Bibliography for TC-1 EMC Management

This bibliography represents a starting point for materials available from the open literature relating to EMC management issues. Materials researched to date include: records from the IEEE EMC symposia from 1962 to 1998 and the Interference Technology Engineers' Master (ITEM) from 1992 to 1998. Although the content of some of the references may seem rather dated, these references provide insightful historical perspectives on present-day EMC management issues.

When available from the reference itself, the abstract has been quoted verbatim, grammatical errors, spelling errors and all. When not available, an abstract has been generated from the introduction of the reference to capture its essence. In some instances, a reference has been listed because it was cited from within another reference. In such instances, the abstract in this bibliography will be left blank until the reference has been appropriately reviewed.

This bibliography lists the references in reverse chronological order of date of publication and is periodically updated. It is advisable to check with the TC-1 secretary or the TC1 website for the latest revision of this bibliography.

[1] Bogazici, B. Altay, "EMC management: for quality assurance and accreditation," *EMC'98 Roma International Symposium on Electromagnetic Compatibility*, Rome, Italy, September 14-18, 1998.

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[2] Braxton, Thomas E., "The Challenge of Regulatory Compliance Testing of a Large Distributed System," *1998 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 98CH36253, Denver, CO, August 24-28, 1998, pages 711-716.

Abstract: Though test procedures specified by standards bodies provide direction in the technical steps that are to be taken in performing a large-system EMC test, the management of such a project has not been widely discussed. In the case of a large distributed system, the organization, preparation and test execution become a logistical challenge.

This paper reviews experience in performing such tests, provides observations on the planning process, and gives recommendations to regulatory engineers and developers who plan to perform an EMC test on a such a large scale.

[3] Eroglu, Kursat, and Goodrich, Darrell, "Regulatory Compliance, A Manufacturer's Perspective," *1998 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 98CH36253, Denver, CO, August 24-28, 1998, pages 250-252.

Abstract: With the implementation of the EMC Directive and similar regulations following in other countries, the regulatory compliance became one of the major milestones in product development and marketing for most manufacturers. Many papers have been published about the technical and/or legal requirements. Others have focused on compliance methods and design techniques. A manufacturer has to consider a multitude of issues, when it comes to regulatory compliance however. Interpretation of standards, keeping abreast of changes in regulatory environment, setting up test and continued compliance plans, certifications, cost considerations are only a few of these issues. This paper tries

to draw a more comprehensive picture of regulatory compliance from a global manufacturer's perspective.

[4] Case, David A., "The Role of Individual Certification for EMC Engineers and Technicians," *1995 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 95CH3577-2, Altanta, GA, August 14-18, 1995, pages 444-446.

Abstract: This paper describes the role of individual certification of EMC personnel. In comparison, if our test labs and equipment are required to meet certain standards of conformance, should not then EMC people also have to meet some standard? Whether certified in-house or by an independent certification agency like NARTE, the certification of EMC personnel does play an important role in the EMC Community. This paper discusses the current criteria needed to obtain national EMC certification and the benefits of certification to not only the individual or the organization they work for but to the EMC community as a whole.

[5] Hansen, Diethard, "Global Aspects of EMC Management," *Interference Technology Engineers' Master (ITEM) 1994*, ISSN 0190-0943, ROBAR Industries, West Conshohocken, PA, 1994.

Abstract: Electromagnetic compatibility problems have increasingly become nasty technical side effects of modern electronics, causing sporadic malfunctions or even destruction of components as well as unintentional electromagnetic spectrum pollution in the vicinity of electronic/electrical equipment or larger systems. However, cost-effective mitigation techniques are available, and are being documented in international and national EMC standards and handbooks. With the EC EMC Directive and CENELEC TC 110, different European EMC standards are being harmonized to provide the end user with a free flow if reliable goods. This article discusses key normative and socio-political factors, and some historical EMC background is clarified. An attempt is made to describe market needs and perspectives.

Real-world scenarios and EMC case studies are also presented to demonstrate the importance of awareness, professional training, effective organization and good management. Centralized versus decentralized test house concepts and their investment costs are outlined. Finally, a recommendation for EMC cost minimization in small- and medium-size companies is given.

[6] Netzer, Moshe Z., "Preparing an EMI Control Plan (EMICP)," *Interference Technology Engineers' Master (ITEM) 1992*, ISSN 0190-0943, ROBAR Industries, West Conshohocken, PA, 1992.

Abstract: Government agencies and their contractors who perform work in the development and construction of military systems and equipment are often required to submit EMI control plans (EMICPs). These deliverables are required subsequent to the end of the conceptual/feasibility phase and before the beginning of the contractual phase.

...Numerous issues are addressed [in the required content of the EMICP:] EMI management, spectum conservation, EMI mechanical design, electrical wiring design, electrical circuit design, analysis, R&D testing, problem areas, [and] revisions of the EMICP document. ...The objective of this article is to assist both the engineer tasked to write the EMICP and the contractor engineering

office in collecting, sorting and processing the information required for the completion of a comprehensive EMICP.

[7] Roleson, Scott, "Capture EMC Design Successes as Recyclable Assets," *Interference Technology Engineers' Master (ITEM) 1992*, ISSN 0190-0943, ROBAR Industries, West Conshohocken, PA, 1992.

Abstract: Nothing frustrates a manager more than seeing engineers solving problems that have been solved before. Good engineers are natural problem solvers, and sometimes they would rather solve problems themselves than spend the time to find out if a solution exists. Some engineers prefer to work out their own solutions than to accept someone else's. Even when a new or innovative solution is found, the time pressure of getting a product to market may deter engineers from effectively sharing what they've learned. Allowing this infomation to be lost increases both the cost of new product development and the time required to market the product.

... An alternative approach is to view solutions as recyclable assets. Once found, solutions are added to the broad body of knowledge or best practices resident within an organization. These best practices are used in later product designs, enhancing quality and reducing development time. To be successful, a systematic, regularly applied method is necessary to capture EMC successes, distill them to manageable and easily readable form, and disseminate the new information. A method for archiving best practices for easy retrieval is also necessary.

[8] Somech, Jacques, "An EMC System Design Approach that Ensures MIL-E-6051 Safety Margins are Incorporated," *1992 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 92CH3169-0, Anaheim, CA, August 17-21, 1992, pages 68-71.

Abstract: This paper presents a comprehensive approach to Electromagnetic Compatibility (EMC) at the system level when it is required to demonstrate MIL-E-6051 safety margins. System EMC requirements are discussed briefly and are then used to derive the requirements for all subsystems down to each unit. The discussion is broken into two parts; intersystem and intrasystem compatibility. In both cases an apportionment method that ensures adequate system level margin is developed. A design example is worked out at the end to give a feel for the approach that is presented.

[9] Stoner, R.D., "Impact of the Use of Commercial Off-the-Shelf Equipment on the Requirements for Electromagnetic Interference (EMI) Control," *1992 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 92CH3169-0, Anaheim, CA, August 17-21, 1992, pages 518-519.

Abstract: With the continued need to use commercial off-the-shelf equipment, the EMI impact must be considered. The responsibility of meeting contractual requirements for EMI standards using commercial equipment usually falls on the contractor. This can have a major cost impact on any program using these EMI standards. Case histories show omission of specific EMI requirements caused failures during EMI testing. This has had a cost impact on these programs.

[10] Osburn, John D.M., "The Role of Systems EMC Analysis in Large System EMC Management by Equipment EMC Assurance," *1991 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 91CH3044-5, Cherry Hill, NJ, August 12-16, 1991, pages 189-192.

Abstract: Electromagnetic compatibility (EMC) at the system level is often ignored, to the detriment of total system performance. Complete systems EMC is often a difficult and elusive goal, since systems are often too large to adequately or efficiently test, or complete systems are not for test available until initial customer installation, where testing could be impractical. Following a review of definitions of system EMC, This paper describes an effective approach to systems EMC analysis, continues with a discussion of interpretation of analytical results. After interpretation of results the paper describes using the results to assure system EMC. Key to the management of systems EMC approach is the management of subsystem component EMC on an individual component basis as a prerequisite to system EMC.

[11] Freyer, Gustav J., and Osburn, John D.M., "Methodology and Decision Making during High Confidence System Level EMC Analysis," *1991 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 91CH3044-5, Cherry Hill, NJ, August 12-16, 1991, pages 193-197.

Abstract: This paper discusses the management and technical issues encountered in producing a high confidence electromagnetic compatibility (EMC) analyses for a complex system, when it became necessary to demonstrate MIL-E-6051 [1] safety margins without the benefit of system level EMC test. The successful approach, involving application of validated, system level EMC analysis codes; provided acceptable, high confidence predictions of ordnance (-20 dB) and non ordnance (-6 dB) safety margins [2]. The type of system, the compliance specifications and other pertinent technical and management information are described. The most significant ground rules applied to the analysis were: redundancy of analytical approaches and independent review of all phases of activity. The managerial issues and decisions required at various phases the process are described. A structured, disciplined approach; and the methodology for comparing, evaluating and resolving the predictions from two different system level codes are presented.

[12] Boone, T. Gerald, "Software as a Tool for Controlling EMI/EMC," *1991 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 91CH3044-5, Cherry Hill, NJ, August 12-16, 1991, pages 198-199.

Abstract: Traditional methods of controlling Electromagnetic Interference (EMI) typically deal with hardware based solutions such as: grounding, bonding, shielding, filtering, and equipment placement. With the evolution of microprocessor and computer controlled systems, system flexibility and effectiveness increase up to a point where ambiguities reduce effectiveness and introduce the potential for a new form of EMI. Software, however, can become a tool for system designers, E^3 and software engineers to use in controlling EMI and managing system EMC.

[13] Hansen, D., "First WS on EMC Management," *International EMC Symposium*, Zurich, Switzerland, March 1991.

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[14] Ly, Steven A., Ferraro, Robert J. Jr., and Zeger, Andrew E., "Electromagnetic Environmental Effects Engineering Support System," *1990 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 90CH2903-3, Washington, DC, August 21-23, 1990, pages 554-557.

Abstract: The need for a centralized database of Electromagnetic Environmental Effects (E3) information along with an easy method of access has resulted in the development of the E3 Engineering Support System (ESS). The ESS is a centralized database of E3 information compiled from existing documentation. The ESS is also a management information system (MIS) for E3 conference scheduling and action item (AI) tracking. User friendly programs are used to search the database and generate reports. These programs provide the necessary link between the managers and E3 engineers and the ESS database. The ESS is made accessable to remote users through local area network or telephone line communications. The purpose of the ESS is to assist managers and E3 engineers in assuring a Electromagnetic Compatibility (EMC) of present and future naval air systems and equipment.

[15] Braxton, Thomas E., "What is a Manufacturer's EMC Obligation," *1990 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 90CH2903-3, Washington, DC, August 21-23, 1990, pages 507-512.

Abstract: Commitment to good EMC practice does not guide EMC policy. As with most things in business, sales volume and market share are the driving forces in any product decision. EMC is good business, if one considers the evolving European standards and the FCC requirements as necessary considerations for product sales. But can EMC stand on its own, or must it be imposed by legislative fiat? Would manufacturers have an EMC concern if it weren't for Part 15? This paper will discuss these questions, and attempt to provoke discussion of corporate obligations.

[16] Staggs, David M., "Ethics Within the Corporate Structure," *1990 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 90CH2903-3, Washington, DC, August 21-23, 1990, pages 526-528.

Abstract: This paper discusses several important issues facing the Electromagnetic Compatibility (EMC) Engineer today. Ethics and the corporate bottom line are many times at odds with one-another. Sometimes unethical conduct and practices occur within the EMC Department due to pressures from management to give them the answers they want to hear. Interdepartment communication plays a key roll in running an efficient and respected EMC department. The corporate commitment in dollars is many times superficial and misdirected. These and other important issues such as liability, the decision triangle and EMC Engineer, along with the credibility, independence and the integrity of the EMC Test Lab, will be discussed in detail.

[17] Staggs, David M., "Corporate EMC Programs," *IEEE 1989 National Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 89CH2736-7, Denver, CO, May 23-25, 1989, pages 320-325.

Abstract: This presentation outlines how to set up a credible corporate electromagnetic compatibility program. Many corporations spend years of conflict and turmoil trying to establish an efficient and adequate facility for testing emissions and susceptibility, including personnel and equipment. Several areas are necessary in establishing an effective program; corporate commitment, process flow, the EMC engineer and EMC oriented design philosophies.

[18] Braxton, Thomas E., "Selling EMC in a Large Organization," *IEEE 1988 International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 88CH2623-7, Seattle, WA, August 2-4, 1988, pages 447-451.

Abstract: Those in the EMC community are often a distinct minority in the technical population. EMC engineers are surrounded by designers, manufacturers, and managers who have little patience with the vagaries of EMC. Interference control is many times at the bottom of the list of design considerations, due to the focus on schedule commitments and product performance. This paper discusses such an environment, and offers some thoughts on how best to raise on organization's EMC consciousness.

[19] Hurlimann, A., "Some Notes on EMC Management," *1987 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 87CH2487-7, Atlanta, GA, August 25-27, 1987, pages 251-254.

Abstract: It is a fact that good management alone cannot solve technical problems. But it is also a fact that efficient management combined with proficient technical resources can produce technically and economically optimal solutions. This fact guided the systematic integration of EMC technology in the products of the company discussed until the beginning of the 80's.

[20] Fos, Joseph E. Jr., and Stelma, Tony T., "Using the EMCAB to Your Advantage," *1986 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 86CH2294-7, San Diego, CA, September 16-18, 1986, pages 435-438.

Abstract: Electromagnetic Compatibility Advisory Board (EMCAB) identified. Electromagnetic Compatibility Program Plan (EMCPP) identified. Authorization for EMCAB and responsibilities toward EMC discipline through EMCAB charter. Establishing control of the EMCAB through the co-chairmen. EMCAB members identified. Coordinated exchange of technical EMI/EMC problem resolution. Duties and responsibilities of EMCAB coordinator and members. Technical advisors and guest speakers identified. Conducting an EMCAB.

[21] Simons, D.H. Jr., "Practical EMI/EMC Documentation," *1984 IEEE National Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 84CH2035-4, San Antonio, TX, April 24-26, 1982, pages 73-75.

Abstract: The impact of electromagnetic interference (EMI) and electromagnetic compatibility (EMC) design and test activities on electrical and electronic equipment, during the next quarter century, will become even more critical than in the past. Furthermore, the usage of frequencies, intentional and unintentional. is growing at a phenomenal rate. The EMI/EMC specialist must communicate test results and his or her concerns, in a permanent way through effective documentation. A primary goal is to make an influential impact on the audience or reader by providing documentation that is concise, accurate and timely. This

paper will review formal and informal EMI/EMC documentation and present this authors experience in achieving this goal.

[22] Free, W.R., and Clark, D.E., "Management and Design Guidance for EMR Hardening," *IEEE 1983 International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 83CH1838-2, Washington, DC, August 23-25, 1983, pages 237-239.

Abstract: To ensure that future guided weapon systems are capable of operating in the increasingly severe military electromagnetic environments, all three DoD services have developed programs to ensure that adequate electromagnetic radiation (EMR) hardness measures are incorporated in the design and development of future weapon systems.

The availability of adequate guidance information to assist program managers and system developers in establishing, implementing, and managing effective EMR hardness programs is an essential element in realizing the goals of these programs.

This paper describes two documents that have recently been developed to provide guidance information for program managers and system developers in establishing and implementing effective EMR hardness programs.

[23] Simons, D.H. Jr., "Electromagnetic Compatibility Management in the 1980s," *1982 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 82CH1718-6, Santa Clara, CA, September 8-10, 1982, pages 11-15.

Abstract: The present administration in Washington has a monumental task in maintaining a super power military status within tight budget constraints. The President has asked for cooperation from all areas, and each individual, each discipline, must consider what contribution can be made to this endeavor. Much can be done in the electromagnetic compatibility (EMC) community to minimize costs of prime weapon systems without compromising electromagnetic compatibility (EMC) concerns. A plan is presented in this paper to place proper emphasis, and associated menies, in the critical areas of a total EMC program. The entire relationship of electromagnetic interference (EMI) design and test, followed by EMC design and test, will be evaluated from a fresh viewpoint. This report presents a critical look at EMI test methods and specification limits in relation to the attainment of EMC.

[24] Doeppner; Thomas W.J., and Heverly. Ross, "Improved EMC Management," *1975 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 75CH1002-5EMC, pages 6AIe1-6AIe6.

Abstract: This paper reports on a study which was conducted for the Department of the Army to develop realistic and cost-effective means of assuring that EMC is adequately considered in the design, acquisition, development, and operation of the Army's communications-electronics (C-E) based equipment and systems. The objective was to reach the Army planner rather than the design engineer; the logistician rather than the radio operator; the procurement officer rather than the assembly line inspector. No attempt was made to develop new EMC standards or specifications, but to provide guidelines and procedures for Army management to make the right development and acquisition decisions at the right time, and for the right reasons; at least insofar as EMC is concerned. The product of the study was a document entitled "EMC Guide for Developers,"

recently published by the Army as a Department of the Army Pamphlet (DA Pamphlet 11-13), "Army Electromagnetic Compatibility Program Guide."

[25] Osburn, John D.McM., "Optimum Employment of Electromagnetic Compatibility Engineers," *1975 IEEE International Symposium on Electromagnetic Compatibility*, IEEE Catalog Number 75CH1002-5EMC, pages 6AIh1-6AIh5.

Abstract: The optimum utilization of Electromagnetic Compatibility personnel is highly dependent on the organizational framework in which the EMC engineer attempts to function. The typical organizations, as are employed throughout the electronics industry, are discussed in terms of efficiency of execution of the EMC task. The organizational structure is a factor in determining the effectiveness of the EMC control task. The utilization of EMC engineers and the effectiveness of their work is directly related to the responsibilities and tasking as a function of the organizational structure in which they must operate.

This paper discusses the organizations which may be encountered and describes some of their inherent advantages and disadvantages. The problems encountered by the working engineer as a function of organization are discussed. The complications caused by customer interfaces are also reviewed. Management/engineer interfaces are discussed.

In closing, an organization, tasking, effective utilization and functional interface that has proved successful is described and general recommendations for improving EMC control task efficiency are presented.

[26] Fousel, V.L., "On Achieving Compatibility Between the Management and EMC Specialists," *1970 IEEE Electromagnetic Compatibility Symposium*, IEEE Catalog Number 70C28-EMC, Anaheim, CA, July 14-16, 1970, pages 120-123.

Abstract: Will the "black art cults of EMC" really become the "Expanding Science of EMC" Engineers of the 70's?

Will the specialized interest of job security isolationists who have generated the "You must come to ME" empires really condescend to develop a basis of value in education and information sharing?

For many years, the EMC specialists have been crying about not getting enough recognition, not enough money, not enough glory. So what have they done about it besides bleat? What have they tried to engender the appreciation and understanding of the current co-workers who may (or have) become the management of the future? Especially, what have they done to demonstrate their own understanding of managing a major operation or program?

[27] Freeman, E.R., and Sachs, H.M., "Compatibility Management – A Situation Report," *1969 IEEE Electromagnetic Compatibility Symposium*, IEEE Catalog Number 69C3-EMC, Asbury Park, NJ, June 17-19, 1969, pages 138-142.

Abstract: This paper provides an overview of the EMC management area, and points out major problem areas which management must resolve if an effective national EMC program is to exist.

[28] Nichols, Fred J., "RFI/EMI at the Crossroads," *Unclassified Proceedings of the Ninth Tri-Service Conference on Electromagnetic Compatibility*, Contract No. DA 36-039SC-89102, Chicago, IL, October 15-17, 1963, pages 45-58.

Abstract: Electromagnetic interference controls at this time are not compatible with our nation's newer electronics systems. Specifications, instrumentation, and controls are basically based on policies established for long range communications as typically used by aircraft and naval vessels. The excellent policies of these "near past" systems have not truly been upgraded into the policies required for today's electronic systems. We have examples of the necessary efforts of ECAC, the Electronic Proving Grounds at Ft. Huachuca, and the recently announced electromagnetic test facility for the Navy at the Navy Electronics Laboratory, San Diego.

These programs are aimed at defining the existing problem areas and will produce information to prevent a re-occurence of the problems. However, these programs basically exist today because strong management policies were not established, or the existing policies of ten to fifteen years ago were not enforced.

A strong awakening is vitally needed today to prevent further collapse of existing specifications so that the output of ECAC, Ft. Huachuca and NEL is not obsolete when published. Further, strong EMI policies are immediately required at the planning stage of new electronic systems in order that they will be compatible with themselves as well as the environment in which they will be utilized.

Our modern electronic systems should be thought of in terms of full operational usage, just as a countermeasure is designed jointly with a new offensive device or system.

This paper will illustrate some typical examples of the crossroads that RFI/EMI is at and make recommendations to establish early EMI policies on a per program basis, as well as recommending EMI specifications on a per type of equipment or system basis, and on an intra and inter-system basis.

[29] Nichols, Fred J., "Management Responsibility in Obtaining an Electrical/Electronic Compatible Weapon System," *Unclassified Proceedings of the Eighth Tri-Service Conference on Electromagnetic Compatibility*, Contract No. DA 36-039SC-89102, Chicago, IL, October 31 – November 2, 1962, pages 44-58.

Abstract: Today's and tomorrow's weapon systems, be they an intercontinental missile, an early warning system, a communication system, an airplane, or the like, all use portions of the electromagnetic spectrum from the lowest power line frequencies on up through microwave regions. On an intra-system we have the need to functionally integrate electrical, electronic, and RF devices and systems in order to utilize the spectrum or to control the spectrum so that they might use it wisely. On an inter-system basis we have the same needs, plus frequency allocation techniques as licensed emitters are also used. The recognization of this, while immediately evident to the RFI/EMC engineer, is not always apparent to top engineering management. A management recognization of electrical/electronic/RF integration is acknowledged, as the system must perform to its requirement. However, a plan, or even the need for an electromagnetic compatibility plan to achieve this, is seldom recognized. In fact, it seems that in many cases management thinks of this type of integration as a test program. It cannot be emphasized too strongly that EMC is not a test program, and this paper will bring these points out and describe management's area.