EMC Standards Activities

by Don Heirman, Associate Editor

This article appears as a result of a new initiative by the Standards Education and Training Committee (SETCom), chaired by Hugh Denny. The charter of SETCom is twofold; namely 1) seek to better train working groups and working group chairs so as to facilitate acceptance of a standard by the IEEE Nescom and Revcom after it has been prepared by the working groups, and 2) provide an education forum for the broader EMC community on various EMC standards, both civilian and military. In pursuit of this second goal, the following article was prepared by EMC community luminaries Warren Kesselman and Herb Mertel. If you have material you would like to contribute for publication in this Newsletter that provides educational and historical background on EMC standards, please contact Hugh Denny via e-mail at hugh.denny@gtri.gatech.edu

The History of Military EMC Specifications

By Warren Kesselman, IEEE and Herbert Mertel, IEEE

1 The Early Years - Control of Ignition interference

The US military first encountered Radio Frequency Interference (RFI) some time prior to World War I when a radio was first installed on a vehicle. However, little is known about early efforts to address RFI problems until the early 1930s. The IRE (Institute of Radio Engineers) 1932 Proceedings included a paper on electrical interference in car radios.[1] The first military specification was published by the US Army Signal Corps in 1934 as SCL-49 entitled "Electrical Shielding and Radio Power Supply in Vehicles". That document "protected" radio receivers from interference by requiring shielding of the vehicle ignition system, regulator and generator. The requirement was simply that the vehicle operation not "disturb" radio reception. With the increased use of mobile radio communications, it became apparent SCL-49 was inadequate. In 1942 it was superseded by specification 71-1303, "Vehicular Radio Noise Suppression" that addressed (in addition to shielding) the use of filters, by-pass capacitors, resistor-suppressors, bonding, grounding and proper wire routing. This specification also defined an instrumentation system and a limit. During the 1940s military standards were principally concerned with RFI suppression components for internal combustion engines and electrical machinery.[2] In 1945 a joint Army-Navy (Air Force not yet "born") standard JAN-I-225 entitled "Interference Measurement, Radio, Methods of, 150 Kilocycles to 20 Megacycles (For components and complete assemblies) was issued.[3] Then in 1947, AN-I-40 established limits for aircraft systems. [4]

The subsequent succession of military EMC specifications closely follows the evolution of our electrotechnology. Initially, military specification limits for radio frequency interference were established to protect the minimum usable field strength on board vehicles for land, sea, and air. As more sensitive equipment was developed, susceptibility (immunity) limits were established. With the space age came the concept of electromagnetic compatibility within small platform systems and also between platforms. As a consequence, the equipment and system specifications became more general to include all types of electrical and electronic equipment that require application of EMC techniques during the design, development, production, installation, and operational states.

2 1950 - 1965: A Proliferation of Interference and Susceptibility Specs

In the 1950s and up to 1965, each major military agency imposed its own electromagnetic interference (EMI)/ EMC specification in the procurement of electronic systems and equipment. For instance, the Air Force used MIL-I-6181 and MIL-I-26600, the Navy used MIL-I-16910, and the Army used MIL-I-11748 and MIL-E-55301(EL). These specifications limited the amount of conducted and radiated EMI emissions and set susceptibility levels which systems and equipment must reject. The specifications also set forth the test configurations and techniques needed to demonstrate compliance with the requirements therein.

The existence and application of different EMC specifications for each service caused quite a dilemma. They were significantly different from each other, so that when a component was designed to meet one specification, it usually had to be redesigned and tested to meet another. The frequency ranges covered were different and the limits for overlapping frequencies varied. More significantly, each specification required the use of different test equipment, making it quite expensive for an organization to be fully equipped to test to all EMC specifications.

The problem was compounded by additional specifications for specific systems, such as Minuteman AFBSD-62-87 initiated by the Boeing Company; GSFCS-523-P-7 prepared by Genisco under contract from Goddard Space Flight Center for Aerospace Ground Equipment (AGE); and those issued by technical centers, such as MSFC-SPEC-279 issued by the Marshall Space Flight Center and MIL-STD-1541 issued by the USAF/SAMSO. It became obvious that there was a need to limit these different specifications and the generation of one unified standard to serve all government and military agencies.

The first attempt to issue a specification which would be acceptable to all branches of the government was the publication of MIL-STD-826 in January 1964. This document presented a new set of limits. However, this effort was ill-fated and MIL-STD-826 was used only by the USAF. [5,6]

3 1967: MIL-STD-461 Arrives on the Scene

In 1960 [7] the US Department of Defense (DoD) enacted a comprehensive Defense Radio Frequency Compatibility Program (later renamed Electromagnetic Compatibility Program) that focused the Military Services R&D programs "to provide a means whereby electromagnetic compatibility should be 'built into' military communications-electronics equipment in the research and development stage". In 1966, EMC personnel of the three military departments jointly drafted standards addressing the interference reduction needs of the entire Department of Defense.

That effort culminated in 1967 in the issuance of Military Standards 461, 462 and 463. As a result, approximately 20 basic and subsidiary specifications were superseded. The 461 document focused on requirements and the 462 standard prescribed measurement methodology. Definitions and acronyms were contained in 463.

Considerable revision was required and MIL-STD-461A was issued in August 1968. MIL-STD-461 was accepted by the joint services and was also used by many other countries. Eventually, the different military agencies (Army, Air Force, and Navy) found many items to their dissatisfaction, and thus many revisions were issued by each of the three services until 1989. The most noted difference was the "Pink Copy" issued by the Army.

4 1990 - 2000: Military EMC Specifications Mature

An effort was started in 1990 by the Tri-Service EMC Committee to prepare an updated MIL-STD-461 and MIL-STD-462. MIL-STD-463 was withdrawn and definitions were referenced in American National Standards Institute (ANSI) C63.14 "Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP) and Electrostatic Discharge (ESD)". [8,9]

Since the 1970s EMC personnel of the US Army, Navy and Air Force have periodically met and upgraded MIL-STD-461 and 462. The latest revision (1999) consolidated the two standards (Limits and Measurement Methods) into one standard: MIL-STD-461E "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment". This latest edition is an "interface" standard of requirements to provide reasonable assurance (during development) that a system, subsystem or equipment will be compatible with its anticipated electromagnetic environment. [8]

The most significant changes in MIL-STD-461D/-462D and the subsequent MIL-STD-461E as compared with the previous MIL-STD-461C are as follows:

- Broadband emission tests are deleted.
- Measurement (6 dB) bandwidths are specified.
- Radio frequency (RF) susceptibility scan times are specified.
- The 50 Σ line impedance stabilization network (LISN) is used for conducted emission.
- Test setup calibration is required.
- Absorber in shielded room is specified.
- Bulk cable injection is specified.
- Conducted emission measurements stop at 10 MHz.
- Explanatory appendices were added to MIL-STD-461D and MIL-STD-462D.
- Receiver susceptibility tests must be defined for each procurement.
- MIL-STD-463 was canceled. American National Standards Institute (ANSI) C63.14 is referenced for definitions.

The most valuable sections of these two specifications and of MIL-STD-461E are the appendices, which give the technical rationale for the limits and measurement procedures. These appendices should be read first because the material gives the logic behind the requirements. Although it is not customary that military specifications are accredited to an author; the appendices of MIL-STD-461D/-462D as well as of -461E are accredited to one of the main contributors of the -461D and -461E re-write: Mr. John Zentner of the Air Force Systems Division of Wright-Patterson Air Force Base.

The technical work was completed in November 1992. The two documents were published in January 1993 as MIL-STD-461 and MIL-STD-462D [6, 7]. The work for MIL-STD-461E was completed in 1999. The basic concepts of 461 standards were adopted by several non-US military organizations and also influenced national and international standardization efforts

5 Progress and Future of Military EMC specifications

Thus, over the past seven decades, US Military EMC Standards have evolved from a simple beginning to keep pace with the "technology explosion" and the resultant complex electromagnetic environment. The MIL-STD-461 D requirements (limits) and MIL-STD-462D test methods as well as the new "Interface Standard" MIL-STD-461E were developed by approximately 15 U.S. government and industry experts during the 1990 to 1999 time period under the leadership of Mr. Stephen Caine, USN/SPAWAR, retired.

However, the development of EMC specifications is never finished since the technology requiring compatibility constantly changes. Since 1998, the Defense/Industry E3 Standards Committee has been trying to find a compromise between the (1) Policy of DOD to use commercial EMC standards whenever possible and (2) the use of MIL-STD-461E. The work is continuing at the time when this paper was prepared (May, 2000). However, the work to-date seems to indicate that there is very limited overlap of the military vs. the commercial EMC requirements. The EMC requirements of the military pertain to small metallic platforms with unique requirements that are different from the commercial needs.

References

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[3] Joint Army-Navy Specification (1945). "Methods Of Radio Interference Measurement, JAN-I-225. 150 kc to 20 Mc," Army No. 71-3233, Navy No. 16-I-14

[4] Army-Navy Aeronautical Specification (1947). "Propeller Systems Radio Interference Limits," AN-1-40.

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[6] Interference Technology Master (1971). "The Origin of Military EMC Specifications." ITEM, pp.50-53. Plymouth Meeting, PA. Robert D. Goldblum, Editor.

[7] Memorandum from the Acting Secretary of Defense to the Secretaries of the Army, Navy and Air Force. Subject - Radio Frequency Compatibility with attachment: "Radio Frequency Compatibility Program, dated 9 June 1960."

[8] Military Standard (1993). "Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility," MIL-STD-461D. Available from Naval Publications and Forms Center, Attention: NPODS, 700 Robbins Avenue, Philadelphia, PA 19111-5093.

[9] Military Standard (1993). "Measurement of Electromagnetic Interference Characteristics," MIL-STD-462D. (Companion document to MIL-STD461 D.)

[10] Military Standard (1999). "DoD Interface Standard, Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility", MIL-STD-461E

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