OMNETICS
CONNECTOR CORPORATION

# THE HIGH-SPEED NANO-D:
# Merging the Needs for a Miniature, Ruggedized Connector with the Need for High-Speed

As the complexity of modern defense systems and the demand for satellites increase, there is a need for interconnects that are not only miniature and rugged but can also transfer high-speed data. Historically, these solutions have been mutually exclusive– connectors are either miniature and rugged or they are high-speed. It is only recently that reliable solutions have become available that merge these separate solutions into one. Manufacturers of miniature, rugged connectors are finding ways to maximize the signal throughput without sacrificing the reliability and ruggedness that many applications require.

## The Need for Miniaturization

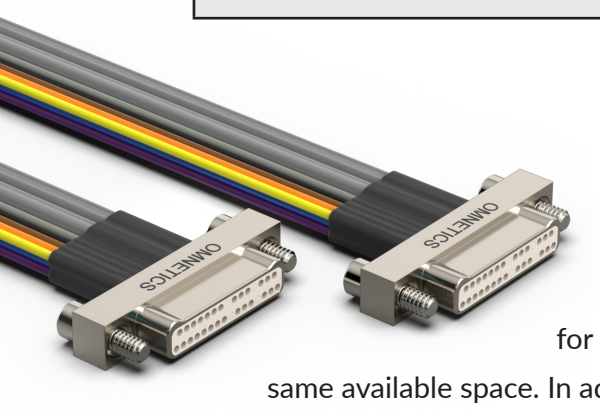
Connector design over the past few decades has demonstrated an insatiable need for size and weight reduction. In the past, the most successful connectors were either MIL-DTL-38999 connectors or Mighty Mouse series connectors. These connectors still exhibit great success in the industry, but many users sought smaller solutions through Micro-D (MIL-DTL-83513) connectors. Not surprisingly, in the never-ending pursuit for smaller and lighter, the Nano-D connector (MIL-DTL-32139)

was introduced and has found great success as a premier solution for next-generation systems.

## Nano-D Connector Strengths

The primary strength of the Nano-D lies in its ability to significantly reduce weight and size while remaining a reliable solution in extreme environments. In order to get an idea of size, the below table shows the pin-to-pin spacing of many of the common connector families.

| PRODUCT FAMILY | PIN SPACING |
|---|---|
| MIL-DTL-38999 | 0.100” and up |
| Mighty Mouse Connector | 0.076” |
| Micro-D (MIL-DTL-83513) | 0.050” |
| Nano-D (MIL-DTL-32139) | 0.025” |

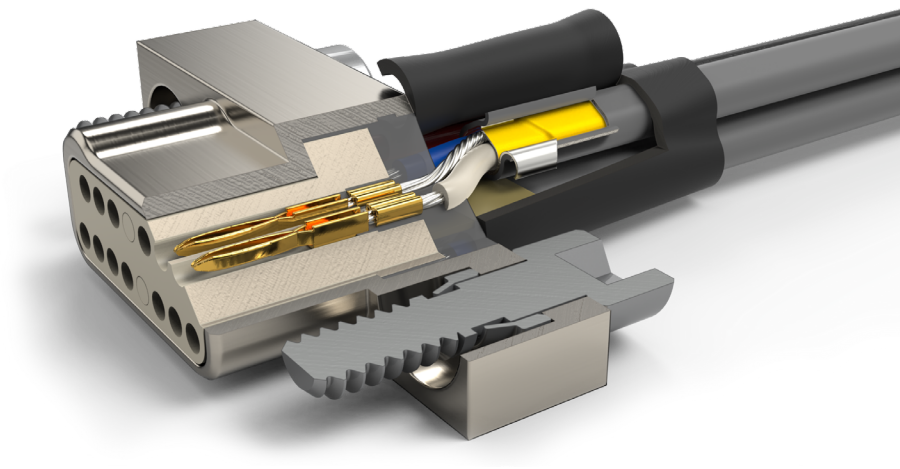



The size reduction in Nano-Ds allows designers to increase pin count within a similar footprint, allowing for more functionality within the same available space. In addition to space savings, there is significant weight reduction, as the Nano-D typically weighs only about a quarter of its Micro-D counterpart; for example, a 21 position Micro-D weighs approximately 2.4 grams while a comparable Nano-D weighs approximately 0.5 grams. This is of great importance for aerospace industry, where mass on satellites is scrutinized to the gram.

For some applications, there are trade-offs that must be considered when selecting the Nano-D. Each Nano-D contact can support a maximum current flow of about 1 Amp, compared to 3 Amps for the Micro-D. While contact resistance through the connector remains low, the standard wire for Nano-D is 30AWG which carries a higher resistance than a 26AWG wire (the standard for the Micro-D).

## Resilience in Extreme Environments

Nano-D connectors are designed to perform in the world’s most extreme environments, particularly those characterized by high levels of shock and vibration. Due to their lower mass, Nano-D connectors can withstand higher levels of mechanical stress than Micro-D variants, as well as nearly all other larger connectors. Per the MIL-DTL-32139 specification, they must withstand 20g of vibration (same as Micro-D) and 100g of shock (twice the 50g shock rating of the Micro-D).

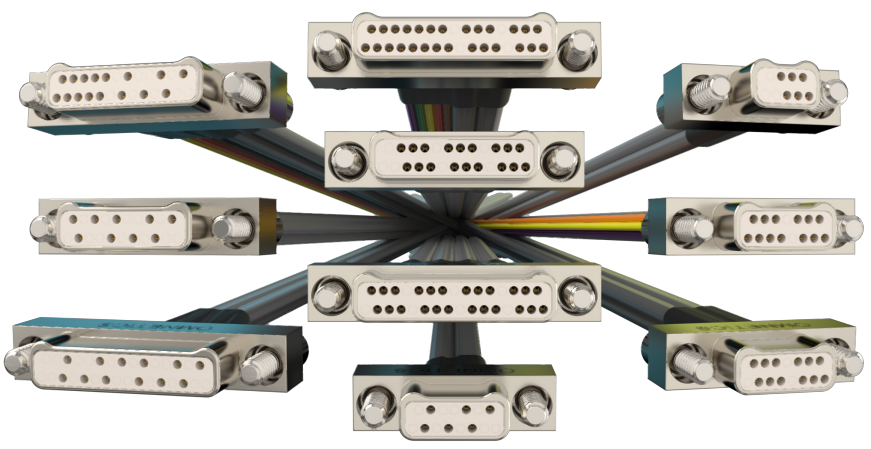


In specialized ballistic applications, these lightweight connectors have even demonstrated the ability to survive shock environments exceeding 10,000g.

Thermal resilience is another hallmark of the Nano-D. These connectors perform across a wide specified operating temperature range of -55°C to +125°C. For ultra-high-temperature requirements, manufacturers like Omnetics Connector Corporation offer options to increase this limit to +260°C upon request.

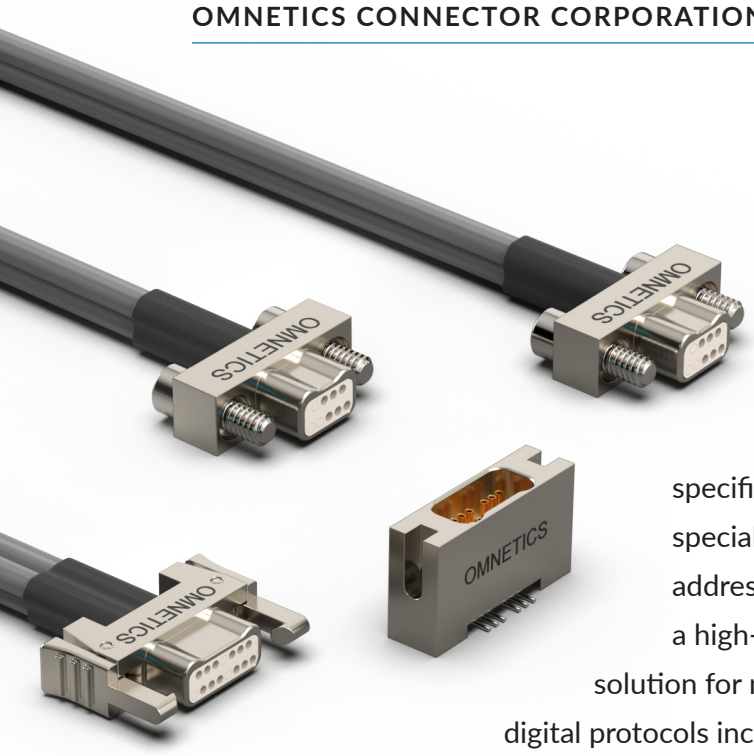
## Space Qualification and Global Standards

Due its small size and weight, the Nano-D is an ideal solution for modern satellite and space flight technology. In addition to the weight reductions mentioned above, the Nano-D in manufactured with low-outgassing materials. The reliability of the Nano-D connector family is backed by qualifications from the world’s leading space agencies, including NASA (National Aeronautics and Space Administration), the ESA (European Space Agency), JAXA (Japan Aerospace Exploration Agency), and ISRO (Indian Space Research Organization).



## The Evolution to High-Speed Connectivity

As data rates for some military and aerospace applications increase, there became a demand for a high-speed solution in the Nano-D form factor, which the High-Speed Nano-D is designed for. The High-Speed Nano-D is an offshoot of the Nano-D product line – using the same hardware and components while relying on modifications to the pinouts, cabling, and assembly to yield high-speed performance while maintaining the ruggedness parameters of the MIL-DTL-32139




specification. This specialized interconnect addresses the need for a high-performance solution for multi-gigabit digital protocols including Ethernet and other high-speed digital signals.

## The Challenges of High-Speed Design

High-speed signaling introduces new challenges to connector design that need to be considered. One key consideration is impedance. Electrical signals reflect back to the source whenever the path impedance deviates from the application impedance, and the magnitude of the reflection is related to the speed of the signal. At very low speeds, the reflection is negligible, which is why impedance is not an issue for these applications. But At high speeds, the reflections can destroy the ability of the system to transfer accurate data. It is for this reason that the impedance of the cable and the connector are important.

## What is Impedance?

Impedance is different than resistance. Resistance is a point-to-point measurement that is typically measured between the ends of a component or path. Impedance, on the other hand, is a value that is based on the cross-section at any given path. That is, there is not one single impedance for any given component but instead a specific impedance can be provided for any point along the path. The many cables and connectors that do state a single impedance value are stating a value that the product maintains (within some tolerance) throughout the path.

At a basic level, the impedance is determined by the size of the conductor, the distance between the conductors, and the distance to ground[1]. For cables, this means the impedance is determined by the wire gauge, the insulation diameter (which determines the minimum spacing between the signal wires), with the cables generally having a shield around the wires to maintain a close ground reference.

For connectors, the impedance is determined by the pin diameter and the pin-to-pin spacing of the connector, with a ground pin in very close proximity whenever possible.

## The Process: Making a Connector “High-Speed”

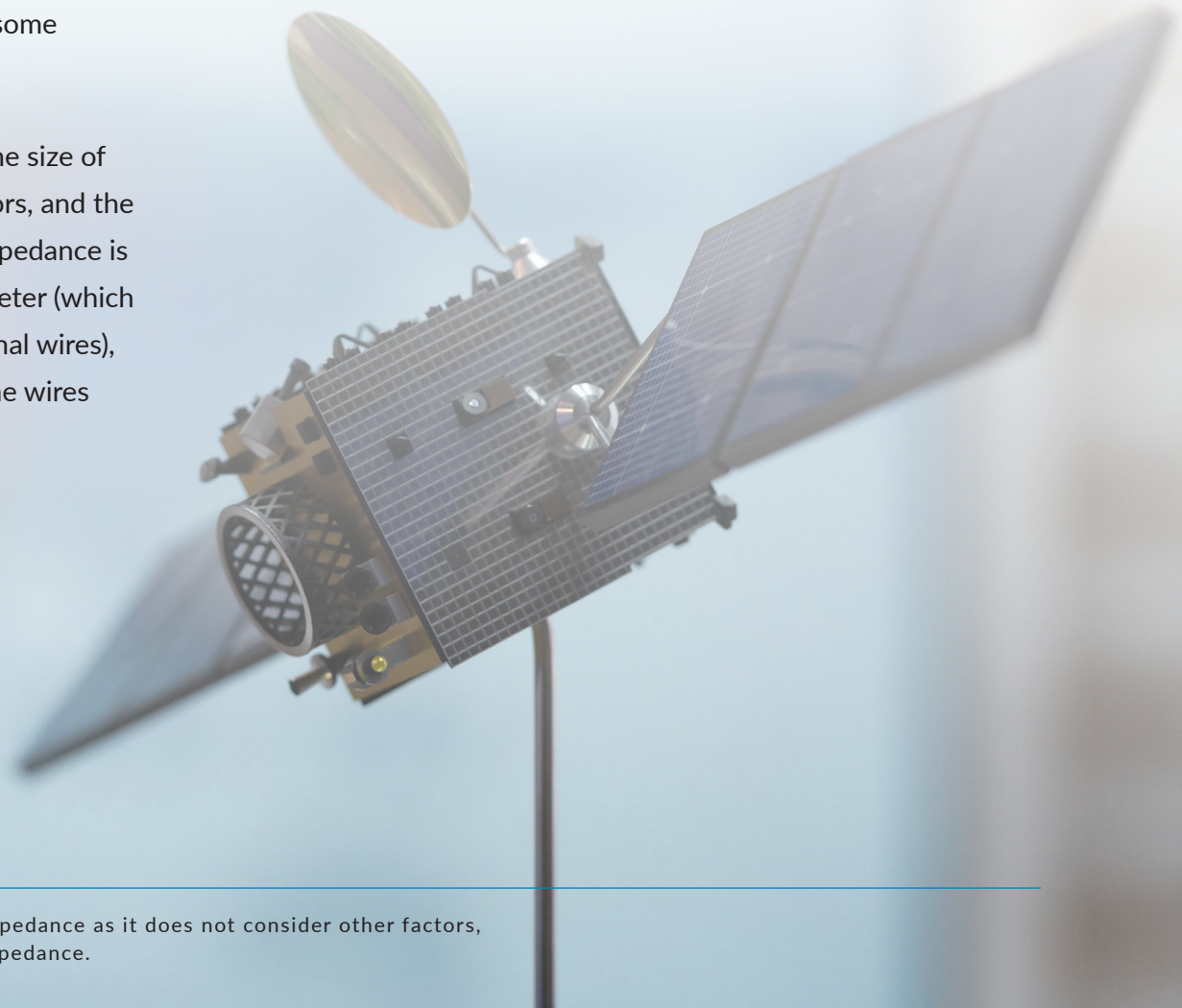
Transforming a standard Nano-D into a high-speed variant requires several technical enhancements and design refinements to ensure signal integrity. A 30AWG 100 Ohm impedance cable generally requires wire with insulation diameters around .035”. This is much larger than the .025” that the connector pins are spaced at, so the connector cannot be fully populated.

Additionally, it is critical to properly manage the shield on the high-speed pairs as the shield plays a critical role in maintaining proper impedance. When crimping a pin to the wire and inserting the pin into the connector, a portion of the shield must be removed in order to allow space for the operator. However, the portion of the shield that is removed must be kept to a minimum in order to minimize the impact on performance. Lastly, the shield must be connected to a pin in close proximity, either by soldering or crimping a pin directly to the shield.

The difficulty of all this is magnified in the Nano-D by the fact that there is very little space to ensure this is all achieved.

## Expected Performance

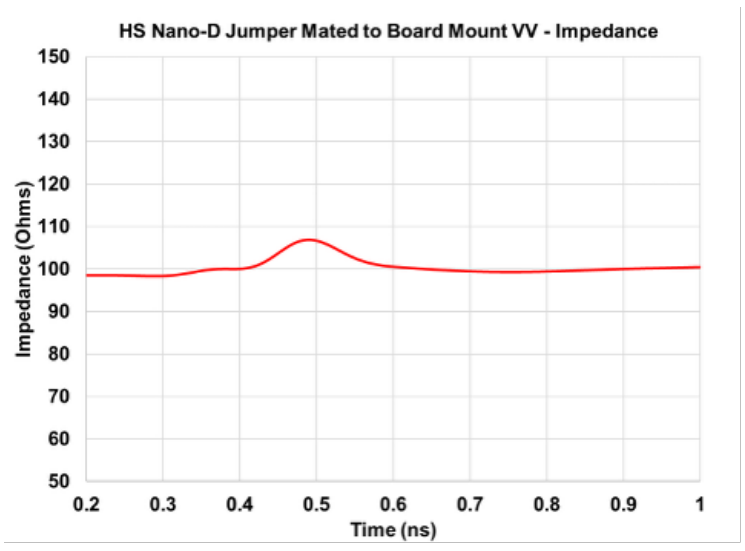
The High-Speed Nano-D provides impressive data performance benchmarks that compare favorably to larger, non-rugged, industry-standard high-speed connectors. Because it is built upon the MIL-DTL-32139 standard, it sacrifices none of the ruggedness of the original Nano-D line.

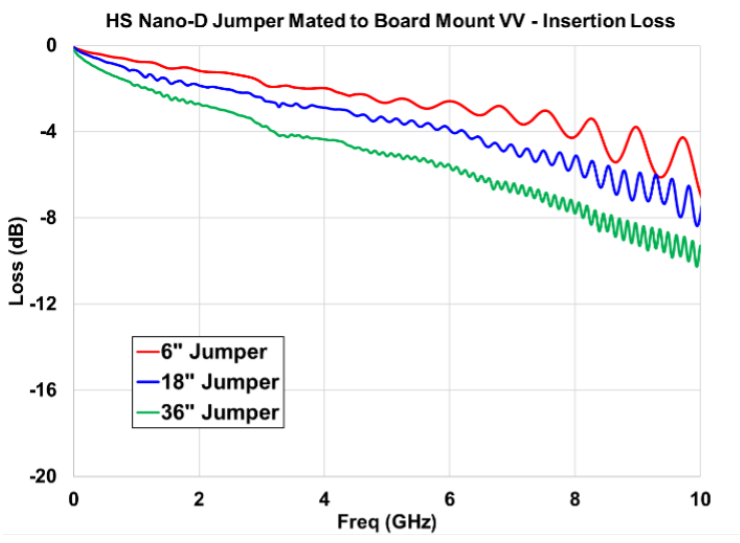


[1] This description provides a 1st order approximation of impedance as it does not consider other factors, such as insulator material, which can have an impact on impedance.

## Nano-D High-Speed Performance – Vertical Surface Mount

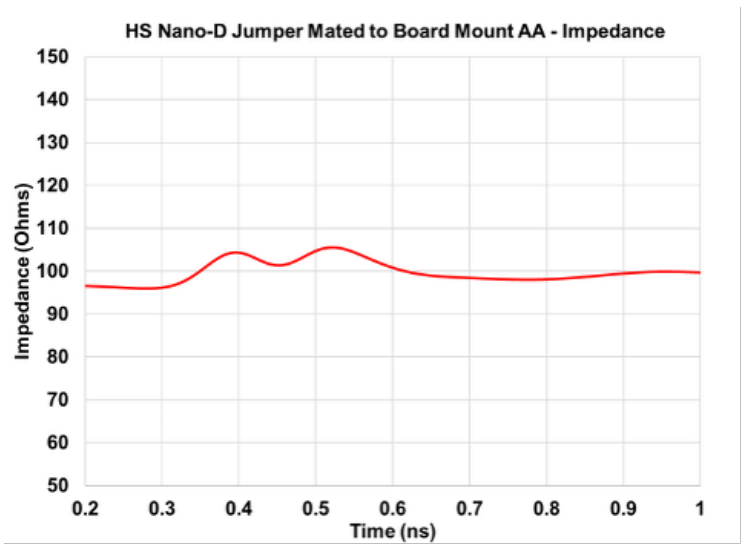
Below is the impedance and insertion loss for a High-Speed Nano-D jumper mated to vertical surface mount connectors ('VV') on both ends.

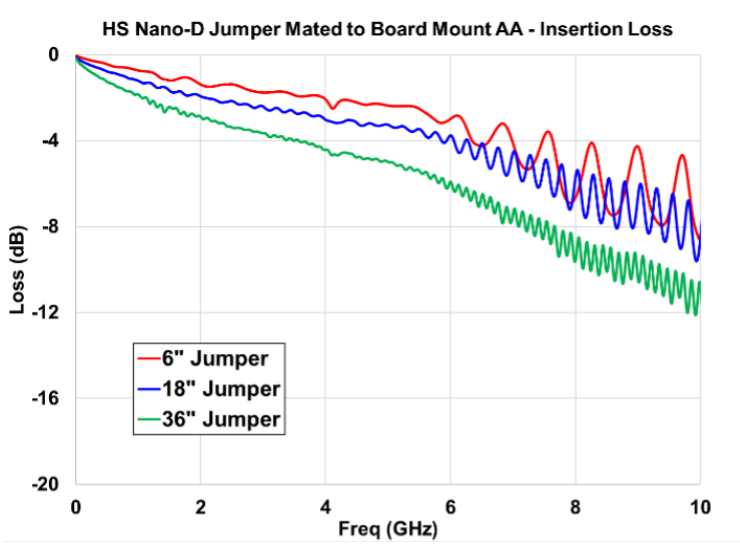



## Nano-D High-Speed Performance – Horizontal Surface Mount

Below is the impedance and insertion loss for a High-Speed Nano-D jumper mated to horizontal surface mount connectors ('AA') on both ends.




## Performance Summary

An industry standard method of approximating data rate is based on insertion loss using the -7dB insertion loss point (and multiply by 2 to get data rate in Gbps). Using this method, the table below shows the expected data rates[2]:

| JUMPER LENGTH | DATA RATE (Mated to Board Mount AA) | DATA RATE (Mated to Board Mount VV) |
|---|---|---|
| 6" | 17 Gbps | 20+ Gbps |
| 18" | 16 Gbps | 19 Gbps |
| 36" | 13 Gbps | 15 Gbps |

## Conclusion

The High-Speed Nano-D represents an excellent solution for the merging of two interconnect families – the miniature, ruggedized connector and the high-speed connector. By combining the proven mechanical reliability and extreme environmental resilience of the MIL-DTL-32139 standard with improvements that allow for excellent high-speed performance, the High-Speed Nano-D is an excellent solution to meet the needs of the latest generation of electronics. Whether utilized in a soldier-worn surveillance device, or a deep-space satellite, the Nano-D provides the necessary size and weight specifications along with data throughput required for the next generation of electronic innovation.

[2] There are two different pinouts in the High-Speed Nano-D. The table refers to the High-Speed version which prioritizes performance yet reduces the number of pairs available in the connector.