CHAPTER X

Interconnection History in Brief

Interconnection technology is in the midst of profound change, and stands on the threshold of greater change. The most significant developments of the future, like previous ones, will be based on a real understanding of the past. It is this chapter's purpose to highlight the innovations which have most influenced the shape and direction of the industry's history.

The First Modern Connectors

The development of small, light, rugged, and reliable connectors was fueled by the fires of war. World War II brought mass production of military aircraft and the rapid development of many new electronic and communication systems, all requiring new and better interconnection methods.

The first good answer was the MIL-C-5015 connector. Simple, tough, inexpensive and capable of considerable standardization, it was a highly useful device. By war's end it had become the standard connector for airborne applications, and was widely used in ground support, electronic, and communications systems as well.

Through the years, better materials and design improved this old standby, yielding superior performance and reductions in size and weight. In fact, MIL-C-5015 connectors are still produced in quantity, and are useful in many applications. An elementally sound design defies obsolescence.

New life was given these handy connectors in 1969 when two new specifications defined rear-release connectors which mate with MIL-C-5015 connectors. The decade following World War II saw many improvements in connector design. In the 1950's the first miniature connectors were introduced. MIL-C-26482 defined the forerunners of today's high-performance connectors. These were smaller and lighter

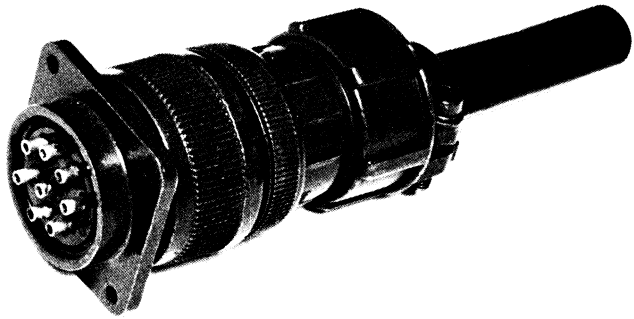

Figure X-1
The MIL-C-5015 connector has been an old standby since the late 1940's.

for a given number of contacts than the MIL-C-5015 by a factor of three.

Miniature connectors were enthusiastically accepted. A wide variety of cylindrical connectors were quickly developed: bayonet, push-pull, thread, rack-and-panel, and the less frequently used rectangular connectors.

New specifications defined connectors which mate with or replace the basic class specified. The early 1960's saw rear-release trend boosted by two new specifications: MIL-C-0026482 (Series 2) and

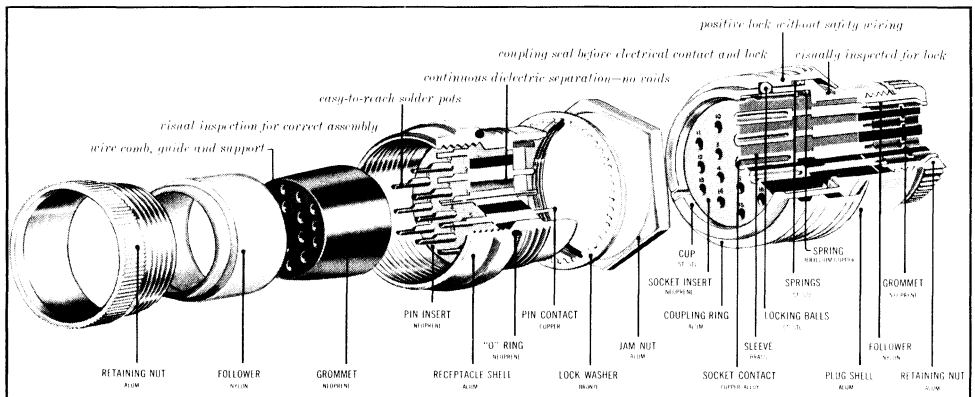

Figure X-2
Typical miniature connectors with push-pull coupling.

MIL-C-83723 (Series 1). As soon as there were connectors qualified to MIL-C-0026482, it again became MIL-C-26482.

In 1971, a new specification, MIL-C-81703, took the push-pull connectors out of MIL-C-26482, leaving only the bayonet coupling type included. Cylindrical rack-and-panel plugs were added to MIL-C-81703 at the same time.

New materials. Following the lead of the miniatures in the use of superior insert materials, hard plastics such as melamine, were replaced in the MIL-C-5015, first with neoprene inserts, and in the late 1960's, with silicone. Silicone was superior in a number of ways: it gave greater resistance to wide temperature variations, (from −55°C to +200°C); its better permanent-set characteristics meant more reliable sealing. And its softer composition permitted interfacial compression for a void-free contact-to-contact moisture seal.

Silicone's high temperature resistance was not used in these early connectors. Their soldered wire terminations did not allow exploitation of silicone's 200°C capabilities. Mechanically terminating the wire to the contact—crimped terminations—was the answer.

Improved design. The miniaturization of electronic components and the increasing complexity of systems brought a demand for ever more interconnections per unit of volume and weight. More and more contacts had to be crammed into a given sized connector. Once more silicone provided an answer. Its superior dielectric properties, along with improved manufacturing techniques, made this possible.

But as the number of contacts increased, so did problems of isolation, insulation, and shielding. And as contact diameter grew smaller, so did current-carrying capacity. Nonetheless, imaginative use of the new materials meant miniature connectors which were appreciably better than their bulkier predecessors. For example, the smallest pin contact in a typical miniature connector is 0.040" in diameter. This is about two-thirds the diameter of a MIL-C-5015's 0.062" pin contact diameter. Yet the miniature connector outperforms the MIL-C-5015 in every respect.

Space Age Subminiatures

In the late 1960's, the industry did it again: achieved another three-to-one size and weight reduction. The new high-density subminiature

connectors were one-third the size and weight of the miniatures which had themselves offered performance comparable to a MIL-C-5015 at one-third the size and weight. In short, that's the same number of contacts at one-ninth the size and weight. A miniature will accommodate 32 #20-contacts in a size 18 shell. A subminiature will accommodate up to 85 #22-contacts in the same shell size.

Near the end of 1966, two subminiature military specifications provided for connectors of the bayonet coupling type. However, they

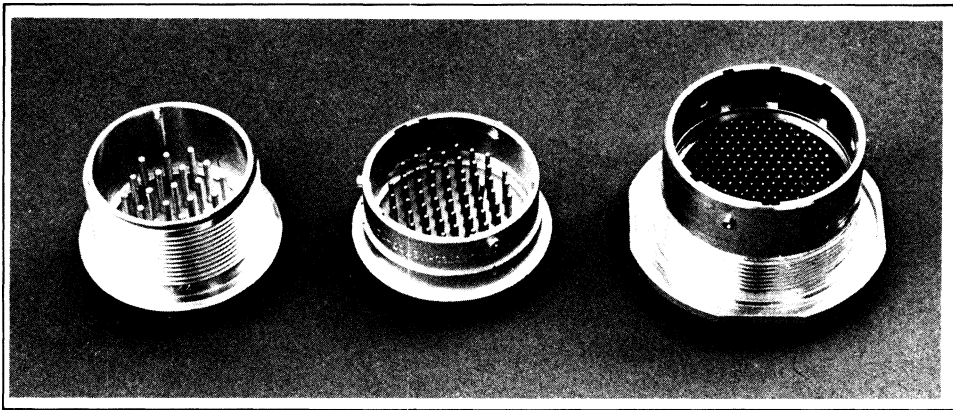

Figure X-3
A comparison of contact densities.

were not intermateable. MIL-C-38999, using a rear-release contact retention system, defined the first individual contact release system in subminiatures. MIL-C-81511 defined a gang-contact release, locking or unlocking all contacts at once.

The subminiature connectors had many design advantages over previous connectors. "No-void" design minimized corona-effect by preventing the insert from trapping appreciable quantities of gases. New insert materials improved dielectric properties. Shorter contacts brought smaller diameters without sacrificing strength. Better springs, more durable and corrosion-resistant platings, more efficient lubricants: all these contributed to a superior product.

Microminiature Connectors

Designers are now striving for practical designs one-third the size and weight of the subminiature, one-ninth that of the miniature, one-twenty-seventh that of the MIL-C-5015.

When developed, the microminiature connectors will offer nearly thirty times the number of contacts in a given size as the standard workhorse connector of World War II. That's a thirty-fold decrease in size and weight in as many years: a satisfying achievement.

However, there are many significant manufacturing problems to be solved before such connectors become a practical reality.

Microminiatures, ideally, should have electrical and mechanical attributes equal to or better than the larger connectors, accepting up to 24-gauge wire. But as contact densities increase, tolerances shrink. In connector microminiaturization, quality control takes on an entire new dimension. Configuration control—holding the product to uniform performance—becomes of the essence.

Rear-Release Boosts Standardization

In the early 1960's, the Aerospace Industries Association (AIA) instructed the National Aerospace Standards Committee (NASC) to develop a family of superior miniature connectors with configuration control and improved maintainability. The original specification made no mention of rear-release. It did, however, require closed-entry pin and socket fronts. The logical arrangement to meet this requirement was a system with access through the wire entry cavity at the connector's rear. As a result, rear-release connectors (NAS 1599) and insertable/removable crimp-type contacts (NAS 1600) with associated installation tooling were developed. Performance exceeded AIA's expectations, in every way.

By the early 1970's, almost all major specifications included rear-release connectors which intermate with older style solder and front-release connectors. This has permitted an easy transition without undue delay or expense.

Standardization

Connector history is one constant change. Resistance to ever more severe environments has been specified. There has been constant pressure for more contacts per unit area. Space and weight limitations have become more stringent each year. Fortunately, with improved materials and better production techniques, superior connectors have been designed and produced.

Standardizing parts. The demand for "more and better" will doubtless continue. There is increasing pressure to standardize connector elements, such as contacts, so that "interconnection systems" can be designed around basic modules of similar performance, using standard installation tooling and techniques.

The military implemented a vigorous standardization program in February of 1970 by issuing MIL-STD-1353, "Electrical Connectors and Associated Hardware, Selection and Use of." By late 1973 this document recommended the use of rear-release connectors almost exclusively. Crimp-type insertable/removable contact systems are used throughout, thus excluding potted connectors. The swing toward a rear-release contact retention system fostered the introduction of various junctioning devices. Among them were devices which connect existing electrical components such as relays and switches to the junction family.

When this concept was accepted in the early 1970's, it made a reality of the dream to simplify all terminations. It also became possible to reverse the practice whereby each segment of the electrical industry developed unique ways for attaching wires; thus the way for standardization by interconnection systems was paved.

Standardizing the System. While a definite step forward, standardization by component did not address the major problem: The electrical industry was smothering in the products of its own ingenuity. What was needed next was an electrical connecting system composed of connectors and junctions with similar performance, installation and tooling.

An important step in the right direction and still a viable approach to solving many termination problems was the Integrated Termination System (ITS). The ITS concept embraced the idea that all electrical devices can be terminated the same way: using the same techniques and application tooling, with the same performance capability throughout. Such a family of components obviously simplifies the engineer's problems. He needs to know only one set of performance standards. Furthermore, where one of the components resists an environment, so do all the others. Hence, complete freedom in locating components. Savings in time, space and weight immediately result plus improvements in reliability and maintainability.

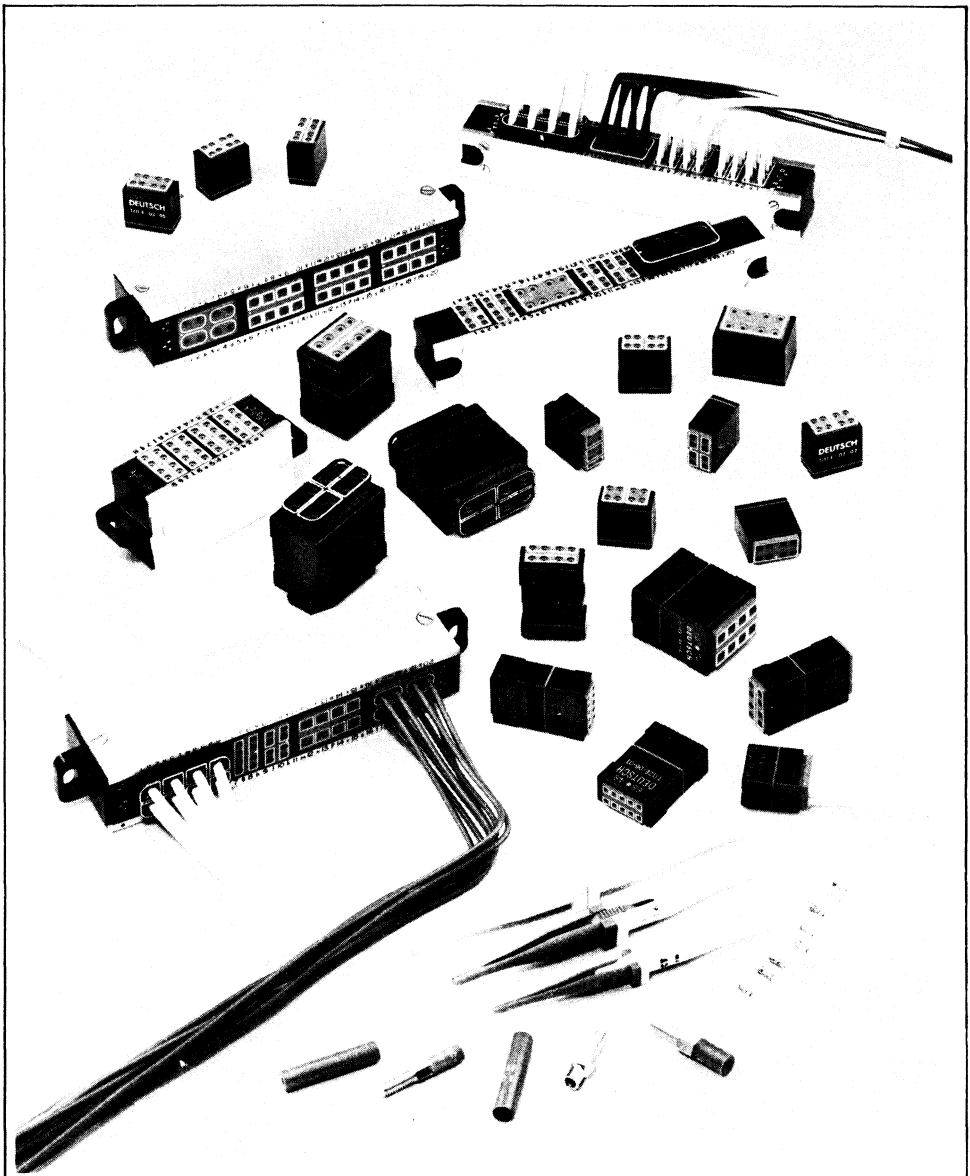

Figure X-4
Integrated Termination System (ITS) family of junctions.

Although ITS requires additional design and manufacturing efforts by the supplier, problems are solved efficiently and economically far back in the sequence of design and manufacture, at a point where there are skilled workers and well-equipped facilities.

In the late 1960's, the military and industry issued specifications for termination systems with identical installation tooling: MS3191 and MS3198 crimping tools and NAS1664 insertion/extraction tools. Unfortunately, the contacts were different (MIL-C-39029 and NAS1749).

ITS tooling, originally designed for installing contacts in multi-pin connectors, had an immediate impact on all terminations. When insertion/extraction tools were developed for rear-release connectors of the NAS1599 type, there was complete freedom to remove and add wires without disturbing adjacent wiring. This same flexibility made it possible to provide environment-resistant junction terminations equal to performance in multi-pin connectors.

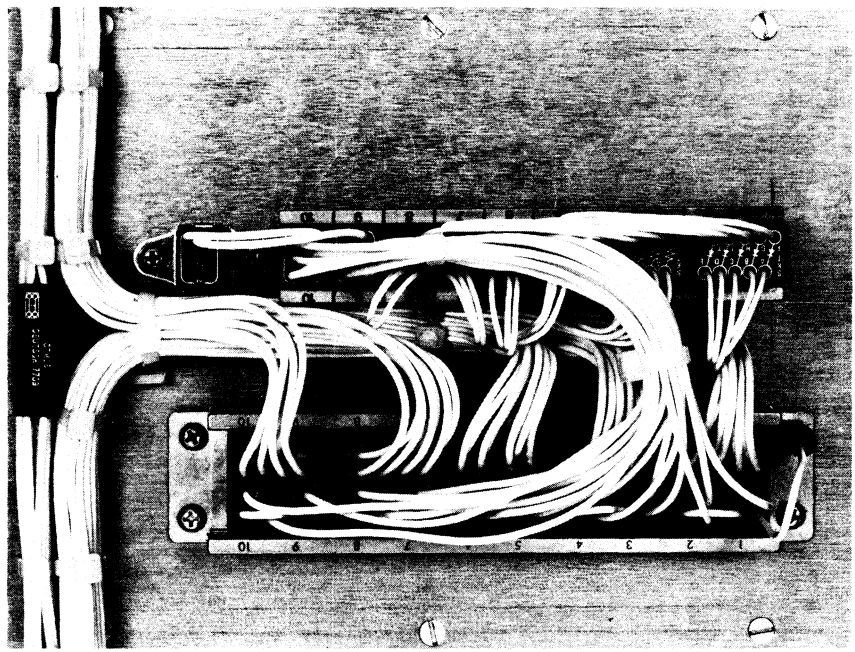

Figure X-5
A Common Termination System. Result: easy assembly and maintenance.

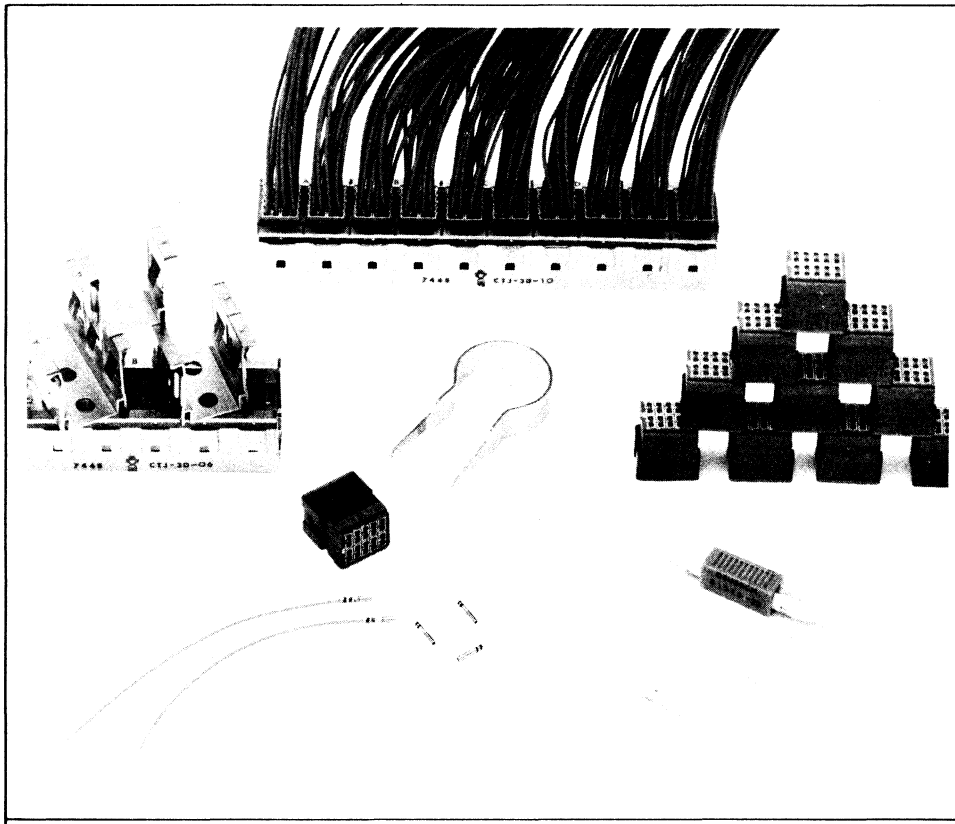

Figure X-6
Junctions in the Common Termination System.

The mid-1970's saw the development of the common termination systems (CTS). *For the first time in the short but fast-moving history of interconnector technology, a system was designed which offered uniform performance throughout a circuit.* The universe of interconnections had been defined as connectors plus junctions. But CTS gave the industry the connector-junction, and with it new levels of performance, reliability and cost savings.

CTS socket contacts were specified in MIL-C-39029. MS27726, "Integrated Wire Termination System for Use on Electrical Components," specified the design of CTS components and the expected performance. In mid-1974, it was replaced by MIL-STD-1549, "Common Termination System for Electrical and Electronic Parts."