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EMP Vulnerability Assessment of the AN/USM-410, a Computerized, Van-Mounted Electronic Equipment Test System

by Thomas A. Rose

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An analytical study was performed to assess the survivability of the AN/USM-410, van-mounted configuration, to the nuclear electromagnetic pulse. The AN/USM-410 is an automated test system for repairing electronic equipment. The system uses commercial, off-the-shelf automatic data-processing equipment to control specially designed test and interface equipment. This report describes the philosophy and technique for the assessment

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and presents conclusions and recommendations for reducing the system susceptibility level.

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1. INTRODUCTION

This report describes an analytical assessment of the AN/USM-410 automated test system which was performed to determine and improve, if necessary, the system's survivability to the nuclear electromagnetic pulse (EMP). Presented are the philosophy and technique of the assessment and conclusions and recommendations relating to the system's survivability. Section 1 provides an overview of the assessment including a summary of conclusions and recommendations. Later sections describe pertinent aspects of the assessment in greater detail.

The assessment is referred to as analytical because the conclusions are based primarily on the application of analytical prediction tools, general knowledge of the performance of electronic equipment and EMP protection measures, and extrapolation of data gathered from past testing of other military electronic systems. Actual hardware and final schematics of the electronic circuits to be used in the AN/USM-410 were not available at the time of this assessment. For this reason no system testing was performed. Limited laboratory testing was performed to characterize the performance of some components.

The assessment was sponsored by the Product Manager (PM), Test Measurement and Diagnostic Systems (TMDS), U.S. Army Materiel Development Readiness Command (DARCOM)* who is the system developer. At the request of PM-TMDS, the assessment considered only the van-mounted configuration of the AN/USM-410 and did not consider the survivability of external support equipment such as the mobile electric power (MEP). Figure 1 and table 1 identify the nomenclature associated with the AN/USM-410. In precise terms, this effort assessed the OQ-290 Electronic Equipment Test Facility, which includes the AN/USM-410 Electronic Equipment Test Station with the MK-2046 Power Protection kit and installed in the V-516 Test Facility Van. All conclusions and recommendations presented here refer to the complete van configuration. The results are not relevant for other possible AN/USM-410 configurations since the protection provided by the van and system installation in the van are prominent factors in the overall survivability. Throughout this report references to the AN/USM-410 should be interpreted as referring to the OQ-290 van configuration.

The AN/USM-410 van configuration is an automated test equipment (ATE) facility housed in an XM-995 35-ft semitrailer van. The XM-995 is a modified XM-913 semitrailer van (modifications are discussed in later sections). System power is provided by either MEP (in the 30- to 60-kW range) or commercial power (220 Vac, 3 phase, 60 Hz). The ATE consists of commercial, off-the-shelf automatic data processing (ADP) equipment which controls specially designed test and interface equipment.

**A glossary of terms and acronyms is included at the end of this report.*

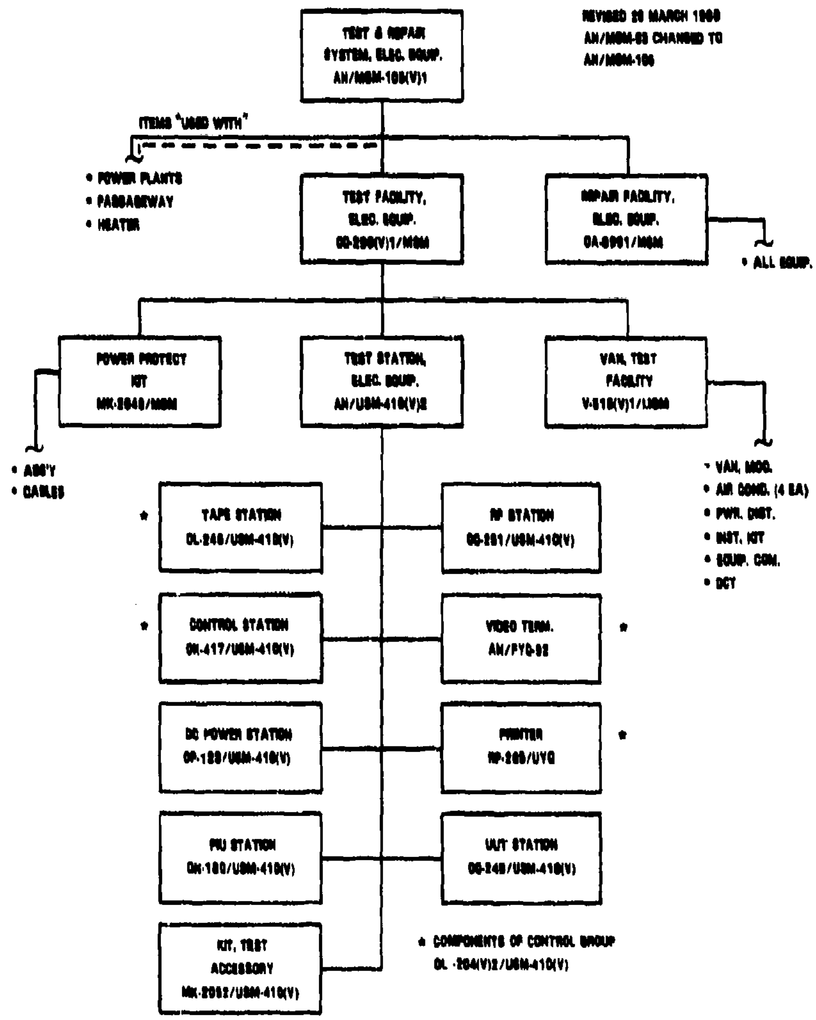

Figure 1. Nomenclature tree for van-mounted AN/USM-410 (V).

TABLE 1. AN/USM-410 NOMENCLATURE

Revised 3/20/80

	Nomenclature (comments)	Type designator	National stock No.
1.	Test and repair system, elec equip, family	AN/MSM-105(V)	None required
2.	Test and repair system, elec equip	AN/MSM-105(V)1	Pending
3.	Test facility, elec equip, family	OQ-290(V)/MSM	None required
4.	Test facility, elec equip	OQ-290(V)1/MSM	Pending
5.	Repair facility, elec equip (uses XM-991 van)	OA-8991/MSM	6625-01-070-4404
6.	Power protect kit	MK-2046/MSM	Pending
7.	Van, test facility, family (modified XM-995 van)	V-516(V)/MSM	None required
8.	Van, test facility (modified XM-995 van)	V-516(V)1/MSM	6625-01-069-8667
9.	Test station, elec equip, family	AN/USM-410(V)	None required
10.	Test station, elec equip (18 GHz)	AN/USM-410(V)1	6625-01-07-03658
11.	Test station, elec equip (18 GHz for van)	AN/USM-410(V)2	6625-01-069-4223
12.	Test station, elec equip (500 MHz)	AN/USM-410(V)3	6625-01-077-5452
13.	Computer control group, family	OL-204(V)/USM-410(V)	None required
14.	Computer control group, fixed inst	OL-204(V)1/USM-410(V)	6625-01-070-4405
15.	Computer control group, van inst	OL-204(V)2/USM-410(V)	6625-01-070-4403
16.	Power supply group (DC station)	OP-123/USM-410(V)	6625-01-057-6259
17.	Interconnect-interface group	ON-180/USM-410(V)	6625-01-068-8566
18.	Test station group, meas-stim	OQ-249/USM-410(V)	6625-01-066-4493
19.	Test station group, microwave	OQ-251/USM-410(V)	6625-01-052-1341
20.	Magnetic tape group (tape station)	OL-246/USM-410(V)	Pending
21.	Operator control group (control station)	OK-417/USM-410(V)	Pending
22.	Video display terminal (HP 2645A)	AN/FYQ-92	Pending
23.	Line printer (DG 4215)	RP-275/UYQ	Pending
24.	Line printer (mil type HSP-3609-212A)	RP-265/UYQ	5895-01-085-3437
25.	Kit, test accessory (for 18-GHz systems)	MK-2052/USM-410(V)	Pending
26.	Kit, test accessory (for 500-MHz systems)	MK-2049/USM-410(V)	Pending

The ATE will, with limited operator control, test and verify correct operation of supported electronic equipment from major items down to printed circuit boards. The ATE can isolate faults to the replaceable piece-part level. The ATE consists of computer-controlled, modular building blocks which comprise a flexible (hardware and software) system which can be configured into specific testing stations to satisfy varying user needs.

The AN/USM-410 van configuration is deployed with a second van which serves as an electronics repair facility (ERF). This van contains the necessary tools and equipment for accomplishing required repairs. Plans call for the interconnection of the ATE and ERF vans at the side doors with a canvas covered passageway (refer to Electronics Command (ECOM) drawing SC-D-506827).

The AN/USM-410 is planned to provide general support (GS) and divisional and nondivisional aviation intermediate-level maintenance (AVIM) support to over 50 items of communications-electronics/aviation equipment. The system does not have a communications requirement. This study assumes, however, and initial prototypes provide for, an intercom between the ATE and ERF vans and a field telephone within the ATE van.

It is important to include a note of warning at this point regarding application of results presented here to other systems. The conclusions and recommendations presented here refer to a specific configuration of a specific system, the AN/USM-410 van configuration. The effectiveness and adequacy of particular system features and hardening measures discussed in this report depend on many system-dependent factors and their interrelationships. The same system features and hardening measures applied to another system will not necessarily be appropriate and adequate for HEMP survivability of that system. Until such time as comprehensive EMP hardening standards and specifications are available for systems and their components, each system must be assessed individually.

1.1 Objective

The object of this project was to assure the survivability of the van-mounted version of the AN/USM-410 to the effects of the EMP produced by nuclear weapons. EMP survivability is specified in the AN/USM-410 ROC (Required Operational Capability)[1] in paragraph 5a(19) as follows: "The AN/USM-410 will provide nuclear survivability to effects of electromagnetic pulse (EMP) in the mounted configuration in the

[1] *Required Operational Capability (ROC) for AN/USM-410 Automatic Test Equipment (ATE) Facility, U.S. Army Training and Doctrine Command, ACN 22358 (22 February 1980).*

field, exclusive of the power plants, which were not developed as part of the system." No other nuclear survivability requirements exist. No specific quantitative nuclear EMP survivability criteria have been placed on the system.

Guidance from PM-TMDS has directed that Harry Diamond Laboratories (HDL) (1) should address only the survivability of the van-mounted version of the AN/USM-410, (2) should not address the survivability of the MEP, and (3) should limit survivability considerations to protection of the system ADP equipment from hardware damage (see definition of damage and upset in glossary). This latter guidance is based on the philosophy that EMP-induced upset is tolerable since the system mission does not require either the ability to operate through a nuclear event or the rapid recovery from upset.

The specific nuclear threats addressed by this vulnerability and hardening assessment were limited to the high-altitude EMP (HEMP) at the threat levels commonly prescribed for Army tactical systems. This position is consistent with the lack of a required balanced hardening requirement for protection against the other nuclear effects (blast, thermal radiation, and nuclear radiation) and is appropriate for the AN/USM-410 mission and planned deployments. Since no requirement exists for survivability to blast, thermal radiation, and nuclear radiation, it is felt that there is no basis for examining the low-altitude EMP (LEMP) or other forms of EMP (other than high-altitude EMP--HEMP). In general cases, where these other forms of EMP are significant, the effects of blast, thermal radiation, and nuclear radiation would control the vulnerability of the system's hardware and operations personnel.

Hardening the AN/USM-410 to the HEMP threat will in no way degrade the system's survivability to any other nuclear weapons effects. Hardening measures recommended for protection against HEMP will contribute to enhanced survivability to LEMP. Incorporation of all recommended HEMP hardening measures and the certification of the system as being hard to HEMP will indicate an improved survivability to LEMP. However, unless the LEMP case is specifically addressed, these measures are not known to be adequate hardening for any specific LEMP threat scenarios.

The basic guiding philosophy was to assess the protection inherent in the system design and configuration and attempt to limit any needed supplemental protection measures to (1) primarily, the overall system inclosure (i.e., the van structure, entry panels, external cables and cable entry points, doors, vents, external ground system) and (2) secondarily, hardware installation techniques internal to the van (cable routing, cable shielding or ducting, interrack transient protection). This philosophy was mutually agreed by HDL and PM-TMDS to be the best approach in that it takes full advantage of the potential protection provided by the XM-995 van while minimizing the need to make costly modifications to the commercially available and proven internal ADP hardware.

Another reason for stressing HEMP protection at the overall inclosure level is that the ATE internal circuitry is not permanently and totally defined and may change in the future. In future years alternate sources or improved models of ADP equipment may be used. There is a substantial benefit to being able to provide HEMP survivability independent of the internal system components.

1.2 Summary of Results

Based on this analytical assessment, engineering judgement is that an acceptable level of HEMP survivability can be provided by protection afforded at the overall inclosure levels. No need exists for modifications to the ATE. A reasonable level of survivability which is consistent with the system's mission and planned deployments is expected when the recommendations outlined below are properly followed.

No quantitative confidence level can be assigned to this prediction without system testing, which was not part of this effort. In order to define a confidence level and verify the survivability predicted here, it is recommended that limited testing of the system in a simulated EMP environment be performed. Because of the many interrelated physical variables which contribute to EMP survivability and because of the limitations of present analytical prediction tools, testing is necessary to reach a high-confidence EMP survivability conclusion: Development of a data base of EMP test data for the XM-995 type semitrailer is important, not only for the AN/USM-410, but also for the many other Army systems which use similar vans.

XM-995 Van.--The XM-995 semitrailer van (modified XM-913) basic construction is considered acceptable for the required HEMP survivability with the exception of the doors and air-conditioning mounting points which are discussed below. This conclusion is based on examination of engineering drawings, applicable TM's (technical manuals), on-site inspection of one van at Tobyhanna Army Depot (TOAD) and review of the 12 February 1980 shielding effectiveness test report by Martin Marietta Corporation.[2] The shielding effectiveness provided by the van is generally in the desired 60-dB range, except at certain frequencies at locations adjacent to the van doors.

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[2]W. L. Clark, *Report of Shielding Effectiveness Test for Miller Trailer Model: XM-913 Semitrailer, Product Order 0375, Martin Marietta Corporation (1980).*

Better semitrailer vans can be provided by the U.S. Army Tank-Automotive Materiel Readiness Command (TARCOM) and are provided at present to Pershing II. Such vans are desirable for HEMP protection but the added cost is estimated at 50 percent. The selected XM-995 van is as good as any available semitrailer which has not been specifically designed as a shielded shelter. If future AN/USM-410 survivability requirements are made more rigid, or if HEMP survivability deficiencies are identified, then conversion to a better shielded semitrailer van is a primary recommendation for achieving an enhanced HEMP margin of protection.

Van door seals.--On-site examination of the first prototype van at TOAD has produced serious concerns about the radio frequency interference (RFI) seals around the van doors. The design of the door seals and the material used appear acceptable. The construction tolerances and installation techniques, however, are suspect. The van seen at TOAD had marginal problems on both side and rear doors. The seals were not installed completely as expected. The RFI seals were not one continuous piece joined tightly at the top of the doors. The seal material showed signs of distortion at several places. The most serious condition was that the RFI door seals did not mate with the door frames over the full width of the seal at all points around the periphery. This situation produces the concern that, after field use and the resultant inevitable distortion of the seals, there will be places around the door periphery where the seals do not mate at all.

The RFI shielding test report[2] indicates that, for one van, attenuations of as low as 40 dB were measured. It is recommended that the manufacturer be requested to review his construction and installation practices regarding the doors and RFI seals to assure adherence to specifications. If assurance of an improvement is not obtained it is recommended that PM-TMDS consider conversion to an improved type of door seal.

HEMP-produced transients on the semitrailer skin will produce a significant and troublesome voltage differential across mating joints where proper shielding is not present. This voltage differential will induce transient currents on internal cabling routed near the fault. The ATE signal cabling will not be affected since this is routed well away from all doors (and all other apertures for that matter, which is excellent). Of concern is the power cabling which is routed peripherally around the doors. Signal cabling is not routed with power cables at any point, so there should be no problem of coupling power cable transients to the signal cables.

[2]*W. L. Clark, Report of Shielding Effectiveness Test for Miller Trailer Model: XM-913 Semitrailer, Product Order 0375, Martin Marietta Corporation (1980).*

It is imperative that operations or maintenance procedures call for periodic inspection of the door RFI seals. If surfaces are dirty or seals are broken or distorted, then maintenance should be performed to rectify the problem.

Van doors--Standard Operating Procedures.--The possibility that van doors will be left open is a major concern. All van doors must be closed and tightly latched to avoid sacrificing the majority of the shielding benefits provided by the van structure. It is recommended that (1) an all-metal RFI-quality shielding inclosure be fabricated and used in place of the canvas passageway, (2) strict and realizable standard operating procedures (SOP's) be defined to insure that doors are normally closed (and tightly latched), or (3) the ATE must be required to meet transient specifications that will permit survivability in the less-shielded environment that results from open doors.

Power and signal-entry panel.--Examination indicates that design and installation of the entry panel is adequate for the required HEMP survivability. The only concern here is that TOAD had not provided to PM-TMDS or to HDL any documentation defining the entry panels. Knowledge to date is based on an on-site inspection of one custom-made and -installed entry panel. There is no documented assurance that all entry panels will be as good, although TOAD SOP seems to be good.

Air-conditioners.--The installation of the air-conditioning units examined on the one van at TOAD revealed a serious deficiency. Large spaces were present at many points and over large lengths around the periphery of the air-conditioners where they mate to the van body. TOAD indicated they were aware of the problem and explained that their plans call for sealing the joints with a conductive caulking. That treatment is the minimum that should be performed. It is recommended that PM-TMDS obtain RFI shielding test information on the finished product to verify an acceptable shielding effectiveness.

The air-conditioners selected for use are not the available electromagnetically hardened type. No electromagnetic shielding is present over the vents. Honeycomb-type shielding is desired for the vents, although it is not known without HEMP testing whether this is necessary. At minimum, RFI testing should be performed to indicate approximate leakage levels. Such testing should be made at a wide distribution of points within the van near the air-conditioners. It may be necessary either to convert to the hardened types of air-conditioners or to retrofit the present types of units with vent shielding.

Operations or maintenance procedures should call for periodic inspection of the RFI sealing around the air-conditioners. Any visible deterioration should be repaired.

Power and signal cable terminal protection.--Current prototypes of the AN/USM-410 have filters installed on both the power cables and signal cables where they enter the van. No further terminal protection devices (such as surge suppressors) are used at the entry points.

The particular filters used are judged to provide adequate protection for the desired HEMP survivability for the AN/USM-410 van configuration examined.

The power filters presently supplied are All-tronics part number A5053 and are specified by Military Control Drawing 02777 1969-4W. The filters are specified to provide 100 dB minimum over the frequency range from 15 kHz through 10 GHz. These filters provide adequate attenuation for protection against predicted HEMP transients coupled to exterior power cables for this particular AN/USM-410 configuration.

The signal filters presently used are Sprague part number JW17 1122. Two sample filters were acquired and characterized in laboratory tests (see appendix A). The filters provide marginally acceptable protection. Since (1) the AN/USM-410 mission does not have an essential communications requirement and (2) field telephones have been shown in previous testing not to be highly susceptible to damage, the signal filters used are judged to be adequate.

It is recommended that the final drawings and specifications require all future AN/USM-410 systems to include power and signal filters at least as effective as those now used.

Grounding.--For grounding the AN/USM-410 van externally to earth, normal Army grounding procedures are acceptable, with the following additional recommendations: One ground rod should be located as close as possible to the combined signal and power-entry panel. The ground strap connecting the entry panel to the ground rod should be as low an impedance as possible. This suggests selecting a ground strap with a large surface area such as a wide flat braid rather than a round conductor.

The intent is that the external ground system should present as low an impedance path to earth as possible for the frequency range from 10 kHz to 100 MHz. This will allow transients to be quickly dissipated to earth rather than distributed over the van body.

2. EMP OVERVIEW AND ASSESSMENT APPROACH

This section is intended to stress fundamental characteristics and concerns of the HEMP threat relevant to the AN/USM-410 assessment. For a brief yet comprehensive overview of EMP the reader is directed to chapter 11 (pp 514-540) of Department of the Army pamphlet No. 50-3.[3] A second reference particularly relevant to the AN/USM-410 is the Harry Diamond Laboratories report, HDL-TR-1891, sections 3.1 and 3.2.[4] This report was reviewed by PM-TMDS as initial guidance for hardening the AN/USM-410.

The HEMP threat is of major importance because of the wide geographical area over which the effect is felt from a single nuclear burst. The potential for widespread damage simultaneously to many systems is of great concern. A single nuclear burst of a few hundred kilotons or more exploded above 19 miles (30 km) will generally produce electromagnetic fields in excess of 25,000 V/m on the ground in all directions as far as the line of sight. A burst at an altitude of 50 miles (80 km) will affect a land area with a radius of roughly 600 miles (965 km). A burst at an altitude of 200 miles (320 km) would affect an area greater than that of the continental United States (see DA PAM 50-3, p 519, par 11.15).[3]

The HEMP effects are not accompanied by any other nuclear effects (blast, thermal radiation, and nuclear radiation). HEMP poses no significant threat to personnel (see DA PAM 50-3, p 521, par 11.20).[3]

The AN/USM-410 draft version of the ROC (27 July 1979)[5] tentatively predicted deployment of 27 systems in the continental U.S. (CONUS), 4 systems in the Pacific, and 15 systems in Europe. A single high-altitude nuclear burst could damage all HEMP-susceptible systems either in the CONUS or European theaters. Although, by tradition, support equipment such as the AN/USM-410 may be considered a low priority for nuclear hardening, in reality the AN/USM-410 is highly critical because of the nature of the equipment it is intended to support. PM-TMDS has developed and functionally proven an excellent ATE system for which the Army has a critical need. If the Army must be able to operate effectively for extended periods after inital nuclear action, then key maintenance support systems, like the AN/USM-410, must be nuclear hardened to at least HEMP.

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[3]*The Effects of Nuclear Weapons, Department of the Army, Pamphlet No. 50-3 (March 1977).*

[4]*Thomas A. Rose, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

[5]*Proposed Required Operational Capability (ROC) for the AN/USM-410 Automatic Test Equipment (ATE) Facility (27 July 1979).*

Because of the possibility of losing all theater AN/USM-410's, the possible contingency plan of reverting to backup systems is questionable. However, a backup system might survive where a deployed system would not, if the backup system were stored in a more shielded environment and/or were not configured in an operational mode with power cables attached, etc.

The AN/USM-410 is inherently as susceptible to the effects of EMP as any Army system because of the presence of low-power logic circuit equipment and large amounts of semiconductor electronics (see DA PAM 50-3, p 525, table 11.32[3] and HDL-TR-1891, pp 14, 15[4]). The AN/USM-410 system configuration provides several efficient media (external power cabling, external ground conductors, and possibly external field telephone cabling) for coupling EMP energy into the sensitive system circuitry (see DA PAM 50-3, p 520, paragraphs 11.16, 11.17 and table 11.17[3]).

The installation of the system components in a metallic van is an inherent advantage in that it provides a convenient potential means for isolating the components from the EMP environment. The thrust of the hardening effort for the AN/USM-410 is logically directed at blocking passage of the energy from the primary coupling media (external cabling) to the van interior. The energy collected on these media must be blocked and diverted to ground. The external ground system is important in two ways. First, the ground system, if not properly configured, is a potential means by which EMP energy may be coupled into the system circuitry. Second, it is the ground system by which, it is hoped, EMP energy will be diverted away from the system.

All factors that can defeat the shielding effectiveness of the van or otherwise degrade the shielding effectiveness must be addressed (see HDL-TR-1891, pp 18, 19[4]). Thus, AN/USM-410 system features which received primary attention are:

external power cabling
power entry panel
external ground system
external signal lines
signal entry panel
side door
rear door
air-conditioner installation hole
air vents
van panel seams and joints
any other holes in van structure

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[3] *The Effects of Nuclear Weapons, Department of the Army, Pamphlet No. 50-3 (March 1977).*

[4] *Thomas A. Rose, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

Common protection measures for other electrical transients, including electromagnetic interference/electromagnetic compatibility (EMI/EMC), power overloads, surges, outages, and lightning, provide some protection against the effects of EMP, but are not adequate. Each of these other phenomena differ in significant ways from HEMP. The HEMP threat environment illuminates the entire system area, simultaneously exciting all external conducting media, including all cables and the van structure. The HEMP energy is compressed into a very brief time window. The initial and largest peak (25 to 70 kV/m) occurs within a few nanoseconds. The frequency range of HEMP, 10 kHz to 100 MHz, is greater than the other phenomena. Protection devices for the other phenomena--that shield, divert, or filter transients--either fail to react quickly enough, operate at the wrong levels, or fail to eliminate an adequate portion of the HEMP-induced energy.

2.1 Assessment and Hardening Techniques

The common and preferred technique for assessing and hardening a system to the EMP threat is first to perform an analytical study and second to verify hardness through testing (see DA PAM 50-3, p 525, par 11.33 and p 527, par 11.41[3]). In the first effort the system and its components are identified. Sensitive or critical electronic components are identified. Significant coupling media are identified. Any present protection measures (hardware and software) are analyzed for effectiveness. The system's mission and deployment configurations are examined. Existing EMP prediction tools are exercised to predict approximately the effectiveness of existing protection measures and the coupling of EMP energy into the system. Results on related systems from previous assessments, including testing, are analyzed for relevance and are extrapolated, if possible, to the system under study. System circuit damage thresholds are calculated. The result is that weak areas are identified and appropriate hardening measures are recommended.

The second phase, which involves testing an actual system in a simulated environment, is primarily for the purpose of verifying the predictions from the previous analytical study. The physical processes involved in the EMP problem are so complex that predictive analytical tools cannot yield highly confident results. Not only are the individual means by which energy couples into a system complex and not fully quantified, but there are complex interrelationships between the coupling processes.

Both the analytical and testing assessments are complex and can be lengthy and thus expensive. However, the testing phase is by far more expensive both in time and in direct equipment costs. For this

[3]*The Effects of Nuclear Weapons, Department of the Army Pamphlet No. 50-3 (March 1977).*

reason it is considered best to solve as much of the problem as possible analytically. However, limited testing is necessary as well. It is the Army's and HDL's position, and it is widely accepted throughout the EMP community, that verification testing is essential for certifying a system hard to the EMP threat (see DA PAM 50-3, p 527, par. 11.41[3]).

2.2 Related Past Work

In the past decade, since the EMP problem was fully recognized, much research and testing has taken place. The emphasis of this work has been toward strategic and critical tactical weapons systems and communications networks and equipment. Little or no work has been directed toward logistics and maintenance support equipment and ADP systems. In particular, little is known about shielding effectiveness afforded by Army semitrailer vans.

In 1978 and 1979, HDL performed an analytical HEMP assessment of the developmental DAS3 logistics computer system (see HDL report HDL-TR-1891, June 1979[4]). The physical and functional nature of the AN/USM-410 is closely related to DAS3; therefore, the EMP study of DAS3 is relevant. Findings in this study support the recommendations made for DAS3 survivability being relevant to the AN/USM-410.

All the characteristics which were of concern for DAS3 are also of concern for the AN/USM-410. All recommendations made for DAS3 are relevant for the AN/USM-410. The study performed for DAS3 was not sufficient, however, for adequately assessing and hardening the AN/USM-410.

The DAS3 study was limited in that it did not examine the actual ADP hardware to be used and the installation of that ADPE, since that information was not available at the time. Actual external power cable configurations were also not examined in detail for the same reason. No testing was performed to verify predictions of the study.

It was strongly recommended that DAS3 should be further studied and should undergo an EMP hardness verification test. Without further study and testing the confidence of the DAS3 conclusions is not very high.

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[3]*The Effects of Nuclear Weapons, Department of the Army, Pamphlet No. 50-3 (March 1977).*

[4]*Thomas A. Roso, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

Differences between DAS3 and the AN/USM-410 do exist, and these differences made direct extrapolation of results and conclusions questionable without further study. The DAS3 study was based primarily on procurement specifications which were quite comprehensive and which specified numerous features which were effective for EMP survivability. These features (see HDL-TR-1891, pp 34, 35[4]) included transient surge suppressors, filters, fault tolerance measures (including hardware redundancy), and a rigid requirement for immunity to power outage or power-line transients. The AN/USM-410 ROC[1] has no specifications of this kind.

The DAS3 study did involve first-hand examination of the XM-971 semitrailer which is similar to the XM-912 and XM-913 to be used by the AN/USM-410. But, here again, no previous testing had been performed on the XM-971 van, and no testing was done as part of the DAS3 assessment. Although limited EMI/EMC MIL-STD-285 test data are available on related vans, these data are of limited value for EMP prediction purposes.

MIL-STD-285 test procedures, as commonly practiced, are deficient for EMP purposes for two reasons. This testing does not illuminate the entire van but rather involves a single point-source radiator outside the van at close range and a detector at a few locations within the van. The second reason is that MIL-STD-285 testing involves only discrete measurements at select (and very few) frequencies.

2.3 Specific Approach

The specific approach for assessing the AN/USM-410 was divided into six tasks. The following describes those six tasks as originally planned.

Task 1, evaluation of coupling by external power cabling.--This task involves examination of all possible external power cabling configurations which will be used to supply power to the system from both MEP and commercial power. Effectiveness of protection measures at the power entry panel will be evaluated. Coupling via the power cabling to internal circuitry will be predicted. If damage is predicted, final conclusions will recommend additional terminal protection at power entry, shielding of power cables, or alternate configurations of power cabling.

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[1] *Required Operational Capability (ROC) for AN/USM-410 Automatic Test Equipment (ATE) Facility, U.S. Army Training and Doctrine Command, ACN 22358 (22 February 1980).*

[4] *Thomas A. Rosa, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

Subtask 1(a): Identify system circuitry which interfaces to the power entry panel and which may be subject to damage.

Subtask 1(b): Identify any existing protection measures applied at the power entry panel, to power cabling, or in interface circuitry.

Subtask 1(c): Identify all power cable configurations. Of importance is: What type of cables will be used (how many conductors, how constructed, what shielding exists)? What type of connectors and receptacles will be used? How will cables be routed and laid?

Subtask 1(d): Predict the EMP coupling onto the power cables. This will involve the use of existing mathematical and computer tools and data from previous testing of other systems and requires knowledge of information gained in subtasks 1(a) through 1(c).

Subtask 1(e): Evaluate the damage threshold levels for the internal system circuitry and predict whether damage will occur. The effectiveness of any existing protection measures will be included.

Subtask 1(f): Conclude whether further power cable protection measures are necessary. Hardening options will be recommended if needed.

Task 2, evaluation of coupling by external signal cabling.-- This task involves examination of any external signal lines which may be associated with the system. This task will involve the same subtasks as for task 1, but will relate to the signal lines rather than to external power.

Task 3, evaluation of effectiveness, external ground system.-- This task involves evaluating (1) the effectiveness of the external ground system for dissipating EMP-induced energy on system components and (2) the possible coupling of EMP energy to the system via the ground system.

Subtask 3(a): Identify pertinent features of the external ground system configuration.

Subtask 3(b): Evaluate effectiveness of ground system.

Subtask 3(c): Determine the need for modifying or supplementing the existing ground system.

Task 4, evaluation of overall shielding effectiveness of van.--This task involves identification and evaluation of the degrading effects of all potential weak spots in the van structure. Weak spots include panel-entry holes, air-conditioner installation hole, all vents, all doors, panel seams (walls, floor, and roof), and any other apertures which may exist. Field levels inside the van will be predicted. This task involves a more rigorous analysis than previously done for DAS3 and involves use of recent research findings from other related projects.

Subtask 4(a): Define potential weak spots in the van structure.

Subtask 4(b): Evaluate degradation to shielding effectiveness due to each weak spot.

Subtask 4(c): Predict internal van field levels due to HEMP.

Subtask 4(d): Conclude the overall shielding effectiveness provided by the van configuration.

Task 5, examination of feasibility of hardening at zone 0/1.--Based on results of the other tasks, a conclusion will be reached as to whether or not it is feasible to harden the AN/USM-410 with measures applied exclusively at zone 0 (external environment) and the zone 0/1 boundary (van structure level).

Task 6, evaluation of transients within the van structure.--Based on results of task 4 and on examination of internal equipment configurations and cable routings, internal van transient levels will be predicted.

Subtask 6(a): Identify internal van equipment and cable configurations.

Subtask 6(b): Predict coupling to internal power signal and ground cabling.

Subtask 6(c): Evaluate potential damage.

Subtask 6(d): Conclude need for further protection measures internal to van.

3. SYSTEM FEATURES

Appendix B lists the major documentation which defined the AN/USM-410 system for the purposes of this assessment. Throughout the time period of this EMP assessment, the physical configuration of the AN/USM-410 van version has been evolving. Initially, when the assessment began in July 1979, the physical details of many of the system components and the ultimate configuration into a complete system were defined only in general terms. A proven set of commercial-grade (i.e., not military ruggedized) electronic automatic test equipment was to be configured into a mobile system by means of installation into an existing-model military semitrailer van. The particular van to be used was undetermined. Also unspecified were the final air-conditioners and MEP. Of particular importance to this assessment was the physical layout of equipment in the van; the grounding system; the signal and power routing within the van; the type, length, and deployment of external power and communication cables; and the installation specifications for entry panels. These factors, undefined initially, have gradually been better defined during this assessment.

Since no quantitative or specific qualitative survivability criteria were stated for the system, the assessment effort examined the mission and planned deployments in order to formulate such criteria. These survivability criteria, along with the resolution of the factors discussed in the previous paragraph, allowed the generation of an assessment and hardening approach which was adequate yet involved minimum cost and impact to the system development.

The system's charter and development plan was gradually defined, leading to an initial draft ROC[5] and then a final approved ROC.[1] The survivability criteria and the assessment and hardening approach were reevaluated as all factors were better defined.

The Army, recognizing the growing difficulty of maintaining increasingly complex electronic systems, which more and more permeate all Army activities, has turned to the ATE concept. The ATE developed by the PM-TMDS represents a powerful capability which has been well proven in a depot atmosphere and can provide a critical asset to the future Army. The need to get ATE into the field nearer the equipment to be supported, together with the general Army mobilization policy, has produced the requirement for the mobile AN/USM-410.

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[1] *Required Operational Capability (ROC) for AN/USM-410 Automatic Test Equipment (ATE) Facility, U.S. Army Training and Doctrine Command, ACN 22358 (22 February 1980).*

[5] *Proposed Required Operational Capability (ROC) for the AN/USM-410 Automatic Test Equipment (ATE) Facility (27 July 1979).*

As ATE transitions into a field environment and proliferates, becoming a critical support element, nuclear weapons effects survivability must be addressed. HEMP survivability was assessed and hardening recommendations were provided consistent with system and mission needs.

The HEMP assessment and hardening approach determined to be best suited to the Army's needs for the AN/USM-410 is a relatively new concept of evaluating protection by a top-down, system-level approach. In this approach, emphasis is placed on protection afforded at the overall system level. Maximum importance is placed on van shielding and suppression of transients presented to the inner van environment by external conductors (power, communication, and ground conductors). Little attention is directed at the circuitry of internal system equipment except for purposes of estimating damage thresholds of such equipment. The system-level approach has the disadvantage of possibly requiring over-hardening at the overall levels, but it is considered highly cost-effective for the AN/USM-410 case, since detailed circuit analysis and modification is not required of the existing and proven ATE.

Figures 2 through 4 show the exterior of the prototype van examined at TOAD in April 1980. This van is like future ones to be used for the AN/USM-410, except that future XM-995 vans will have double rear doors with a removable center post.

Changes made to the XM-913, according to production specification received from PM-TMDS, include:

(1) The door in the curb-side wall (28 × 74.94 in.) will be located 128 in. measured from the finished interior of the front wall to the front part of the door opening.

(2) The floor structure behind the 11 in. drop will consist of 3-in.-high lateral channels for supporting an evenly distributed payload proportional to 20,000 lb for the whole vehicle length, covered with a 1-in.-thick plywood cover, NN-P-530, Grade A/C. One section in the plywood floor cover will be removable. The location will be specified later. The floor structure on the first and the second steps will be the same as for model XM-913. Doors will be lowered so thresholds will be flush with the floor, with 1/8-in. space provided for floor tile.

(3) Foam-in-place insulation, 2 in. thick, per MIL-P-21929, Class I, will be applied in the floor structure between the channels.

(4) Provisions will be made in the front wall for installing four 18,000 BTU/hr air-conditioners. No foam-in-place will be applied in the spaces where the air-conditioners will be mounted.

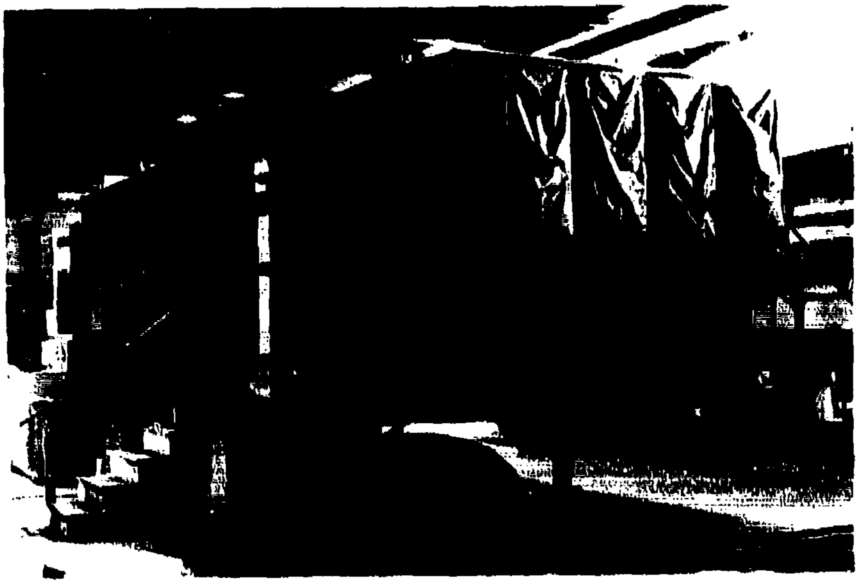

Figure 2. XM-995 front curb-side view.

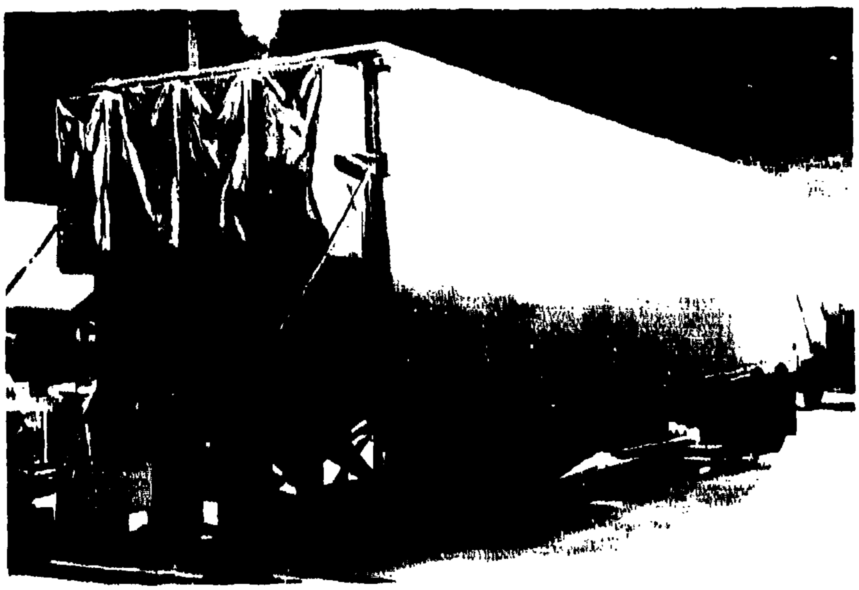

Figure 3. XM-995 front roadside view.

(5) Two doors with 28 in. openings and the standard removable center post will be installed in the rear wall.

(6) Interior lining on walls, ceiling, and doors: Royal Harborite or Duraply. Countersink all rivets.

(7) The roof skin will be cemented to the roof bows with Sikaflex 221, Industrial Adhesive Sika Chemical Corp., Lyndhurst, NJ, or equal.

(8) The framework for the power and signal entry will be omitted.

(9) RFI provisions will be made per drawings K11684570 (caulking) and B11607458 (wire mesh). The trailer will be tested per MIL-STD-285.

(10) The front and rear platforms will be installed by the trailer manufacturer in compliance with installation drawings D11684616 and D11684615, respectively.

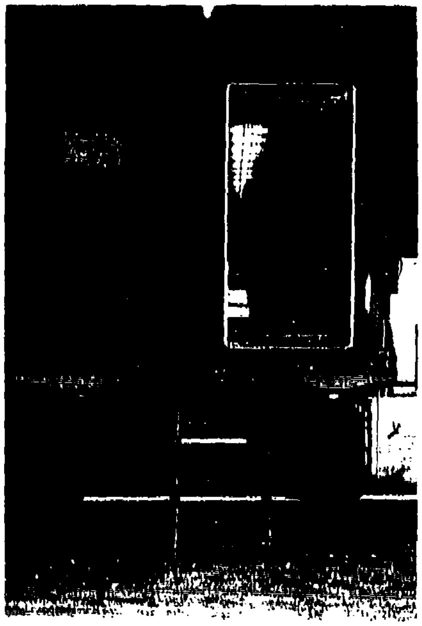

Figure 4. XM-995 rear view.

(11) The 11-in. drop will be moved as far as possible to the front.

(12) Insulation: Foam-in-place, per MIL-P-21929, Class I, in roof, walls, floor, doors, and behind fording plate. Block urethane foam insulation may be used in the floor area on the first and second steps.

(13) Polyurethane paint, forest green, per MIL-C-46168A.

(14) No grabhandle at the rear door.

(15) No door vents.

(16) Two boarding ladders, USA P/N 11684408, and one 12-ft ladder, USA P/N 11684609, will be stowed under the van body above the skidline.

The XM-995 van has a single metal skin on all exterior surfaces, including the floor. There is one curb-side door and there are two rear doors. All doors have RFI seals around the periphery where they mate with the van body. There is one combined signal and power-entry panel on the curb side, just forward of the side door. A pressure relief valve has been added for pressure equalization during air travel. Four vertical-style air-conditioning units are mounted on the front wall. The van has no apertures (holes) other than those mentioned above.

Figure 5 shows the layout of equipment within the XM-995 van. The lower diagram of figure 5 is a view of the curb-side wall as seen from the roadside. The middle diagram is a floor plan. The upper diagram is an upside-down view of the roadside wall as seen from the curb side.

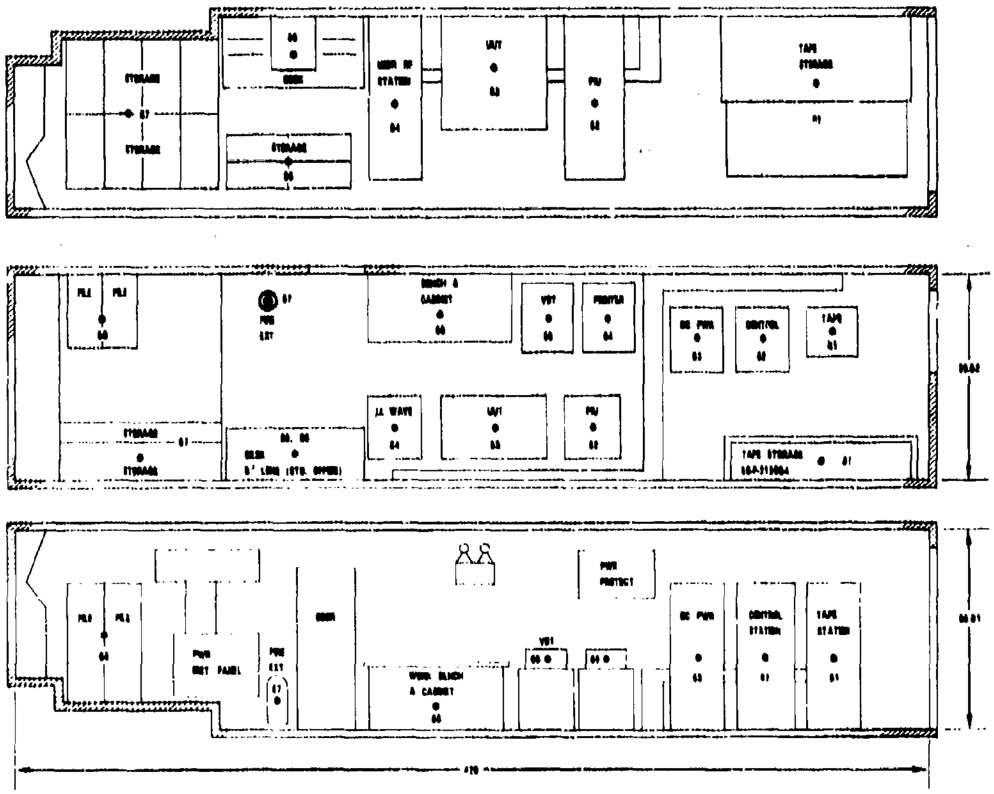

Figure 5. AN/USM-410 equipment layout.

The power and signal filters are on the curb-side wall inside the van at the entry panel. All power and signal wiring inside the van is inclosed in metal ducts or raceways.

4. ASSESSMENT DESCRIPTION

4.1 General

The first major issue addressed in the AN/USM-410 assessment was the feasibility and practicality of providing HEMP survivability by using hardening measures at the highest system level. The intent of any hardening effort is to isolate the system electronics in question from the adverse effects of a HEMP environment surrounding the system. The question here was: Is it practical to do this primarily or exclusively at the first zone of penetration?

For the AN/USM-410, a first level of protection is inherently provided by the metallic shell of the van which totally incloses the system electronics. There are two major advantages to hardening at the system level for this case. First, there would be a great cost savings if no modifications needed to be made to the existing system electronics. Second, the degree of HEMP survivability attained would be for the most part independent of future changes to the system electronics.

The question of system-level hardening involved determining the amount of protection required by the ATE and the possible protection provided by the van inclosure. The protection required by the system is, at first analysis, high, due to the presence of low-level semiconductor logic circuitry, featuring relatively susceptible integrated circuit components. However, the level of protection needed is significantly reduced since there is no requirement for upset protection as explained in section 1.1.

The level of shielding required between the HEMP environment and the environment surrounding the electronics, for damage protection, is considered to be 60 dB. If the HEMP field levels outside the van were attenuated by 60 dB before penetrating the internal van area, then van-level hardening would be feasible. Initial indications, based on previous system assessments, previous testing, and attributes of the XM-995, were that 60-dB shielding would be obtained.

To support this conclusion the assessment needed to examine the system electronics in more detail to assure that no highly sensitive circuitry existed which would require greater protection. Further, the assessment needed to examine the XM-995 van in more detail to assure that it would indeed provide the 60 dB desired. Intentional apertures (doors, vents, pressure relief valve) and unintentional apertures (panel seams, entry panel hole, air-conditioner holes, etc.) would have to be analyzed for possible leakage and hardened appropriately.

The major task remaining would be to predict the energy coupled from the external HEMP environment to external penetrators (external power and signal cables) and to provide sufficient terminal protection (filtering and transient suppression) at their point of entry into the van. A moderately long run of unshielded cable in the external HEMP environment can pick up a large amount of energy requiring terminal protection much greater than 60 dB in order to attenuate transients to a level tolerable to the system electronics.

The AN/USM-410 has both external power and external signal cables. The power cables will normally be 125 feet long when MEP is used and will be effectively much longer when connected to an unprotected commercial power distribution system. The signal cable for intercommmunications between the ATE and ERF vans will be 10 to 15 ft long. A signal cable from a field telephone in the ATE van to a remote command point would be of indefinite length. All the external cabling used by the AN/USM-410 is unshielded. These cables, whether or not they are laid on the ground or strung on poles, have the potential to pick up transients of several thousand amperes and hundreds of thousands of volts.

4.2 Van Structure

The materials and construction of the XM-995 are effective for attenuation of HEMP fields, although the van was not designed for use as a shielded shelter. The material and thickness of the wall, roof, and floor panels are sufficient to provide more than the desired attenuation. The panel seams and other joints in the basic walls, roof, and floor appear to be adequate. A very small spacing between rivets and bolts, as is used on the XM-995 for panel connections, is desirable for a good electrical bond. The potential for joints to loosen after extended use is not considered to be great.

Better shielded semitrailers, ones which were designed as shielded shelters, are available. Such vans would provide a greater margin of protection. The question of how the shielding of vans in general, and the XM-995 in particular, varies with age has not received sufficient attention by the Department of Defense research and development community. It is widely acknowledged that shielding degradation, primarily due to joints and seams loosening from motion, does occur. A van with a higher initial shielding rating would thus be desirable.

The determining argument for whether to use a better shielded van is cost versus margin of protection. A better van might cost 50 percent more. Such a cost increase does not appear justifiable in consideration of the system's nuclear weapons effects survivability requirement.

4.3 Van Door Structure

The critical factor about the shielding effectiveness of the doors is how well they seal (electrically) when closed. The type of seal used is defined in the following van drawings.

11592542 Seal, door
11607458 RFI mesh
11607459 Seal, door
11684572 Door assembly

The seal serves both as an environmental seal and an RFI seal. From an RFI or EMP point of view the seal is not the best design commonly used, but it appears to be adequate.

Installation of the RFI door seal is critically important. To be effective the metal mesh part of the seal must, when the door is closed, contact both the mating surfaces at the door and door frame around the entire periphery of the door. To insure good contact the metal mating surfaces must be highly conductive electrically. They cannot be painted with a nonconductive finish or corroded. To insure a good contact around the entire door, the seal must be compressed when the door is closed.

The prototype XM-995 van was examined at TOAD in April 1980, revealing a possible problem with the RFI door seal. Figure 6 shows a portion of the seal on the rear door. The seal is not installed according to note 8 of van drawing 11684572 (there should be only one joint in the seal and that should be at the top of the door). A more serious concern is raised by figure 7, which shows part of the mating surface of the door frame. The rough marks indicate a scrubbing action between the wire mesh on the seal and the frame. This is good, since it serves to keep the mating surfaces free of corrosion. Unfortunately, it seems that the RFI seal nearly misses the mating surface in one area. This indicates a possible poor alignment between the door and the frame.

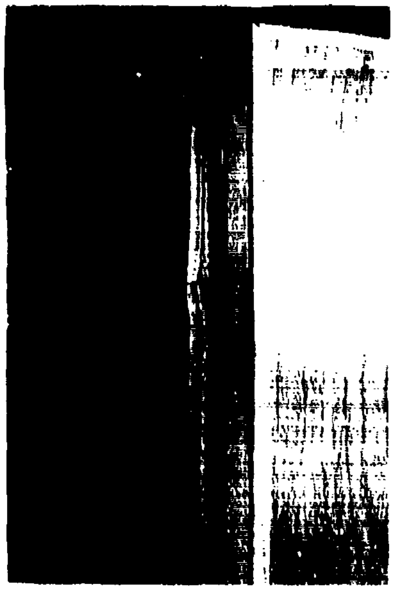

Figure 6. Door RFI seal.

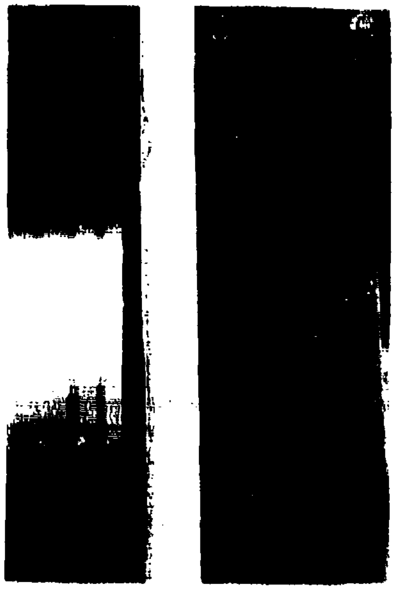

Figure 7. Door frame showing scrubbing action with RFI seal.

The RFI shielding test[2] performed on one trailer indicated poor shielding results in the areas around the doors. It is felt that the present doors and RFI seals can do the job if the installation quality control can be improved. It is recommended that more extensive RFI testing be conducted to verify improvements and insure good quality control.

A note is in order here regarding the interpretation of RFI test data. The differences between the HEMP environment and electromagnetic radiation involved in RFI testing require the extrapolation of the attenuation levels measured by MIL-STD-285 RFI testing. RFI attenuation levels do not directly indicate HEMP shielding effectiveness. In the interpretation of all RFI test data the procedures described in HDL-TR-1636[6] were followed.

[2] *W. L. Clark, Report of Shielding Effectiveness Test for Miller Trailer Model: XM-913 Semitrailer, Product Order 0375, Martin Marietta Corporation (1980).*

[6] *R. L. Monroe, EMP Shielding Effectiveness and MIL-STD-285, Harry Diamond Laboratories, HDL-TR-1636 (July 1973).*

4.4 Van Door Operation

All van doors must be closed and tightly latched to avoid sacrificing the majority of the shielding benefits provided by the van structure. The design of the door latches on the XM-995 is such that as the door is latched it compresses the door seal in the desired way. This insures a good electrical seal between the door, the RFI seal mesh, and the door frame.

Because the AN/USM-410 is provided with an inclosed passageway to connect the ATE and ERF vans at the side doors, there is even more reason than usual to be concerned about the possibility that operations personnel will not always close the doors. With the passageway in use, personnel can leave the side door open without greatly suffering from loss of air-conditioned comfort. The passageway, because it is canvas covered, provides no EMP protection whatever.

Operations procedures should clearly require and convincingly explain the need for closed doors. It is recommended that an explanatory sign be located at each doorway.

An alternative type of passageway (vestibule) which is effective for EMP protection is described in HDL-TR-1891.[4] The significant difference between the one proposed there and the one planned for the AN/USM-410 is that a metal structure is used instead of canvas.

4.5 Entry Panel

When the van wall is cut to allow for installation of the entry panel, a large aperture is formed. Such an aperture will allow HEMP radiation to enter the van and thus will seriously degrade the shielding effectiveness of the entire structure. The entry panel must be installed so that the aperture is effectively sealed. Installation guidelines are provided in HDL-TR-1891.[4]

TOAD procedures appeared to be adequate when examined on the one prototype. The only concern is that the installation procedures were not documented at the time of this assessment. It is recommended that final documentation be checked to insure inclusion of proper procedures.

[4]*Thomas A. Rose, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

4.6 Air-Conditioners

Figure 8 shows the overall installation of the air-conditioners on the front wall of the XM-995. There are two concerns with the air-conditioners. Figure 9 shows the air-conditioner intake and exhaust vents. These units are not the EMP-hardened types of units and do not have shielding over the vents. If this type of unit is used, RFI testing, as a minimum, should be performed to determine the leakage through the vent area. Shielding may have to be retrofitted to the vents as described in HDL-TR-1891.[4]

Figure 8. Overall view of air-conditioners.

[4]*Thomas A. Rose, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979).*

Figure 10 shows a significant gap between the air-conditioner body and its supporting frame on the van. The white in the photograph is light from inside the van. The photograph was taken before conductive caulking was applied. It illustrates the need for the caulking. RFI testing is recommended to insure the adequacy of the caulking. It is further recommended that operations or maintenance procedures require the periodic inspection of this caulking to insure that it remains effective. The large gap between the frame and the air-conditioners greatly increases the chances that overall shielding effectiveness will deteriorate substantially with system age. It seems unlikely that caulking at such a stress point will withstand prolonged vibration due to normal air-conditioner operation and van movement on the road. EMP system testing with faulty caulking would show the extent of leakage possible.

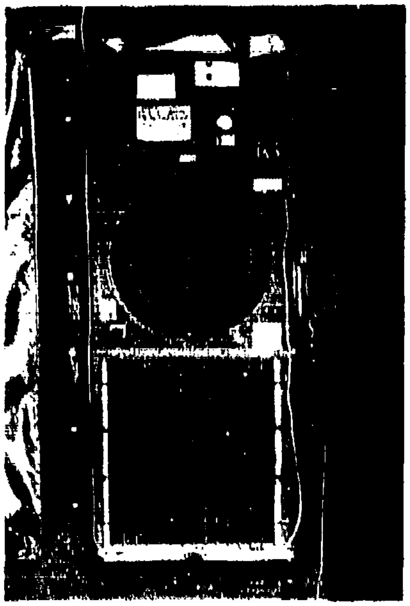

Figure 9. Air-conditioner closeup showing vents.

Figure 10. Air-conditioner closeup showing gap in frame.

4.7 Terminal Protection

Terminal protection for the AN/USM-410 consists of filters on both the power and signal lines at the entry panel inside the van. No further terminal protection is provided for these penetrators.

Analysis indicates that the filtering is adequate for HEMP protection. See section 1.2 for more discussion.

The power filters used are All-tronics part number A5053. The performance of the filters is specified by Military Control Drawing 02777 1969-4W. Specifications on this drawing require 100 dB minimum attenuation in the frequency range from 15 kHz through 10 GHz. The filters are judged to be adequate based on specifications on the drawing and based on examination of manufacturer's data obtained from All-tronics, Inc.

Information obtained on the signal filters, Sprague part number JW17 1122, was not adequate. Therefore, two filters were obtained from Sprague and were tested in the HDL laboratory (see app B) to insure adequate attenuation over the frequency range of interest.

4.8 Grounding

Refer to section 1.2 under the heading "Grounding."

4.9 Hardness--Maintenance

Routine required maintenance procedures should be established to assure continued effectiveness of HEMP protection measures throughout the life of the system. Maintenance documentation should require periodic examination or testing of all important HEMP protection measures and should call for appropriate repair, replacement, or adjustment as necessary.

As a minimum, inspection or testing should be performed to verify the following.

(1) Grounding systems
- (a) proper installation
- (b) good electrical continuity of all connections and wiring

(2) Van integrity
- (a) no openings or loose members in van walls, floors, or ceiling
- (b) all metal grills, filters, etc, properly installed
- (c) all removable panels tightly and properly installed

(d) all unused connectors or holes in signal and power-entry panel properly sealed or capped
(e) joints between air-conditioners and van frame properly sealed

(3) Shielding
(a) all ducts and raceways properly installed and in good physical condition
(b) door seals in good physical condition (i.e., no breaks, not crushed, or otherwise distorted)
(c) door seals and mating surfaces clean and bare for good electrical contact (i.e., no dirt, grease, or nonconductive paint)
(d) proper closing of doors; when closed and latched, doors should apply a positive pressure on the electromagnetic gasketing around the entire perimeter of the door in such a way as to slightly compress the gasket

(4) Terminal Protection Devices
(a) proper installation of all filters
(b) proper electrical operation of all filters

All the above checks (except 4b) should be performed routinely at frequent intervals (at least once a year) and also following any physical movement of the equipment. All the above checks except the last (4b) can be performed by operations personnel.

5. CONCLUSION

Based on this analytical assessment, engineering judgement is that the AN/USM-410 van configuration will possess a satisfactory level of nuclear HEMP survivability, which is consistent with the system's mission and planned deployments, when the recommendations presented here are followed.

Conclusions of this study apply only to the AN/USM-410 van configuration and cannot be applied to other systems or configurations without knowledgeable consideration of all physical and functional differences which may affect the need for, and effectiveness of, HEMP hardening measures.

Testing of the AN/USM-410 in a simulated HEMP environment is recommended to define a confidence level and to verify the survivability predicted here. Testing is necessary because of the numerous interrelated physical factors which affect HEMP survivability and because of the limitations of present analytical prediction tools.

The AN/USM-410, as examined for this assessment, was not totally defined. System documentation, including parts specifications, operation and maintenance manuals, and engineering drawings of electronic circuits, cable interconnections, equipment installation, and van modifications, was not completed in final form. The final documentation should be reviewed to insure that those features assumed by this assessment become, in fact, required features of the system.

6. RECOMMENDATIONS

a. Improve the installation of RFI door seals or use an improved door seal (see sect. 1.2 and 4.3).

b. Insure that the system is normally operated with all doors closed and tightly latched or use a shielded vestibule over doors (see sect. 1.2 and 4.4).

c. Verify that final system documentation requires adequate installation of a power and signal-entry panel as on the prototype examined in this assessment (see sect. 1.2 and 4.5).

d. Examine the need for additional shielding over air-conditioner intake and exhaust ports (see sect. 1.2 and 4.6).

e. Examine the need for improved installation of an air-conditioner in the front wall of the van (see sect. 1.2 and 4.6).

f. Verify that final documentation defines adequate installation of air-conditioners.

g. Verify that final documentation specifies filters for power and signal lines (at entry to van) equivalent to those examined in this assessment (see sect. 1.2 and 4.7).

h. Specify in system documentation the use of a low-impedance overall system ground with a ground rod placed as near as possible to the signal and power-entry panel (see sect. 1.2 and 4.8).

i. Require HEMP hardness to be maintained as part of operation and maintenance procedures (see sect. 4.9).

LITERATURE CITED

(1) Required Operational Capability (ROC) for AN/USM-410 Automatic Test Equipment (ATE) Facility, U.S. Army Training and Doctrine Command, ACN 22358 (22 February 1980).

(2) W. L. Clark, Report of Shielding Effectiveness Test for Miller Trailer Model: XM-913 Semitrailer, Product Order 0375, Martin Marietta Corporation (1980).

(3) The Effects of Nuclear Weapons, Department of the Army, Pamphlet No. 50-3 (March 1977).

(4) Thomas A. Rose, HEMP Study of Planned DAS3 Configuration, Harry Diamond Laboratories, HDL-TR-1891 (June 1979)

(5) Proposed Required Operational Capability (ROC) for the AN/USM-410 Automatic Test Equipment (ATE) Facility (27 July 1979).

(6) R. L. Monroe, EMP Shielding Effectiveness and MIL-STD-285, Harry Diamond Laboratories, HDL-TR-1636 (July 1973).

GLOSSARY

ADP--automatic data processing.

ADPE--automatic data processing equipment.

ATE--automatic test equipment.

AVIM--aviation intermediate-level maintenance.

CONUS--continental United States.

damage--The irreversible failure of an electrical component. Examples are (1) burnout of a transistor, diode, or integrated circuit, (2) degradation of a semiconductor's operating characteristics such that it will no longer function as intended, and (3) voltage breakdown of a capacitor or resistor.

DARCOM --U.S. Army Materiel Development and Readiness Command.

DAS3--Decentralized Automated Service Support System.

ECOM--U.S. Army Electronics Command. Present name, U.S. Army Communications and Electronics Materiel Readiness Command (USACERCOM).

EMC--electromagnetic compatibility.

EMI--electromagnetic interference.

EMP--electromagnetic pulse, generated by detonation of a nuclear weapon.

ERADCOM--U.S. Army Electronics Research and Development Command.

ERF--electronics repair facility.

GS--general support.

hardware--physical equipment (as opposed to the computer program or method of use); for example, mechanical, magnetic, electrical, or electronic devices. Contrast with software.

HDL--U.S. Army, Harry Diamond Laboratories.

HEMP--high-altitude electromagnetic pulse. EMP produced by nuclear bursts at altitudes above 30 km (19 miles). Sometimes referred to as HAEMP.

LEMP--low-altitude electromagnetic pulse. EMP produced by nuclear bursts at altitudes below 30 km (19 miles). Sometimes referred to as LAEMP.

MEP--mobile electric power.

PM-TMDS--Product Manager, Test Measurement and Diagnostic Systems, DARCOM.

RFI--radio frequency interference.

ROC--Required Operational Capability.

software--In general: A set of programs, procedures, and possibly associated documentation concerned with the operation of a data-processing system; for example, compilers, library routines, manuals, circuit diagrams. Software as used in this document does not include procedures and documentation. Contrast with hardware.

SOP--standard operating procedures.

TARCOM--Army Tank Automotive Materiel Readiness Command.

TMDS--Test Measurement and Diagnostic Systems.

TOAD--U.S. Army Tobyhanna Army Depot.

TPD--terminal protection device. A protection device applied to a penetrator at the point where it enters a shielded environment in order to reduce the energy coupled into system electrical circuits via that penetrator. TPD's include surge-suppression devices and filters.

upset--The unwanted action of a system, subsystem, or component. Examples are (1) altering of a flip-flop state, (2) altering of one or more bits in a memory word or register, (3) communication errors, and (4) misread, miswritten, or overwritten areas of storage or memory.

APPENDIX A.--Signal Filter Frequency Characterization

Laboratory testing was performed to obtain high-frequency attenuation characteristics for the filters used at the AN/USM-410 signal entry. This appendix includes a description of the characterization of the Sprague JW17 1122 signal filters.

APPENDIX A

Component identification: Sprague JW17 1122

Manufacturer's specifications: (Based on Sprague engineering bulletin 8105)

cutoff frequency--15 kHz
impedance--300 ohms, single circuit
attenuation--3 dB minimum at 15 kHz
90 dB typical at 150 kHz and above

Date tested: 9 September 1980

Tested by: Christian Fazi

Purpose: To determine high-frequency attenuation.

Description: The filter was analyzed on a 50-ohm system using a Hewlett-Packard 141S spectrum analyzer and a Hewlett-Packard 8443 tracking generator. The attenuation was examined over the swept frequency range from 0.1 to 100 MHz.

Results: The minimum attenuation measured in the range from 0.1 to 100 MHz was 40 dB. Figure A-1 is a photograph of the test data oscillogram.

Figure A-1. Frequency characterization of Sprague JW17 1122 filter.

APPENDIX B.--AN/USM-410 Documentation

This appendix lists the primary documentation which defined the AN/USM-410 for the high-altitude electromagnetic pulse (HEMP) assessment.

MIL-STD-454F, Military Standard, Standard General Requirements for Electronic Equipment (15 March 1978), Notice 1 (1 September 1978), Notice 2 (30 June 1979), Notice 3 (10 September 1979).

MIL-STD-633D, Military Standard, Mobile Electronic Power Engine Generator, Standard Family Characteristics Data Sheets (30 September 1974).

MIL-STD-1408A, Military Standard, Air-Conditioners, Family of Environmental Control Units, General Application Characteristics (9 April 1975).

MIL-A-52767B, Military Specification, Air-Conditioners: Vertical and Horizontal, Compact (4 September 1979).

CR-76-588-023, Operation and Maintenance Manual, Part One, Operator and Organizational Level Maintenance, Test Station, Electronic Equipment, AN/USM-410(XE-3)(V) (July 1976).

CR-76-588-023, Operation and Maintenance Manual, Part Two, Intermediate Level Maintenance, Test Station, Electronic Equipment, AN/USM-410(XE-3)(V) (July 1976).

PDEP 11-6625-2773-12-3, Operator's and Organizational Maintenance Manual (with Parts List), Test Station, Electronic Equipment, AN/USM-410(XE-3A)(V), AN/USM-410(XE-3B)(V), AN/USM-410(XE-3C)(V) (November 1979).

PDEP 11-6625-2773-40, Intermediate Level Maintenance Manual, Test Station, Electronic Equipment, AN/USM-410(XE-3A)(V) (July 1978).

FM 11-490-9, Field Manual, Communications--Electronics Facilities: Grounding, Bonding, and Shielding (December 1977).

TM 5-6115-365-15, Organizational, DS, GS, and Depot Maintenance Manual Including Repair Parts and Special Tools List, Generator Sets, Gasoline and Diesel Engine Driven, Trailer Mounted (May 1966).

TM 5-6115-545-24P, Organizational, Direct and General Support, and Depot Maintenance Repair Parts and Special Tools List, Generator Set, Diesel Engine Driven, Tactical, Skid Mtd., 60 kW, 3 Phase, 4 Wire, 120/208 and 240/416 Volts, Including MEP 006A, including Change No. 1 (August 1977).

TM 5-6115-545-34, Intermediate (Field) (Direct and General Support) and Depot Maintenance Manual, Generator Set, Diesel Engine Driven, Tactical, Skid Mtd., 60 kW, 3 Phase, 4 Wire, 120/208 and 240/416 Volts, including MEP 006A, including Changes 1 through 4 (10 June 1973).

APPENDIX B

TM 9-2330-271-14, Operator's, Organizational, Direct Support and General Support Maintenance Manual, Semitrailer, Van: Electronic 10-Ton, 4 Wheel, including XM-913 (12 May 1972), including updates through Change No. 2 (26 November 1976).

U.S.Army Communications and Electronics Materiel Command (USACERCOM) drawing SC-D-506827, Military Passageway Assembly, and related drawings, as indicated on Technical Data Package List SC-D-506827 (received 7 July 1980).

U.S. Army Tank-Automotive Materiel Readiness Command (USATARCOM) Drawing package (partial) for XM-913 semitrailer van.

Required Operational Capability (ROC) for AN/USM-410 Automatic Test Equipment (ATE) Facility, USATRADOC ACN 22358 (22 February 1980).

Proposed Required Operational Capability (ROC) for the AN/USM-410 Automatic Test Equipment (ATE) Facility (27 July 1979).

Production Specifications for modifications of XM-991 from XM-912 and XM-995 from XM-913 (received 7 April 1980).

Test Measurement Diagnostic Systems (TMDS) AN/USM-410 Test and Maintenance Vans Statement of Work (received 7 April 1980).

W. L. Clark, Report of Shielding Effectiveness Test for Miller Trailer Model: XM-913 Semitrailer, Prod. Order 0375, Martin Marietta Corporation (1980).

Report of Shielding Effectiveness Tests of Miller Trailer 79-0247-001, Prepared for Miller Trailers, Inc., 333 6th Avenue, Bradington, Florida 33505, by W. L. Clark, Martin Marietta Corp., Orlando, Florida (23 January 1979).

Report on Test on Radio Frequency Attenuation of Trailer XM-703, Miller Trailers, Inc., Electronic Communications, Inc., 4-1160 (6 July 1965).

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