RAM AND SUPPORT CONSIDERATIONS IN ARMY TRAINING DEVICE DEVELOPMENT

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ABSTRACT

Although reliability, availability and maintainability (RAM) and system support policies for Army equipment in general are fairly well defined in such documents as AR 700-127 and AR 702-3 or various MIL STD's, there is little that recognizes unique RAM and support considerations that apply to training systems. The authors identify some of these considerations, which, though largely unique to training systems, are generic to most training systems. They then discuss the impact of these considerations, with emphasis on how RAM specification and growth and support management differ from that of the combat systems around whose needs AR 702-3 and the MIL STD's are principally modelled. The authors develop specific conclusions as to policy and practice distinctions from the combat systems model that should be made in training systems development programs.

INTRODUCTION

The subject of this paper is one that is perhaps as much a cause of frustration, and a cost driver, as any in the field of materiel acquisition management. On the face of it, it wouldn't seem that it should be. The acronym "RAM", Reliability, Availability, Maintainability, can be re-arranged to make a very simple mathematical statement

$$A = f(R, M)$$

that availability of a system is a function of reliability — how often it fails — and maintainability — how much time it takes to fix it and keep it operating. The implementation of this relationship does not seem much more difficult. The customer presumably knows what availability he will require. Volumes of data exist on the reliability of almost any class of components. The mathematics of reliability calculations are not unusually difficult, and engineering to enhance maintainability is generally well documented. So, is it really necessary for this almost trivially simple seeming relationship to cause so much heartache and cost so much money?

The answer, of course, is that it is necessary only to the extent that we accept Murphy's Law as an inviolable rule of nature. In our more rational moments, as when we are contemplating someone elses' problems, we know Murphy's Law to be mostly a consequence of human carelessness and poor judgement. We are, then, led to a conclusion that most RAM fiascos, as most other manifestations of Murphy's Law, can be avoided by using more care and better judgement.

Recognizing that that last piece of advice, left standing alone, is not particularly useful, the Army has created a substantial body of regulations, standards and methodology to guide our judgement and prompt our memories. This has evolved over many years and, in our opinion, when applied to types of systems with which the Army has had extensive experience, represents an excellent prescription for achieving the required level of reliability, availability and maintainability within a stated cost and time. Indeed, we would suggest that most failures of RAM programs in conventional military hardware development have occurred when the developers put their RAM engineering emphasis in areas with minimum payback and tried to take shortcuts in some of the important ones. As the hobbit, Bilbo Baggins, observed "Shortcuts make for long delays". This is particularly true if the short cuts are in the wrong areas.

The previous observation applies, of course, to systems where the paths have been trod before and the way has become well charted. Even with those systems, there was a period when delay and expense were incurred not due to any shortcutting, but just from being down on the learning curve. As we came up on the learning curve, the guidance could be formulated and then extended to other type systems, where, again there would be a learning period until the variations in the guidance applicable to the new type systems could be recognized.

The growth in recent years of complex major training simulation systems has presented us with the maturing of just such a set of altered RAM guidelines. We, the authors, have worked for the past several years in RAM development and management of these training devices within the general context of AR 702-3, the primary source for RAM development guidance in Army materiel acquisition programs. As with any good regulation, intelligent interpretations, weighing payoffs against cost and time, are possible, and we have made them, and seen them made, some more successfully than others. With our share of bruises from climbing up the learning curve, we feel we can now speak with some authority on what these emerging guidelines are. The interesting aspect of this is that, as yet, the rest of the user and development community, to include RAM people, who have not yet had this experience naturally think in terms of the standard procedures and each new project and each new person coming into the project represents a new education effort. This conference is, therefore, a timely opportunity to get some of our ideas and experience before the training device community, discuss them, and suggest some steps for recognition of changes in RAM policy and procedure that will expedite development of adequately available and supportable training simulation systems.

RAM REQUIREMENT DEFINITION

As we mentioned earlier, RAM performance is something that costs money and takes time. The users' bottom line is being able to count on the system when he needs it, for as long as he needs it. In saying this, it is important to understand what overstated RAM requirements mean to the developer and the logistician. The developer is committed to high reliability parts, heavily derated circuits, rigorous QA inspections and redundancy in mission essential functions. When the thing goes down, we can't take the time to isolate the failure to the piece part, nor to send for the technician and equipment that could, so we will replace the obviously failed major assembly and be back up in a few minutes. That the logistician is now stocking the supply system with these major assemblies, instead of just replacements for the failed parts, is something we have to decide to afford. The off-line time to repair the major assemblies has become a secondary consideration, way behind that on-line time to get the system back up.

With combat systems, when failure or unavailability can get people killed and battles lost, it is possible to justify some very expensive RAM requirements. In the Concept Formulation Phase of the Life Cycle Management Model (DA PM 11-25) a generic process for all Army materiel acquisition is spelled out for justification of requirements, to include RAM requirements. For this process to work properly, it must be carried out jointly by the user and the developer in three distinct and separate steps. First the user must determine, in profiles of all missions and a summary of all operational modes, just how the system will be used throughout its life. This Operational Mode Summary/Mission Profile document can then be used by the user and developer to jointly determine a realistic definition of just what will constitute a mission or system failure and define objective criteria for determining how incidents are to be classified. With the Operational Modes summary, Mission Profile (OMS/MP), and Failure Definition and Scoring Criteria (FD/SC) in hand, the user and developer can then jointly develop numerical RAM requirements that realistically relate operational readiness and mission success to acquisition cost and logistic supportability. The basis for these requirements is stated in a RAM Rationale Annex to the official requirements document used to establish the development program. The methodology for preparing this annex and therefore for arriving at the numerical values, is excellently stated in the joint TRADOC/DARCOM RAM Rationale Annex Handbook. Besides calling for the OMS/MP and FD/SC as input, this procedure also requires consideration of the RAM assumptions made in the user's Cost and Operational/Training Effectiveness Analysis (COEA/CTEA) and of the developer's best technical approach analysis performed in Concept Formulation. The user then performs an analysis to determine the minimum acceptable values that will permit the system to be useful to him. The developer determines the best operational capabilities that are inherent to the selected technical approach and attainable within the projected development program. Hopefully, these will differ by enough and in the proper direction, to permit initiation of a program with realistic cost and mission effective RAM program objectives.

It should be noted, in regard to reliability qualification testing, that recent changes to AR 702-3 and the joint OTEA/TRADOC/DARCOM baseline FD/SC extend operational failure chargability beyond contractor produced hardware to include Government furnished equipment and the total support system. This will significantly increase the number of items which can result in an unsatisfactory RAM report card. Training Device contractors should be aware of this important new change and thrust in the RAM area.

We said that we were going to discuss variations from the standard RAM procedures that we considered applicable to training devices, but, in this case, we find the generic model to be admirably applicable to training devices as it stands. The unique feature in this case is that the generic model does not get applied to training device requirements definition as often or as thoroughly as it should. The RAM requirements analysis is usually done quite thoroughly for major combat systems. After all, the Army cannot afford to either gold-plate or come up a loser on such highly visible projects. The analysis is usually performed, albeit sometimes somewhat perfunctorily, (e.g., rarely is a CTEA available in time to support preparation of the RAM Rationale Annex) on lesser systems, to include stand-alone or non-system derivative training devices. The problem really arises when the training package is included in the overall development program of a major system. Priority goes to definition of the RAM requirements of the major system itself and its key support equipment. There doesn't usually seem to be enough left over to get around to the training devices, at least in time for the statement of requirements to have any effect on the development program. What results is that the users wind up shaping their program around what they are going to get, instead of telling the developers what they need in order to run the program they want.

RELIABILITY PROGRAM TASKS

An essential reference in preparing or evaluating any reliability program is MIL-STD-785B. This contains descriptions and guidance on the use of the various reliability engineering, management and accounting tasks that may comprise the reliability program of any material acquisition program. This MIL-STD enables the developer to put together a reliability program optimized around the needs of his particular project, to include training devices. These tasks, and their recommended applicability to the major phases of a material acquisition program, are shown in Figure 1.

While these tasks are written with the objective of general applicability, there are a number of considerations that guide their selection and use in training device programs. Many of these will be touched on later in this paper. One aspect of training device procurement, however, cuts across a number of these tasks and should be pointed out in this discussion. This is the tendancy of a training device developer to use more commercially available major assemblies and less development from the piece part level of major assemblies unique to the system. Thus monitoring and controlling vendor supplied items is keyed more to performance of fewer, more complex items and less to inspection of a large number of smaller parts. Failure Reporting Analysis and Corrective Action Systems (FRACAS) and Failure Review Boards must deal with failures within these vendor assemblies that are not necessarily controllable by the developer. The analytical processes, Failure Modes Effects and Criticality Analysis (FMECA) and reliability modeling, allocation and prediction are facilitated, but also constrained by the predetermined characteristics of these fewer, larger assemblies. Reliability growth, which, as we shall see, needs help, can get it by taking advantage of the

APPLICATION MATRIX

TASK	TITLE	TASK TYPE	PROGRAM PHASE			
			CNCPT	VALID	FSED	PROD
101	RELIABILITY PROGRAM PLAN	MGT	S	S	G	G
102	MONITOR/CONTROL OF SUBCONTRACTORS AND SUPPLIERS	MGT	S	S	G	G
103	PROGRAM REVIEWS	MGT	S	S(2)	G(2)	G(2)
104	FAILURE REPORTING, ANALYSIS, AND CORRECTIVE ACTION SYSTEM (FRACAS)	ENG	NA	S	G	G
105	FAILURE REVIEW BOARD (FRB)	MGT	NA	S(2)	G	G
201	RELIABILITY MODELING	ENG	S	S(2)	G(2)	GC(2)
202	RELIABILITY ALLOCATIONS	ACC	S	G	G	GC
203	RELIABILITY PREDICTIONS	ACC	S	S(2)	G(2)	GC(2)
204	FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA)	ENG	S	S (1)(2)	G (1)(2)	GC (1)(2)
205	SNEAK CIRCUIT ANALYSIS (SCA)	ENG	NA	NA	G(1)	GC(1)
206	ELECTRONIC PARTS/CIRCUITS TOLERANCE ANALYSIS	ENG	NA	NA	G	GC
207	PARTS PROGRAM	ENG	S	S(2)(3)	G(2)	G(2)
208	RELIABILITY CRITICAL ITEMS	MGT	S(1)	S(1)	G	G
209	EFFECTS OF FUNCTIONAL TESTING, STORAGE, HANDLING, PACKAGING, TRANSPORTATION, AND MAINTENANCE	ENG	NA	S(1)	G	GC
301	ENVIRONMENTAL STRESS SCREENING (ESS)	ENG	NA	A	G	G
302	RELIABILITY DEVELOPMENT/GROWTH TESTING	ENG	NA	S(2)	G(2)	NA
303	RELIABILITY QUALIFICATION TEST (RQT) PROGRAM	ACC	NA	S(2)	G(2)	G(2)
304	PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAM	ACC	NA	NA	S	G(2)(3)

CODE DEFINITIONS

TASK TYPE:

ACC - RELIABILITY ACCOUNTING
ENG - RELIABILITY ENGINEERING
MGT - MANAGEMENT

PROGRAM PHASE:

S - SELECTIVELY APPLICABLE
G - GENERALLY APPLICABLE
GC - GENERALLY APPLICABLE TO DESIGN CHANGES ONLY
NA - NOT APPLICABLE
(1) - REQUIRES CONSIDERABLE INTERPRETATION OF INTENT TO BE COST EFFECTIVE
(2) - MIL-STD-785 IS NOT THE PRIMARY IMPLEMENTATION REQUIREMENT. OTHER MIL-STDS OR STATEMENT OF WORK REQUIREMENTS MUST BE INCLUDED TO DEFINE THE REQUIREMENTS.

FIGURE 1

demonstrated reliability within proven components. In summary, the reliability program for a training device must consider and take advantage of the reliability program previously carried out in major developed assemblies which the training device developer has generally greater latitude to use.

AVAILABILITY

An obvious difference between combat systems and training devices is that in controlling and scheduling the use of a combat system, one must concede some degree of initiative to the enemy and provide a great deal of flexibility to respond to unexpected requirements. A training manager, on the other hand, generally has to have complete control of his scheduling and rarely does he have to schedule equipment around the clock. Thus the typical availability requirement for a combat system is long periods of standby in readiness for immediate response in periods of short intense use. This leads to definition of operational availability in AR 702-3 in terms of total available time within a stated calendar period. Any particular calendar period of use of a training system, however, is going to include scheduled periods of downtime, i.e., periods when the system is not required to be available. Describing operational availability as in AR 702-3 results, therefore, in stating an availability requirement that does not, in fact, exist. PM TRADE and the Naval Training Equipment Center have developed and used for a number of years availability characteristics based on schedulled usage. An article in the Army Logistic Center's RAM/ILS Bulletin of November 1981 addresses this case and provides an operational availability definition that uses only the system's availability during the periods when it is required to be available. Publication in this bulletin has not had a significant impact on training device availability specification; however, we anticipate bringing the idea to the forefront in future documents in order that it will take a more meaningful place in training device availability considerations.

RISKS

Risks are the considerations which cause some failure modes to be more critical than others and reliability of some components to be more critical than others. In combat systems, these risks are generally those that lead to mission failure. Preventing mission failure is also, of course, a major objective of reliability engineering of training devices, too. We have, however, already observed that the generally less catastrophic consequences of failure of a training mission affect the level of reliability that we can justify paying for. There are, however, some risks that require more stringent control than does the combat system. No one wants a combat system to be unsafe for its crew, but the level of safety that is sought reflects the fact that the battlefield is an inherently dangerous place. By contrast, death or injury in the training environment are unacceptable. Combat is also rather hard on the natural environment, while preservation of the environment is always a major concern of the training manager. These two considerations frequently inhibit the use of combat systems in training and make training simulation necessary. For example, one of the reasons for turret maintenance trainers is to permit students to work on the drive, hydraulic and electrical systems without being exposed to the lethal levels of force, pressure and voltage that are present in the actual turret. Therefore, while one can perhaps settle for a lesser probability of mission success in a training device, reliability engineering must do its part to absolutely preclude injury or environmental damage, risks which are generally acceptable at some level in combat systems. A good FMECA and a FRACAS program are therefore no less necessary in the development of a training device. The determinants of criticality may, however, differ from like analyses and programs in developing a combat system.

ENVIRONMENTAL DESIGN CRITERIA

The combat system must work in whatever environment the combat takes place. Thus AR 70-38 and MIL-STD-810 prescribe some demanding and expensive environmental design criteria: heat, cold, humidity, dust, moisture, shock vibration, etc. The training system, of course, must work where the training takes place and, for some systems, such as the Multiple Integrated Laser Engagement System (MILES), that is essentially the same as the combat system being simulated. Many training simulators can, however, be used in a fully controlled environmental shelter, subject to movement only under administrative conditions and generally can live with the same environmental design criteria as are commercially applied to fixed, interior electronic equipment. Even those training devices that are used in the same environment as the combat systems can enjoy some measures of relief from at least the extreme environmental criteria imposed on the combat system. As we have previously observed, the training manager has control over when his equipment will be used in extreme climatic conditions, and also, only a relatively small proportion of training occurs under those conditions. This is in contrast with most combat systems, where any one item must be inherently capable of quick deployment and use to counter any threat. This suggests that the training device can be designed to criteria that are less demanding than those of the combat system, and a kit or modification procedure provided for those relatively infrequent and scheduled periods of use in more severe conditions. Thus, while the combat systems on which MILES is used were designed for use in the full range of the former AR 70-38 climatic categories, MILES was specified to only the intermediate categories 5 and 6.

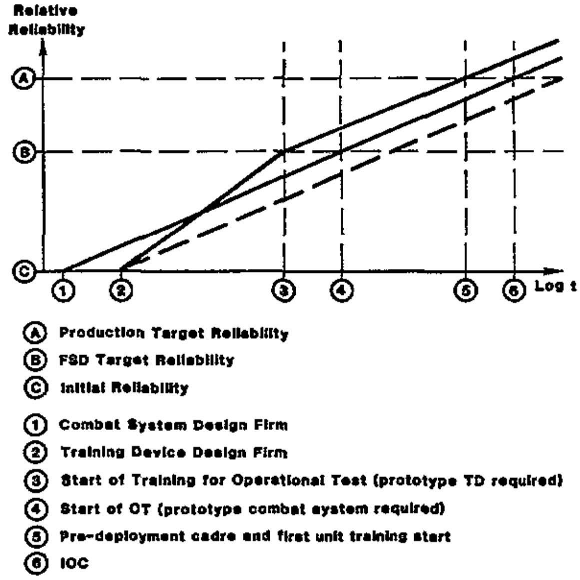
DURABILITY

The preceding discussion suggested a possible relaxing of standards for the severity of the use environment. Paradoxically, this paragraph is going to suggest that in the area of durability i.e., resistance to wearing out, what is adequate for the combat system may not be adequate for the training device. Consider that the gunnery controls of a tank are used only when that crew uses that tank in gunnery training or an engagement. It is very important that the controls work, but it probably isn't subject to very many use hours per year. Now consider the same controls in the Armor Unit Conduct-of-Fire Trainer. These will be used all day, every day by every crew in the battalion, probably more hours in a year than most tank controls will see in the life of the tank. Or consider an installation set of MILES equipment. Each unit scheduled to use it will come out, put it on their weapons, run the exercises, take the MILES gear off and, after restoring the weapons to inspection condition, replace them in the arms room. The MILES gear, on the other hand, will be inventoried, maybe get a quick check for serviceability, and be back out in the field with another unit the next week. Clearly use and wear out factors that determine the replacement and rebuild periods in the combat system must be reconsidered when the same component is used in the training device. Training systems that are of comparable durability and used on an hour-for-hour basis with combat system may in fact see a much shorter calendar life between replacement or rebuild. These are considerations that need not cause any problems if they are appreciated and dealt with *in the life cycle support planning for the* system, but they do cause some nasty surprises downstream if they are overlooked.

RAM GROWTH RATE

RAM growth management and projection are a normal part of any materiel development program and the methodology for doing this in training devices is not different from that of other comparable materiel. Several inherent characteristics of the development schedules for training devices do, however, have an interesting impact on training device RAM growth. First of all, design of a training device to simulate a combat system must unavoidably lag the design of the system. Changes after the system design is supposed to be firm will play crack-the-whip with the training device design. Thus the design effort on which the RAM growth is based starts later and suffers more rapid perturbation than does the design of the system itself. At the other end of the schedule lies operational test and evaluation of the system, which at least theoretically includes use of the operational training package to train test personnel. Evaluation of that package, to include devices, is one of the objectives of the OT&E. Thus the training device developmental period, in which the Army's Life Cycle Management Model concentrates most of the RAM growth of a system, is inherently truncated at both ends, as compared to that of the combat system, and perturbed in the middle.

Figure 2 shows the effect of this. In order to have a training device that can support the training package the device must be available, at its full scale development (FSD) reliability level, before the FSD prototype of the combat system, yet design cannot start until the combat system design is firm. Thus it has an inherently steeper growth rate than the combat system (and those are notoriously not conservative), yet it is a lower priority system. Not surprisingly, very few, if any, combat systems related training devices have ever met the schedule of their major combat system. What usually happens is shown by the dotted line, where the attainable growth rate causes the training device to reach the desired RAM goals at a later time than the combat system does. If the training device design can perform the necessary functions at the start of OT and pre-deployment training, this lag is not necessarily *catastrophic, provided some realism has been employed in* planning the initial training cycles. Specifically, that means that the attainable reliability in the prototypes that will be available in the early training cycle must be recognized and compensated for. For example, more intensive contractor support, rather than the test system support package, could be used to provide the required availability. *This would also apply during the early cycles* of post deployment training. The test program should be set up to provide realistic interim RAM goals during the formal test period, with follow on RAM growth and testing continuing until the fully matured RAM goals are met on an attainable schedule. The cost of more intensive contractor support or other measures to boost availability during the RAM maturation phase is not really an added expense; it is a recognition, before rather than after the fact, of a cost that is inherently there when procurement of the training simulator is tied to both the design and the schedule of a major combat system.



TRAINING DEVICE RELIABILITY GROWTH

FIGURE 2

SUPPORT CONCEPT

It is in the area of system support that some of the most significant differences between combat and training system use environments exists. Fundamental objectives of combat system support are to keep maintenance and repair of an item as far forward as possible and to minimize the skills and special equipment required forward to do it. A great deal of ingenuity has gone into meeting these two seemingly countervailing requirements, and the results, as noted in the introduction, are not *inexpensive. The support system must also be fully* transportable with the combat system, to include operating under combat conditions. An effect of this is that the support must be provided by uniformed personnel and the allowable tasks become constrained by the skills that can be taught in the military training context. It also means that support equipment must be transportable and operable under some very adverse conditions. It means that everything needed to operate and maintain the system must be available through the Army supply system. In summary, all the way back to its roots, the support system is, or can be, detached from civilian industrial or commercial resources.

Obviously, such extreme support measures apply to few if any training devices. Those that are placed in the TO&E of a tactical unit come closest to such support requirements. Such devices would require the totally transportable and Army contained support system. Since the training systems will inevitably have a lower priority than the unit's weapons, transportation and communications systems, it is most important that such a training device impose a minimum burden on the owning unit. This means no additional skills can be required. It means minimum maintenance, parts stockage or additional tools and test equipment. These conditions have generally limited TO&E training equipment to very simple devices.

The more common case, applicable to more complex devices in which the support requirements become more demanding, are those where the device is treated as part of the Post, Camp and Station property. It may, in fact, be on the property book of a tactical unit, but not as an item to be carried to the field and through combat with them. If the unit moves to another station, the trainer would be shipped administratively. Obviously, a lot more options are available for supporting a training system in this environment than in the full TO&E environment. It remains true that use and support of the device should not be a burden to the unit. Yet we are now dealing with devices that require some unique skills, training and logistic effort to use and support. We must obviously take advantage of the access to fixed facilities and civilian industrial skills that the garrison environment affords. Operator/organizational maintenance becomes reduced to simple GO-NO GO checks with turn-in to a central facility (or facility contact team) for any failed units. The trainee operator is not to be burdened with any additional learning in order to be able to use his training device. The central facility will therefore provide any unique operating skills that may be needed. This central facility, which can be either a contract operation or a Government industrial one, also equates to the DS/GS level in the combat system support model. It should, however, be able to effect significant economies over a field DS/GS operation due to its personnel stability and technical skills, access to fixed industrial facilities and commercial sources and the scheduled nature of training equipment use.

TYPE CLASSIFICATION

The environment in which the training device is used in a scheduled manner, at a given station and supported out of an industrial facility is, we have seen, a major departure from the one in which most type classified standard Army systems are used. The check list of plans, studies, tests, reports and evaluations by which the materiel acquisition decision process arrives at a type classification standard decision is necessary to insure that all elements of that transportable self-contained support system are in place and balanced with regard to each other. It goes far beyond merely ensuring that the performance of the system is adequate. It insures that all parts, tools, and test equipment are correctly entered in the Army supply system, all skills necessary to use and support the system are correctly identified, that stand-alone literature is in place, that everything is quantitatively distributed where and when it will be needed and can be moved as tactical or strategic exigencies may dictate.

No one would say that a garrison use training system should be put in place without adequate planning for its support, but some economies relative to the effort for a worldwide combat survivable support system may be attainable. Let us look at what is really required. The Government should require the contractor to develop and document a complete technical description, identify, describe and validate all maintenance and repair tasks, along with the skills, tools and written instructions to perform them, establish parts stockage and use rates and validate commercial transportability. These are the things the Government needs to set up its own industrial support operation or to "should cost" or compete a contractor support operation. They are still a far cry from MIL STD documentation, accession of all end items, parts and tool to the Army supply system, Army personnel and force structure realignments and school curriculum changes. Appreciable savings in cost and time have been realized when acceptance procedures for such training devices have recognized the differences in support environment from a standard combat system.

SUMMARY

We have seen that the Army's policies and procedure for defining and specifying RAM requirements and managing the attainment of those requirements are largely modelled around combat systems, though they contain the flexibility to adjust to other systems. The training system sometimes lacks priority, in competition with the combat system, to get a timely and adequate definition of its RAM requirements. There are also a number of differences in the use environment, development processes and support concept of training devices that require the application of that flexibility. Component and part vs. major assembly considerations effect the reliability program. Availability definitions need to take full advantage of the training managers greater control over how and when the device will be used and of regularly scheduled periods of downtime. Risks of mission failure that are unacceptable in a combat system must be balanced against cost in a training system, but risks of injury and environmental damage that can be traded for mission performance in a combat system become unacceptable in a training system. We can take advantage of the generally more benign and controllable environment in which training devices are used to relax some of the very severe environmental standards to which combat systems are built. On the other hand the more frequent use that training devices receive means that we must either build more durability into them or accept more frequent rebuild or replacement. We cannot expect the training device to achieve RAM maturity in the same growth pattern, relative to the decision points, that the combat system does, if we must inherently curtail and perturb its design and development period and assign it a lower priority. The training device has access to a much less expensive and laborious support concept than is necessary for combat systems. This, in turn, means that some (by no means, all) of the steps in justifying type classification standard of a combat system are not necessary for training systems.

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ABOUT THE AUTHORS

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Mr. Gardner was born in Council Bluffs, Iowa and graduated from Iowa State University with a Bachelor's degree in Electrical Engineering in 1973. He entered Civil Service as an intern in the Quality and Reliability Engineering course at the U. S. Army Management Engineering Training Agency (AMETA), Rock Island, Illinois. Mr. Gardner was employed as an engineer in the Product Assurance Directorate, U. S. Army Aviation Systems Command and Product Assurance Directorate, U. S. Army Troop Suppport and Aviation Materiel Readiness Command, St. Louis, Missouri from 1974 through 1977. Mr. Gardner joined the Product Assurance Branch of PM TRADE as a Product Assurance and Test Engineer in 1977. He has been involved in numerous high priority programs while at PM TRADE.

Mr. Francis King has been active for the past two years as an employee of Science Applications, Inc., in providing technical analyses and reports in the RAM and logistic support area to the US Army Project Manager for Training Devices. Prior to that activity, he worked in the development of the training methodology for the US Army National Training Center and for use of the Multiple Integrated Laser Engagement System (MILES) (see proceedings of second Annual I/ITEC, Development Test for Artillery Engagement Simulation). Prior to these activities, Mr. King completed a 27 year Army career which included, among a number of test and evaluation assignments, a major role in the preparation of the initial issues of AR 70-10, AR 71-9 and AR 702-3 which provide the authoritative guidance for development, user and RAM testing, respectively.