

**ARMP-1
(Edition 3)**

**NATO REQUIREMENTS FOR RELIABILITY AND
MAINTAINABILITY**

**ARMP-1
(Edition 3)**

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NORTH ATLANTIC TREATY ORGANIZATION
NATO STANDARDISATION AGENCY (NSA)
NATO LETTER OF PROMULGATION

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Rear Admiral, NONA
Chairman NSA

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RECORD OF CHANGES

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FOREWORD

This Allied Reliability and Maintainability Publication (ARMP) provides a basis for achieving high Availability and the required mission success for all military materiel. It is designed primarily for use in, but not limited to, NATO Collaborative procurement programmes.

The imperative for high Reliability & Maintainability (R&M) is as urgent today as it has ever been. Modern Armed Forces cannot tolerate poor mission availability; neither can they accommodate long and expensive logistic “tails” or “supply chains”. R&M have a direct impact on mission availability and life cycle costs.

In 1998, it was recognised that the existing Standards and Guidance embraced a prescriptive culture no longer compatible with the demands of procuring increasingly complex military equipments. It was therefore decided, in accordance with NATO policy, to revise ARMPs 1 and 2, using an international, national or commercial standard as a basis. After a review of all available standards, the NATO R&M Working Party recommended that the SAE JA 1000 (Reliability Programme Standard) and JA 1010 (Maintainability Programme Standard), together with their associated guides, be adopted as a basis for use within NATO. All these SAE documents were drafted by an international committee, which included representation from many industry sectors.

The SAE standards are published in the form of a programme standard, designed for use in contracts, with a companion supporting programme guide, which gives information and advice on techniques to achieve Reliability and Maintainability. This distinction between standard and guide is reflected in the format of ARMP-1. ARMP-1, Part 1, is based on the use of SAE JA 1000 and JA 1010, and is suitable for contractual use. ARMP-1, Part 2 is based on the SAE JA 1000-1 and JA 1010-1 guides, which are the primary guidance publications for their associated publications SAE JA 1000 and JA 1010. It is not mandatory to invoke the guidance documents in contracts, however parts of the guide include material suitable for inclusion in contracts e.g. methods for conducting Reliability Growth Programmes. The structure and numbering of paragraphs in this document correspond with those in the referenced SAE Reliability and Maintainability Programme Standards: JA 1000 and JA 1010.

The Guide is applicable to all project staffs, whether based in industry or in government, who are involved in reliability and maintainability programmes.

PART 1

1. Scope

SAE Standard JA 1000 fully applies for Reliability and associated activities.

SAE standard JA 1010 fully applies for Maintainability and associated activities.

In addition to the requirements and contents of the SAE Standards listed above, the NATO Supplements in the following paragraphs shall be applied.

NATO SUPPLEMENTS

The structure and numbering of paragraphs in the NATO supplements to this document correspond with those in the referenced SAE Reliability and Maintainability Programme Standards: JA 1000 and JA 1010. Where no NATO supplements are required, then references to the SAE document paragraphs are omitted from this document.

1.1 Purpose

For the purpose of this standard, all the reliability and maintainability activities together constitute the R&M programme.

1.2 Applicability

This document applies to all materiel when referenced, in part or as a whole, in a contract or in a contract purchase order. If any inconsistency exists between the contract requirements and this document then the contract requirements shall prevail. This standard does not preclude the use of other standards, provided the intent of this standard is preserved.

This standard applies to all phases of the R&M programme. It also applies to all acquisitions whether acquired from design and development efforts, from production efforts, from existing stocks (e.g.: off-the-shelf), or from some combination thereof.

Sub-Contractors

The Supplier (at all tiers) shall ensure that system elements obtained from sub-contractors will enable him to meet the R&M requirements. All sub-contracts shall include provisions for the Supplier to monitor, review and evaluate the R&M activities of the sub-contractor.

Off-the-Shelf Procurement

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The procurement and integration of off-the-shelf equipment can provide particular challenges to system reliability and maintainability; therefore it is important that this document is rigorously applied to military procurement projects where the use of off-the-shelf equipment is being considered.

Integration of Customer Supplied or Specified Equipment (CSE)

Where the customer provides CSE, the customer shall provide the supplier with all available information on R&M of CSE. The supplier shall evaluate the implications of integrating the CSE in achieving the system R&M requirements, notify the customer of potential problems in achieving these requirements, propose solutions and agree an acceptable plan of action with the customer.

1.3 Tailoring

In certain circumstances the customer may specify R&M activities which shall be included in the R&M programme.

2. References

SAE JA 1000: Reliability Program Standard¹.

SAE JA 1010: Maintainability Program Standard.

ARMP-7: NATO R&M Terminology applicable to ARMPs.

3. Definitions

The definitions and terminology provided in SAE standards JA 1000 and JA 1010 are supplemented by those in ARMP-7. If during the execution of a contract, any contradictions in definitions or terminology are detected, then firstly the contract takes precedence, followed by the terminology in ARMP-7. For definitions not provided by SAE standards JA 1000 and JA 1010, ARMP-7 definitions shall apply.

¹ Society of Automotive Engineers, Inc (SAE) Publications are available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001. SAE Web Address: <http://www.sae.org>.

4. **Programme Requirements**

4.1 The Supplier Shall Ascertain Customer Requirements

Integrated Logistics Support (ILS) plans and considerations should be linked to the R&M requirements, especially with respect to the maintenance concept and support plans. The supplier shall analyse the maintenance concept and support plans in conjunction with the R&M requirements of the customer and derive system design requirements accordingly.

4.3 The Supplier Shall Assure That Customer Requirements Have Been Met

Planned activities for product R&M assurance including any demonstrations, data collection and classification arrangements shall be subject to prior agreement by the customer.

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PART 2

GUIDE TO APPLICATION OF PART 1 OF ARMP-1

Introduction

Part 2 of ARMP-1 is a guide to the application of Part 1. Part 1 is based on the use of SAE JA 1000 and JA 1010 (see References in ARMP-1 Part 1). Part 2 is based on the use of SAE JA 1000-1 (Reliability Programme Standard Implementation Guide) and SAE JA 1010-1 (Maintainability Programme Standard Implementation Guide), which are the primary guidance publications for associated publications SAE JA 1000 and JA 1010. Indeed **Part 2 cannot be applied without reference to SAE JA 1000-1 and JA 1010-1**. However, Part 2 also includes additional guidance material, which relates primarily to military factors.

The guidance material in this document refers to paragraph numbers in SAE JA 1000, JA 1010 and ARMP-1 Part 1, where applicable.

The Guide is applicable to all project staffs, whether based in industry or in government, who are involved in reliability and maintainability programmes.

Using this guide

SAE JA 1000-1 and JA 1010-1:

SAE JA 1000-1 and JA 1010-1 are the reference publications for this guide to Part 1 of ARMP-1. They provide focussed and concise guidance in the application of the ARMP-1 reference Standards, SAE JA 1000 and JA 1010. In broad terms they each contain two sections.

- a. The bodies of the guides (JA 1000-1 and JA 1010-1) offer practical guidance in implementing the reliability and maintainability programme required in JA 1000 and JA 1010. They explain all aspects of implementing and undertaking the reliability and maintainability programme based on the approaches set out in JA 1000 and JA 1010. This includes guidance in the following areas:

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- (1) A framework for the development of a reliable and maintainable product including the application of the three foundation principles which are at the heart of the Standards themselves. **These principles are new in the field of defence procurement and it is important that users understand fully their means of application.**
 - (2) The responsibilities of primarily the Supplier but also the Customer at each stage of the programme.
 - (3) Managerial issues in reliable and maintainable product development.
 - (4) A framework for developing a reliability and maintainability programme including an integral assurance programme.
- b. The appendices summarise the main reliability and maintainability methods which can be applied in a programme. Each technique is laid out in a common format which makes the information easy to assimilate. This includes a summary of the advantages and disadvantages of individual reliability and maintainability methods.

Amplification Material

There are various requirements in Part 1, including the NATO amplification material relating primarily to defence programmes, which demand additional guidance to that offered by JA 1000-1 and by JA 1010-1. For ease of reference these amplification comments have been correlated against specific main paragraph headings detailed in Part 1 (which also relate directly to the same paragraph numbers in JA 1000 and JA 1010). **Only those paragraph headings from ARMP-1 Part 1, SAE JA 1000 or JA 1010, that require additional guidance for NATO use, over and above that offered by JA 1000-1 and JA 1010-1, are listed below.**

Paragraph 1.1 of ARMP-1 Part 1

Purpose

The three principles are at the heart of the Standard. They are deliberately framed in high level terms to afford the Supplier latitude - but also responsibility - in designing and implementing a reliability and maintainability programme appropriate to the demands of the product. The three principles implicitly assume a measure of a dialogue between Supplier and Customer. They also lay greater stress than hitherto on the Supplier providing progressive assurance, throughout the programme, that the R&M requirements will be met. **Guidance to the Customer for developing and writing R&M requirements documents can be found in ARMP-4.**

Paragraph 1.2 of ARMP-1 Part 1

Applicability

Sub-Contractors

Selection of Sub-Contractors: The requirements in Part 1 of ARMP-1 are designed to be applied to the entire supply chain. Therefore, an important criterion in the Supplier's selection of Sub-contractors, should be that their R&M policy accords with the three principles of the standard. Other criteria such as the following should be considered when a Supplier is selecting a Sub-contractor:

- The Sub-contractor should have proven R&M competence and have demonstrated cost effective application of R&M principles and methods;
- The Sub-contractor should have the necessary R&M resources; and
- Sub-contractors should be able to deliver evidence in support of their claims for R&M of the equipment, including off-the-shelf equipment.

Monitoring of Sub-Contractors: The Supplier's rights to monitor, review and evaluate the R&M activities of the Sub-contractor should include:

- The right to monitor all sub-contractors within the level of detail required including the review of sub-contractor's predictions, analyses, design techniques and technical documentation for conformance to R&M specifications;
- Attendance and participation in sub-contractor's Programme and Design Reviews; and
- The provision of all available documentation records and data if requested.

Off-the-Shelf Procurement

In common with all components of a system, the use of Commercial off-the-shelf (COTS) or Military off-the-shelf (MOTS) components should respect all R&M requirements of the system. Off-the-shelf (OTS) refers to products that require little or no further development effort. OTS procurement may include distinct advantages (e.g. shortened acquisition, reduced costs and risks, the use of state-of-the art technology) and certain challenges (e.g. possible review of requirements, changes in logistic strategies, availability of R&M data may be limited).

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The impact of off-the-shelf components on R&M performance should be determined. This is usually be done by market investigations which may consist of:

- Identification of possible suppliers for OTS purchases
- Review and assessment of suppliers' relevant data
- Review of logistic supportability (including software) and cost in terms of Life Cycle Cost
- Possible review of requirements

The investigations may either lead to a selection of a specific supplier which meets customer requirements, or to a decision for a conventionally military procurement.

For COTS equipment, directly applicable R&M data is not always available or the data obtainable from suppliers was collected in a far less demanding environment than that required. Therefore, various strategies including testing, should be considered for all cases where COTS or MOTS components are considered for integration into a system.

Integration of Customer Supplied or Specified Equipment (CSE)²

The supplier should consider R&M characteristics of the entire system, including any integrated CSE and their interfaces with the system. In assessing the implications of the integration of CSE, the supplier should use associated R&M data (if available) provided by the customer. If applicable data is not available, the supplier should propose activities to acquire the information required, which could include:

- Performing estimations or analyses for CSE or making inquiries about additional R&M data from the manufacturer or supplier of the CSE; or
- Performing R&M tests.

Paragraph 1.3 of ARMP-1 Part 1

Tailoring

Paragraphs 4.1.4 and 4.1.5 including supporting tables of both SAE JA 1000-1 and JA 1010-1 provide comprehensive guidance in selecting appropriate

² CSE includes Government Supplied Equipment (GSE) and Government Furnished Equipment (GFE).

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methods for each stage of a R&M programme and will be of value primarily to suppliers, but can also be utilised by customers. Where it is clear that a selected supplier is unable to fully satisfy the customer's needs, the customer may specify certain methods or techniques.

Paragraph 2 of ARMP-1 Part 1

References

The documents listed below are the implementation guides for the references in paragraph 2 of part 1 of this document:

SAE JA 1000-1 (Reliability Program Standard Implementation Guide)

SAE JA 1010-1 (Maintainability Program Standard Implementation Guide).

Paragraph 4 of ARMP-1 Part 1

Programme Requirements

Many defence procurement programmes are long and complex and the Standard implicitly assumes the need for dialogue between customer and supplier throughout the R&M programme. It also assumes an "intelligent customer" and thus, in many cases project managers will require the support of R&M specialists.

Paragraph 4.1 of ARMP-1 Part 1

The Supplier Shall Ascertain Customer Requirements

Before commencing dialogue with the Supplier, it is necessary for the Customer to prepare a set of R&M requirements. The NATO publication which provides guidance on writing R&M requirements documents is ARMP-4; the Customer is strongly recommended to consult this guide in defining and writing R&M requirements prior to dialogue with the Supplier. The use of ARMP-4 will help the supplier to ascertain the customer's requirements, by making them mutually understandable.

In certain circumstances e.g. where the technical solution is uncertain, the Customer's requirements may be expressed in terms of availability. In this case the Customer should ensure that these can be translated into R&M requirements and the Supplier should ensure that such availability requirements are translated into acceptable R&M requirements.

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R&M have an impact over the entire life-cycle of a product, so it is important that the dialogue between Customer and Supplier identifies R&M requirements applicable to the whole product life-cycle³.

Paragraph 4.1.2 of SAE JA 1000 and SAE JA 1010:

Identify conditions of use

Suppliers should note that the environment in which military equipment can be called upon to operate can often far exceed most commonly encountered environments in the "home" environment. Although conditions and environmental factors are spelled out within the mission statement for the equipment, the supplier must appreciate that military equipment must often operate in hostile climactic, geographic, and storage conditions and even corrosive chemical and or battlefield environments. The mission requirements can also entail a rapid transition from one environmental extreme to another. Unlike commercial products there may be a requirement for long-term storage of equipment. All of these factors can adversely affect reliability and maintainability. Therefore, suppliers should take particular care in determining the Customer's requirements for operating conditions.

Paragraph 4.1.3 of SAE JA 1000 and SAE JA 1010:

Define Maintenance and Service

In the main, this task will be undertaken as part of the Integrated Logistics Support (ILS) work in support of a specific project. Logistics Support Analysis will utilise R&M data in defining maintenance and support requirements.

Paragraph 4.1.5 of SAE JA 1000 and SAE JA 1010:

Develop Product Specification

R&M requirements should be specified as minimum values which meet the customer's operational and logistics needs taking into consideration the whole spectrum of environmental and operational conditions. To be meaningful the R&M requirements should be specified quantitatively. For details of R&M specifications see ARMP-4.

³ There are various sources of terminology defining the phases of the project life-cycle e.g. NATO Phased Armaments Programming System (PAPS); the agreed terminology should be defined in the contract.

Paragraph 4.2 of SAE JA 1000 and SAE JA 1010:**The Supplier Shall Meet Customer Requirements**

There is likely to be considerable commonality between the R&M programmes for military and commercial products. However, the need for military equipment to operate in demanding environmental conditions dictate that additional programme elements be considered; these should address:

- a. The different missions for which the system is being designed, their separation into individual mission phases and their contribution to the overall system use as specified by the Customer.
- b. The external and internal functional and environmental stresses during each phase of each mission profile, also those experienced during the maintenance and support activities appropriate to each level of the system. This analysis might be part of an overall system functional analysis.
- c. The effects caused by interactions (e.g. man - machine, hardware - software) during manufacturing, testing, storage, packaging, transportation, handling and maintenance.

(Further guidance is available in STANAG 4370 – Environmental testing).

Paragraph 4.2.2 of SAE JA 1000 and SAE JA 1010:**Assess and Manage Risk**

There is a wide range of risks which threaten the achievement of costs, performance and timescale, all of which must be managed by the Customer and Supplier. Within the R&M programme the Supplier should assess, manage and reduce those risks which arise from R&M and those which affect the achievement of R&M requirements, through the use of a plan to reduce the risks. The R&M risk reduction plan should be an integral part of the R&M programme. For more detail on Risk Assessment refer to SAE JA 1000-1.

Paragraph 4.3 of ARMP-1 Part 1**The Supplier Shall Assure That Customer Requirements Have Been Met**

Part 1 of ARMP-1 places a heavy reliance on a progressive assurance throughout a project to justify that the reliability and maintainability requirements will be met. SAE JA 1000-1 proposes a systematic and

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auditable approach for progressive assurance. Essentially, this comprises a documented body of evidence that is instituted at the outset of a project and progressively compiled throughout the term of the project.

SAE JA 1010-1 proposes a similar systematic and auditable approach for maintainability.

For this process to work effectively, it is essential that both the customer and supplier utilise R&M specialist support and assistance throughout all phases of the programme. Any evaluation of suppliers regarding R&M competence will necessarily include an evaluation of R&M specialist support available to them. This support will include specialist advice in scoring of the tenders; it should not only take into account the R&M characteristics and techniques offered by the possible suppliers, but also the positive commitment of the supplier to progressive R&M assurance (including a recovery strategy in the event that the product fails to meet the R&M requirements).

It is an essential part of the progressive assurance process that the Supplier keeps the Customer informed of progress towards meeting the R&M requirements on a regular basis, at intervals appropriate to the project. This activity could be achieved by including the review of R&M in formal design reviews, which are detailed in SAE JA 1000-1 and SAE JA 1010-1. The timing and details of these reviews should appear in the R&M programme plans agreed between the Supplier and Customer. These reviews enable the Customer to ensure that the R&M programme proposed by the Supplier is properly applied.

Paragraph 4.3.1 to 4.3.3 of SAE JA 1000 and SAE JA 1010:**Qualify the Product and Process, Establish Process Controls and Pursue Continuous (Process) Improvement**

Results from (successful) development testing, usually gained from prototypes, are often not representative of production equipment, because prototypes are usually specially built and assembled by highly skilled personnel in design and development centres. It is important that the R&M characteristics are sustained in the transition from development to production.

Therefore, timely development of manufacturing architecture is a necessary part of the product development, so that the reliability and maintainability of the equipment will be maintained. The main objective must be to guarantee performance with the proven design, by establishing and sustaining Quality Control.

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In order to ensure that the transition from development to production has not reduced the product R&M, trials under service conditions should be conducted before the equipment is issued to service use, or shortly thereafter. Additional assurance that the product R&M performance is maintained throughout the production period can be gained by activities such as Production Acceptance Tests.

Paragraph 4.3.4 of SAE JA 1000 and SAE JA 1010:

Establish Data Collection and Reporting

The classification of data, sometimes known as incident sentencing or failure scoring should be conducted to agreed rules by a special team of experienced personnel representing all interested parties (e.g. Official Service, industry, design authority, user, reliability advisers and, if necessary, other specialists). The prime function of such a committee is to examine and sentence failures into relevant and non-relevant categories.