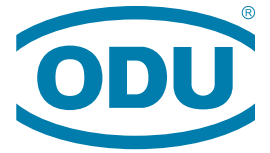


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ODU WHITE PAPER 09 | 2020

# RUGGED CONNECTORS FOR THE BATTLEFIELD ENVIRONMENT



# EXTRACT

Manufacturers of military electronics have many options available to them for making equipment of the highest quality. In this paper we evaluate some of the limiting factors related to the design and manufacture of equipment used by soldiers and in ground robotic systems, drawing special attention to connector selection. Connectors are often critical to the performance of a finished system so five popular styles of threaded and twist-locking connectors are evaluated.

## 01 | DURABILITY

Durability is the attribute of a product that describes its usable service life. Whether measured in years, minutes or missions, the more durable the product, the longer it can remain in service. When evaluating durability, one needs to think about the routine, ordinary use case of the product – repeated with realistic frequency. LCD display life (or half life), for example, is commonly measured in hours of use, with many displays capable of operating continuously for 10+ years. Similarly, key pads are often measured in clicks, with many capable of millions of clicks. Again, even when used continually, most are capable of operation for decades.

What about connectors used on these systems? As illustrated below, many are capable of withstanding 500 mating cycles or less, before their performance begins to deteriorate. Although there is no “universal” use case, it might be valuable to assume any electronic equipment that’s carried by a soldier will be connected and disconnected once per day, 365 days per year. Depending on the chosen connector, many of these devices will be limited to less than two years of use before needing to be serviced.

The story is fairly similar with secure communications devices and NSA Type 1 certified storage. Because these systems often need to be stored securely, one can assume the device will be connected and disconnected with nearly every use. Although solid state drives and signal processors may be functional for decades, with daily use, a system’s useful life before service may be limited to less than two years because of the I/O connector selected. If the application warrants the use of a twist-lock or threaded mating system, two connector options appear to outshine the rest: MIL-DTL-55116 connectors and Threaded Technology connectors from ODU.

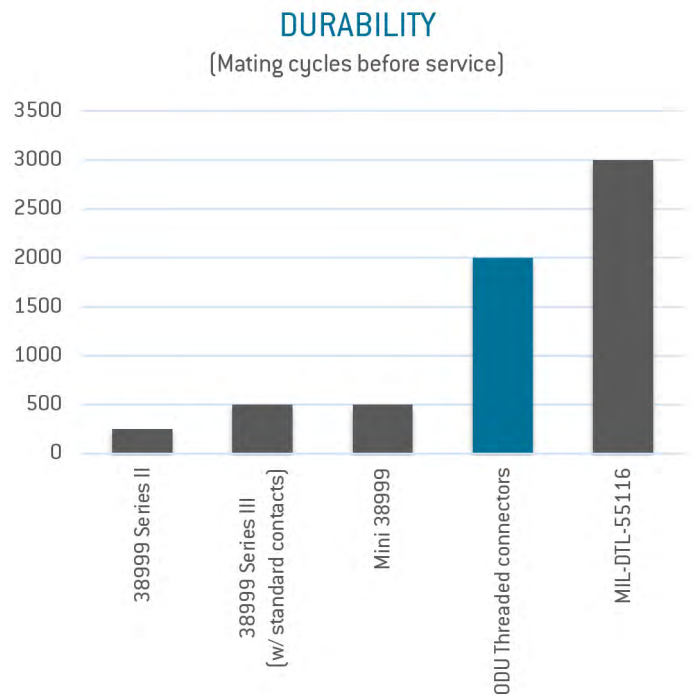


Table 1 – Durability of common connector families

The issue of durability is further complicated when you consider that contact technology is often the limiting factors for many Mil spec connectors. Thus users are given the option to either replace the contacts after 500 mating cycles or use extended-durability contacts. Products conforming to SAE-AS39029/106 offer up to 1500 cycle durability and are available from a number of manufacturers. For durability beyond 1500 cycles, interested parties should contact an electrical contact specialist, such as ODU.

## 02 | INGRESS PROTECTION

A second consideration related to the survivability of an electronic system for use in a battlefield environment is one of protecting the sensitive electronics from damage. Ingress Protection ratings are specified in the IEC (International Electrotechnical Commission) standard 60529. The standard classifies and rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion by body parts (such as hands and fingers), dust, accidental contact and water.

Table 2 illustrates how the IP rating codes are structured. Specifically, IP67 requires that the device under test must be capable of total

immersion in water at a depth of 1.0 meters for a minimum of 30 minutes. However, when looking into the IP specifications, there are particulars that are omitted. For example, IP68 requirements are only loosely specified as “under conditions which shall be agreed between manufacturer and user but which are more severe than for numeral 7”. Additionally, IP67 specifies that “Ingress of water in quantities causing harmful effects shall not be possible...” It does not completely preclude the entrance of water; just an amount that would be harmful.


















| Code letters<br>(International Protection) |  | First code number<br>(Degrees of protection against access to hazardous parts respectively against solid foreign objects) |  | Second code number<br>(Degrees of protection against water) |  |   |
|--|--|---|--|---|--|---|
| IP   |  | 6   |  | 5   |  |   |
| Code number                                | Protection against access to hazardous parts /<br>Protection against ingress of solid foreign objects                                  |   |  | Code number   | Protection against harmful effects due to the ingress of water   |   |
| 0  | No protection<br>                                     | No protection against contact /<br>No protection against solid foreign objects  |  | 0   | No protection against water<br>  | No protection against water   |
| 1  | Protection against large foreign objects<br>        | Protection against contact with the back of the hand / Protection against solid foreign objects $\varnothing \geq 50$ mm  |  | 1   | Protection against dripping water<br>                                | Protection against vertically falling water droplets  |
| 2  | Protection against medium-sized foreign objects<br> | Protection against contact with the fingers / Protection against solid foreign objects $\varnothing \geq 12.5$ mm         |  | 2   | Protection against dripping water (tilted)<br>                       | Protection against falling water droplets when tilted (any angle up to 15° from the vertical) |
| 3  | Protection against small foreign objects<br>        | Protection against contact with tools / Protection against solid foreign objects $\varnothing \geq 2.5$ mm                |  | 3   | Protection against spray water<br>                                   | Protection against spray water (any angle up to 60° from the vertical)                        |
| 4  | Protection against granular foreign objects<br>     | Protection against contact with a wire / Protection against solid foreign objects $\varnothing \geq 1.0$ mm               |  | 4   | Protection against splashing water<br>                               | Protection against splashing water from all directions  |
| 5  | Dustproof<br>                                       | Protection against contact with a wire / Protection against uncontrolled ingress of dust                                  |  | 5   | Protection against water jet<br>                                     | Protection against water jet from all directions  |
| 6  | Dustproof<br>                                       | Protection against contact with a wire / Complete protection against ingress of dust                                      |  | 6   | Protection against powerful water jet<br>                            | Protection against powerful water jet from all directions                                     |
|  |  |   |  | 7   | Protection against the effects of temporary immersion in water<br>   | Protection against ingress of harmful quantities of water by temporary submersion into water  |
|  |  |   |  | 8   | Protection against the effects of continuous immersion in water<br>  | Protection against ingress of harmful quantities of water by continuous submersion into water |
|  |  |   |  | 9K  | Protection against high pressure and high water jet temperatures<br> | Protection against water from all directions by high pressure and high temperatures           |

Table 2 – The meaning of IP ratings

Many mil spec connectors are not rated according to the IP schedule, instead reflecting test standards that apply to various specific-use cases. Evaluating and comparing the significance of these standards is highly subjective and beyond the scope of his paper. Instead we will consider only whether or not the products have been tested to a standardized method for fluid ingress protection.

For MIL-DTL-55116 connectors, the fluid ingress protection characteristics of the product are explicitly defined under the “water immersion” requirement of the specification.

For MIL-DTL-38999 and Miniature 38999 connectors, sealing properties are interpreted from the “altitude immersion” requirement of specification.

For ODU Threaded connectors, sealing properties have been provided by the manufacturer according to IP rating.

### 03 | SIZE

Several manufacturers offer connectors designed for use in military and industrial applications, unfortunately most are big and bulky. For many applications including soldier-wearable technology, ground robotics and in-vehicle communications, flange size represents a critical dimension. This dimension sets the minimum distance between any two connectors, or the distance from connector to side wall. So that the enclosure stays environmentally protected, a jam nut receptacle with o-ring is preferred. In order to objectively compare the options available, an example might be helpful. In this example, we’ll consider a system requiring a minimum of 20 signal lines, terminated to 22 gage wire. Unfortunately this requirement would exclude the MIL-DTL-55116 option, which offers only a maximum of 6 contacts. The four “best” remaining options would be a MIL-DTL-38999 Series III receptacle, with C35 insert or a MIL-DTL-38999 Series II (MS27474) receptacle with 12-35 insert, a Miniature 38999 with 20 contact insert, or an ODU Size 3 Threaded connector with 26 contact insert. All four options would satisfy the requirement, yet the space required is vastly different depending on the connector selected.

### 04 | CONCLUSION

There are numerous attributes a designer needs to consider when creating electronic devices for the battlefield environment and it’s clear that the service life and performance of the I/O connector are among them.

| Connector Family        | Sealed when mated | Sealed when unmated |
|-------------------------|-------------------|---------------------|
| 38999 Series II         | yes               | no                  |
| 38999 Series III        | yes               | no                  |
| Mini 38999              | yes               | no                  |
| ODU Threaded connectors | yes               | yes                 |
| Mil-DTL-55116           | yes               | yes                 |

Table 3 – Comparison of sealing for popular connector families

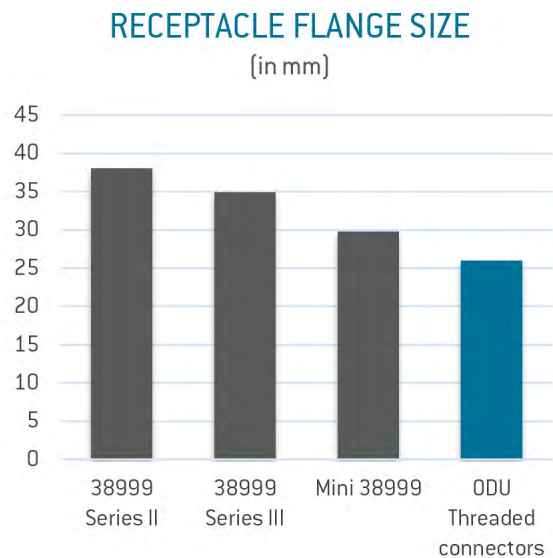
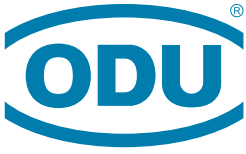


Table 4 – Size comparison of popular connectors

As illustrated above, there is a considerable difference between the connector options, with the smallest option, offered by ODU, being over 30% smaller than the largest option. Furthermore it’s valuable to point out that the ODU Threaded connector contains 26 contacts in the specified space, whereas the others offer only 20 or 22 contacts.

Having evaluated several popular connector options with respect to ruggedness, size and fluid ingress protection, the ODU Threaded connector family appears to offer the strongest mix of high performance and small size.



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## FIND OUT MORE

Get in touch with us:  
[sales@odu.de](mailto:sales@odu.de)

### **ODU GmbH & Co. KG**

Pregelstraße 11, 84453 Mühldorf a. Inn, Germany  
Phone: +49 8631 6156-0, Fax: +49 8631 6156-49

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