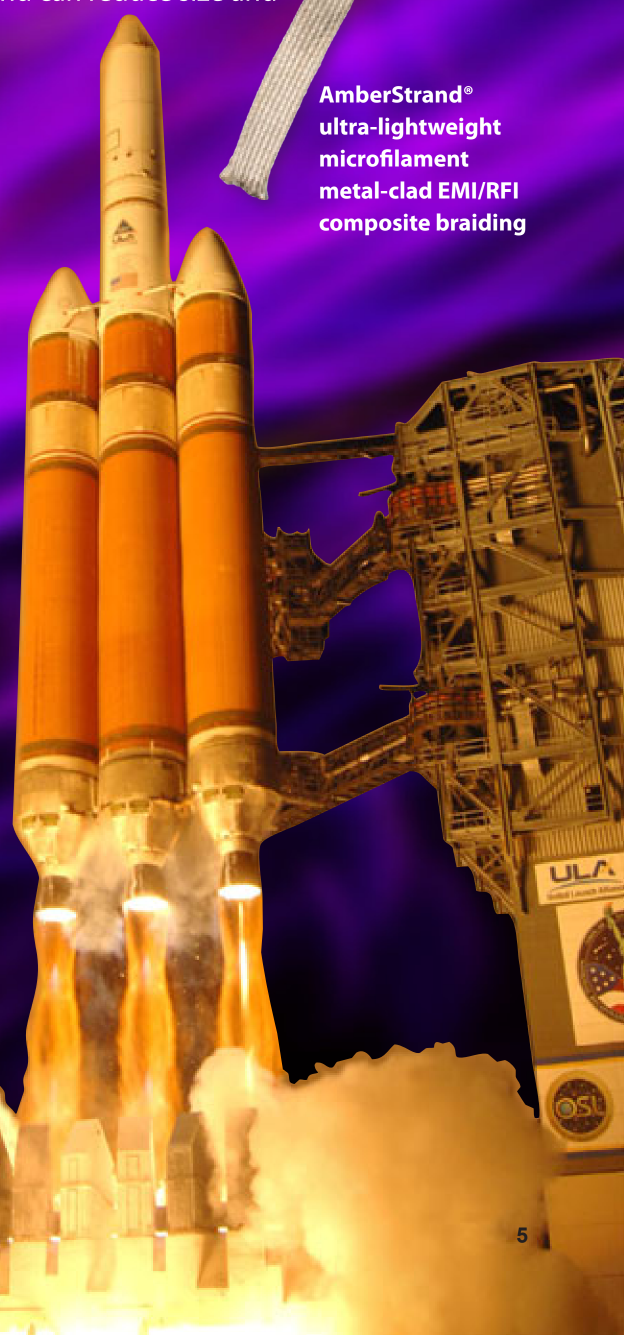
…to MIL-DTL-38999 (6 Contacts) Up to 71% weight savings and 52% size savings

Precision-machined aluminum shell MIL-DTL-24308 intermateable HiPer-D connector

Microminiature MIL-DTL-83513 rectangular connector

High performance Micro-Crimp rectangular with advanced EMC and environmental performance

MIL-DTL-32139 Nanominiature connector—the smallest and lightest in the business



Job Three: Managing Material Outgassing

Non-metallic materials such as rubber, plastic, adhesives and potting compounds can give off potentially harmful gasses when subjected to a vacuum or high heat. Condensable material in the gas has the potential to reduce the conductivity of electronic circuits, damage optical instruments or cause other problems in the vehicle or satellite. This issue impacts a broad range of interconnect products.

The space industry has adopted a standardized test procedure, ASTM E 595, to evaluate out-gassing properties of polymers and other non-metallic materials. To conduct the test, small samples of material are heated to 125° C at a vacuum of $5 \text{ X } 10^{-5}$ torr for 24 hours.

As the test proceeds, any outgassed matter will condense on a cooled collector plate. The quantity of outgassed matter, or the amount of Collected Volatile Condensable Material (CVCM) on the plate can be calculated by weighing the original sample before and after outgassing to determine its Total Mass Loss (or TML). For the material to be considered safe for use in space applications, the TML cannot exceed 1.00% of the total initial mass and the CVCM cannot exceed 0.10% of the original specimen mass.

The same process used to test materials can be used to proactively remove volatile condensable materials that have the potential to damage sensitive equipment. Glenair offers an 8 hour @ 400° F bakeout process as well as a 24 hour @ 125° C thermal vacuum outgassing process. These bakeout processes assure that all volatile materials are removed prior to the products use in the space application.

NASA Spec EEE-INST-002 is a key specification for screening of non-metallic materials for space. The specification provides instructions on selecting, screening and qualifying parts for use on NASA space flight projects. Combined with the ASTM E 595 test regimen, it provides guidance on preparing and qualifying interconnect parts for use in space.

Glenair has created an in-house mod-code system that allows us to reliably apply the different levels of NASA screening to various connector families. As the mod-code identification is permanently marked on the part, it allows easy and reliable part identification and the specific screening or bakeout process they have undergone. All screened parts are supplied with a lot acceptance test report. This process takes all the pain and confusion out of the bake-out and screening process, essentially reducing it to a part number specification exercise.

Space-Grade KNOWLEDGE

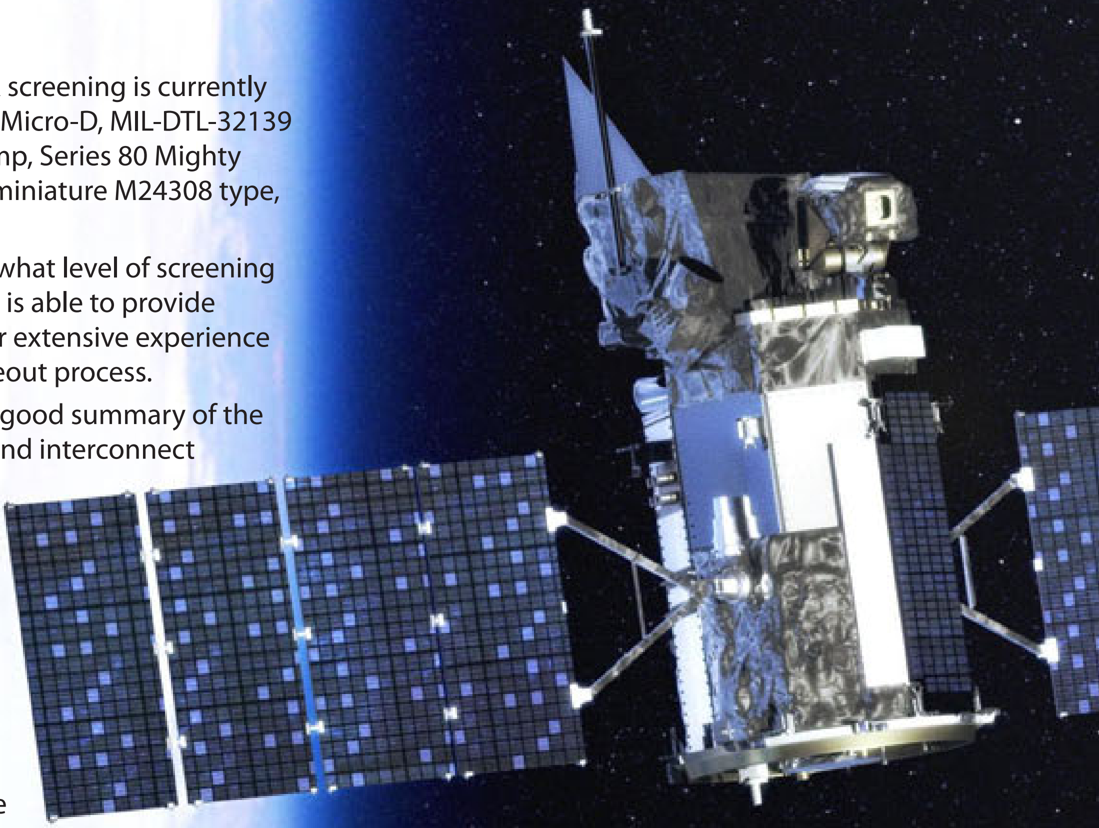
OUTGASSING

Outgassing (sometimes called offgassing, particularly when in reference to indoor air quality) is the release of a gas that was dissolved, trapped, frozen or absorbed in some material. For example, research shows the concentration of carbon dioxide in the Earth's atmosphere has sometimes been linked to ocean outgassing. Outgassing can include sublimation and evaporation which are phase transitions of a substance into a gas, as well as desorption from cracks or internal volumes and gaseous products of slow chemical reactions. Boiling is generally thought of as a separate phenomenon from outgassing because it consists of a phase transition of a liquid into a vapor made of the same substance. Outgassing is a challenge to creating and maintaining clean high-vacuum environments. NASA and ESA maintains a list of low-outgassing materials to be used for spacecraft, as outgassing products can condense onto optical elements, thermal radiators, or solar cells and obscure materials not normally considered absorbent can release enough light-weight molecules to interfere with industrial or scientific vacuum processes. Moisture, sealants, lubricants, and adhesives are the most common sources, but even metals and glasses can release gases from cracks or impurities.

The rate of outgassing increases at higher temperatures because the vapor pressure and rate of chemical reaction increases. For most solid materials, the method of manufacture and preparation can reduce the level of outgassing significantly.

This mod-code system for NASA screening is currently available for Glenair MIL-DTL-83513 Micro-D, MIL-DTL-32139 Nanominiature, Series 79 Micro-Crimp, Series 80 Mighty Mouse, MIL-DTL-38999 type, D-Subminiature M24308 type, and Filter connectors.

Typically the customer dictates what level of screening their project must meet, but Glenair is able to provide considerable guidance based on our extensive experience with the testing, screening and bakeout process.



The outgassing table below is a good summary of the main materials used in connectors and interconnect accessories that are subject to outgassing, but before any special space-grade processing such as bakeout or thermal vacuum outgassing.

The critical columns in this table are the Total Mass Loss or "TML %" which cannot exceed 1.00% of the total initial mass and Total Collected Volatile Condensable Material or "TCVCM," which cannot exceed 0.10% of the mass.

Grommets and Seals | **Environmental O-rings** | **Dielectric Insulators** | **Coupling Nut Retainers** | **Potting Compounds** | **White Epoxy Marking Ink**

Outgassing Properties of Materials Used in Glenair Connectors

Component	Material	TML %	TCVML %	Test Reference
Front and Rear Insulator	Liquid Crystal Polymer Vectra C130	0.03	0.0	NASA Test # GSC17478
Rear Grommet Interfacial Seal Peripheral Seal	Blended fluorosilicone/silicone elastomer, 30% silicone per ZZ-R-765, 70% fluorosilicone per MIL-R-25988	0.48	0.14	Glenair testing conducted at NuSil Technology 02/27/2001
Front-To-Rear Insulator Bonding Material	Eccobond 104 A/B	0.52	0.08	Emerson & Cuming Data Sheet
Insulator-to-Rubber Bonding Material	DC3145 RTV, per MIL-A-46146	2.52	0.58	NASA Test GSC28621
Coupling Nut Retainer	Torlon® 4203L	1.88	0.01	Glenair Test at NuSil Technology 03-12-2003
Coupling Nut Epoxy	Hysol C9-4215	0.48	0.01	Glenair Test
O-Ring	Fluorosilicone Rubber	0.32	0.03	NASA Test GSFC8687
White Epoxy Ink for Silkscreening	Markem 7224 White	0.49	0.03	NASA Test #GSC19899
Potting Compound, Solder Cup and PC Tail Connectors	Hysol C9-4215	0.48	0.01	Glenair Test
Potting Compound, Solder Cup and PC Tail Connectors	DC3145 RTV, per MIL-A-46146	2.52	0.58	NASA Test GSC28621
Potting Compound, Filter Receptacles	Stycast epoxy, 2850FT/Catalyst 11	0.29	0.02	Mfgr Data Sheet

Space-Grade Knowledge

SOLAR AND COSMIC RADIATION

The ultraviolet (UV) radiation from the Sun (without our protective ozone layer and atmosphere to protect us) would be enough to rapidly give you sunburn, melanoma, and other ill effects. However, unless spacesuit or spacecraft windows are specifically designed to let UV pass through, enough will be blocked that you don't have to worry about it too much.

When the Sun flares, it produces x-rays, gamma-rays, and energetic particles. The energetic particles are the worst and a bad solar flare can kill someone in space by radiation sickness.

The hard radiation (particles and x/gamma rays) from the non-flaring Sun is small compared to the galactic cosmic ray exposure. These cosmic ray particles come from deep space more or less continuously. Using very conservative rules of thumb, a week in space's cosmic ray environment will shorten your life expectancy by about a day. Since space is inherently dangerous at the present state of the art, cancer due to cosmic rays is relatively small additional risk.

Outgassing Processing for Fluorosilicone

Processing Method	Total Mass Loss TML	Pass/Fail	Collected Volatile Condensable Material CVCM	Pass/Fail
No Special Processing	0.97%	Pass	0.14%	Fail
48 Hour Bake @ 175° C	0.10%	Pass	0.03%	Pass
24 Hour Thermal Vacuum Outgas @ 125°C	0.17%	Pass	0.04%	Pass

Here is another figure for reference, this time on fluorosilicone, a common material used for interfacial seals in connectors. Note it details the TML and CVCM for the material before and after processing.

Job Four: Preventing Atomic Oxygen Corrosion

In low Earth orbits (LEO; altitudes of between 200 km and 700 km), satellites encounter the very low density residual atmosphere composed primarily of oxygen in an atomic state. A satellite moves through the atomic oxygen at a velocity of about 7.5 km/sec. Although the density of atomic oxygen is relatively low, the flux is high. The large flux of atomic oxygen, which is in a highly reactive state, can produce serious erosion of surfaces through oxidation. Thermal cycling of surfaces, which go in and out of the earth's shadow frequently in this orbit, can remove the oxidized layer from the surface. Some surfaces respond differently by changing dramatically their surface structure and therefore properties, which are important for spacecraft thermal control.

Since atomic oxygen density varies strongly with altitude, strong variations are also expected in atomic oxygen effects, and in a decaying satellite orbit such as Long Duration Exposure Facility (LDEF), most of the damage is caused towards the end of the mission.

Whenever we talk about our space-grade capabilities, we feel compelled to mention the golden umbilical life support cable built by Glenair for use by in the first spacewalk in 1965. This was a complex cable assembly with an exacting set of performance requirements—one of which included immunity from the corrosive effects of atomic oxygen. Commander White's umbilical support cable, and the many interconnect components we build today for use in exposed interconnect systems in LEO, was able to resist atomic oxygen corrosion due to the purity (nobility) of the gold plating.

Job Five: Surviving Temperature Extremes

When calculating the temperature in space, it is important to understand that estimates must take into account the varied makeup of space. Outer space is usually considered to be the portion of the universe that is almost entirely empty and, from the point of view of Earth, officially begins at an altitude of about 62 miles (100 kilometers) above sea level. In the void between planets, star systems and galaxies, the temperature in space is generally considered to be 2.725 Kelvin which is -454.72°F (-270.4°C). This is only a very small amount above absolute zero, the coldest possible temperature at which the movement of all matter ceases at -459.67°F (-273.15°C).

NASA Astronaut Ed White made history on June 3, 1965, when he floated out of the hatch of his Gemini 4 capsule into the void of space for the first American spacewalk. White was attached to the capsule by a 25 foot umbilical cord, Manufactured by Glenair. The golden umbilical was displayed for more than a decade at the Smithsonian National Air and Space Museum in Washington, DC.

Measuring the temperature in space is more complicated than just using a thermometer, since temperature is only a meaningful figure when heat can be efficiently transferred from one body to another. In space, while the temperature of particles can be very high, their density is very low so the ability to transfer heat is minimal. They could be at millions of degrees in the Kelvin range, but since they so rarely collide with one another, the actual phenomenon of temperature or heat exchange doesn't takes place. The temperature in space therefore has to do with the movement and concentration of the molecules, which in turn determines how often they collide with one another to gain or lose energy.

Due to this phenomenon, the temperature must be determined using Planck's law, which says that every object in the universe emits radiation according to its temperature. By looking at the radiation emitted from space and using this formula, scientists have found that the temperature is about 2.725 K. Different parts of space actually have different temperatures, and the Milky Way galaxy — where the Earth is located — is slightly warmer than many other areas.

Designing interconnects for space requires an in depth understanding of peak temperature and cycling stress in metal, glass and polymer materials. The combination of temperature extremes and other stress factors, such as corrosion, can also lead to performance degradation and must be accounted for in designs and material selections.

Space-Grade KNOWLEDGE

SHOOTING STARS

How are shooting stars made and how often do they occur during the night?

There are many little chunks of rock present in space. Their sizes range typically from the size of a grain of dust to the size of a golf ball (the latter being more impressive in the night sky, but also more rare). As the Earth moves around the Sun, its atmosphere runs into some of these small rocks at great velocities. Going through the atmosphere, the rocks begin to heat up, start to glow, and then burn up. This is what we see when we look at a shooting star (which we call a meteor). Anything above a few kilograms should make it to the ground, depending on the composition. There are millions of particles colliding with the atmosphere every day. But since you can only see them at night, and you can only look at a small part of the sky at once, when stargazing you can expect to see a shooting star every 10 to 15 minutes.

Job Six: Resolving Ferromagnetic Material Issues

In electromagnetism, permeability is the measure of the ability of a material to support the formation of a magnetic field within itself. In other words, it is the degree of magnetization that a material obtains in response to an applied magnetic field. Magnetic permeability is typically represented by the Greek letter μ.

Permeability is the measure most commonly employed by interconnect engineers. The more conductive a material is to a magnetic field, the higher its permeability. While this property may be desirable in certain applications, it is verboten in interconnect systems serving certain classes of electronic equipment where even low levels of magnetism can effect circuit performance and degrade signal clarity. Metal materials (see sidebars) that are generally free of ferromagnetic properties include aluminum, titanium, copper and austenitic stainless steels. Interconnect designers generally avoid ferromagnetic materials, such as the carbon steels formerly used in many MIL-DTL-24308 D-Subminiature connectors, which can interfere with sensitive instruments. As a benchmark, connectors and other interconnect components with a maximum permeability of 2 μ are generally required for space. Additionally, D-Subminiature interconnects must not exceed residual magnetism of 20 gamma for Level C testing—to achieve this requirement, brass shell materials with gold over copper flash finish are typically used.

Job Seven: Adhering to Known Prohibitions

Several general prohibitions exist for materials which may not be used in space applications, including: Cadmium plating, due to sublimation regardless of underplate; Zinc plating, due to sublimation regardless of underplate; Dissimilar metals for all connector parts (refer to MIL-STD-889 for metal compatibility); recycled (regrind) dielectric materials; Silver underplate or overplate (as it becomes nonconductive from atomic oxygen); localized contact finish (contacts must have uniform plating over engagement area); Polyvinylchloride; and pure Tin.

Job Eight: Qualifying to Performance Standards

NASA-STD-7001A, Payload Vibroacoustic Test Criteria, sets overall policy for random vibration testing of flight hardware. The standard calls for random vibration workmanship testing in a hard-mounted test configuration to screen electrical and mechanical products for flaws and hidden defects. Additionally, the standard establishes a minimum workmanship random vibration threshold for electrical, electronic, electromechanical, mechanical components and mechanisms weighing less than 50 kg (110 lbs.). An industry study found more than 80% of all of their component failures for space vehicles are due to workmanship quality and assembly issues. The Workmanship vibration test can detect defects not detectable by thermal screens such as loose contact, debris, loose hardware and mechanical flaws.

Typical Workmanship issues include: Loose electrical connections; Loose nuts, bolts, etc.; Physical contaminants (loose foreign matter); Cold solder joints and solder voids Incomplete weld joints; Defective piece parts; Improperly crimped connections; Wire defects; Insufficient clearance; Shrinkage of or too soft potting material; Wire fatigue failure due to routing; Loose or missing mounting hardware.

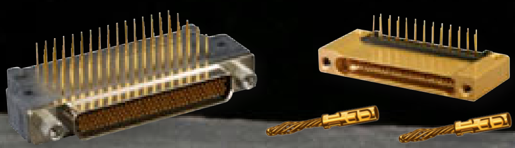
Here is a summary of the key space-grade requirements met by Glenair that broadly apply to interconnect components, as defined by NASA as well as the European Space Agency, the Japanese Aerospace Exploration Agency and the Russian Space Agency:

Glenair Conformance to Space Agency Interconnect Requirement Standards

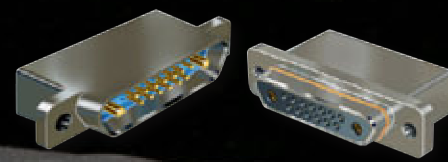
	NASA	ESA	JAXA	RKA
Non-galvanic, conductive metal materials	✓	✓	✓	✓
Low total mass loss (TML) materials	✓	✓	✓	✓
Qualified outgassing/screening procedures	✓	✓	✓	✓
Sub 2μ magnetic permeability	✓	✓	✓	✓
Cryogenic temperature capable materials	✓	✓	✓	✓
Visual inspection/workmanship standards	✓	✓	✓	✓
Air leakage level testing (hermetic only)	✓	✓	✓	✓
Resistance to soldering heat	✓	✓	✓	✓
Min/max contacts engagement and separation force	✓	✓	✓	✓
Mechanical functionality	✓	✓	✓	✓
Insulation resistance	✓	✓	✓	✓
Voltage (DWV)	✓	✓	✓	✓
Crimp termination standards	✓	✓	✓	✓

Space-Grade Interconnect Line-Card

The following interconnect technologies are all optimized for use in space application environments, from ground launch support to deep space. All are available with outgas processing and space-grade materials and plating. Chose from high-availability catalog products to build-to-order solutions—all with Glenair's "Design-Partner" promise to deliver exactly what your application demands when and where you need it.



Nanominiature and Micro-D Subminiature Connectors deliver optimal size and weight reduction and precision machined shells. TwistPin contacts perform best in high shock/vibration and high temperature applications.



Series 79 Micro-Crimp is the crimp contact equipped high-performance rectangular with outstanding shielding and sealing performance.

Series 28 HiPer-D inter-mates and mounts with standard MIL-DTL-24308 D-subs but delivers out-of-this world durability and reliability.

Series 80 Mighty Mouse is the new space industry standard for high-performance, ultra miniature connectors. Save half the size and weight compared to D38999.

MIL-DTL-38999 type special-purpose circular connectors: from unique zero-extraction force versions to EMI filters and hermetics, Glenair offers the widest range of of solutions available in the space industry.

Series 970 PowerTrip: The revolutionary, high-performance power connector for mission-critical applications.

Locking Sav-Con® Connector Savers are available for every circular and rectangular MS type connector to eliminate mating cycle wear and damage to deliverable connectors.

Special Purpose Connector Accessories and Composites: From our Space Station Qwik-Clamp to our next-generation composites solutions, Glenair Backshells reduce weight and improve performance.

Light Weight EMI Cable Shielding: Metal composite AmberStrand® and micro-filament Stainless Steel ArmorLite™ braided cable shielding provide electrical and mechanical shielding of interconnect cabling at a fraction of the weight of nickel copper.

High-Performance Connector Contacts: from QPL 39029 signal solutions to shielded data contacts, fiber optic termini and opto-electronic designs, Glenair keeps your space applications connected.

***These solutions, and dozens of others, available now from Glenair—
The Interconnect Design Partner to the Space Industry***

★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★

★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★ Safety Is No Puzzle ★

Space Facts Countdown

10 *The light hitting the earth right now is 30 thousand years old*

The energy in the sunlight we enjoy today started out in the core of the sun 30,000 years ago and spent most of this time passing through successive layers of the solar photosphere. Finally escaping into space, sunlight takes only an additional 8 minutes to reach earth.

9 *The moon is drifting away from Earth*

Scientists believe that the Earth's moon was created about 4 1/2 billion years ago when a Mars-sized object crashed into Earth and sent molten chunks into space that eventually cooled and formed into the moon. Since then, *la bella luna* has moved about 38 mm away from the Earth every year due to tidal effects that torque the earth's rotation and add angular momentum to the moon's orbit. This tidal drag will continue until the spin of the Earth and the orbital period of the moon match, allowing the moon to escape Earth's gravitational pull. But not to worry, the sun will have morphed into a Red Giant and engulfed the Earth long before this happens.

8 *If two pieces of metal touch in space, they become permanently stuck together*

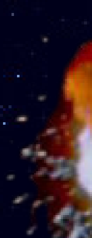
The process is called cold welding, in which two clean, flat surfaces of similar metal would bond together at the molecular level if brought into contact in a vacuum. This doesn't happen on Earth because our atmosphere puts a layer of oxidation between metal surfaces. Mechanical problems in early satellites were once attributed to cold welding. It was a suggested cause for the Galileo spacecraft's antenna deployment anomaly that occurred in 1991. However, the only empirical evidence of this so far has been in lab experiments designed to provoke the reaction.

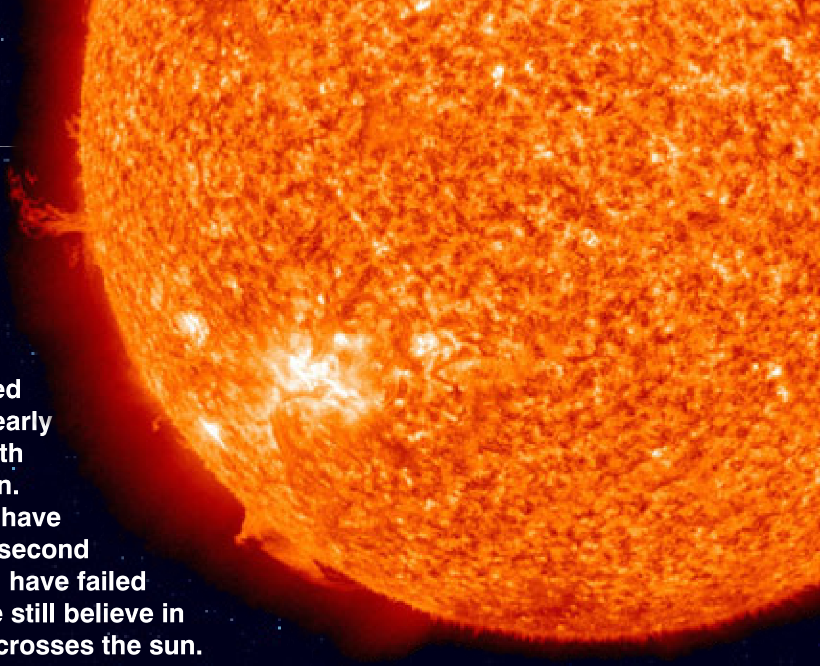
7 *If you put Saturn in water it would float*

The density of Saturn is so low that it could float on water. Saturn's density is 0.687 g/cm^3, while the density of water is 0.998 g/cm^3. Of course, Saturn has an equatorial radius of 60,268 km, so you would need an immense body of water to prove this theory.

6 *We are moving through space at the rate of 530km a second*

Our Galaxy—the Milky Way—is spinning at a rate of 225 kilometers per second, and is travelling through space at the rate of 305 kilometers per second. Which means that the Earth is traveling through space at a total speed of 530 kilometers (330 miles) per second, and that you are now about 19 thousand kilometers away from where you were when you started reading this paragraph!





5 *Earth has a second moon*

Well, not exactly… but there is an asteroid 5km across whose orbit appears to follow Earth's. Discovered in 1986 by Duncan Waldron, this periodic planetoid is named *Cruithne* (pronounced krin-yə), named after a people of early medieval Ireland. Because of its 1:1 orbital resonance with Earth, it is sometimes referred to as Earth's second moon. Since its discovery, at least three other similar asteroids have been discovered. While genuine scientific searches for "second moons" have been undertaken since the 19th century, all have failed to confirm a permanent natural satellite… although some still believe in the astrological second moon Lilith, only visible when it crosses the sun.

4 *The Big Dipper is not a constellation*

Most people think of the big dipper as a constellation but in fact, it is an asterism. An asterism is a pattern of stars in the sky which is not one of the official 88 constellations; it can also be composed of stars from one or more constellations. The Big Dipper is composed entirely of the seven brightest stars in the Ursa Major (Great Bear) constellation.

3 *The Sun is shrinking*

A stream of charged particles is being ejected from the surface of the sun. It's called Solar wind—the phenomenon that causes the aurora borealis (northern lights) as well as the tails on comets. The total number of particles carried away by solar wind is 1.3×10^{36} per second, equivalent to the mass of Earth every 150 million years. But only 0.01% of the Sun's total mass has been lost, so it should keep us warm for a while yet.

2 *Uranus was originally called George's Star*

Sir William Herschel discovered Uranus in 1781, using a telescope of his own design. He originally thought it was a comet, but when astronomers agreed that it was indeed a planet, Herschel was given the honor of naming it. He chose "Georgium Sidus" (George's Star) after his new patron, King George III. Herschel wrote:

"In the fabulous ages of ancient times the appellations of Mercury, Venus, Mars, Jupiter and Saturn were given to the Planets, as being the names of their principal heroes and divinities. In the present more philosophical era it would hardly be allowable to have recourse to the same method… The first consideration of any particular event…seems to be its chronology: if in any future age it should be asked, when this last-found Planet was discovered? It would be a very satisfactory answer to say, 'In the reign of King George the Third."

Not surprisingly, this name was not popular outside of Britain. German astronomer Johann Elert Bode, who determined the orbit of the newly discovered planet, took recourse to the ancient method and suggested the name Uranus, after the Greek god of the sky.

1 *Space is silent*

Like the theoretically infinite universe, silence in space is endless. On Earth, sound travels in waves that vibrate air molecules. But in the vacuum of space there aren't any molecules to conduct sound. Even a catastrophic explosion in space would be perfectly silent…and not a soul would hear your scream.

Space-Grade Screening and Mod Codes

The information below explains NASA guideline for connector selection, screening and outgassing and provides step-by-step instructions for connector screening to meet NASA EEE-INST-002.

What is NASA screening?

NASA specification EEE-INST-002 provides instructions on selecting, screening and qualifying parts for use on NASA GSFC space flight projects. Table 2A in the NASA specification contains inspection instructions for circular connectors including MIL-DTL-38999. Glenair qualifies our original and proprietary connector solutions by similarity.

What screening level is required?

NASA defines three levels of screening: level 1 for highest reliability, level 2 for high reliability, and level 3 for standard reliability. Level 3 equates to standard lot acceptance inspection. Levels 1 and 2 call for additional testing.

How to Order Space Grade Connectors
Step 1: Find a Standard Glenair Connector Part Number Electroless nickel plated shells are preferred for space flight. Cadmium plating is prohibited.
Step 2: Select a NASA Screening Level The term "Screening Level" refers to the final inspection procedure. Level 1 for mission-critical highest reliability Level 2 for high reliability Level 3 for standard reliability
Step 3: Choose Outgassing Processing As explained, the fluorosilicone rubber seals commonly used on aerospace-grade connectors such as MIL-DTL-38999 and Series 80 connectors, along with certain bonding agents and inks, do not meet NASA outgassing requirements unless the connector is specially processed. Glenair outgassing tests have shown oven baking or thermal vacuum outgassing processing are sufficient to reduce outgassing levels to NASA standards. Oven baking is more economical than thermal vacuum outgassing.
Step 4: Select the Mod Code that Matches the Desired Level of Screening and Outgassing Use the following table to choose the right modification code. Add the mod code to the connector part number. Example: 801-007-16M6-7PA-429C

NASA screening levels and modification codes

NASA Screening Level	Special NASA high-reliability screening and processing	Special Screening Plus Outgassing Processing	
		48 Hour Oven Bake @ 175° C.	Thermal Vacuum Outgassing 24 hrs. @ 125° C.
Level 1 Highest Reliability	Mod 429B	Mod 429J	Mod 429C
Level 2 High Reliability	Mod 429	Mod 429K	Mod 429A
Level 3 Standard Reliability	(Use standard part number)	Mod 186	Mod 186M

Space-Grade KNOWLEDGE

Galvanic Corrosion/ Galvanic Compatibility

If two or more dissimilar materials are in direct electrical contact in a corrosive solution or atmosphere, galvanic corrosion might occur. The less resistant material becomes the anode and the more resistant the cathode. The cathodic material corrodes very little or not at all, while the corrosion of the anodic material is greatly enhanced.

In the construction of a satellite, two metals that form a compatible couple may have to be placed in close proximity to one another. Although this phenomena may not cause anomalies or malfunctions in space, spacecraft stored on earth for considerable periods may inadvertently be exposed to environments where galvanic corrosion can take place. In fact, this is known to have taken place on several occasions and it is for this reason that the ESA has been studying the dangers involved.

What materials are approved for space flight?

Section C2 "Connectors and Contacts" of NASA EEE-INST-002 provides guidelines for materials used in connectors for space flight applications. Aluminum is a preferred material for connector components, and electroless nickel is the preferred finish. Beryllium copper is a preferred material for contacts. 50 microinch minimum gold plating is the preferred contact finish. LCP is a preferred material for dielectric insulating materials.

What materials are prohibited?

100% tin plating shall not be used. Pure tin can grow "whiskers" which can lead to catastrophic electrical short circuits. Silver plating is prohibited because of corrosion concerns. Cadmium is prohibited because it is unstable in vacuum environments.

Specifying connectors for space flight

Standard Series 80 connectors meet NASA guidelines for material selection. Specify "M" for aluminum shells with electroless nickel finish. The table below lists the Series 80 materials.

Connector Materials Approved for Space Flight		
Component	Material	Notes
Shells, Coupling Nuts, Jam Nuts	Aluminum alloy 6061 T6, electroless nickel plated	Approved for Space Flight
Rigid Insulators	DuPont™ Teflon® PFA	Approved for Space Flight
Contact Retention Clip	Beryllium copper, heat-treated, unplated	Approved for Space Flight
Grommet, Peripheral Seal, Interfacial Seal, O-ring	Blended fluorosilicone/silicone elastomer, 30% silicone per ZZ-R-765, 70% fluorosilicone per MIL-R-25988	Requires outgassing processing
Hermetic Insert	Vitreous glass	Approved for Space Flight
Pin Contact	Beryllium copper alloy per ASTM B197, 50 microinches gold plated per ASTM B488 Type II Code C Class 1.25 over nickel plate per QQ-N-290 Class 2, 50-100 microinches	Approved for Space Flight
Pin Contact, Hermetic	Nickel-iron alloy per ASTM F30 (Alloy 52),50 microinches gold plated per ASTM B488 Type II Code C Class 1.25 over nickel plate per QQ-N-290 Class 2, 50-100 microinches	Ferromagnetic material.
Socket Contact	Beryllium copper alloy per ASTM B197, 50 microinches gold plated per ASTM B488 Type II Code C Class 1.25 over nickel plate per QQ-N-290 Class 2, 50-100 microinches.	Approved for Space Flight
Socket Contact Hood	Stainless steel, passivated per AMS-QQ-P-35	Approved for Space Flight
Adhesives	RTV and epoxies (see following table for outgassing info)	Requires outgassing processing
Potting Compound, PCB and Solder Cup Versions	Environmental and Hermetic Connectors: Stycast 2651/Catalyst 9 epoxy encapsulant. Filter Connectors: Stycast 2850FT/Catalyst 11 thermally conductive epoxy encapsulant.	Approved for Space Flight
Filter Element	Multilayer Ceramic Planar Array, ferrite inductors	Approved for Space Flight

SpaceWire

SpaceWire is a spacecraft communication network standard. It is coordinated by the European Space Agency (ESA) in collaboration with international space agencies including NASA, JAXA and RKA. Within a SpaceWire network the nodes are connected through low-latency, full-duplex, point-to-point serial links and cables—now qualified and available from Glenair.

Space-Grade KNOWLEDGE

Halar

Halar, E-CTFE (Ethylene-ChloroTriFluoro-Ethylene) is a space-grade plastic material offering high temperature and flame resistance with excellent abrasion resistance and inertness to most chemicals and fungus. Halar is used as an overbraiding material over wires, tubing, cables, wire bundles, and wire harnesses to provide tough, durable protection and convenient, low profile bundling of bulky, multiple elements. Its high temperature, non-burning characteristics render Halar particularly suitable for aerospace applications where flammability and chemical exposure are critical issues. Halar is rated for continuous service from -62°C through 150°C and tolerates short-term exposure above 200°C. With an oxygen index of 0.48, Halar will not support combustion.

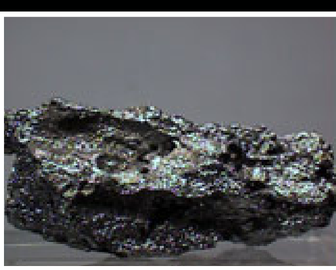
Space-Grade KNOWLEDGE

Titanium

Titanium and Ti-alloys are ideally suited for space due to their mechanical properties, temperature resistance and/or chemical resistance and in areas where operating temperatures preclude the use of aluminium alloys.

Commercially pure (CP Ti) products are normally selected for chemical resistance. Impurities in CP Titanium can increase strength but with a loss in corrosion resistance.

Titanium alloys are also typically selected for their strength, which depend on a number of specific heat-treatments (age hardening, quench and temper). The most commonly used titanium alloy is Ti6Al4V for which extensive mechanical and corrosion property data is available.

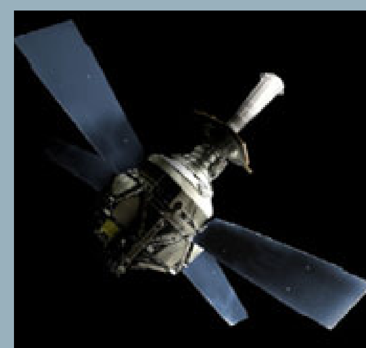


Glenair in Space

Atmospheric Infrared Sounder (AIRS)

The **Atmospheric Infrared Sounder (AIRS)** instrument will make highly accurate measurements of air temperature, humidity, clouds, and surface temperature. Glenair-built cables provide signal and power interconnection.

The **Gravity Probe** was designed to measure two key predictions of Einstein's general theory of relativity by monitoring the orientations of ultra-sensitive gyroscopes relative to a distant guide star. Glenair-built cables are on board.



Gravity Probe

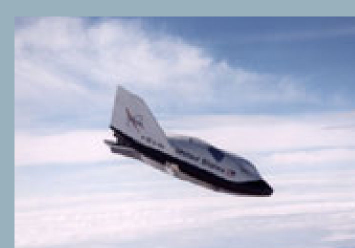
Complex interconnect cable assemblies made by Glenair have also traveled to and from orbit dozens of times on the **Space Shuttle**.

Titan II space-launch vehicles, with Glenair-made interconnect harnesses, propelled all twelve manned Gemini capsules.

Space Shuttle

Hermetic connectors are ideal for high-pressure/low-leakage applications in air, sea and space environments. Made of stainless steel (CRES) with glass insulators fused to the connector shell, and suitable contacts meeting a leak rate of 1 X 10^{-6} cubic centimeters of Helium per second, these mounted receptacle connectors and bulkhead feed thrus prevent gasses from travelling through apertures or penetrations created for the routing of interconnect cabling. Glenair hermetics have protected a range of space programs including:

The **X-38** program implemented to design and build a spacecraft capable of flying itself and the Space Station crew back to Earth in an orbital emergency.



The X-38

Pegasus rockets, the winged space booster vehicles used in an expendable launch system developed by private industry.

MetOp-A

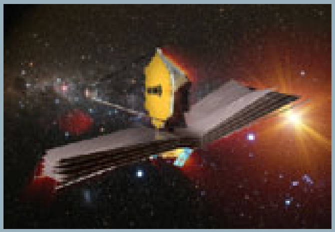
MetOp-A, Europe's polar-orbiting satellite dedicated to operational meteorology.

Designing interconnect systems which deliver clean data streams, undistorted by electromagnetic interference or pulses (EMI/EMP) is a significant challenge. A well designed interconnect system will include a complement of grounding and shielding technologies to insure EMC. EMI filter connectors, packaged in just about any connector style or interface size, are an effective method to achieve electro-magnetic compatibility. The filter device strips off unwanted signals which have grounded to conductive wires and enclosure surfaces before the signal can affect system performance.

Skynet

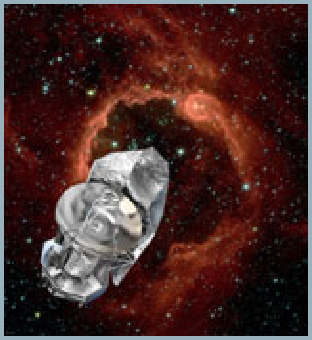
Glenair is extremely well versed in supplying filter connector products optimized for use in space-grade applications, providing products compliant to EEE-INST-002, Table 2G, the recognized standard for space grade filters. Glenair Filtered connector space applications include:

Skynet, for the United Kingdom Ministry of Defence, to provide strategic communication services to the three branches of the British Armed Forces and to NATO forces engaged on coalition tasks.



JWST

The **Lincoln Near Earth Asteroid Research (LINEAR)**, an MIT Lincoln Laboratory program funded by the US Air Force and NASA. LINEAR is dedicated to the problem of detecting and cataloging near-Earth asteroids that threaten the Earth.



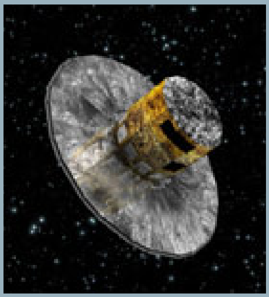
Herschel Space Observatory

The **James Webb Space Telescope (JWST)** is a large, infrared-optimized space telescope, scheduled for launch in 2014. JWST will find the first galaxies that formed in the early Universe, connecting the Big Bang to our own Milky Way Galaxy.

Micro-D connectors, including standard potted products, hermetics, filters, and flex assemblies are commonly used in space applications due to their high-performance and small size. The precision machined shell of the Micro-D, with its robust mating retention forces makes for an ideal connector for missile, rocket and space-vehicle applications that are subject to high levels of vibration and shock. The Micro-D is easily customized with package and mounting modification to fit virtually any integration challenge. Here is a selection of current and past space applications that use these miniaturized Glenair Micro-D connectors:

The **Herschel Space Observatory**, from the European Space Agency, will determine facts about Galaxy formation, Star formation, and the Chemical composition of atmospheres and surfaces of planets, comets and moons.

The European Space Agency is also developing and building the **Gaia** satellite due to be launched in 2013. Its mission is to construct the largest and most precise map to date of the Milky Way.



Gaia satellite

Space-Grade KNOWLEDGE

Copper

Copper and copper-based alloys are established materials in electrical, electronic and also in more general engineering applications. The main applications for copper in space include electrical/ electronic subsystems (wiring, terminals in soldered assemblies) and plating (electronics, thermal control, corrosion protection and so on). Electronic assemblies use wires made of high-purity copper or copper alloy and terminals of copper alloy.

Beryllium-copper (also known as copper-beryllium) is an alloy with small additions of Beryllium commonly used for spring members and retention clips particularly in high-strength, corrosion resistant components and in safety applications in hazardous environments (no sparks are produced when impacted).

Space-Grade KNOWLEDGE

Aluminum

Aluminium alloys exhibit excellent corrosion resistance in all standard tempers. However, the higher-strength alloys—which are of primary interest in aerospace applications—must be approached cautiously. In structural applications preference should be given to alloys, heat treatments and coatings which minimize susceptibility to general corrosion, pitting, intergranular and stress-corrosion cracking. MIL-DTL-38999 allows alloy configurations clad with thin layers of pure aluminium to improve corrosion performance. Corrosion must be considered during the whole manufacture and prelaunch phase. Electrolytic couples should be avoided and all metals should be suitably protected against external damage by the use of plating, conversion coatings, paints and strippable coatings. Atomic oxygen in low earth orbit (LEO) does not degrade aluminium alloys.

An earth-orbiting satellite system combining surveillance and intercept functions on a single spacecraft that would be able to detect, identify, discriminate, and track ballistic missile targets. An interceptor would destroy a missile by direct impact at high speed.

Cassini-Huygens

Cassini–Huygens is a joint NASA/ESA/ASI robotic spacecraft mission currently studying the planet Saturn and its moons.

CrIS NPOESS Satellite

CrIS is an advanced atmospheric sounding instrument being built for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). CrIS will provide accurate, detailed atmospheric temperature and moisture observations for weather and climate applications.

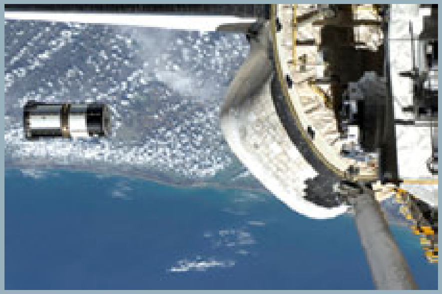
Nanominiature connectors are high-reliability ultraminiature interconnects for critical applications where size and weight restrictions will not allow the use of larger connectors. Contact spacing of 0.025 (25 thousandths) of an inch combined with a rugged twist pin contact system allow these nano connectors to be used in extremely small applications, such as satellite payloads, while still delivering reliable electrical and mechanical performance.

Glenair M32139 Class S Nanominiature connectors are DSCC approved for space programs.

LSST Telescope

Glenair Nanominiature connectors, cable assemblies and flex circuit assemblies are currently in use on the several space-based telescopes, including the **Large Synoptic Survey Telescope (LSST)**, a ground-based facility in Chile designed to provide an unprecedented wide-field astronomical survey of the universe.

The Micro-Crimp connector is a Glenair original design. It features crimp, rear-release size #23 contacts on 0.075 (75 thousandths) of an inch spacing, as well as size #12 and #16 power and coaxial crimp contacts available in 29 insert arrangements for data and power transmission. The Series 79 Micro-Crimp is ideally suited for blind-mate rack and panel and/or module-to-chassis applications. Panel mounted connectors feature conductive sealing gaskets. Right angle printed circuit board connectors have an EMI shroud to prevent electromagnetic interference. Wire sealing grommets and interfacial seals protect circuits from moisture and contamination.



A NASA LEO (Low Earth Orbit) Satellite

The Micro-Crimp connector's crimp, rear-release contact system can be terminated onto complicated, multibranch wiring harnesses without splicing or soldering. This crimp-and- poke contact feature is especially helpful in the confined spaces typical of satellites and other space craft.

A relatively new product, Micro-Crimp is nonetheless beginning to see considerable interest for space applications, in particular on LEO and GEO satellites and on the Orion Space Shuttle replacement program.

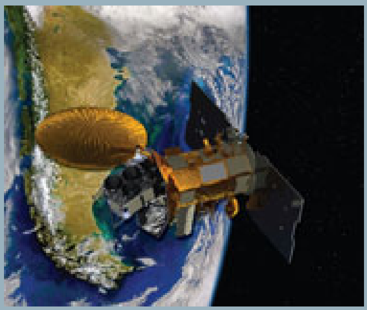
Glenair Series 80 Mighty Mouse connector and cable assemblies were developed as a smaller and lighter alternative to MIL-DTL-38999, offering virtually equal performance with up to 71% (weight) and 52% (size) savings for similar contact layouts. Mighty Mouse is well established in hundreds of safety-critical military, medical, industrial and geo-physical and space applications.

Some space applications for this reduced form factor connector include:

NASA's **Mars Exploration Rover (MER)** Mission, an ongoing robotic mission to explore the Martian surface and geology.

Mars Curiosity Rover

The Mars Science Laboratory **Curiosity** recently landed on the Marian surface. This rover is over five times as heavy and carries over ten times the weight in scientific instruments as previous rovers. It will analyze soil samples to determine Mars' ability to support microbial life.



Aquarius Satellite

Aquarius is a satellite mission to measure global Sea Surface Salinity. It provides the global view of salinity variability needed for climate studies.

The Series 80 Mighty Mouse connectors shown in the graphic below are on an experimental JPL space application.

Over the last several years, fiber optics have become increasingly popular in space environments as a medium of choice for a variety of instrument applications. Fiber offers some distinct advantages over other mediums including:

- Immunity to EMI & radiation
- Low attenuation of light power over long distances
- Wide transmission bandwidth (10 – 100 Gbps)
- Small physical size and weight
- Immunity to chemical corrosion
- Analog and digital transmission

Mighty Mouse connectors

NASA's GOES-P Geosynchronous satellite

On missile programs, we make the fiber optic cable assembly terminating a diode/laser that controls destructive pyrotechnics, in case the missile goes awry.

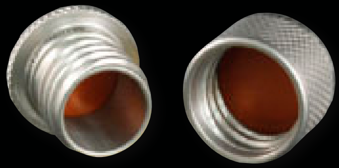
Other potential applications include several geo-synchronous satellites that use fiber optics to communicate with each other in space.

Space-Grade KNOWLEDGE

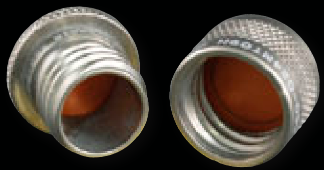
Space-Grade Plating Materials

Nickel as a protective barrier plating is used extensively in space-grade interconnect applications. Other appropriate platings for space applications include:

Electroless Nickel

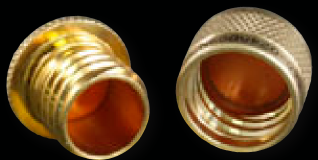


Stainless Steel



Nickel-PTFE

Plated Composite



Gold

Space-Grade KNOWLEDGE

Steels

Steels consist of alloys of iron and carbon (between 0.05% – 2%C). All steels contain additional levels of other elements. For example, plain carbon steels (up to 1.7% C) contain manganese up to about 1%Mn. Impurity levels (e.g. phosphorus and sulphur) depend mainly on the smelting and melting processes used. Alloy steels contain one or more additional alloying elements to improve properties and workability. The tensile strength of plain carbon steels increases with carbon content. Hardness increases progressively with C-content, so that low- (0.1–0.3%C) to medium-carbon steels (0.3–0.6%C) are used for various 'engineering' components, whereas high-carbon steels (0.6–0.9%C) are used for space-grade applications requiring hardness and wear resistance.

The Space Shuttle in orbit

Glenair Sav-Con® Connector Savers protect deliverable connectors subject to repeated mating and unmating cycles, especially from repetitive qualification test cycles. Sav-Con® Connector Savers prevent costly repair or replacement of cable plugs and receptacle connectors by absorbing connect and disconnect abuse and by reducing mating cycles during testing to the absolute minimum.

A virtual "Who's Who" of space programs use Glenair Sav-Cons both during fabrication testing and in operation.

One of the most dramatic applications of our Sav-Con connectors is on the **Space Shuttle Orbiter** where they provide protection for the umbilical connectors from liftoff to touchdown on every mission.

Glenair's Gamma Processed ETFE Convoluted Tubing is extruded from thermally-stable ethylene tetrafluoroethylene. With an operating temperature range of -55° C to 200° C, this tubing withstands temperature excursions to 300° C. The material is designed to protect wire conductors from all forms of mechanical damage and electromagnetic interference while offering better flexibility, ease-of-routing and assembly convenience than traditional cables.

The Mars Pathfinder rover

Metal-core conduit versions are specified for extreme crush resistance and optimal EMI shielding The helically-wound metal conduit provides extremely high levels of EMI protection across all radiation fields and frequencies. Stainless steel versions are often specified for environments with the temperature extremes of space.

For many space applications, the cable shield is the most important element in controlling EMI and radiation damage. Unfortunately, metal shielding—especially when applied in multiple layers—can be extremely heavy. AmberStrand composite thermoplastic braid provides robust EMI shielding at a fraction of the weight of metal. Additionally, AmberStrand is a corrosion-free material. ArmorLight, a lightweight plated stainless stell micro-filament braid may be applied in applications where AmberStrands plastic core is unsuitable. These unique products are in service on:

The **Cassini-Huygens** Program, an international science mission to the Saturnian system.

Mars Pathfinder delivered an instrumented lander and a free-ranging robotic rover to the surface of the red planet.

Nowhere in the world does anyone manufacture and supply such a complete selection of backshell connector accessories—for space as well as all other mission-critical applications. In addition to traditional metal materials, Glenair also manufactures an extensive line of lightweight, corrosion-free composite thermoplastic interconnect components ideally suited for systems requiring electromagnetic compatibility, long-term durability and weight reduction.

The Glenair Qwik-Clamp connector accessory shown here is used on the **International Space Station**. This gold plated part is extremely resistant to space corrosion and radiation and is designed with all smooth surfaces to eliminate potential damage to space suits.

Glenair space-grade Qwik-Clamp backshell

Here are some other Glenair backshell and connector accessory space applications:

Ariane 5

Made by the European Space Agency, **Ariane 5** launches satellites and other craft into geostationary transfer orbit GTO), medium and low Earth orbits, Sun-synchronous orbits (SSO) and Earth-escape trajectories

Sea Launch is a spacecraft launch service using a mobile sea platform for equatorial launches of commercial payloads.

As with circular backshells and accessories, Glenair has the rectangular interconnect world well covered. We supply everything from miniaturized backshells for Micro-D connectors to larger rack and panel connector accessories. Choose from traditional metals—with appropriate plating for space use—and light weight composite thermoplastic materials. Glenair rectangular accessories are used on dozens of space programs.

Sav-Con® Connector Savers are the smart solution for preventing contact damage and reducing mating and demating cycles on mission-critical connectors

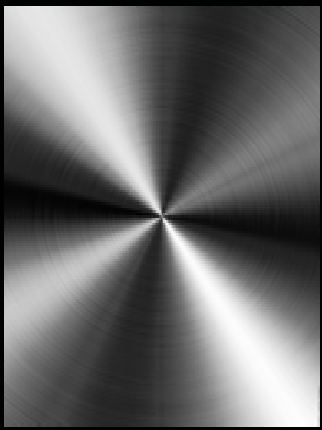
Available Sav-Con® Series Solutions

- MIL-DTL-26482 Series I and II
- MIL-DTL-28840
- MIL-DTL-38999 Series I, II and III
- MIL-DTL-83733
- LN 29729 (SJT)
- PATT 105 and PATT 602
- MIL-DTL-5015
- Series 801 and 805 Mighty Mouse
- M24308 Subminiature
- Micro-D Subminiature UniSaver
- Filtered Micro-D Subminiature
- Hermetic Solutions
- Series 28 HiPer-D
- Series 79 Micro-Crimp
- EMI/EMP Filter Specials

Space-Grade KNOWLEDGE

Stainless Steels

Stainless steels—or corrosion-resistant steels alloyed with at least 12% Chromium—incorporate an adherent, self-healing oxide film to reduce corrosion. In addition to corrosion resistance, stainless steels also provide oxidation resistance, creep resistance, toughness at a broad range of temperatures. Austenitic steels of the 300-series are generally resistant to stress-corrosion, cracking, and exhibit extremely low levels of magnetic permeability. Use of stainless steels in spacecraft center on applications requiring corrosion resistance (e.g. storage and handling of liquids and waste), components within some thermal protection systems and connectors requiring high-strength and temperature tolerance.



Outlook

One Era Ends, Another Begins

Recent Space Shuttle retirement celebrations remind us just how long Glenair has been "in space," and how our future "in space" never looked brighter. Space Shuttle Endeavor made the trip to Southern California last month and, during transport, it was flown on its Boeing 747 transport directly over the Glenair Global Headquarters building in Glendale, California (Glenair employees snapped the photos at right with smart phones as the Endeavor flew overhead).

As you read on several pages in this edition of *QwikConnect*, Glenair products from cable assemblies to Sav-Con® Connector savers, to backshells and accessories played key roles in the Space Shuttle program. In fact, our space *bona fides* go all the way back, even before the golden umbilical life support cable built by Glenair for use by in the first spacewalk in 1965. Since man has been in space, so has Glenair.

"Glenair in Space," beginning on page 18, highlights a number of our past, current and future Space applications and reference accounts. The NASA Mars Exploration Rover Mission and the Mars Science Laboratory *Curiosity* have enjoyed considerable recent success and media attention. Glenair Series 80 Mighty Mouse connectors, cables and related products helped put Curiosity on Mars.

Domestic or international, public or private, commercial or military, Glenair will continue to look back to the blue planet for as long as man ventures into space.

Chris Toomey

QwikConnect
GLENAIR ▪ VOLUME 16 ▪ NUMBER 4

Publisher
Christopher J. Toomey

Executive Editor
Marcus Kaufman

Managing Editor
Carl Foote

Editor/Art Director
Mike Borgsdorf

Graphic Designer
George Ramirez

Technical Consultant
Jim Donaldson

Issue Contributors
Deniz Armani
Greg Brown
Greg Cameron
Ken Cerniak
Brendan Dempsey
Guido Hunziker
Christian Koppe
Mike MacBrair

Distribution
Terry White

QwikConnect is published quarterly by Glenair, Inc. and printed in the U.S.A.

A complete archive of past issues of QwikConnect is available on the Internet at www.glenair.com/qwikconnect

GLENAIR, INC.
1211 AIR WAY
GLENDALE, CA 91201-2497
TEL: 818-247-6000
FAX: 818-500-9912
E-MAIL: sales@glenair.com
www.glenair.com

Glenair®