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Product Assurance

Reliability, Availability, and Maintainability

By Order of the Secretary of the Army:

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General, United States Army
Chief of Staff

Official:

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Administrative Assistant to the Secretary of the Army

History. This publication is a major revision. The portions affected by this major revision are listed in the summary of change.

Authorities. This regulation implements DoDI 5000.88.

Applicability. This regulation applies to the Regular Army, the Army National Guard/Army National Guard of the United States, and the U.S. Army Reserve, unless otherwise stated.

Proponent and exception authority. The proponent of this regulation is the Assistant Secretary of the Army (Acquisition, Logistics and Technology). The proponent has the authority to approve exceptions or waivers to this regulation that are consistent with controlling law and regulations. The proponent may delegate this approval authority, in writing, to a division chief within the proponent agency or its direct reporting unit or field operating agency, in the grade of colonel or the civilian equivalent. Activities may request a waiver to this regulation by providing justification that includes a full analysis of the expected benefits and must include formal review by the activity's senior legal officer. All waiver requests will be endorsed by the commander or senior leader of the requesting activity and forwarded through their higher headquarters to the proponent. Refer to AR 25–30 for specific requirements.

Army internal control process. This regulation contains internal control provisions in accordance with AR 11–2 and identifies key internal controls that must be evaluated (see appendix B).

Suggested improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to the Assistant Secretary of the Army (Acquisition, Logistics and Technology) (SAAL–ZF) via email to usarmy.pentagon.hqda-asa-alt.mbx.asa-alt-publication-updates@army.mil.

Distribution. This publication is available in electronic media only and is intended for the Regular Army, Army National Guard/Army National Guard of the United States, and the U.S. Army Reserve.

*This regulation supersedes AR 702–19, dated 12 February 2020.

SUMMARY of CHANGE

AR 702–19
Reliability, Availability, and Maintainability

This major revision, dated 25 March 2024—

- Updates roles and responsibilities of Assistant Secretary of the Army (Acquisition, Logistics and Technology) (para 1–7).
- Adds roles and responsibilities of U.S. Army Futures Command, Futures and Concept Center (paras 1–13*a*(1)–(10)).
- Adds resource responsibilities of U.S. Army Materiel Command (paras 1–15*b*(8)–(10)).
- Adds design for reliability (para 2–4*d*).
- Adds software reliability (para 2–4*f*).
- Adds materiel developers' responsibility of parts, materials, and processes (para 2–4*h*).
- Adds program review using the development command data and analysis center (para 2–4*j*(5)).
- Adds reliability, availability, and maintainability design review for program reviews (para 2–4*k*).
- Adds program manager's responsibility for reliability and maintainability during specific phases (paras 2–4*l* and 2–4m).
- Adds program manager's responsibilities for assessment (para 2–6*d*).
- Adds post fielding requirements (paras 3–5*b*(1)–(7)).
- Adds developmental testing requirement (para 5–1*a*(8)).
- Adds the Middle Tier Acquisition (throughout).

Contents (Listed by chapter and page number)

Chapter 1
Introduction

Section I

General

1–1. Purpose
This regulation sets forth policies for planning and managing Army materiel systems' reliability, availability, and maintainability (RAM) during development, procurement, deployment, and sustainment. It applies to all combat or mission essential developmental, non-developmental, commercial items adapted for military use, and product improved hardware and software systems.

1–2. References, forms, and explanation of abbreviations
See appendix A. The abbreviations, brevity codes, and acronyms (ABCAs) used in this electronic publication are defined when you hover over them. All ABCAs are listed in the ABCA directory located at https://armypubs.army.mil/.

1–3. Associated publications
This section contains no entries.

1–4. Responsibilities
Responsibilities are listed in section II of this chapter.

1–5. Records management (recordkeeping) requirements
The records management requirement for all record numbers, associated forms, and reports required by this publication are addressed in the Records Retention Schedule–Army (RRS–A). Detailed information for all related record numbers, forms, and reports are located in Army Records Information Management System (ARIMS)/RRS–A at https://www.arims.army.mil. If any record numbers, forms, and reports are not current, addressed, and/or published correctly in ARIMS/RRS–A, see DA Pam 25–403 for guidance.

1–6. Concepts and coordination
The Development and execution of RAM programs must be flexible and adaptable. RAM programs will be tailored to the individual needs of each system and are expected to vary in scope and complexity between major and non-major systems and between developmental and non-developmental, commercial-based systems. Materiel developers should pursue system and program alternatives that are cost-effective in achieving reliable and maintainable materiel systems.

a. Logistics. System RAM characteristics can be significantly altered by changes in operational, environmental, or logistic support concepts. Throughout a system's life cycle, organizations concerned with the RAM of a system and its components must closely coordinate with organizations responsible for its operation and logistic support. This coordination should ensure that system RAM characteristics, requirements, and allocations (such as hardware, software, personnel, and support system) are mutually compatible with logistic concepts. Maintenance concepts, spare and repair parts provisioning, and allocation of maintenance resources must support the system readiness objective. The RAM program must interface with logistic support planning and execution to ensure that each complements the other. The interface will enhance the achievement of an affordable and supportable system. Procedures will be established to ensure that RAM data are compatible with logistics support analysis requirements contained in AR 700–127. This will include documenting a product/system's logistics product data in accordance with Government Electronics Information Technology Association SAE GEIA–STD–0007, to facilitate integration with the Logistics Product Data Store (LPDS) and the conduct of subsequent analyses needed to conduct post-fielding segments and modifications based on field experience.

b. Personnel and training functions. System RAM characteristics are interrelated with human performance requirements and the development and use of trained personnel. Throughout the life cycle, coordination among the warfighter, logistics planning, personnel, and training agencies is required. This

planning will be accomplished to ensure compatibility between quantitative and qualitative personnel resources and materiel readiness.

c. Defense Standardization Program. Developing and procuring commands and activities will participate in the Defense Standardization Program. Applicable military specifications, standards, handbooks, and standardization studies will be used to improve interchangeability, reliability, and maintainability of military equipment, supplies, and their associated product data.

d. Test, measurement, and diagnostic equipment. Use of test, measurement, and diagnostic equipment (TMDE) and built-in test equipment (BITE) for hardware systems' diagnosis and built-in test (BIT) for software system diagnosis will be considered during design and development. TMDE requirements will be coordinated with the Executive Director, TMDE Activity. This will ensure maximum use of items available to the Army. Weapon system developers and managers requiring TMDE will submit acquisition requests to the Program Executive Officer Combat Support and Combat Service Support, Product Director via email at tmdecoordinator@army.mil (see AR 750–43).

Section II

Responsibilities

1–7. Assistant Secretary of the Army (Acquisition, Logistics and Technology)

The ASA (AL&T) will—

a. Have primary responsibility for the overall RAM program pertaining to materiel.

b. Develop, issue, and maintain Army policies on RAM planning and execution in acquisition programs.

c. Supervise the Middle Tier Acquisition (MTA) and the major RAM program elements to—

(1) Ensure that operationally focused, achievable, affordable, and testable RAM requirements are included in the requirements documentation.

(2) Define the acquisition strategy (for example, developmental, government off-the-shelf (GOTS), commercial off-the-shelf (COTS)/nondevelopmental item (NDI)) in the capability development requirements documentation. GOTS/COTS/NDI acquisition strategy implies acceptance of the item's inherent RAM characteristics, without the need for further RAM development or testing.

(3) Ensure that planning under the provisions of AR 70–1 and AR 73–1 include a RAM program and its funding.

(4) Ensure that the RAM program is executed in accordance with the approved System Engineering Plan.

(5) Promote the development, improvement, and application of RAM technology and design practices.

(6) Ensure that RAM is evaluated in product improvement programs.

(7) Ensure that RAM requirements fully consider integrated product support, performance based logistics, and system readiness objectives.

d. Ensure that system operational RAM characteristics are reviewed during the Department of the Army (DA) decisionmaking process.

e. Ensure compatibility between the integrated product support program (see AR 700–127) and the RAM program.

f. Provide policy guidance on the provision of logistics support data to capability development and materiel development organizations for use in developing and validating RAM requirements for new materiel systems.

g. Ensure continued data collection and assessment of RAM performance for deployed systems.

h. Assist in Army staff evaluation of proposed changes to operational systems' RAM characteristics in product improvement programs.

i. Review the logistics-related RAM requirements for adequacy.

j. Provide a member for RAM working groups and RAM scoring and assessment conferences throughout development and operational testing.

k. Program, product, and project managers will—

(1) Assist the capability developer (CAPDEV) with establishing RAM requirements consistent with system operational and support concepts, current technology, Army doctrine, organization and force structure, analysis of alternatives (AoA), and expected war losses.

(2) Generate the materiel availability (A_M) component of the availability key performance parameter (KPP) and operations and support (O&S) cost key system attribute (KSA) for inclusion into the requirements documentation and reliability, availability, and maintainability-cost (RAM–C) report.

(3) Lead development and updates of the RAM–C report in conjunction with the CAPDEV and U.S. Army Test and Evaluation Command (ATEC).

(4) Provide the administrative and logistics downtime (ALDT) value for all programs requiring availability metrics.

(5) Provide the Test and Evaluation Master Plan (TEMP) with inclusion of associable RAM system attributes.

(6) Assist the CAPDEV in selecting the support concept, with corresponding RAM requirements and document in the Life cycle Sustainment Plan.

(7) Validate the technical feasibility and affordability of proposed RAM requirements. The feasibility assessment will include GOTS, COTS items, and NDIs at the system level requirements. These assessments will be conducted as part of the RAM–C report compilation.

(8) Establish and maintain integrated controls to ensure achievement of RAM requirements and compliance with this regulation. This includes the development of the RAM program.

(9) Identify and implement RAM engineering, design, manufacture, test, and management practices sufficient to ensure delivery of reliable and maintainable systems and equipment.

(10) Represent established RAM requirements with appropriate specification values and thresholds in contracts. These requirements will be coordinated with the ATEC and CAPDEV. The specification values will be translated from the operational RAM requirements.

(11) Execute the reliability and maintainability (R&M) program.

(12) Assess critical elements of RAM throughout the life cycle to detect trends indicating degraded system performance, degraded operational readiness, or increased life cycle costs and propose or take corrective action based on the assessment.

(13) Ensure that RAM will be a primary objective in contractor and Government system level testing. All plans for testing and assessing RAM performance will be coordinated with and provided to ATEC.

(14) Maintain a RAM database for materiel under their responsibility throughout the life cycle.

(15) Develop and execute the plan for attaining required reliability requirements, to include reliability growth planning curves (RGPC) developed in coordination with ATEC.

(16) Conduct developmental tests (DTs) on assigned items of materiel to assess RAM and to provide the RAM DT portion of the TEMP.

(17) Conduct RAM assessments in support of decision/technical and post fielding reviews.

(18) Provide necessary manpower and funding during development of missiles/munitions/ammunition to optimize the design and minimize future ammunition stockpile reliability program testing.

(19) Document life limiting components identified as a result of reliability testing and/or predictive technology prior to fielding.

(20) Provide manpower resources and training to support RAM program development and execution.

(21) Provide RAM support to science & technology programs.

(22) Track implementation of corrective actions associated with reliability failures and provides periodic updates to the ATEC and the CAPDEV.

(23) Support RAM effort for materiel release in accordance with AR 770–3.

(24) Establish and chair the RAM working group.

(25) Ensure RAM requirements align with AR 385–10, MIL–STD 882, and AR 70–62.

(26) Support independent technical risk assessment execution, to include providing access to programmatic and technical information.

(27) Include RAM activities (for example, failure mode, effects and criticality analysis (FMECA) reliability growth, prediction, and so forth) as an integral part of the systems engineering process at acquisition pathway initiation and continuing through the program life cycle.

(28) Initiate, resource, and establish a failure reporting, analysis, and corrective action system (FRACAS) for development, production, and post-production /sustainment chaired by the program's chief systems engineer. The product support manager and lead RAM engineer will serve as deputy chairs of the Failure Review Board.

(29) For programs at or before Milestone B or MTA Rapid Prototyping/Rapid Fielding, provide a description of the FRACAS in the systems engineering plan and RAM program planning documents. For programs at Milestone C or later, provide a detailed description of how the FRACAS will be maintained and executed in the O&S phase of the life cycle, in the Life Cycle Sustainment Plan.

1–8. Deputy Chief of Staff, G–2
The DCS, G–2 will include RAM (as appropriate) in all Army requirements development and review processes.

1–9. Deputy Chief of Staff, G–3/5/7
The DCS, G–3/5/7 will include RAM (as appropriate) in all Army requirements development and review processes.

1–10. Deputy Chief of Staff, G–6
The DCS, G–6 will include RAM (as appropriate) in all Army requirements development and review processes.

1–11. Chief of Engineers
The COE will include RAM (as appropriate) in all Army requirements development and review processes.

1–12. The Surgeon General
The TSG, through the U.S. Army Medical Command, will include RAM (as appropriate) in all Army requirements development and review processes.

1–13. Commanding General, U.S. Army Futures Command
The CG, AFC, will—

a. Through the Director, Futures and Concepts Center—

(1) Lead the AFC CAPDEV user-representative proponent RAM Engineering Program. Support all AFC CAPDEV user-representative proponents (for example, Capability Development Integration Directorates (CDID) and cross-functional teams (CFTs)) RAM activities through a central activity or office.

(2) Advise the AFC CAPDEV user-representative proponent during development of a system's concept of employment (CONEMP) and associated formation concept of operations (CONOP).

(3) Develop applicable mandatory reliability, operational unit availability (AO), and maintainability attributes (for example, KPP, KSA, additional performance attribute, or other) and rationale (per JCIDS Manual and Instruction) for inclusion in user-representative requirements documentation (for example, capability development document (CDD)) and the ASA (AL&T) led RAM–C report. Ensure the RAM attributes are operationally focused, achievable, affordable, and testable.

(4) Provide operational, logical, and analytical AFC CAPDEV user-representative proponent RAM Engineering assessments and recommendations supporting Army Requirements Oversight Council (AROC), AROC Capability Board, and AROC Review Board activities and decisions.

(5) Develop a system's failure definition and scoring criteria (FDSC) document describing a system's essential operational functions and allowable levels of degradation. Provide the FDSC across the Army's CAPDEV, materiel developer, and test and evaluation (T&E) capabilities development community as the primary guide in the reliability scoring of systems during DTs and operational tests (OTs) RAM T&E activities.

(6) Represent or advise the AFC CAPDEV user-representative proponent (for example, CDID and CFT) at RAM T&E activities (for example, DT, OT, reliability scoring conferences, reliability assessment conferences, and integrated product teams).

(7) Monitor materiel development, track achievement of RAM requirements, and support any impact assessment.

(8) Conduct all AFC CAPDEV user-representative proponent activities in collaboration with Army modernization agencies, in particular with the ASA (ALT) materiel developer and ATEC.

(9) Provide AFC CAPDEV user-representative support to RAM Engineering policy and procedures across the Army compliant with Office of Secretary of Defense and Headquarters, Department of the Army (HQDA) directives.

(10) Provide resources and training to support RAM program development and execution.

b. Through the commanders and directors of all capability development activities—

(1) Establish and document the basis of RAM requirements, system and system-of-system CONEMP, and FDSC, in coordination with the materiel developer and ATEC.

(2) Provide input to the materiel developer for inclusion into the RAM–C report.

(3) Establish the support concept with materiel developer assistance.

(4) Monitor materiel development, track achievement of RAM requirements, and support any impact assessment.

c. Through the Director, U.S. Army Combat Capabilities Development Command (DEVCOM) Centers—

(1) In support of the program manager and CAPDEVs, assist establishing RAM requirements that are consistent with system operational-and-support concepts, current technology, Army doctrine, organization and force structure, AoAs, and expected war losses.

(2) Characterize the RAM attributes, provide O&S cost data for alternative materiel solutions—with CAPDEV assistance—and document in the RAM–C report.

(3) Assist generating the A_M component of the availability KPP and O&S cost KSA, to include with the requirements documentation and RAM–C report.

(4) Assist developing and updating the RAM–C report, with the materiel and CAPDEV.

(5) Assist the CAPDEV selecting the support concept, with corresponding RAM requirements.

(6) Validate the technical feasibility and affordability of RAM requirements proposed for items that are within the command's development responsibilities. The feasibility assessment will include Government-furnished equipment, COTS items, and NDI system-level requirements. These assessments will be conducted as part of the RAM–C rationale report compilation.

(7) Establish and maintain integrated controls to ensure achievement of RAM requirements and compliance with this regulation. This includes developing the RAM program.

(8) Identify and implement RAM engineering, design, manufacture, test, and management practices sufficient to ensure delivery of reliable and maintainable systems and equipment.

(9) Assist the materiel developer represent RAM requirements, with appropriate specification values and thresholds in contracts. These requirements will be coordinated with the ATEC and CAPDEV. The specification values will be consistent with, and provide for the achievement of, RAM requirements.

(10) Execute the RAM program during sustainment for Army programs.

(11) Assess critical elements of RAM throughout the life cycle to detect trends indicating degraded system performance, degraded operational readiness, or increased life cycle costs; propose, or take, corrective action based on the assessment.

(12) Ensure that RAM will be a primary objective in contractor and Government system-level testing. All plans for testing and assessing RAM performance will be coordinated with, and provided to, ATEC.

(13) Maintain a RAM database for materiel throughout the life cycle.

(14) Present the plan for attaining required reliability requirements, to include RGPCs developed in coordination with ATEC, at program reviews.

(15) Conduct DT on assigned items of materiel to assess RAM.

(16) Conduct RAM assessments on assigned items of materiel before major decision reviews.

(17) Develop and execute the Army Ammunition Stockpile Reliability Program.

(18) Document life-limiting components identified through reliability testing and/or use of predictive technology, prior to fielding.

(19) Provide manpower resources and training to support RAM program development and execution.

(20) Provide RAM support to MTA and science and technology programs.

(21) Track the implementation of corrective actions associated with reliability failures, and provide periodic updates to the program manager, ATEC, and the CAPDEV.

(22) Prepare RAM statement for materiel release (see AR 770–3).

(23) Manage FRACAS.

(24) Maintain and use a database to track failures, root cause analyses, corrective actions, testing validation, and implementation dates, making it accessible to the sustaining command. Utilize FRACAS data for metrics and RAM assessments.

d. Through the Director, DEVCOM Data and Analysis Center—

(1) Support the ATEC, program, project, or product managers, and the other DEVCOM and AFC elements with early engineering reviews, to include using the reliability scorecard, to determine if the subject system is on a path to achieve the early engineering and manufacturing development (EMD) phase reliability threshold, established by the RAM working group, as well as the system operational-reliability requirements.

(2) Serve as a lead for the Army’s Center for Reliability Growth.

(3) Perform RAM analyses in support of HQDA; Headquarters, U.S. Army Materiel Command (AMC); materiel developers; AFC elements; and ATEC.

1–14. Commanding General, U.S. Army Test and Evaluation Command

The CG, ATEC will—

a. Serve as the Army's independent evaluator.

b. Perform continuous evaluation of system RAM characteristics throughout DTs and OTs.

c. Manage and conduct developmental and operational testing to enable RAM evaluation.

d. Review and comment on documents pertinent to RAM T&E such as the TEMP.

e. Design the overarching RAM T&E program to evaluate system RAM capabilities against approved RAM requirements as documented in the Joint Capabilities Integration and Development System (JCIDS) documents; RAM–C report, and contract specifications.

f. Maintain a common system RAM database for DTs and OTs.

g. Provide a member to the RAM working group and RAM scoring and assessment conferences throughout development and operational testing.

h. Support the development of a system-level reliability growth program.

i. Serve as the chair for the impact assessment committee in the event of a system reliability growth plan threshold breach and provide findings to the ASA (AL&T).

j. Review and provide disposition of the RAM–C reports.

k. Support and assist with post fielding sustainment reviews and independent logistics assessments, as needed.

l. Support and assist with RAM assessments before major decision reviews.

m. Assist the CAPDEV in establishing testable RAM requirements consistent with system operational and support concepts, Army doctrine, organization, and force structure.

1–15. Commanding General, U.S. Army Materiel Command

The CG, AMC will—

a. Demonstrate advanced technologies that lead to new and improved RAM, and that ease technology transition and integration into current capabilities, after items have transitioned to sustainment.

b. Through the commanders of life cycle management commands—

(1) Plan for maintenance and other logistics support compatible with specified RAM design requirements.

(2) Ensure RAM characteristics are maintained or improved during product improvement of materiel.

(3) Issue RAM data on fielded systems to interested Army activities.

(4) Coordinate with the involved Army commands, Army service component commands, and/or direct reporting units for on-site monitoring and collection of RAM data of deployed materiel.

(5) Assist the CAPDEV in selecting the support concept, with corresponding RAM requirements.

(6) Work with the U.S. Army DEVCOM elements, Software Engineering Centers, and program managers in identifying product improvement opportunities associated with life limiting components and high replacement items.

(7) Review and provide disposition of the RAM–C report.

(8) Resource RAM data collection on fielded systems and database management with Global Combat Support System–Army.

(9) Resource U.S. Army DEVCOM Centers for Ammunition Stockpile Reliability Program for fielded systems in accordance with AR 702–6.

(10) Resource U.S. Army DEVCOM Centers for RAM analysis/assessment for fielded systems.

1–16. Commanding General, U.S. Army Training and Doctrine Command

The CG, TRADOC will, through commanders and directors of all TRADOC capability development activities—

a. Establish and document the system and system-of-system CONEMP in coordination with the material developer and ATEC.

b. Ensure CDDs include applicable RAM attribute(s) per the JCIDS manual.

c. Document the basis of RAM requirements, and FDSC.

d. Establish the support concept with materiel developer assistance.

e. Monitor materiel development, track achievement of RAM requirements, and support any impact assessment.

f. Coordinate with materiel developers and ATEC to assist with the review and exchange of RAM data needed to develop requirements for emerging systems.

g. Provide a member to the RAM working group and RAM scoring and assessment conferences.

Chapter 2
Reliability, Availability, Maintainability Policy

2–1. Management

a. Materiel developers are responsible for establishing system life cycle RAM programs that maximize operational readiness and assure mission accomplishment while minimizing maintenance manpower cost, and logistic support cost. The Army DEVCOM and life cycle management commands support the materiel developers in the establishment of the RAM programs. RAM programs will include a mix of RAM engineering and accounting activities that achieve a balance between life cycle costs and system effectiveness and readiness. RAM management applies to all acquisition category (ACAT) programs where the CAPDEV has determined RAM to be an attribute of operational importance. RAM management applies to all programs when the requirements document contains RAM attributes. The RAM program designed by the materiel developer will—

(1) Ensure that materiel systems provided to the Army—

(a) Are operationally ready for use when needed.

(b) Will successfully perform their assigned functions.

(c) Can be operated, maintained, and sustained within the scope of logistic concepts and policies with skills and training expected to be available to the Army.

(2) Ensure that the RAM program contributes to reducing life cycle costs, while maintaining or increasing overall effectiveness and suitability.

(3) Ensure that RAM requirements for systems developed, procured, or improved meet the CAPDEV's requirements.

(4) Ensure that the system's integrated developmental and OT program will enable the ATEC to assess the system's RAM characteristics.

(5) Analyze RAM trade space against the operational concepts and in coordination with the CAPDEV.

(6) Ensure that the independent evaluator(s) and CAPDEV(s) are involved throughout the materiel acquisition process. The program manager will establish a RAM working group to include the CAPDEV and independent evaluator as soon as practical after the materiel development decision.

(7) Ensure that the materiel solution addresses the impact of hardware, software, firmware, operator/maintainer skills, and environment on RAM performance.

b. Materiel developers, with support from the CAPDEV and the ATEC, will prepare a preliminary RAM, and cost rationale (RAM–C) report in support of the Milestone A decision for all ACAT I and designated ACAT II and ACAT III programs requiring quantitative RAM attributes, as required by DoDI 5000.88 (see para 4–4, below). The RAM–C report provides a quantitative basis for reliability requirements and improves cost estimates and program planning. The report will be attached to the systems engineering plan submitted at Milestone A and updated in support of Milestones B and C. Programs that enter the acquisition system after Milestone A will prepare and submit a RAM–C as soon as practicable but not later than the next program Milestone. Programs that enter the acquisition system in sustainment will be assessed by the CAPDEV, materiel developer, the ATEC, and the AMC to determine the necessity of the RAM–C report for successful sustainment planning.

2–2. Reliability, availability, and maintainability emphasis in contract

RAM planning, programming, and resource allocation will be provided throughout the life cycle of each system (see Section 4328, Title 10, United States Code (10 USC 4328))—

a. Clearly defined and measurable RAM specifications will be included in the solicitation for and terms of contracts for design of weapon systems.

b. Clearly defined and measurable RAM engineering activities will be included in the solicitation for and terms of contracts for design of weapon systems. RAM engineering activities will focus on design, manufacture, test, and management practices that will result in reliable and maintainable items for operational forces from fielding to disposal. Acquisition and program plans will stress early investment in RAM engineering tasks.

c. Contracts shall, as appropriate, include provisions for the payment of incentive fees to the contractor based on achievement of design specification requirements for reliability, maintainability, and availability of weapon systems under the contract, or the imposition of penalties to be paid by the contractor to the

Government for failure to achieve such design specification requirements. Information about such fees or penalties will be included in the solicitation for any covered contract that includes such fees or penalties.

d. Determinations of contractor's performance on RAM, and evaluation of payment of incentives or imposition of fees, will be based on RAM data collected during the program. Such data collection and associated evaluation metrics will be described in detail in the contract. To the maximum extent practicable, such data will be shared with appropriate contractor and government organizations. RAM accounting will provide information essential to acquisition, operation, and support management to include properly defined data for estimating operational effectiveness and O&S costs.

e. If the materiel developer determines that engineering activities and design specifications for RAM should not be a requirement in a contract or solicitation for such a contract, the materiel developer will document in writing the justification for the decision. The decision will also be documented in the program acquisition strategy.

2–3. Reliability, availability, and maintainability emphasis during source selection

Sustainment factors, including RAM, will be identified in the source selection plan as a technical evaluation subfactor in making a source selection. When O&S costs can be accurately estimated and evaluated, these costs will be considered during the source selection decision. Whenever RAM and logistics are evaluated the source selection board should include a reliability engineer, reliability evaluator, or reliability manager for all major defense acquisition programs.

2–4. Reliability, availability, and maintainability engineering and design

a. The RAM program will provide a clear understanding of RAM requirements along with appropriate translation into contractual specifications that are logically traceable to user-defined requirements.

b. RAM engineering activities will be tailored to each system acquisition program by the materiel developer. Essential RAM tasks and tests will be identified, together with the RAM requirements and program schedules, to ensure delivery of reliable and maintainable systems and equipment. Critical RAM tasks will be summarized in the systems engineering plan and tests that contribute to RAM assessment and evaluation will be described in the TEMP.

c. Early design maturity will be the objective of each system acquisition program. Component and subsystem level RAM testing will be planned and funded early in the development phase with prioritization based on those areas where the potential return on investment (in terms of system level RAM) is assessed to be the greatest. Such RAM testing will be conducted well before the components are incorporated into system prototypes and system level RAM testing begins. Testing will be planned, funded, and conducted on all acquisitions, unless shown not to be appropriate or of no benefit. Sufficient test items (components and systems) will be funded throughout the system acquisition to support this component testing effort. This early work will serve as a basis for a well-founded estimate of the system's initial reliability at the beginning of the reliability growth program. Programs that enter the acquisition system after development will coordinate with the CAPDEV and the ATEC to determine the extent of test and demonstration required for program evaluation.

d. The RAM program is an integral part of the systems engineering process and must include design for reliability (DFR)/design for maintainability. It should identify specific design activities required that minimize the risk(s) of not achieving the system's RAM requirements. Apply the DFR approach using specific analysis tools (reliability requirement allocation, system block diagram and prediction, risk assessment–failure mode and effects analysis (FMEA), accelerated testing, and FRACAS) to manage reliability development throughout each phase of the product lifecycle. The basic DFR process involves; developing system reliability requirements, allocation of requirements to lower level, development of system reliability model and prediction, assessment of reliability gap–requirement versus predicted reliability, establishment of a reliability critical items list and mitigation of gap through risk assessment processes–design failure mode and effects analysis (DFMEA)/FMECA. Hardware, software, operator, training, mission profile, maintenance, manufacturing variation and errors, and technical manuals are the minimal set of risk areas that must be addressed and be documented in the program's System Engineering Plan. The Defense Acquisition University Reliability and Maintainability Engineering Community of Practice (www.dau.edu/cop/rm-engineering) provides source material for RAM program development. The RAM program should use an appropriate strategy consisting of engineering activities, products, and digital artifacts, including—

(1) RAM allocations, system reliability block diagrams and predictions.

(2) Refining the FDSC.
(3) FMECA or DFMEA.
(4) Maintainability and BIT/BITE analysis and demonstrations.
(5) Reliability testing including growth at the system and subsystem level.
(6) FRACAS.

e. The RAM program will include the development and implementation of a closed-loop failure-mode mitigation process to address potential failure modes from the FMECA/failure modes effects analysis as well as observed failure modes to reduce risk.

f. Reliability focused software development must include software design attributes to handle fault tolerance and off-nominal conditions. Guidance on fault tolerance and off-nominal conditions can be found in IEEE–1633.

g. Highly accelerated life testing, and/or modeling and simulation must be planned and funded prior to prototype fabrication, to support reliability characterization and the establishment of profiles for environmental stress screening (ESS). The ESS planning and profiles will be developed prior to production for all Army acquisitions that include electronic, electrical, or electromechanical hardware.

h. Materiel developers, with the support of the DEVCOM, will emphasize management of parts, materials, and processes (PM&Ps) to ensure hardware high reliability performance in operating and non-operating environments (for example, storage) across the acquisition life cycle. The approach will address the requirements of MIL–STD–11991 including: supply chain disruption, counterfeit PM&P, lead-free electronics usage, and the selection, acceptance test, and qualification approaches for PM&P items. Additional management and design "best practices" to improve quality and reduce reliability risk to fielded hardware are provided for reference in SD–18 and SD–19. Program and project PM&P selection and application requirements will be initiated in the technology maturation and risk reduction (TMRR) phase, become mandatory at the beginning of the engineering and manufacturing development phase, and continue thereafter.

i. Materiel developers with the support of the DEVCOM will designate RAM engineering activities in solicitations that will establish and implement RAM programs intended to achieve RAM requirements. The materiel developer will continually assess RAM progress toward requirements achievement. Independent evaluators will conduct system evaluations to identify deficiencies and determine whether intermediate thresholds are met. Prompt management action and allocation (or reallocation) of resources to correct deficiencies will be used to concentrate engineering efforts where needed (for example, to improve mission reliability by correcting mission critical failures, or to reduce maintenance manpower and logistic cost by correcting repetitive failures).

j. RAM design reviews are an integral part of system design reviews and audits; these are conducted throughout the item life cycle and acquisition process. Solicitations and contracts will contain the necessary provisions to support design reviews. Design review procedures will be tailored to specific commodity areas and life cycle phases. The general objectives of design reviews and audits are to—

(1) Evaluate the adequacy and completeness of technical requirements.
(2) Evaluate the ability of the design of the system, or configuration item, to satisfy its technical requirements.
(3) Verify that actual performance of the system, or configuration item, met its technical requirements.
(4) Evaluate adequacy of resources (schedule, funding, and so forth) to achieve technical requirements.
(5) Conduct an early engineering-based reliability program review using the DEVCOM data and analysis center reliability scorecard, which is a tool available for use by the materiel developer.

k. A RAM design review should be part of a specific product development milestones Preliminary Design Review, Critical Design Review, Test Readiness Review, and so forth, and specifically focus on—

(1) DFMEA/FMECA results and the Failure Mode Critical Items List.
(2) System reliability prediction model results.
(3) Reliability critical items list.
(4) The assessment of reliability gap based on comparing reliability allocation requirements to the reliability prediction.
(5) Design Verification/Product Validation test results and demonstrated reliability.
(6) FRACAS, and so forth.

l. For defense acquisition programs, the program manager will integrate R&M engineering as an integral part of the overall engineering process and into the digital representation of the system being developed.

m. The program managers of major defense acquisition programs and Major Systems must provide justification in the acquisition strategy for not including R&M requirements and engineering activities in TMRR, EMD, or production solicitations or contracts.

2–5. Reliability growth

a. Reliability growth, as used in the materiel acquisition process, is an Army management tool rather than a technical tool. Reliability growth management should—

(1) Aid in allocating resources to achieve reliability requirements on schedule and within cost constraints.

(2) Establish a feasible path to demonstrate system-level reliability requirements with statistical confidence.

(3) Focus attention on achieving reliability growth by following industry best practices for DFR, identifying operationally relevant failure modes, implementing corrective actions, and verifying the effectiveness of those corrective actions.

(4) Serve as an enabler to assess the O&S cost impact of fielding the system.

b. The materiel developer will plan an approach to reliability growth, to include a planning model, prior to Milestone A that will be applied starting in EMD, and continue through the production and deployment phase. A period of testing will be scheduled in conjunction with post Milestone B to identify design, software, or manufacturing defects. Test time and resources will be scheduled to correct deficiencies and defects found during prior testing. The test-analyze-fix-test (TAFT) program will have dedicated resources (people, facilities, and test units for the necessary duration) to effectively eliminate deficiencies. The TAFT program is required to begin prior to the production phase.

c. Materiel developers will develop and use reliability growth plans on all ACAT I, II, and selected nonmajor systems. The reliability growth plans will include RGPCs. Materiel developers will include a RGPC in the System Engineering Plan, the TEMP, and the Life cycle Sustainment Plan at the first program Milestone and all subsequent Milestones. The RGPC will also be included in EMD contracts. If a single RGPC is not an adequate tool to aid in the management of system-level reliability growth, multiple RGPC may instead be used for critical subsystems with rationale for their selection.

d. At program reviews, materiel developers, with support from the DEVCOM, will present the coordinated RGPC to provide a realistic portrayal of system reliability in relation to requirements. All updates to the RGPC will be provided to the RAM working group members.

(1) Materiel developers will incorporate initial, interim, and final reliability goals, test phases, corrective action periods and reliability thresholds into the RGPC.

(2) The RAM working group will establish a reliability threshold on the RGPC for the EMD phase of acquisition. If agreement for this value is not reached, then the default for the reliability threshold value(s) will be 70 percent of the threshold reliability requirement(s) specified in the JCIDS document. The threshold must be demonstrated with a minimum of 50 percent statistical confidence, calculated using standard confidence level procedures, unless the RAM working group jointly agrees upon a different standard.

(3) The reliability thresholds will be documented in the acquisition program baseline and TEMP no later than Milestone B and will be translated into the EMD contracts/solicitations. If a program enters the acquisition system after Milestone B, the reliability thresholds will be documented as soon as practicable but not later than the next Milestone.

(4) The program will be expected to meet or exceed the reliability threshold value at the end of the first full-up, integrated, system-level DT event conducted within the EMD phase.

(5) In the event that the system fails to meet or exceed the early reliability threshold established by the RAM working group, the assigned user tester from ATEC will convene an in-process review to address the following:

(a) The program manager’s planning and implementation of corrective actions, the projected reliability as the corrective actions are implemented, and the programmatic impacts.

(b) ATEC assessment of the program manager’s corrective action plan, the system's limitations and capabilities given the current level of reliability maturity, the projected reliability, and the risk of the program not getting back on track.

(c) CAPDEV/Sponsor/Proponent will assess the utility of the system considering its current and projected reliabilities.

2–6. Reliability, availability, and maintainability accounting and assessment

a. Materiel developers will conduct a RAM assessment before each programmatic and technical event to estimate the RAM levels of performance. Materiel developers will consider the appropriate amount and specificity of data necessary to detect relevant failure modes, in order to conduct root cause analysis (RCA), devise effective corrective actions, and improve system-level reliability.

(1) The collected data should reflect the loads and stresses of the anticipated operational environment consistent with the CONEMP.

(2) Data should include observed failure modes, total test duration, number of groups/intervals within the test and the duration of each group/interval, description of testing environment/procedure, system configuration, corresponding test incident reports (TIRs), when corrective actions were implemented and any other pertinent material.

(3) Updates from the FRACAS activity should be reflected in the risk assessment DFMEA/FMECA in order to track risk mitigation status.

b. RAM assessments, including any reliability growth, will be monitored and reported throughout the acquisition process. Materiel developers will report the status of RAM objectives and/or thresholds as part of the formal design review process, during program support reviews, during systems engineering technical reviews, post-fielding reviews or any other relevant contractual reviews.

c. The RAM prediction model should be linked to the risk assessment evaluation (DFMEA/FMECA) in order to specifically reflect the design impacts from corrective action and their relationship to the realized system reliability.

d. Program managers will track hardware and software failures, repair histories (for example, repair times, number maintainers), and operating metric (for example, hours, miles, cycles) failure and repair histories for fielded systems, beginning with the first unit equipped. Tracking should focus on the identification of operating and support cost drivers and lead to cost-effective improvements. The level of data collected should be sufficient to assess if system level reliability requirements continue to be met, detect component and system aging, identify components that repeatedly fail, and assess individual component reliability. The program managers should consider incorporating appropriate data collection capabilities as an integral (that is, embedded) part of their systems design, to collect this information cost effectively and unobtrusively.

Chapter 3
Reliability, Availability, and Maintainability Documentation

3–1. Requirements documents

a. Development of requirements documents is detailed in AR 71–9. Quantitative RAM requirements will be stated in requirements documents unless not appropriate for the item.

b. Quantitative RAM requirements stated in requirements documents represent the operational need and capability for the system, based on currently available knowledge. Capability and materiel developers will initiate a change to the appropriate RAM requirements when new data indicates a change in the threat, need, operational capabilities, or technical capabilities.

c. A RAM–C report will be prepared for all ACAT I and designated ACAT II and ACAT III programs requiring quantitative RAM attributes. The report is a separate document from the requirements document. Quantitative RAM requirements, as well as any higher order effectiveness parameters, and associated cost considerations will be documented and justified in the RAM–C report. The report will be submitted with the AoA and Systems Engineering Plan. Guidance for development of the RAM–C report is found in the DoD Reliability, Availability, Maintainability, and Cost Rationale Report Manual.

d. The RAM–C report will be reviewed for concurrence by the following organizations:

(1) The commander of the applicable U.S. Army Life Cycle Management Command.

(2) The Commander, ATEC.

(3) The CG, TRADOC.

(4) The program, product, and project managers of the applicable U.S. Army Program Office.

(5) The CG, AFC.

e. When quantitative RAM requirements do not apply, a statement with rationale will be included in the System Engineering Plan and requirements document.

f. The RAM working group will be established before the draft RAM–C report is prepared. The materiel developer will be the lead participant in coordinating the RAM–C report. The RAM working group will assure interagency communication throughout the program life cycle.

3–2. Management documents

The systems operational RAM requirements (from the JCIDS document) and technical RAM capabilities will be summarized and documented in the RAM–C, TEMP, RAM program plan, Life Cycle Sustainment Plan, and System Engineering Plan. The critical RAM issues to be addressed during DT and evaluation and operational test and evaluation (OT&E) will be included in the TEMP. The RAM program to design and produce a reliable and maintainable system will be summarized in the program management documents (see AR 70–1).

3–3. Technical data package

a. RAM characteristics for system level and critical lower level work breakdown structure elements, along with related requirements and tests, will be integrated into the technical data package. These requirements and tests will be sufficient to ensure the delivery of a product satisfying its RAM requirements.

b. Reliability requirement allocations should be defined for lower level product structure elements and monitored to assess reliability gap during various activities conducted throughout product development.

c. The materiel developer will define technical RAM values and quality assurance provisions in specifications. The requirements and provisions will be developed to the lowest work breakdown structure level necessary to control the RAM characteristics of future repair part procurement and reconditioned materiel. These requirements will be consistent with those of the requirements document.

3–4. Test documentation

a. Test and Evaluation Master Plan. The TEMP will include description of key RAM requirements, test events, configurations, and reliability growth curve(s).

b. System evaluation plan. The ATEC will prepare the system evaluation plan. The evaluation methodology and criteria to be employed for evaluating the system RAM characteristics will be included in the system evaluation plan. The plan will include a data source matrix that shows the relationship between critical operational issues, evaluation measures, test events, and data sources.

c. Test plan. The ATEC will prepare detailed test plans and OT agency test plans describing all RAM test activities. The materiel developer will coordinate test planning activities with ATEC and the RAM working group for all customer or vendor tests that are intended to support a formal RAM evaluation. These RAM test plans as described in the TEMP should include the number of test assets, the number of asset firing rounds or operating hours, the duty cycle applied during operation, and the appropriate operating environment in order to adequately demonstrate the prescribed allocated reliability requirement at the specific confidence level.

d. Test incident reports. The test organization assigned responsibility to conduct tests contributing to the overall evaluation will document each test anomaly or RAM incident observed during testing in the form of a TIR. Each TIR will include, at a minimum, the nature of the failure, the associated diagnostic and corrective maintenance time, system state (on mission, standby, and so forth), and operational impact (that is, immediate action required or partially mission capable). The data contained in the TIR should be sufficiently complete and detailed such that the RAM scoring conference can score the incident in terms of severity and chargeability. The TIR must be detailed enough to use as a basis for RCA and to discern differences between similar failure modes.

e. Independent evaluation report. The ATEC will perform a comprehensive evaluation of system RAM characteristics, leveraging all available data sources, as appropriate (for example, DT, OT, operational environment), to produce a report.

3–5. Post fielding data assessment

a. Processes to capture relevant RAM information and record it in field data collection systems (for example, LPDS maintained by the Logistics Data Analysis Center) will be planned and documented in the Life cycle Sustainment Plan. Execution of the post fielding data collection and continuous RAM assessment will be arranged prior to the program's full rate production decision review.

b. Provides a formal FRACAS process or methodology followed by the entire organization to help promote product system field RAM, and (O&S cost improvement throughout the life cycle). It gives the following benefits:

(1) Provides field performance engineering data and analysis for corrective and preventive action decisionmaking.

(2) Identifies developing field performance patterns of deficiencies.

(3) Provides field incident (failure) data for R&M analysis to help assess risk and critical items, update and compare RAM field model against requirements, and optimize operating and support costs throughout lifecycle.

(4) Establishes a closed-loop process for field failure recognition (analysis and prioritization) and resolution (root cause, corrective action, and verification), with a link back to risk assessment and RAM model.

(5) Helps to avoid reoccurrence of failures in future designs through integrated use of risk assessment/critical items lists and reliability centered maintenance activities.

(6) Provides into a centralized location for storing lessons learned related to field R&M, helping to reduce time and effort for resolving both individual incidents as well as problems.

(7) Provides updates into the DFMEA/FMECA.

Chapter 4
Reliability, Availability, and Maintainability Requirements Generation

4–1. Overview

a. The CAPDEV has the overall responsibility for establishing meaningful operationally based RAM requirements and properly documenting them in capability documents. Operational RAM requirements will be translated into appropriate technical parameters by the materiel developer for testing and contracting purposes. RAM requirements are generated in coordination with the materiel developer, T&E community (ATEC), and Army logisticians to ensure requirements are achievable, feasible, cost effective, testable/verifiable, and reflect the full spectrum of attributes that impact mission success and logistics effectiveness (for example, reliability, maintainability, maintenance force structure, employment concepts, resupply distribution, and so forth). Other agencies including DEVCOM Analysis Center, The Research Analysis Center, and Sandia National Labs may be utilized to supplement the analysis capabilities of the CAPDEV.

b. RAM is composed of three elements—

(1) The RAM requirements and their numerical values.

(2) The CONEMP.

(3) The FDSC.

c. The CAPDEV will, as part of the capabilities development process, develop operationally focused RAM requirements. A RAM–C report will be prepared for any program which establishes a sustainment KPP. Guidance for development of the RAM–C report is available in the DoD Reliability, Availability, Maintainability, and Cost Rationale Report Manual.

d. Changes to the CONEMP or FDSC that impact the numerical RAM values in the approved requirements document must be assessed. Such changes require impact analysis and in turn require acceptance of the change by the document approval authority.

e. Within the bounds of the JCIDS process, the CAPDEV tailors the appropriateness and applicability of quantitative operational RAM requirements for each development, NDI, COTS, and modification program.

4–2. Concept of employment profile

a. The CONEMP provides a detailed operational understanding of expected peacetime and wartime usage and requirements of the materiel system expressed in a structured and quantitative format. An CONEMP is a time based representation of planned operations at the tasks, conditions, and standards level across the full range of military operations. The CONEMP is a source document for many functional areas engaged in the materiel acquisition process. Users of the CONEMP include the logisticians, testers, evaluators, capability and materiel developers, organization documenters, analysts, trainers, operational planners, and manpower resource personnel. As an integral part of the RAM requirements, the CAPDEV has responsibility for developing the CONEMP and coordinating with the materiel developer and ATEC.

b. CONEMPs are mandated as a basis for the RAM requirements. The development of the CONEMP is fully described in the AFC Future and Concepts Center Writer's Guide for the Development of the

CONEMP (available at https://armyeitaas.sharepoint-mil.us/sites/afc-fcc-hq/sitepages/home.aspx). The CONEMP accompanies the capability document being processed for approval.

4–3. Failure definition and scoring criteria

a. FDSCs are mandated as part of the RAM requirements. Content and development of the FDSC is fully described in the AFC Guide for Developing Reliability Failure Definition and Scoring Criteria (FDSC) (available at https://armyeitaas.sharepoint-mil.us/:w:/r/sites/afc-fcc-fid/shared%20documents/fcc%20ram%20engineering%20division%20(RED)%20Information/FCC%20RAM%20Engineering%20Division%20(RED)%20Information.docx?d=w2070d2fc7f78459284648f07bb430209&csf=1&web=1&e=erHQ9U). As an integral part of the RAM requirements, the CAPDEV has responsibility for developing the FDSC and coordinating with the materiel developer and the independent evaluator, as a minimum.

b. The FDSC provides reliability failure definitions and functionality thresholds applied during reliability design, testing, and assessment. The FDSC is a living document that is updated as the system matures. While it supports the RAM requirements in a requirements document, the focus of the FDSC is to support the T&E process. It does not accompany the requirements document being processed for approval. The failure definition consists of a list of critical tasks (represented by essential functions, which are tied to key requirements in the associated requirements document) and associated standards (failure criteria) which identify when and to what level each essential function are breached. The scoring criteria consist of procedural guidance on scoring.

c. The FDSC provides the ability to support the determination of product failure mode and cause severity level definition during the execution of risk assessment through the use of the DFMEA/FMECA.

4–4. Sustainment parameters

Sustainment planning upfront enables the requirements and acquisition communities to provide a system with optimal RAM to the warfighter at an affordable cost. Sustainment attributes provide an integrated structure that balances sustainment with capability, logistics supportability, and affordability across a system's life cycle, and informs decisionmakers in trade-off analysis. Sustainment is applicable to all CDDs, and capability production documents (CPDs) as mandated by JCIDS for ACAT I programs and designated ACAT II and ACAT III programs by the proponent. In cases where sustainment is not appropriate to the operational context of a capability solution, appropriate justification for non-inclusion must be provided; and the CDD/CPD may include other sponsor defined sustainment metrics as KPP, KSA, or additional performance attributes.

a. Availability key performance parameter. Availability consists of two components: A_M and AO. Respectively, they provide fleet-wide availability (A_M) and an AO. A_M is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. A_M addresses the total population of end items planned for operational use, over the total life cycle timeframe, from placement into operational service through the planned end of service life. A_O is a measure of the degree to which an item is in an operable state and can be committed at the start of a mission when the mission is called for at an unknown (random) point in time.

(1) Development of the A_M metric is a materiel developer responsibility.

(2) Development of the A_O metric is a CAPDEV responsibility.

(3) A_O requirements may be specified for continuous/steady-state conditions, or for short intensive usage periods, that is, "pulse A_O."

(4) Accurate development of availability metrics require modeling and simulation, and in particular the derivation of an operationally relevant ALDT parameter collaboratively between the materiel and CAPDEVs. Since ATEC is required to use model and simulation (M&S) to evaluate the achievement of the sustainment KPP, M&S planning with ATEC involvement must be performed during the requirements development process.

(5) A_M is not applicable to information technology (IT) programs without hardware. However, A_O and reliability requirements as KPPs, KSAs, or attributes may be established for IT programs.

b. Reliability key system attributes. Reliability will be sufficient to support the warfighting capability requirements, within expected operating environments. Considerations of reliability must support both availability metrics. The reliability KSA is determined by the CAPDEV. The JCIDS manual defines "reliability" as the probability the system will perform without failure over a specific interval. Applied to a system,

reliability is the probability that a system will perform a required function or functions under designated operating conditions for a specified period of time (or other units such as miles, cycles, rounds, and so forth) at specified levels of confidence. For a single use system (for example, artillery munitions, missiles, parachutes, and so forth), it will cover the successful performance of the required functions and may not include a specific time interval.

(1) Reliability of the system should not be confused with the mission success rate (which includes reliability and many other factors).

(2) Reliability requirements in capability documents will normally be expressed as probabilistic requirements because they are more operational in nature. Probabilistic reliability requirements are often converted into failure rates for contractual, testing, and logistics purposes. Non-probabilistic reliability requirements are used in cases such as when the reliability of previous increments or predecessor systems were not expressed probabilistically and it is beneficial to continue in the same terms; or, when necessary to reach consensus among Joint Services.

(3) Reliability requirements in capability documents will be expressed in operational terms, meaning that they encompass the inherent hardware, software, typical operators and maintainers, manuals, tools, TMDE, support equipment, and the operational, organizational, and logistical support concepts. Operational RAM quantifies the degree to which the user can rely on required system functions and the burden associated with keeping those functions at his or her disposal.

(4) Reliability requirements in capability documents will include or account for the presence of ancillary, support, or other critical non-system components which may be mandated or are necessary for use with the system.

(5) Reliability requirements should not contain references to test confidence levels or the degree to which they will be tested and evaluated.

c. Operations and sustainment cost key system attribute. O&S cost metrics provide balance to the sustainment solution by ensuring that the O&S costs associated with availability and reliability are considered in making decisions. The O&S cost metric covers the planned life cycle timeframe, consistent with the timeframe and system population identified in the A_M metric. The O&S cost KSA is determined by the materiel developer.

d. Maintainability key system attributes. Maintainability has a significant impact on the operational use of a system and therefore is added as a KSA when sustainment is required or identified.

(1) Even though maintainability can be defined as a probability, the commonly used definition expresses it in terms of the type and amount of maintenance time required to restore an item to a specified condition (amount of corrective maintenance time following a failure); and/or the type and amount of maintenance it takes to restore to and maintain an item in a specified condition (incorporating both preventive and corrective maintenance). Maintainability requirements include both quantitative and qualitative aspects.

(2) Quantitative requirements associated with maintainability include measures such as mean time to repair (MTTR), maximum time to repair (M_{ax} TTR), and maintenance ratio.

e. Follow-on systems. RAM requirements for new systems which replace legacy systems should be established such that the overall impact to the user, in terms of mission success and logistics burden, are not worse than the predecessor system at the time of the legacy system's fielding, and in keeping with the user's current operational need. The intent is that RAM requirements of follow-on systems must be no worse than achieved RAM of predecessor systems; however, reliability trade-offs may be performed to reflect the addition of new capabilities, or other cases such as a one-for-many system replacement.

4–5. Reliability, availability, and maintainability-cost rationale report

a. Guidance for development of the RAM–C report is found in the DoD Reliability, Availability, Maintainability, and Cost Rationale Report Manual (Available at https://www.dau.edu).

b. The RAM–C report is prepared by the program/product managers with input from the CAPDEV, Army logistician, and support from ATEC and AMC elements, as necessary.

c. A preliminary RAM–C report will be prepared in support of all ACAT I and designated ACAT II and ACAT III programs requiring quantitative RAM attributes. However, without an adequate system CONEMP, which may not be available at Milestone A, there cannot be a solid foundation for defining quantitative RAM requirements. A formation level CONEMP can be used to provide an estimate of system usage, and an initial A_O requirement may be established based on readiness constraints. The preliminary RAM–C report may also address sustainment goals or shortcomings identified in the AoA or capabilities

based assessment, or sustainment issues specific to the type of technology envisioned for the system. A preliminary RAM–C report will be limited in scope due to the many unknowns at this stage of program, and may articulate RAM and sustainment requirements or goals in terms of a preferred system concept, support and maintenance concept, and technology development strategy.

4–6. Tailoring of reliability, availability, and maintainability requirements

The CAPDEV first determines whether quantitative operational RAM requirements are appropriate and applicable for each development, COTS, NDI, and modification program (in other words, if quantitative operational RAM requirements will be included in the capabilities document). The RAM requirements provide the CAPDEV's best estimate of what is required to meet the user's operational needs but should also reflect what the materiel developer deems affordable and technically achievable within program funding, risk, and time constraints.

a. Information systems. IT programs without hardware procurement such as tactical command, control communications, computers, and intelligence/IT systems may have reliability and/or A_O requirements established at the discretion of the CAPDEV. Reliability requirements for software-only programs should be probabilistic and focus on successfully completing key or critical functions of the software. IT programs containing hardware must have RAM requirements established.

b. Non-quantitative reliability, availability, and maintainability requirements.

(1) *Passive systems.* Passive systems are systems which do not perform an active function (that is, have no powered or mechanical systems or any significant failure modes), such as non-powered boats, bridge girders, tools, pipe sections, clothing, protective gear, and so forth. Reliability and A_O are generally not applicable to passive systems; however, durability, service life, or maintainability requirements may be applicable.

(2) *Commercial off-the-shelf/nondevelopmental item.* A COTS/NDI acquisition strategy implies that the commercial marketplace supplies an item, which is sufficient to meet all the user's needs. Items supplied by the commercial marketplace have achieved a balance between reliability and cost such that while higher reliability can be obtained, it is usually not cost effective to do so. Availability, however, is highly dependent on the establishment of proper logistics support for the fielded system. The materiel developer is responsible for obtaining the necessary data to support government-provisioning analysis.

Chapter 5
Testing

5–1. Developmental testing

a. DT will be conducted under controlled conditions. The DT RAM emphasis will be to—

(1) Identify design deficiencies, conduct RCA, implement corrective actions, and verify efficacy of the corrective actions.

(2) Promote and assess reliability growth.

(3) Evaluate adequacy of design for logistical support.

(4) Estimate the effect of anticipated field utilization, environmental conditions (that is, operationally realistic loads and stresses), and representative military personnel (where possible).

(5) Determine contract compliance and resolve contractual RAM issues.

(6) Provide a basis for a clear understanding of RAM design deficiencies.

(7) Contribute to the DT/OT RAM database.

(8) Update the results of testing (DT) and resolution of problems (root cause and corrective actions) into the associated system risk assessment–DFMEA/FMECA. The changes to the risk assessment as a function of risk mitigation should be linked to the projected estimates of reliability in the system reliability model.

(9) Provide estimates of RAM characteristics.

(10) Provide shelf life assessment for ammunition stockpile reliability program.

(11) Provide durability estimate of the useful life of certain types of systems (gun barrel, vehicle track, military bridging, and so forth).

b. Testing for RAM at the system level will be designed and conducted to duplicate as closely as possible the CONEMP. When the CONEMP cannot be duplicated, procedures will be established for adjusting the analysis of test data or results to conform to the CONEMP. Tailored environmental profiles should be developed and used for testing components and subsystems. Environmental profiles (like those

contained in MIL–HDBK–781) should be used only when sufficient environmental information is not available and cannot be generated.

5–2. Operational testing

a. OT will provide a characterization of RAM in a variety of expected operational conditions, as established by the CONEMP. OT concentrates on gaining insights into the operational RAM behavior of the system employed by representative military operators under operationally realistic conditions, and not necessarily proving out User technical requirements. OT normally will be conducted for a fixed configuration of the system under evaluation, which must be clearly documented by the developer and provided to the RAM working group prior to the conduct of OT. In support of writing the OT agency test plan, the materiel developer will provide documentation regarding the configuration of the system that is expected to be available during the OT. If the materiel developer determines that the actual system configuration that will be available for the OT is different from the anticipated configuration, the materiel developer will provide an updated document to the RAM working group specifying the nature of any differences as soon as possible and well in advance of the OT date. Modifications to the equipment will be allowed only if the problem is of such a nature that further testing is precluded. When system modifications are approved for OT, they will be planned as block changes. OT RAM emphasis will be to—

(1) Provide a comprehensive characterization of system RAM.

(2) Identify operational RAM deficiencies (by failure mode, subsystem, function, mission, and so forth).

(3) Contribute evaluation of RAM to the overall suitability evaluation for the system.

(4) Represent, to the maximum degree possible, realistic operational conditions based on the CONEMP.

(5) Assess the impact of any vendor corrective actions implemented prior to the OT.

(6) Update the results of testing (OT) and resolution of problems (root cause and corrective actions) into the associated system risk assessment–DFMEA/FMECA. The changes to the risk assessment as a function of risk mitigation should be linked to the projected estimates of reliability in the system reliability model.

b. To the maximum extent feasible, operational testing for RAM will be conducted in accordance with the CONEMP and the program's product support strategy to eliminate the need to adjust RAM estimates. When following the CONEMP is not feasible, procedures to adjust RAM estimates will be determined by the ATEC independent RAM evaluator.

5–3. First article/initial production testing

Production acceptance test and first article test requirements are detailed in AR 73–1. First article/initial production test (FA/IPT) RAM emphasis will be to—

a. Identify initial production deficiencies, conduct RCA, and implement corrective actions, and verify efficacy of the corrective actions.

b. Promote and assess reliability growth.

c. Determine contract compliance and resolve contractual RAM issues.

d. Provide a basis for a clear understanding of RAM initial production deficiencies.

e. Contribute to the RAM database.

f. Provide estimates of RAM characteristics.

g. Test against all support/RAM issues for which waivers were granted in previous testing. Validate corrective actions for issues identified in previous testing.

5–4. Test planning and design

a. Planning for DT, OT, and FA/IPT will be coordinated in order to promote system-level reliability growth and ensure that the potential exists to leverage all data sources in the system RAM evaluation. Subject to program office resource constraints, the test length for a system reliability demonstration event will be established to balance government and producer risks and identification of design deficiencies. During the reliability demonstration event (typically the initial OT), the planned field configuration of the system should be exercised. The system T&E program should include opportunities to involve representative military operators as early and as often as is feasible. As discussed in chapter 3 of this regulation, the ATEC independent RAM evaluator will document the system RAM evaluation approach in the system evaluation plan.

b. The RAM working group will be established as a forum for discussion of the database, the analytical procedures to be used in assessing the data, and for determining the demonstrated RAM values. The RAM working group should strive for a consensus of the principal spokespersons (CAPDEV, materiel developer, and independent evaluator).

5–5. Reliability, availability, and maintainability entrance criteria for test events

RAM test criteria will be defined for each phase of testing by the materiel developer and independent evaluator in coordination with the CAPDEV. Test criteria will be included in the TEMP before the initial phase of testing and will be re-coordinated during TEMP update (see AR 73–1). These test criteria will be established by using RAM requirements, confidence level, reliability growth considerations, and technological assessment of the development program. No single test (or series of tests) can provide all the information upon which to base a decision; therefore, these RAM test criteria are not established as automatic pass-or-fail criteria for the system, but will measure the attainment of the RAM requirements. The test criteria will be used to assess satisfactory progress in achieving RAM requirements. Each RAM value that is a KPP in the requirements document must be addressed by a specific issue and criterion developed by the CAPDEV. RAM and trade-off validation activity will be conducted to ensure continued viability of RAM requirements prior to key design and test activities.

Chapter 6
Scoring, Evaluation, and Reporting

6–1. Scoring conferences

a. The objectives of scoring conferences are—

(1) To establish a RAM database.

(2) To ensure that a proper and consistent determination is made for categorizing (assigning classification and chargeability) test incidents and field data against RAM requirements. The FDSC provides guidelines for these determinations and reflects the user's intent with regard to the operational impact of failures on the essential tasks and standards, which the system is required to perform. Deviations from the approved FDSC or CONEMP may be considered a change to the JCIDS RAM requirements.

b. If no RAM requirements exist, no scoring conference is required.

c. Scoring conferences will be held during and immediately after DT, OT, and at regularly established intervals for assessment of field data. DT scoring conferences will be chaired by the materiel developer. OT scoring conferences will be chaired by the independent evaluator. Field data scoring conferences will be chaired by the materiel developer (life cycle manager).

d. The principal members of scoring conferences are the material developer, CAPDEV, and independent evaluator. Scoring conference advisory members may include the tester, Office of the Director for OT&E, and others as needed. Principal membership is the same for both DT and OT.

e. Scoring conferences may be held in a single physical location with all scoring conference members present, or they may be conducted virtually (teleconference, video teleconference, Web-based, and so forth).

f. Through careful examination of TIRs/field data and relevant supporting system data, the scoring conference members should strive for a consensus regarding the scoring and categorization of each TIR/field data; however, consensus is not required. If consensus is not achieved by the scoring conference, the differing viewpoints will be documented in the minutes of the meeting. The ATEC system RAM evaluation will be based on the independent evaluator's final scores for each TIR/field data for any data intended for use in operational assessments and evaluations. Materiel developers and CAPDEVs may express dissenting opinions during their presentations at the program decision review.

g. The developmental tester or the operational tester (as applicable) will provide a representative to all scoring conferences. For each incident, the tester's representative will provide explanations and background information on test conditions along with resulting maintenance actions and hardware or software conditions for failure analysis.

h. The developmental and operational testers will provide an initial categorization of each test incident in the associated TIR. The final categorization of each TIR is the responsibility of the scoring conference.

6–2. Reliability, availability, and maintainability evaluation

a. Demonstrated reliability, availability, and maintainability. The calculation of a system's demonstrated reliability is based on the observed failures accumulated on all assets during testing and the operating metric (hours, miles, cycles, and so forth). Subsequent to each test event, the independent evaluator will publish results relating to demonstrated system RAM characteristics. Such information should consist of, but not be limited to—

(1) Failure mode event timeline including all test assets.

(2) Breakdown of the relative contribution of each observed failure mode to overall system unreliability, associated repair time, and approximate cost of repair (clock hours, monetary cost of repair parts).

(3) RCA for each failure mode (there may be a delay in receiving this information from the vendor).

(4) The mission impact of each failure mode.

(5) An estimate of the system-level reliability (that is, the probability of completing a mission without a system abort or operational mission failure), availability, and maintainability characteristics.

b. Assessed reliability, availability, and maintainability. The calculation of a system's assessed reliability is based on the observed failures accumulated on all test assets during testing and the operating metric (hours, miles, cycles, and so forth). In contrast to demonstrated reliability, the scoring conference members perform an assessment of the effectiveness of vendor corrective actions associated with the mitigation of observed failure modes. The reliability calculation is adjusted to account for the impact of implemented and/or planned vendor corrective actions. Refer to MIL–HDBK 189 for applicable methodologies.

(1) A RAM assessment conference will be held to discuss and establish the test database, discuss the analytical procedures to be used in assessing the effectiveness of corrective actions (both implemented and planned) aimed at mitigating observed failure modes, and determine the demonstrated RAM estimates. Results from testing should be incorporated back into the respective risk assessment system DFMEA/FMECA. The risk assessment update should capture the responsible component failure rate, failure mode, root cause, and design countermeasure or corrective action. A risk level reassessment should made to determine the new risk level after design risk mitigation. The DT and OT databases that have been formally processed through the scoring conference, and the aggregated DT/OT data from the RAM assessment conference, will be used in assessing achievement of RAM requirements. Minutes of RAM assessment conferences will be provided to the attendees and the logistician. The logistician will be invited to the RAM assessment conference.

(2) At the completion of a phase of DT, the assessment conference will be chaired by the materiel developer's representative. This conference will include the materiel developer, the CAPDEV, and independent evaluator. OT assessment conferences will be chaired by the independent evaluator. In each case, the conference membership will be the same as for the scoring conferences.

(3) The results of the RAM assessment conference will be evaluated and portrayed in test reports, independent evaluations, and assessments for review by, and use in, the decision process (in process review, Army Systems Acquisition Review Council, or Defense Acquisition Board).

c. Evaluation duties. The independent evaluator will provide a RAM evaluation of the total system that includes all mission-essential equipment within the scope of the RAM requirement. The materiel developer will provide an assessment of the ease or difficulty of developing and incorporating design changes to eliminate high priority failure modes or improve maintainability.

d. Maintenance and logistics assessment. The maintenance, manpower, and logistic support cost will be assessed in the light of all DT and OT to date.

(1) The DT maintainability assessment will determine the appropriate maintainability indices, and the degree of adherence to good maintainability and human factors design principles. DT maintenance evaluation also will determine whether the equipment publications, tools, and TMDE have been developed to the point that the complete system is ready for OT. The DT maintenance T&E will be performed in part by military personnel. The DT maintainability assessment supplements the logistics demonstration. Results from the maintainability evaluation should be incorporated back into to the respective system risk assessment (DFMEA/FMECA) to accommodate compensating provisions element (maintenance approach) for the specific assembly/component relative to its failure mode/cause.

(2) The OT maintenance manpower and logistic support assessment will consider the ability of using troops to maintain the system with the tools, equipment, publications, and skills available in an operational environment and in accordance with the program support strategy. OT will consider the impact on maintenance, manpower, and logistic support cost and will include a comprehensive assessment of publications, tools, TMDE, skill levels, and allocation of tasks. A typical range of troop skills and varied

environmental backgrounds will be normal components of OT maintenance evaluation. The OT maintenance manpower assessment will identify the manpower cost of the system based on task loading and basis of issue. System maintainability will be assessed during OT.

6–3. Data collection

a. RAM data are required during all phases of the materiel life cycle. During DT, OT, and FA/IPT, RAM data are required to evaluate the materiel system and plan for its support. In accordance with 10 USC 2399, as implemented by DoDI 5000.02, persons employed by the contractors for the system being developed may only participate in OT&E of systems on DOT&E oversight for OT to the extent they are planned to be involved in the operation, maintenance, and other support of the system when deployed in combat. System contractors are prohibited from participating in the IOT of all programs, regardless of ACAT (see AR 73–1). The intent is to prevent actual or perceived system contractor manipulation or influence during the IOT or during activities that provide input for consideration in the system evaluation. RAM data are required post fielding to evaluate if system RAM requirements continue to be met.

b. System RAM information such as TIRs and/or instrumented data from all testing and events intended to support assessment of RAM requirements will be provided and exchanged among the CAPDEV, materiel developer, testers, independent evaluators, and logistician on a timely and responsive basis. Complete and detailed data collection plans, procedures, forms, and incident reporting procedures will be coordinated among the above parties at a pretest conference to ensure that all data needs are fulfilled. Corrective action summaries (including an implementation date) will be provided by the materiel developer to the same parties as actions are completed.

6–4. System reliability, availability, and maintainability monitoring and reporting

a. In accordance with the guidelines from paragraph 6–2, subsequent to each test event, the independent evaluator will publish results relating to demonstrated system RAM characteristics.

b. In order for the independent evaluator to analyze and publish results relating to a particular test event, the independent evaluator must participate in the planning of the event, and the independent evaluator (or representative) must be present to observe the event. Provided the aforementioned criteria are met, the independent evaluator may publish official findings relating to a test event.

c. Select Army programs are monitored through the Army Data Sampling Program (see AR 750–1 and DA Pam 700–24) and the Ammunition Stockpile Reliability Program (see AR 702–6).

6–5. System contractor restrictions

System contractor personnel will not attend or be directly involved as members or observers in RAM scoring/assessment conferences which address data intended to support evaluation (or assessment) of their system's operational RAM requirements (see AR 73–1 and 10 USC 4171). This includes all OT RAM scoring conferences, all RAM assessment conferences, and any DT RAM scoring conferences where aggregation of DT and OT data for RAM evaluation (or assessment) purpose is anticipated. Discussions with system contractor personnel may be necessary to ensure full technical understanding of test incidents. All discussions with system contractor personnel will be held separate from any scoring and assessment activities. A written record of the nature of these contractor/government discussions will be maintained by the conference chairperson.

Appendix A

References

Section I

Required Publications

Unless otherwise indicated, all Army publications are available on the Army Publishing Directorate website at https://armypubs.army.mil.

AR 70–1
Army Operation of the Adaptive Acquisition Framework (Cited in para 1–7*c*(3).)

AR 71–9
Warfighting Capabilities Determination (Cited in para 3–1*a*.)

AR 73–1
Test and Evaluation Policy (Cited in para 1–7*c*(3).)

Section II

Prescribed Forms

This section contains no entries.

Appendix B

Internal Control Evaluation

B–1. Function
The function covered by this evaluation is the implementation and conduct of RAM by materiel developers, CAPDEVs, and other Army organizations identified in this policy.

B–2. Purpose
The purpose of this evaluation checklist is to assist in evaluating RAM planning, execution, and assessment.

B–3. Instructions
Answers must be based upon the actual testing of controls (for example, document analysis, direct observation, sampling, simulation, and/or others). Answers that indicate deficiencies must be explained and the corrective action indicated in the supporting documentation. These internal controls must be evaluated at least once every year and then certified on DA Form 11–2 (Internal Control Evaluation Certification).

B–4. Test questions
a. Is RAM included in the requirements document(s)?
b. Is there a RAM–C report?
c. Is there a reliability growth plan?
d. Are RAM parameters included as technical evaluation subfactors in source selection plans, when appropriate?
e. Has a RAM working group been established?
f. Has DFR/design for maintainability been used and are the results identified during design reviews?

B–5. Supersession
This evaluation replaces the evaluation previously published in AR 702–19, dated 12 February 2020.

B–6. Comments
Help make this a better review tool. Submit comments to the Office of the Deputy Assistant Secretary of the Army (Acquisition, Logistics and Technology) (SAAL–LP) via email at usarmy.pentagon.hqda-asa-alt.mbx.asa-alt-publication-updates@army.mil.

Glossary of Terms

Administrative and logistics downtime
Time associated with processes or tasks not directly involved in restoration or repair activities, such as processing of requests, short-term non-availability of repair facilities, or delays due to establishment of higher priorities.

Built-in test
An integral capability of the mission equipment which provides an on-board, automated test capability, consisting of software or hardware (or both) components, to detect, diagnose, or isolate product (system) failures. The fault detection and, possibly, isolation capability is used for periodic or continuous monitoring of a system's operational health, and for observation and, possibly, diagnosis as a prelude to maintenance action.

Commercial off-the-shelf
Systems or equipment in which the military operating environment is essentially the same as that to which the system was designed and utilized in the commercial marketplace, that is, construction, firefighting, power tools, and so forth, and which does not undergo any significant modification for government usage.

Concept of employment
The CONEMP (formerly System OMS/MP) establishes system operational tasks, conditions, standards, future operating environment, and operational attributes that are strategy- and threat-driven, concept- and evidence-based, priority-focused, and data-enabled. They describe how the system is used in Joint operations, as well as Joint and Army system dependencies and interdependencies.

Concept of operations
The CONOP (formerly Formation OMS/MP) provides a detailed operational understanding of expected peacetime/wartime usage and requirements expressed in a structured and quantitative format.

Corrective action
A documented design, process, procedure, or materials change implemented and validated to correct the cause of failure or design deficiency.

Corrective maintenance
All actions performed as a result of failure, to restore an item to a specified condition. Corrective maintenance can include any or all of the following steps: localization, isolation, disassembly, interchange, reassembly, alignment, and checkout.

Design failure modes and effect analysis
The DFMEA is a design risk assessment analysis tool to help evaluate the magnitude of risk relative to a component, subsystem, or system and identify the appropriate design control countermeasure to prevent the occurrence of failure. This measure of risk is identified as a risk priority number and is based on failure severity level, probability of occurrence, and design development phase failure detection activity.

Design for reliability
DFR is an engineering process that encompasses tools and procedures to ensure that a product meets its reliability requirements. The reliability requirements should be fully defined and include an item’s function, usage conditions, as well as the tolerated level of risk at specific points in time. The DFR process should be implemented throughout the product life cycle from the design stage through to product disposal. DFR will proactively improve product reliability by seeking to minimize weaknesses in design that lead to early failure. DFR is a process that relies on an array of reliability engineering tools with a focus on using the right tool at the right time in the product life cycle.

Developmental item
An item of equipment or system not available in the commercial sector and developed by the department with the purpose of providing a new or improved capability in response to a stated need or deficiency.

Downtime
The first component is the time waiting for spare parts to arrive via the supply chain, called logistic downtime. The second component is the time to repair, which may consist of maintenance time (that is, MTTR), and in addition, any time that is spent in the queue waiting for the maintenance persons to begin working.

Environmental stress screening
Defined as the removal of latent part and manufacturing process defects through application of environmental stimuli prior to fielding the equipment. ESS and highly accelerated life testing will be used to ensure that reliable, available, and maintainable systems are produced and deployed that will be devoid of latent part and manufacturing process defects.

Failure
The event, or inoperable state, in which any item or part of an item does not, or would not, perform as previously specified.

Failure mode and effects analysis
A procedure by which each potential failure mode in a product (system) is analyzed to determine the results or effects thereof on the product and to classify each potential failure mode according to its severity or risk probability number.

Failure modes, effects, and criticality analysis
FMECA extends FMEA by including a criticality analysis, which is used to chart the probability of failure modes against the severity of their consequences. The criticality measure is a function of failure rate, mission time, failure mode apportionment ratio and the failure effect probability. The result highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

Failure rate
The total number of failures within an item population, divided by the total time expended by that population, during a particular measurement interval under stated conditions.

Failure reporting, analysis, and corrective action system
A closed-loop system of data collection, analysis, and dissemination to identify and improve design and maintenance procedures.

Fault
Immediate cause of failure (for example, maladjustment, misalignment, defect, and so forth).

Maintainability
Maintainability is the ability of an item to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

Maintenance ratio
A measure of the total maintenance manpower burden required to maintain an item. It is expressed as the cumulative number of man-hours of maintenance expended in direct labor during a given period of the life units divided by the cumulative number of end item life units during the ‘same period.

Materiel availability
A_M is a measure of the percentage of the total inventory of a system operationally capable (ready for tasking) of performing an assigned mission at a given time, based on materiel condition. This measure is calculated by the materiel developer and can be expressed mathematically as number of operational end items/total population. The A_M addresses the total population of end items planned for operational use, including those temporarily in a non-operational status once placed into service (such as for depot-level maintenance). The total life cycle timeframe, from placement into operational service through the planned end of service life, must be included.

Materiel solution
Correction of a deficiency, satisfaction of a capability gap, or incorporation of new technology that results in the development, acquisition, procurement, or fielding of a new item, including ships, tanks, self-propelled weapons, aircraft, and so forth, and related software, spares, repair parts, and support equipment, but excluding real property, installations, and utilities, necessary to equip, operate, maintain, and support military activities without disruption as to their application for administrative or combat purposes. In the case of family of systems or systems of systems approaches, an individual materiel solution may not fully satisfy a necessary capability gap on its own.

Materiel system
Materiel systems include, but are not limited to, stand-alone or embedded automatic data processing equipment hardware and software; support and ancillary equipment comprising the total materiel system; and multi-Service materiel systems when the Army is lead Service.

Maximum time to repair
The maximum time required to complete a specified percentage of all maintenance actions. For example, if a system specification indicated M_{ax} TTR (95 percent) =1 hour, this means that 95 percent of all maintenance actions must be completed within 1 hour.

Mean time to repair
A basic measure of maintainability. The sum of corrective maintenance times divided by the total number of repairs of the item. The average time it takes to fully repair a failed system. Typically includes fault isolation, removal, and replacement of failed item(s) and checkout.

Mission profile
A time-phased description of the operational events and environments an item is subject to from the start to the end of a specific mission. Tasks, events, durations, operating conditions, and environmental conditions are identified for each mission phase. The mission profiles should state specific quantities of operation (that is, hours, rounds, miles, or cycles) for each mission-essential function within the mission.

Nondevelopmental item
An NDI is any previously developed item of supply used exclusively for government purposes by a Federal agency, a State or local government, or a foreign government with which the United States has a mutual defense cooperation agreement; any item described above that requires only minor modifications or modifications of the type customarily available in the commercial marketplace in order to meet the requirements of the processing department or agency.

Probabilistic requirements
A statement of a required probability for performance, for example, reliability: probability of survival until time specified; availability: probability that item is ready when needed; and maintainability: probability that repair completed in time. The designated standard for the chance that a given event will occur.

Reliability
Reliability is the probability of an item to perform a required function under stated conditions for a specified period of time.

Reliability critical items list
The reliability critical items list provides an itemization of those system hardware/software elements that produce the greatest difference or gap between the allocated reliability requirement and the predicted value. This list provides engineering the ability to focus on design corrective measure efforts to minimize the gap using DFR techniques.

Reliability scorecard
The Director, Combat Capabilities Development Command Analysis Center reliability scorecard examines a supplier’s use of reliability best practices, as well as the supplier's planned and completed reliability tasks. The scorecard is important for tracking the achievement of reliability requirements and rating the adequacy of the overall reliability program. An early scorecard assessment may be based solely on a reliability program plan, but as time progresses, the scorecard assessment will become more accurate if information from technical interchange meetings, a reliability case, and results from early reliability tests, are included. The reliability case documents the supplier’s understanding of the reliability requirements, the plan to achieve the requirements, and a regularly updated analysis of progress towards meeting the requirements. The reliability scorecard uses eight critical areas to evaluate a given program’s reliability progress: Reliability requirements and planning, training and development, reliability analysis, reliability testing, supply chain management, failure tracking and reporting, verification and validation, and reliability improvements. There are 40 separate elements among the eight categories in the Director, DEVCOM Analysis Center reliability scorecard. Each element within a category can be given a risk rating of high, medium, or low (red, yellow, or green) or not evaluated (gray). The scorecard weights the elements, normalizes the scores to a 100-point scale, and calculates an overall program risk score and eight category risk scores.

Reliability, availability, and maintainability program
Materiel developers establish system life cycle RAM programs that maximize operational readiness and assure mission accomplishment while minimizing maintenance manpower cost, and logistic support cost. The RAM program designed by the materiel developer for his program will: ensure that materiel systems provided to the Army are operationally ready for use when needed, will successfully perform their assigned functions, and can be operated, maintained, and sustained within the scope of logistic concepts and policies with skills and training expected to be available to the Army. In short the RAM program is the materiel developer's plan and process for addressing the CAPDEV's RAM requirement.

Reliability, availability, and maintainability working group
A subgroup of the T&E IPT and established for each Army program with RAM requirements. The RAM working group consists primarily of representatives from the materiel developer, CAPDEV, and the independent system evaluator. The group may be augmented by others as appropriate. The testers should attend in an advisory capacity.

Repair time
The time spent replacing, repairing, or adjusting all items suspected to have been the cause of the malfunction, except those subsequently shown by interim test of the system not to have been the cause.

Root cause analysis
Is a method of problem solving to identify the root causes of faults or problems. Focusing correction on root causes has the goal of preventing problem recurrence. The analysis is typically used as a reactive method of identifying event(s) causes, revealing problems and solving them. Analysis is done after an event has occurred. Failure-based RCA is rooted in the practice of failure analysis as employed in engineering and maintenance.

System readiness objectives
A criterion for assessing the ability of a system to undertake and sustain a specified set of missions at planned peacetime and wartime utilization rates. System readiness measures take explicit account of the effects of RAM, system design, the characteristics and performance of the support system, and the quantity and location of support resources. Examples of system readiness measures are combat sortie rate over time, peacetime mission capable rate, A_O, and asset ready rate.

Test-analyze-fix-test
The process of growing reliability and BIT performance, and testing the system to ensure that corrective actions are effective. Then focus becomes ensuring that the corrective actions are producible and equate to improved RAM in the produced system.