CHAPTER 2

R&M PERFORMANCE SPECIFICATION

CONTENTS

1 INTRODUCTION

1.1 The achievement of R&M in service stems from either luck or a clear, appropriate and realistic specification of the requirements together with a contract that enforces adherence.

1.2 R&M Requirements and their traceability to definitions, assumptions and lower level requirements or constraints can be problematic, particularly where there is significant change in the technical requirements or frequent change of project personnel. This lack of traceability can result in shortcomings in the R&M Requirements and contractual requirements, which in turn may compromise capability and escalate Through Life Cost (TLC).

1.3 This Chapter provides guidance on the methods available to setting R&M requirements and maintaining their traceability. It discusses the importance of alignment of the R&M activities with the wider Requirements Management process and identifies options to enable traceability to be retained in their transition from Capability to SRD.

1.4 One the factor that serves to confound the ready understanding of R&M requirements is the breadth of R&M terms that can be applied in order to obtain a desirable outcome. This is discussed in the text.

2 REQUIREMENTS MANAGEMENT

2.1 General

2.1.1 In order to apply a robust approach for defining the components of a system at various stages of the lifecycle, both MoD and Industry guidance recommend a systems engineering methodology is adopted. Requirements Engineering is an element of a Systems Engineering approach which is applied at the beginning of the project lifecycle to ensure that a set of validated and base lined requirements are produced in order to drive the project in the desired direction.

2.1.2 The Acquisition Operating Framework (AOF) identifies that the planning of this Requirements Engineering activity should be initiated during the very first phase of a project, typically the Concept Phase, and reported formally in a Requirements and Acceptance Management Plan (RAMP). The RAMP will describe the Requirements Engineering approach for the specification of the System and User requirements and proposals for the Project’s implementation of the Plan. The RAMP should detail the activities, resources and tools to achieve a consistent set of Project Requirements and to define how to manage and demonstrate them thereafter.

2.1.3 The RAMP will be owned and controlled by the Project Team as part of the overall Through Life Management Plan (TLMP). The TLMP document acts as the MOD’s link between requirements documentation, the Business Case used for MOD project approval, and the conduct of the project. The key products managed by the RAMP will be the:

a) User Requirements Document (URD).

b) Systems Requirements Document (SRD), and

c) Integrated Test Evaluation and Acceptance Plan (ITEAP).

2.1.4 As the project progresses and the User Requirements become firm then emphasis will shift with time from the RAMP to the Integrated Test, Evaluation and Acceptance Plan (ITEAP) as shown in Figure 1 below.

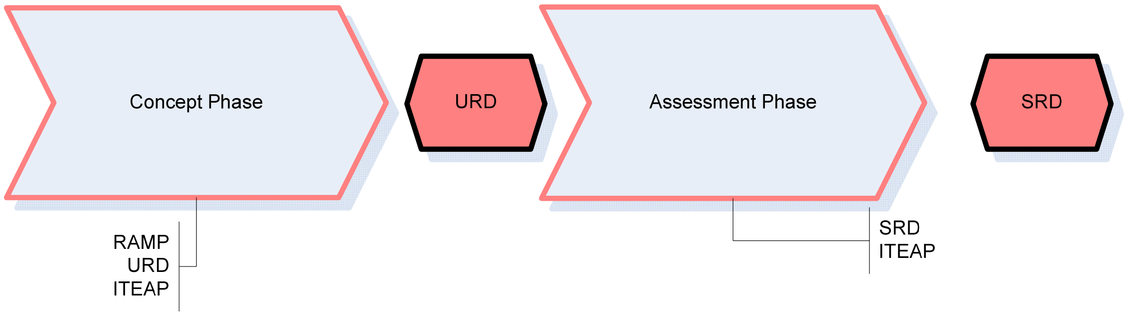

Figure 1 Requirements Management Products

2.1.5 The Integrated Test, Evaluation and Acceptance Plan (ITEAP) assigns responsibilities for test activities and should be used to monitor progress of these acceptance activities. A significant aspect of the ITEAP is the requirement to develop a Verification and Validation Requirements Matrix (VVRM) which provides traceability from requirements to the relevant testing and trials results. It forms the basis for decisions on acceptance and ensuring the stakeholder need is met. This is a critical instrument from the perspective of the R&M professional in identifying not only the Requirements but critically the means by which the satisfaction of the requirements can be assured. Over time the VVRM may then provide the mechanism to provide the traceability of the background to the Requirements. There may be a range of assurance options initially depending upon the solutions being offered but experience suggests that R&M assurance activities will often be significant programme and procurement costs drivers and therefore need to be rigorously investigated and understood as early as possible in the programme.

2.2 RM Tools

2.2.1 RM tools, like any other form of tool, facilitate the undertaking of tasks. There are a range of tools (e.g. DOORS, Caliber-RM) that can be used with different features but in general the reasons and benefits of use of these tools will be similar, they will facilitate:

a) Version and change control.

b) Linkage and dependencies between requirements.

c) Control of access rights and permissions.

2.2.2 Further information on tools and their value to the Requirements Management process is available from References 3-5.

2.3 R&M Requirements Management

2.3.1 Adoption of a formal Requirements Management approach will assist the process of developing R&M requirements. It is critical in any project that the R&M requirements are developed within the RM process, and not separately, in order that they are consistent with the capability or design intent and are at a suitable maturity for the programme. However, adoption of a formal RM process will not guarantee suitable, sufficient, measurable, traceable and realistic requirements, but it will help.

2.3.2 Guidance on the key aspects that must be understood fully during the development of the R&M requirements is consistent between Def Stan 00-42 Part 3 (Ref 1), and the Support Solutions Environment (SSE).

2.3.3 Def Stan 00-42 suggests that traceability and justification for the requirements be provided through production of an Initial R&M Case, as detailed below in Figure 2.

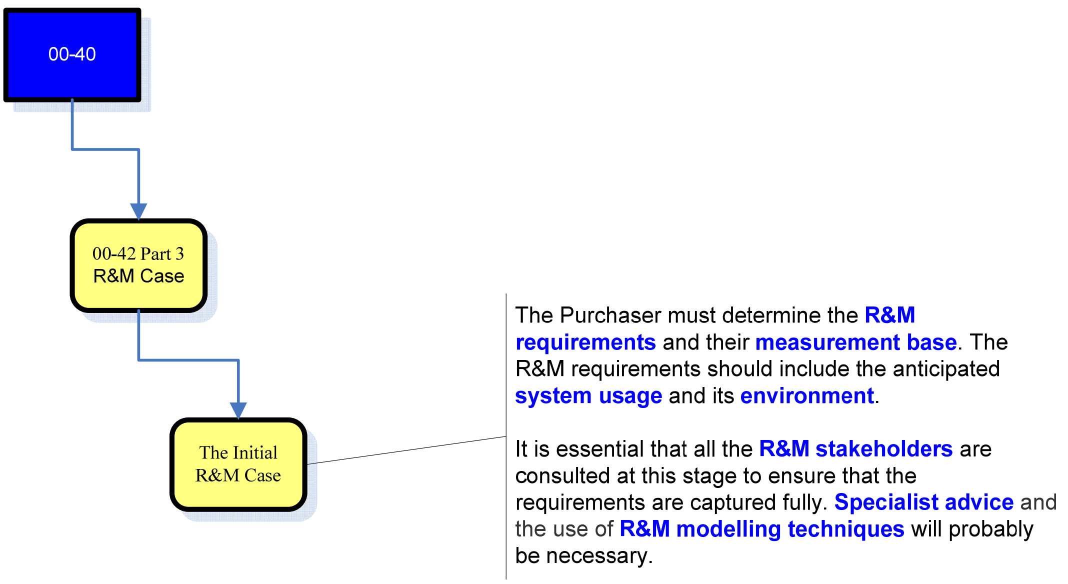

Figure 2 R&M Requirements guidance from Def Stan 00-42

2.3.4 It will be seen from the Def Stan that the following are identified as important to the R&M requirements and should therefore be addressed in any requirements document:

a) Measurement Base - typically this will be usage measure that the requirement is written around and may be taken from a range of potential usage measures including; calendar time, mission time, distance travelled, number of operations etc.

b) System Use and Environment – as presented in Figure 3.

c) R&M Stakeholders – A critical management aspect, not only who the stakeholders are but their role in the RM process.

d) Modelling and specialist advice – Likely to be required on all but the simplest of projects. Modelling will allow the dependencies between requirements to be understood (as discussed in Section 3.2.2) and specialist advice will be required to provide or validate the modelling.

3 MAINTAINING R&M REQUIREMENTS TRACEABILITY

3.1 General

3.1.1 Two aspects of the traceability of R&M requirements are addressed in this Chapter:

a) Traceability of User Requirements (URs) to System Requirements (SRs), expanded in Section 3.2.

b) Traceability of Requirements to their supporting assumptions and definitions, expanded in Sections 3.3.

3.1.2 Lack of a rigorous Requirements Management (RM) process is a key cause of project failure (for example Section 3 of Ref 5). A formal RM process facilitates both of the traceability between SRs and URs and the traceability of all requirements to their assumed baseline and verification and validation measures. Therefore, a brief discussion is provided of how good RM practice is applicable to the setting of R&M requirements and this is presented in Section 2.

3.2 Traceability of User Requirements to System Requirements

3.2.1 Traceability of User Requirements to System Requirements is an important aspect of traceability where the User Requirement is satisfied by a number of System Level requirements. However, it is not always clear to the User which of the many R&M related attributes are required at the concept stage of a project. Potential scenario analysis (See Part PtBCh1 (Ref 6)) supported by R&M modelling or analysis may help identify R&M attributes critical to the Users mission success. For example the User may require a fleet of vehicles to provide his troops with mobility to a given availability. This requirement might be developed through modelling and subsequently broken down into contributory elements including Reliability and Maintainability at the vehicle level for the System Requirement.

3.2.2 In order to maintain the traceability between the UR and SRs then some form of record is required of the assumptions and analyses undertaken. Typically the evidence will comprise R&M Modelling and results providing insight into potential solutions at equipment level that will satisfy the UR. The relevance and applicability of any such evidence can be argued and presented by many of the formal RM tools, (See Section 2.2) but may also be provided by some form of graphical argument approach, using techniques such as Goal Structuring Notation (GSN) or Claim Argument Evidence (CAE) methods (Ref 7).

3.2.3 A project will need to establish the method of recording verification activities, this should be identified within the VVRM (see Section 2.1.5) which should be consistent with the Evidence Framework [1](Annex E of Ref 1) and the project Risk Register.

3.2.4 Traceability of R&M requirements to the supporting assumptions and definitions prevalent at the time of writing is important in order to maintain the meaning of the requirements. This is a general problem for requirements managers and is not confined to the R&M requirements. It is solved through adoption of best practice implemented in a formal Requirements Management (RM) process. The key aspects of the Requirements Management process applicable to R&M is presented in Section 2.

3.2.5 An example of the supporting information that would be required for a reliability requirement is presented below. A Mission Reliability requirement states the probability that an item will perform its required functions for the duration of a specified mission profile. These attributes must be clearly defined in order to bound the requirement as identified in Figure 3 below.

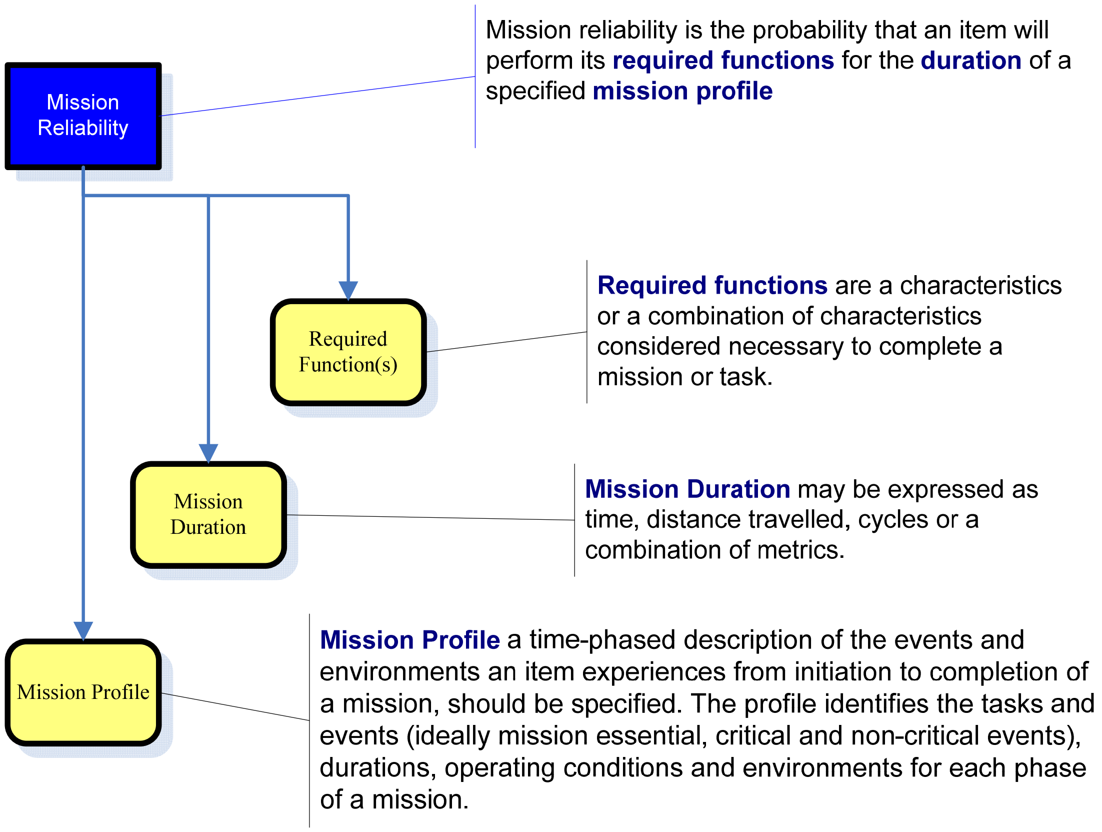

Figure 3 Reliability Guidance from Def Stan 00-49

3.2.6 Figure 3 above provides outline details of supporting conditions necessary for Mission Reliability to be defined and this information must clearly be defined to support such a requirement. Other R&M metrics will also require supporting conditions. A list of possible

[1]In order to avoid duplication of effort and improve integration of the R&M and Risk work streams, the Evidence Framework and the Risk Register should be the same thing for most projects.

R&M Requirements metrics are included in Leaflet 1 attached, but as the list is extensive others can be identified from Def Stan 00-49 (Ref 8). R&M metrics may include:

a) Availability – Operational or Intrinsic availability.

b) Probability of a failure over a given period – Reliability; Basic/logistic reliability; Non-repairable at sea reliability; Mission reliability.

c) Rate of failures or Period between failures - Mean Variate Between Failures (MVBF); Mean Variate Between Mission Failures (MVBMF); Characteristic life.

d) Maintenance performance - Active Repair Time (ART); ART per operating hour; Failure detection rate; False alarm rate; Fault isolation; Preventative maintenance levels; Preventative maintenance time; Maintenance levels; Total maintenance time; Spares availability; Tools and test equipment availability.

e) Cost of Ownership – Labour; Spares and materials costs associated with failures.

f) Others - Single points of failure; Failure Free Operating Period (FFOP); Lifed Items; Maintenance Free Operating Period (MFOP); Technical documentation availability; Manpower availability and performance; Technical support availability; Efficacy of training.

LEAFLET B2/0

REFERENCES

1 Defence Standard 00-42 Part 3, R&M Assurance Guide, R&M Case.

2 R&M, An introduction for MoD Staff.

3 A new way to visualise requirements information and its traceability, Telelogic, May 2008.

4 Automating Requirements Management. Karl Wiegers, Software Development Magazine, July 1999.

5 Requirements Management White Paper, Cynllun Trosolwg Ltd, 2008.

6 Applied R&M Manual for Defence Systems (GR-77), 2008.

7 The Goal Structuring Notation – A Safety Argument Notation, Tim Kelly and Rob Weaver, University of York. Undated.

8 Defence Standard 00-49, MoD Guide to R&M Terminology used in Requirements.

LEAFLET B2/1

R&M METRICS

CONTENTS

1 AVAILABILITY

1.1 Intrinsic Availability:

1.1.1 The probability that the system/equipment is operating satisfactorily at any point in time when used under stated conditions, where the time considered is operating time and repair time (active). Intrinsic availability excludes from consideration all free time, storage time, administrative delay time and logistic delay time[2].

1.1.2 Intrinsic Availability is the availability of the system due to its design characteristics i.e. excluding all non-operating time not due exclusively to the design and layout of the system[3].

Note: Intrinsic Availability is applicable to equipments or systems, but not services.

1.2 Operational Availability:

1.2.1 The probability that an equipment/system at any instant in the required operating time will operate satisfactorily under stated conditions where the time considered includes operating, corrective and preventive maintenance, administrative delay time and logistic delay time[2].

1.2.2 Operation Availability is the availability of the system including all causes of downtime[3]

2 BASIC RELIABILITY

2.1 Definition

2.1.1 Reliability is defined as:

"Ability to perform as required under given conditions for a given time interval".[4]

2.1.2 It is important to clearly define what constitutes a failure to perform as required (failure definitions) and given conditions for a given time interval (mission profile) for any measure of reliability and to ensure that the definitions are agreed with the contractor.

2.1.3 In the case of Basic Reliability, any failure or defect of a system that puts a demand on the logistics support system, regardless of the criticality or impact on the mission, is counted as a basic failure and hence contributes to the Basic Reliability of the system.

2.2 Impact on Intrinsic Availability

2.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

[2] R&MP-7, NATO R&M Terminology Applicable to R&MPs, Edition 1, July 2001
[3] BS5760 Part 2, Reliability of systems, equipment and components. Guide to the assessment of reliability, 1994.
[4] IEC 60050-191 Ed 2.0

2.2.2 There is no direct link between Basic Reliability and Intrinsic Availability. Only a subset of all basic failures (those which are mission critical) impact on Intrinsic Availability (see **Mission Reliability** Metric for details).

2.3 Impact on Operational Availability

2.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

2.3.2 There is no direct link between Basic Reliability and Operational Availability. Only a subset of all basic failures (those which are mission critical) impact on Operational Availability (see Mission Reliability Metric for details).

2.4 Impact on Cost of Ownership

System Basic Reliability is often a significant driver of Cost of Ownership as it is a measure of the demand put upon the logistics support system. Any failure or defect that requires a spare part, specialist equipment or specialist manpower will add to the cost of ownership of a system. It is not only high value items that have a significant impact on Cost of Ownership; low value items which fail often can have a significant impact on the Cost of Ownership through life.

3 NON-REPAIRABLE AT SEA FAILURES

3.1 Definition

A failure of a naval system that can not be repaired whilst the vessel is at sea for any reason. Failures may not be repairable at sea due to the need for shore side equipment or a dry dock facility to remove/replace the failed equipment.

3.2 Impact on Intrinsic Availability

3.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

3.2.2 If a Non-Repairable at Sea Failure is mission critical the effect on Intrinsic Availability can be significant. From the point of failure the system will remain down (unavailable) for the remainder of the mission.

3.2.3 Mission failure due to Non-Repairable at Sea Failures must be mitigated as far as is reasonably practicable by the intrinsic system design. Redundancy or a reversionary mode of operation should be provided in the system design wherever possible.

3.3 Impact on Operational Availability

3.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

3.3.2 As Non-Repairable at Sea Failures can be a driver of Intrinsic Availability, they will also impact the Operational Availability of a system. Any occurrence of a mission critical Non-Repairable at Sea Failure will likely result in low Operational Availability.

3.4 Impact on Cost of

The cost of Non-Repairable at Sea Failures can be considerable as, in the worst case, the vessel may need recovering to the nearest suitable shore facilities, which may be several thousand miles from the point of failure.

Note: For Operational Analysis purposes a vessel may not be restored during a mission but in practical terms ships crews are often able to devise some form of 'jury rig' that, while not restoring the vessel to full capability, will allow a reduced operating capability.

4 MEAN VARIATE BETWEEN FAILURE (MVBF)

4.1 Definition

4.1.1 MVBF is the expected operating variate (often time) between failures[5].

4.1.2 It is important to note that there may often be several definitions of failure for a system e.g. basic failure, mission failure. In the case of mission failures the term Mean Variate Between Mission Failure (MVBMF) is sometimes used.

4.1.3 MTBF can only be applied where a constant failure rate can be assumed (particularly applicable to complex repairable systems or relatively short time periods).

4.1.4 The variable measured can take a range of units (e.g. distance, operating hours, operating cycles), but MVBF is commonly measured using a time unit. In this case the term Mean Time Between Mission Failure (MTBMF) is used.

4.2 Impact on Intrinsic Availability

4.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

4.2.2 MVBF may be a metric for a system or for any of the individual equipments or sub-systems that make up the system. A low MVBF of individual equipments or sub-systems may be mitigated by incorporating redundancy in the design.

4.2.3 Only failures that are mission critical are used to calculate the Mission Reliability of a system, therefore MVBF may have an impact on the Intrinsic Availability of the system, but the magnitude of this impact is dependant on the ratio of mission failures to total failures. A system which experiences many mission failures (low MVBMF) will exhibit poor Mission Reliability. However, a system which experiences many basic failures but few mission failures may have a low MVBF and a high Mission Reliability.

4.2.4 A low Mission Reliability will likely result in low Intrinsic Availability, however a low system MVBF may be acceptable if the system is designed to be easily and quickly restored following a failure.

[5] IEC 60050-191 Ed 2.0

4.3 Impact on Operational Availability

4.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

4.3.2 If a system MVBF is a driver of Intrinsic Availability, it will also impact the Operational Availability of a system. However, a low system MVBF may be acceptable to the user in some cases if the Logistics Support Arrangements can be optimised to provide acceptable levels of Operational Availability.

4.4 Impact on Cost of Ownership

MVBF is a measure of all system failures or (Basic Reliability) and therefore has a direct impact on Cost of Ownership. See Basic Reliability Metric for further details.

5 MISSION RELIABILITY

5.1 Definition

5.1.1 Reliability is defined as:

"Ability to perform as required under given conditions for a given time interval".[6]

5.1.2 It is important to clearly define what constitutes a failure to perform as required (failure definitions) and given conditions for a given time interval (mission profile) for any measure of reliability and to ensure that the definitions are agreed with the contractor.

5.1.3 In the case of Mission Reliability the given conditions and given time interval are a defined Mission Profile. The ability to perform is the ability to complete the defined mission. Only failures that prevent the mission from being completed within the defined timescales are counted as mission failures and hence contribute to Mission Reliability.

5.1.4 Any defect that occurs but does not prevent the capability completing its defined mission is not counted towards mission reliability. Likewise, some failures that require repair during the mission may be acceptable and not counted towards mission reliability if they can be repaired within a time limit and without logistic support such that the effectiveness of the capability is not degraded.

5.2 Impact on Intrinsic Availability

5.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

5.2.2 Mission Reliability of a system has a direct impact on the Intrinsic Availability of the system. A low Mission Reliability will likely result in low Intrinsic Availability, however a low Mission Reliability may be acceptable if the system is designed to be easily and quickly restored following a failure.

[6] IEC 60050-191 Ed 2.0

5.3 Impact on Operational Availability

5.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

5.3.2 As system Mission Reliability is a driver of Intrinsic Availability, it will also impact the Operational Availability of a system. A low system Mission Reliability will likely result in low Operational Availability. However, a low system Mission Reliability may be acceptable to the user in some cases if the Logistics Support Arrangements can be optimised to provide acceptable levels of Operational Availability.

5.4 Impact on Cost of Ownership

Mission Reliability will generally have an impact on Cost of Ownership through the cost of rectifying mission failures, however it should be noted that some Mission Failures may be rectified without the need for spares, additional manpower or specialist equipment. See Basic Reliability metric for more details on the impact of failure on Cost of Ownership.

6 MEAN VARIATE BETWEEN MISSION FAILURE (MVBMF)

6.1 Definition

6.1.1 MVBMF is the expected operating variate (often time) between mission failures[7].

6.1.2 It is important to note that there may often be several definitions of failure for a system e.g. basic failure, mission failure. In the case of MVBMF only mission critical failures (those that prevent the capability from completing a defined operating profile) are counted.

6.1.3 The variable measured can take a range of units (e.g. distance, operating hours, operating cycles), but MVBMF is commonly measured using a time unit. In this case the term Mean Time Between Mission Failure (MTBMF) is used.

6.2 Impact on Intrinsic Availability

6.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

6.2.2 MVBMF may be a metric for a system or for any of the individual equipments or sub-systems that make up the system. A low MVBMF of individual equipments or sub-systems may be mitigated by incorporating redundancy in the design.

6.2.3 System MVBMF is a measure of the Mission Reliability of a system, therefore has a direct impact on the Intrinsic Availability of the system. A low MVBMF will result in the system failing often, and hence the Mission Reliability will be low. A low mission reliability will likely result in low Intrinsic Availability, however a low system MVBMF may be acceptable if the system is designed to be easily and quickly restored following a failure.

[7] IEC 60050-191 Ed 2.0

6.3 Impact on *Operational Availability*

6.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

6.3.2 As system MVBMF is a driver of Intrinsic Availability, it will also impact the Operational Availability of a system. A low system MVBMF will likely result in low Operational Availability. However, a low system MVBMF may be acceptable to the user in some cases if the Logistics Support Arrangements can be optimised to provide acceptable levels of Operational Availability.

6.4 Impact on Cost of Ownership

MVBMF will generally have an impact on Cost of Ownership through the expense of spares and repairs. MVBMF is a sub-set of the total system failures and Basic Reliability. See Basic Reliability metric definition for a description of the relationship between system failures and cost of ownership.

7 SINGLE POINT FAILURE

7.1 Definition

A "*system failure caused by the failure of only one of its constituent items*"[8].

7.2 Impact on Intrinsic Availability

7.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a System.

7.2.2 A Single Point Failure, if it is mission critical and occurs often (low MTBMF) will result in low Mission Reliability. However, single points of failure are sometimes unavoidable in design and can be tolerable if they do not result in a mission failure and/or have a very high MTBF. If Single Points of Failure result in a low Mission Reliability the system will likely also exhibit low Intrinsic Availability. However, a low Mission Reliability may be acceptable if the system is designed to be easily and quickly restored following a failure.

7.3 Impact on Operational Availability

7.3.1 Operational Availability is a measure of Intrinsic Availability and Logistic Support Arrangements.

7.3.2 As Single Points of Failure can impact Intrinsic Availability, they can also impact the Operational Availability of a system. Many and/or low MTBF Single Points of Failure will likely result in low Operational Availability. However, Single Points of Failure may be acceptable to the user in some cases if the Logistics Support Arrangements can be optimised to provide acceptable levels of Operational Availability.

[8] IEC 60050-191 Ed 2.0

7.4 Impact on Cost of Ownership

7.4.1 Single Points of Failure may impact cost of ownership if spares, specialist equipment or manpower is required to rectify the failure. However, it is likely that single point failure will be represent a small proportion of all system failures, and hence will not be a primary driver of cost of ownership.

7.4.2 Single Point of Failure is not always undesirable, as simple systems are generally cheaper to buy and operate than similar designs incorporating redundancy. However, where failure severity is high then robust design principles (e.g. safety limits, component derating) or redundancy should be used.

8 FAILURE FREE OPERATING PERIOD (FFOP)

8.1 Definition

8.1.1 The failure free operating period (FFOP) of a system is defined as a period of operation during which the system is able to carry out all its assigned functions without experiencing a failure[9].

8.1.2 FFOP is typically used for simple mechanical structures where:

- The period of interest is well below the onset of wear out;
- The dominant failure mechanism is age related;
- The other (less predictable) failure mechanisms are all but non-existent; and
- A high factor of safety/design margin assumes that minor production errors are of no effect to function.

8.1.3 FFOP is similar in principle to the Maintenance Free Operating Period (MFOP) (see MFOP metric description).

8.2 Impact on Intrinsic Availability

8.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

8.2.2 A system designed to meet a FFOP requirement would need to exhibit extremely high Mission Reliability. It is possible that the maintainability of the system may be poor at the expense of the reliability focus of the design (e.g. the provision of multiple layers of redundancy in the design may result in poor accessibility and hence long repair times). It is therefore not possible to derive a direct impact of FFOPs on Intrinsic Availability.

8.3 Impact on Operational Availability

8.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

8.3.2 A FFOP may be defined as a requirement for a highly critical period of operation during which an extremely high Operational Availability is required. However, this may be at

[9] (Center for Advanced Life Cycle Engineering) (CALCE))

the expense of Operational Availability during less critical operational periods, as the system may require significant preventative maintenance during these periods to support the FFOP requirement. The impact of failure during the critical period of operation should be assessed and balanced against the need for longer term Operational Availability.

8.4 Impact on Cost of Ownership

A FFOP in itself will not impact Cost of Ownership, as by definition it is a period during which no failures are expected to occur. However, it may be necessary to conduct high levels of preventative maintenance to support an FFOP requirement, and as such the Cost of Ownership may be increased.

9 LIFED ITEMS

9.1 Definition

9.1.1 Lifed Items are those components of a system that have a limited (and predictable) useful life that is less than the life of the system to which they belong. Lifed Items may be replaced at a pre-planned point in time to maintain the full capability of the system through life.

9.1.2 The number and life characteristics of Lifed Items are a measure of the durability of the system.

9.2 Impact on Intrinsic Availability

9.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

9.2.2 A continually operating system with many Lifed Items will exhibit poor Intrinsic Availability if the system needs removing from service for a significant period to replace life expired items. However, if Lifed Items can be replaced quickly, or whilst the system remains operational, they may have little affect on the Intrinsic Availability of the system.

9.2.3 Lifed Items should have no impact on the Intrinsic Availability of systems that are not continually operating as replacements should be scheduled within non-operating (or ‘free’) time.

9.3 Impact on Operational Availability

9.3.1 Operational Availability is a measure of Intrinsic Availability and Logistic Support Arrangements.

9.3.2 Lifed Items will have an impact on Operational Availability of continually operating systems if the system has to be shut down to replace the Lifed Items. It may be possible to isolate a part of the system without impacting the capability of the system as a whole (e.g. a redundant configuration). In this case Operational Availability would be unaffected by the replacement of the Lifed Item.

9.3.3 If the system is not continually operating, it is likely that replacement of Lifed Items can be scheduled to occur during non-operational time. In this case Operational Availability would not be impacted by the replacement of the Lifed Item.

9.4 Impact on Cost of Ownership

Lifed Items will impact the cost of ownership of a system through the cost of the replacement parts, and any specialist equipment or labour required to carry out the replacement. If a system contains many Lifed Items and/or Lifed Items with a short useful life the impact on cost of ownership may be significant.

10 ACTIVE REPAIR TIME (ART)

10.1 Definition

10.1.1 ART is *"the part of maintenance time taken to conduct the repair action. Repair time is comprised of fault localisation, fault correction, and functional checkout, but excludes technical, administrative and logistic delays"*[10].

10.1.2 Corrective maintenance is *"maintenance carried out after fault recognition to effect restoration"*[10] (i.e. repair following a failure). It does not include maintenance carried out on a scheduled basis to maintain the system in a good state and reduce the probability of failure or degradation (Preventative Maintenance) but does include maintenance resulting from fault recognition identified during scheduled maintenance.

10.2 Impact on Intrinsic Availability

10.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

10.2.2 ART is a measure that can be used to describe the maintainability of a system or component. A system or component with a high ART might be described as having poor maintainability. Therefore a system with a high ART may exhibit a poor Intrinsic Availability. However, a high ART may be acceptable, and have minimal impact on Intrinsic Availability, if the system also exhibits a very high Mission Reliability.

10.3 Impact on Operational Availability

10.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

10.3.2 If system ART is a driver of Intrinsic Availability, it will also impact the Operational Availability of a system. A high system ART will likely result in low Operational Availability. It is unlikely that logistics support arrangements can be optimised to provide improvements in Operational Availability if the inherent maintainability of the system is poor.

10.4 Impact on Cost of Ownership

The cost impact of high ART is related to the Maintenance Level. Maintenance that is conducted by the User (typically at Maintenance Levels 'Forward' or 1, 2 and 3) incurs no perceptible cost[11]; however maintenance time of specialist maintainers or the OEM (typically at Maintenance Level 'Depth' or 4) can attract significant costs. If a component has a high

[10] IEC 60050-191 Ed 2.0
[11] The User's time being 'free' at the point of the maintenance operation

ART it is likely that the repair action is complex or simply time consuming and therefore beyond the capability of the User[12].

11 MAINTENANCE FREE OPERATING PERIOD (MFOP)

11.1 Definition

11.1.1 The Maintenance Free Operating Period (MFOP) of a system is defined as a period of operation during which the system is able to carry out all its assigned functions without any scheduled maintenance.[13]

11.1.2 MFOP is typically used for predominantly mechanical systems where:

- The mission (or a period within the mission) is non-interruptible
- The period of use (the mission) is well below the onset of predictable wear out[14];
- The dominant failure mechanisms are age related;
- The other (less predictable) failure mechanisms are all but non-existent; and
- A high factor of safety/design margin assumes that minor production errors have no effect on function.

11.1.3 MFOP is similar in principle to the Failure Free Operating Period (FFOP) (see FFOP metric description).

11.2 Impact on Intrinsic Availability

11.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

11.2.2 A system designed to meet a MFOP requirement would ideally need to exhibit high Mission Reliability. It is possible that the maintainability provisions (in this instance the need for scheduled maintenance) can be programmed to occur at a convenient time (i.e. not detrimental to the mission) with little adverse impact on system performance / intrinsic availability. The provision of multiple layers of redundancy in the design may justify the risk associated with programming (i.e. delaying) scheduled maintenance to an operationally convenient time either during or outside of the mission.

11.3 Impact on Operational Availability

11.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

11.3.2 A MFOP may be defined as a requirement for a highly critical period of operation during which an extremely high Operational Availability is required. However, this may be at the expense of Operational Availability during less critical operational periods, as the system may require significant preventative maintenance during these periods to support the MFOP

[12] Maximum times to repair at 'Forward' levels are normally constrained by doctrine
[13] (Center for Advanced Life Cycle Engineering) (CALCE))
[14] RCM might normally include a scheduled/preventative maintenance task at the point/onset of failure

requirement. The impact of failure during the critical period of operation should be assessed and balanced against the need for longer term Operational Availability.

11.4 Impact on Cost of Ownership

A MFOP in itself will not impact Cost of Ownership, as by definition it is a period during which no scheduled maintenance is expected to occur. However, where it is appropriate to conduct preventative maintenance outside of the mission to support an MFOP requirement the maintenance may be contracted out increasing the Cost of Ownership due to commercial involvement.

12 FAILURE DETECTION RATE

12.1 Definition

The rate at which system failures are detected (become apparent). Failure detection rate can be an attribute of Built In Test (BIT) functionality and Built In Test Equipment (BITE); detection rates can be improved through effective Health and Usage Monitoring Systems (HUMS), troubleshooting procedures and maintainer training techniques.

12.2 Impact on Intrinsic Availability

12.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

12.2.2 The quicker failures can be detected the quicker a repair action can be initiated, therefore a system with a high Failure Detection Rate will exhibit better Maintainability characteristics than one with a low Failure Detection Rate. A system with a high Failure Detection Rate therefore has the potential to exhibit high Intrinsic Availability.

12.3 Impact on Operational Availability

12.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

12.3.2 If failures can be made detectable by the User using BIT functionality, BITE and/or HUMS, it may be possible to reduce repair times and/or logistic delay times either by the User conducting the repair action, or by the User advising the specialist repair crew of the exact failure before they are dispatched to the physical location of the failed equipment. In essence, moving the repair action as far forward as technically feasible. A high failure detection rate can therefore improve Operational Availability.

12.4 Impact on Cost of Ownership

A poor failure detection rate by the User will result in higher support costs as additional support resources would be required to diagnose and rectify failures. If failures can be detected by the User then it may be possible for the User to rectify the failure, or to advise the next level User/Maintainers of the precise nature of the failure, hence the correct parts and equipment can be deployed to the failed system first time minimising errors and improving efficiency.

13 FALSE ALARM RATE

13.1 Definition

Equipment with Built In Test (BIT), Health and Usage Monitoring Systems (HUMS) and prognostics functionality can provide reliable alarms/warnings to the User of faults and potential failures within the system. However, faults/failures of the BIT functionality itself may result in false alarms being generated.

13.2 Impact on Intrinsic Availability

13.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

13.2.2 It is likely that BIT alarms that occur during a mission, if deliberately ignored, will not impact the system functionality and will not cause a mission failure. Hence Mission Reliability or Intrinsic Availability need not be affected.

13.2.3 It is possible that, in some circumstances, BIT failure warnings/alarms will result in a mission failure (e.g. due to procedure, safety concerns, continually operating systems or false shut down of equipment). Therefore false alarms may result in a reduction in Mission Reliability and hence Intrinsic Availability. Effective procedural solutions (technical publications and training) can adequately inform the User as to the most appropriate course of action, notably when it is safe and permissible to ignore a warning.

13.3 Impact on *Operational Availability*

13.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

13.3.2 False warnings and alarms can have a significant impact on Operational Availability. Loading the supply chain with otherwise serviceable items has a direct impact on the whole supply chain with the potential to increase logistic delays substantially. Therefore warnings/alarms resulting in perceived or actual mission failures (due to system shut-down for example) reduce Operational Availability.

13.4 Impact on Cost of Ownership

13.4.1 The cost impact of a high false alarm rate can be significant. There is a potential cost associated with every fault alarm, false or legitimate, in terms of spares, repairs and logistics. The cost of false alarms is clearly wasted expense, hence it is important that the integrity of BIT functionality is specified and validated.

13.4.2 The use of BIT, BITE, HUMS and prognostics can minimise the need for human intervention, reducing or eliminating human error, minimising false alarm rates or the impact of false alarm rates and the related cost consequences.

14 FAULT ISOLATION

14.1 Definition

Fault Isolation refers to the capability to isolate a faulty component or sub system (for repair) without the need to stop the operation of the overall system.

14.2 Impact on Intrinsic Availability

14.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

14.2.2 Fault Isolation can improve the Mission Reliability and hence Intrinsic Availability of a system by allowing part of the system to be repaired whilst the overall system remains operational; in effect minimising system downtime. Fault Isolation methods should be incorporated into design where possible and advantageous to do so.

14.3 Impact on Operational Availability

14.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

14.3.2 Fault isolation can improve Operational Availability through improvement of the Intrinsic Availability of the system. Fault isolation by the User generally allows repair action to be conducted 'on-platform' consequently, as far forward as technically feasible. This minimises reliance on the equipment support chain reducing logistic delays.

14.4 Impact on Cost of Ownership

Less reliance on the equipment support chain, the related supply chain and Contractor Logistic Support[15] in particular can reduce the Cost of Ownership. Increasing the burden on the equipment support chain (increasing the logistic footprint) due to a lack of fault isolation will likely increase the cost of ownership of a system.

15 PREVENTATIVE MAINTENANCE LEVELS

15.1 Definition

15.1.1 Preventative Maintenance is "*maintenance carried out to reduce the probability of failure or degradation. Preventative Maintenance is carried out at predetermined intervals (time or usage based) or other criteria (condition based) before failure occurs*". Maintenance Level is defined as "*maintenance task categorisation by complexity*"[16].

15.1.2 The associated Levels and Lines of Repair currently described in terms of Levels 1-4, 1st – 4th Line or Forward / Depth are the product of service doctrine.

[15] Contractor Logistic Support can, taking the whole maintenance policy into account, reduce the overall cost of ownership. However, repair (by the User) as far forward as technically feasible can, where resources and facilities permit, see the costs of ownership absorbed at Unit level.
[16] IEC 60050-191 Ed 2.0

15.2 Impact on Intrinsic Availability

15.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

15.2.2 High Intrinsic Availability is a product of high reliability and effective preventative maintenance. However, preventative maintenance, regardless of the level at which it is conducted, is not normally considered as affecting Intrinsic Availability as it is normally scheduled to occur when it has least or no impact on availability.

15.3 Impact on Operational Availability

15.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

15.3.2 Operational Availability is affected in a similar way to Intrinsic Availability by Preventative Maintenance, and the level at which it is conducted, but potentially to a greater degree. As the reliance on increasing depths of maintenance are introduced into the repair cycle, for example the conduct of Preventive Maintenance on-platform (Level 1) by a Level 2 Maintainer, the potential for delays is increased. Note however, that scheduling maintenance to occur at periods and /or levels where it has minimal or no effect on a mission can result in minimal or no effect on Operational Availability.

15.4 Impact on Cost of Ownership

15.4.1 Preventative Maintenance that requires the system or part of the system to be physically transported to another location (e.g. returned to the OEM) will impact cost of ownership due to the cost of transportation. However, the cost of training and specialist equipment may prevent maintenance being economically carried out at a lower level.

15.4.2 Level of Repair Analysis (LORA) is a process that establishes the optimum Level and Line of repair for any given task. It takes account of the operational imperative (repair forward for high availability) whilst recognising the economic benefits of conducting maintenance off-platform, at deeper repair levels or indeed commercially.

16 PREVENTATIVE MAINTENANCE TIME

16.1 Definition

Preventative Maintenance is "*maintenance carried out to reduce the probability of failure or degradation. Preventative Maintenance is carried out at predetermined intervals (time or usage based) or other criteria (condition based) before failure occurs*"[17]. Preventative Maintenance Time is the time spent performing Preventative Maintenance on a system.

16.2 Impact on Intrinsic Availability

16.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

[17] IEC 60050-191 Ed 2.0

16.2.2 A continually operating system will exhibit poor Intrinsic Availability if the system needs removing from service for significant periods to conduct Preventative Maintenance. However, if Preventative Maintenance can be performed quickly or whilst the system remains in operation, it may have little if any affect on the Intrinsic Availability of the system.

16.2.3 Preventative Maintenance Time per se has no impact on Intrinsic Availability of systems that are not continually operating as Preventative Maintenance should be scheduled within the non-operating (or 'free') time. However, too little Preventative Maintenance may negatively affect Mission Reliability and hence Intrinsic Availability (see Cost of Ownership below).

16.3 Impact on Operational Availability

16.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

16.3.2 Preventative Maintenance will have an impact on Operational Availability of continually operating systems if the system has to be shut down to conduct Preventative Maintenance.

16.3.3 Preventative Maintenance Time will have no impact on Operational Availability of a single system that is not continually operating, but may negatively affect the Operational Availability of a "system of systems" (e.g. a fleet of vehicles).

16.4 Impact on Cost of Ownership

Preventative Maintenance will impact cost of ownership through the cost of parts, labour and logistics. However, conducting the correct level of Preventative Maintenance at the correct interval will inevitably optimise the Cost of Ownership by reducing the number of failures in service (which typically have a higher cost burden that the cost of prevention). Reliability Centred Maintenance (RCM) is a technique used to optimise Preventative Maintenance regimes.

17 MAINTENANCE LEVELS

17.1 Definition

17.1.1 Maintenance Level is defined as "*maintenance task categorisation by complexity*"[18]

17.1.2 Levels and Lines of Repair, currently described in terms of Levels 1-4, 1st – 4th Line or Forward / Depth, are the product of service doctrine.

17.2 Impact on Intrinsic Availability

17.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

17.2.2 Intrinsic Availability is not directly affected by corrective maintenance, or the level at which it is conducted; however, the need to conduct a corrective repair action can be to the result of poor reliability / Intrinsic Availability.

[18] IEC 60050-191 Ed 2.0

17.3 Impact on Operational Availability

17.3.1 Operational Availability is the product of Intrinsic Availability and logistic support arrangements.

17.3.2 Operational Availability can be impacted by Maintenance Levels. As the reliance on increasing depths (levels) of maintenance are introduced into the repair cycle the burden on the equipment support chain increases. Such reliance introduces the possibility of increased logistic and administrative delays and extends the logistic footprint. Note however, that supply chain analysis/modelling can introduce measures (lower stock out risk – higher spare part availability) to reduce the problems associated with logistic and administrative delays.

17.3.3 The ability to repair as far forward within the area of operations as technically feasible, economically sensible and operationally acceptable, has the benefits of improving Operational Availability. On-platform repair is normally the best repair solution for optimal Operational Availability if 'economically sensible' can be ignored.

17.4 Impact on Cost of Ownership

17.4.1 Maintenance that requires the system or part of the system to be physically transported to another location (e.g. returned to the OEM) will impact cost of ownership due to the cost of transportation. However, the cost of training and specialist equipment may prevent maintenance being economically carried out at a lower level.

17.4.2 Level Of Repair Analysis (LORA) is a process that establishes the optimum Level and Line of repair for any given task. It takes account of the operational imperative (repair forward for high availability) whilst recognising the economic benefits of conducting maintenance off-platform, at deeper repair levels or indeed commercially.

18 TOTAL MAINTENANCE TIME

18.1 Definition

Maintenance time is defined as "*The time interval for which maintenance is performed, including time attributed to maintenance actions, and technical logistic delays*"[19]. Total Maintenance Time is therefore the total of all such time intervals.

18.2 Impact on Intrinsic Availability

18.2.1 Intrinsic Availability is the product of Mission Reliability and Maintainability of a system.

18.2.2 Total Maintenance Time is a characteristic of the Maintainability of a system which in turn is a product of scheduled and corrective maintenance and technical logistic delays. Consequently the impact of maintenance time on Intrinsic Availability is due only to corrective maintenance time (as the time associated with scheduled maintenance can be programmed to avoid any impact on Intrinsic Availability).

[19] IEC 60050-191 Ed 2.0

18.2.3 Hence a high total maintenance time would tend to result in a low Intrinsic Availability; due mainly to the need for unforeseen corrective maintenance as a result of poor reliability.

18.3 Impact on Operational Availability

18.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

18.3.2 Total Maintenance Time has a greater impact on the Operational Availability of a system as all three components (scheduled, corrective and logistic delays) can have an effect. A high Total Maintenance time will have a greater Operational Availability when corrective maintenance time is high and scheduled maintenance is poorly programmed A badly constructed programme of scheduled maintenance can affect availability if scheduled to occur at inappropriate times (affecting the mission) or at the least optimal repair level (increasing logistic delays). It is unlikely however that logistics support arrangements can be optimised to provide improvements in Operational Availability if the inherent maintainability of the system is poor (e.g. poor access to components / poor built-in failure detection).

18.4 Impact on Cost of Ownership

18.4.1 The proportion of Total Maintenance Time that is conducted by the user typically imposes no extra cost; however Maintenance Time of specialist maintainers or the OEM can impact cost of ownership.

18.4.2 Level Of Repair Analysis (LORA) is a process that establishes the optimum Level and Line of repair for any given task. It takes account of the operational imperative (repair forward for high availability) whilst recognising the economic benefits of conducting maintenance off-platform, at deeper repair levels or indeed commercially. LORA provides the means to determine or influence the cost of ownership.

19 SPARES AVAILABILITY

19.1 Definition

Spares Availability is concerned with the Availability of the right spare in the right place at the right time.

19.2 Impact on Intrinsic Availability

19.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

19.2.2 Spares availability has no effect on Intrinsic Availability however poor Intrinsic Availability can significantly impact spares requirements. Poor reliability increases the need for repair activity, both scheduled and corrective, increasing the requirement for spare parts.

19.3 Impact on Operational Availability

19.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

19.3.2 Spares availability is an attribute of the logistic support arrangements. Any delay following a failure due to the unavailability of the required spare will reduce the Operational Availability of the system. Total Maintenance Time is minimised when the required spare is immediately available at the time and point of failure. As this is often impracticable, particularly with 'mobile' systems, a spares modelling/optimisation analysis can be used to identify the optimal spare range and scale, based on the probability of each spares type being required. Where spares can not be stored in close proximity to the system, the Total Maintenance Time can be minimised by optimising the supply chain and the logistics of transporting the spare to the point of failure.

19.4 Impact on Cost of Ownership

The impact on Cost of Ownership is most apparent when there is as increasing reliance on the commercial sector to fill the supply chain. However, the commercial sector can offer significant advantages in the efficient supply of spare parts, optimising the often unavoidable costs whilst leading to improved availability. The costs associated with storage and transportation of spares and the optimisation of spares provisioning therefore can positively impact Cost of Ownership.

20 TOOLS AND TEST EQUIPMENT AVAILABILITY

20.1 Definition

Tools and Test Equipment availability is concerned with the availability of the right equipment in the right place at the right time, permitting the efficient conduct of both scheduled and corrective maintenance, within the recognised timescales at the appropriate maintenance levels.

20.2 Impact on Intrinsic Availability

20.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

20.2.2 The availability of Tools and Test Equipment has no effect on Intrinsic Availability.

20.3 Impact on Operational Availability

20.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

20.3.2 Tools and Test Equipment Availability is an attribute of the Logistic Support Arrangements. Any delay following a failure due to the unavailability of the required Tools or Test Equipment will reduce the Operational Availability of the system. Total Maintenance Time is minimised when the required Tools and/or Test Equipment are immediately available at the time and point of failure. Where Tools and Test Equipment can not be stored in close proximity to the system (i.e. due to physical space/stowage limitations), the Total Maintenance Time can be minimised by optimising the logistics of transporting the Tools and Test Equipment to the point of failure.

20.4 Impact on Cost of Ownership

20.4.1 There is no direct link between Tools and Test Equipment Availability and Cost of Ownership.

20.4.2 However, the costs of acquisition and support of Tools and Test Equipment can be high. Where equipment is required by the User to conduct maintenance at Levels 1 – 3, the cost of ownership can be high and considerable when the equipment is expensive.

20.4.3 The costs can be lessened where specialist and often expensive equipment is passed to the commercial sector, carrying out maintenance in a contractor logistic support framework; the costs being absorbed in the overall contract costs.

21 TECHNICAL DOCUMENTATION AVAILABILITY

21.1 Definition

Technical Documentation availability is concerned with the availability of the right Technical Documentation in the right place at the right time, permitting the efficient and safe conduct of both scheduled and corrective maintenance, using the proper maintenance techniques.

21.2 Impact on Intrinsic Availability

21.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

21.2.2 Technical Documentation Availability has no effect on Intrinsic Availability.

21.3 Impact on Operational Availability

21.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

21.3.2 Technical Documentation Availability is an attribute of the Logistic Support Arrangements. Any delay following a failure due to the unavailability of the required Technical Document(s) will reduce the Operational Availability of the system. Total Maintenance Time is minimised when the required Technical Documentation is immediately available at the time and point of failure. Where Technical Documentation can not be stored in close proximity to the system (e.g. for mobile systems where space limitations prevent carrying all Technical Documentation), the Total Maintenance Time can be minimised by optimising the logistics of providing the correct Technical Documentation to the point of need.

21.4 Impact on Cost of Ownership

21.4.1 There is no direct link between Technical Documentation availability and Cost of Ownership.

21.4.2 However, the costs of acquisition and support of Technical Documentation can be high.

21.4.3 The costs can often be lessened where specialist suppliers from within the commercial sector are used whilst recognising that overly sophisticated solutions are not always appropriate.

22 MANPOWER AVAILABILITY AND PERFORMANCE

22.1 Definition

22.1.1 Manpower Availability is concerned with the Availability of the right Manpower in the right place at the right time.

22.1.2 Manpower Performance is concerned with Manpower (Users and Maintainers) performing or functioning in the best possible manner with the least waste of time and effort. Human Factors is increasingly seen as an important factor.

22.2 Impact on Intrinsic Availability

22.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

22.2.2 Manpower Availability and Performance has no effect on Intrinsic Availability.

22.3 Impact on Operational Availability

22.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

22.3.2 Manpower Availability is an attribute of the logistic support arrangements. Any delay following a failure due to the unavailability of the required Manpower will reduce the Operational Availability of the system. Total Maintenance Time is minimised when the required Manpower is immediately available at the time and point of failure. This is often not possible, particularly for 'mobile' systems that can not be fully maintained by the users. In this case the Total Maintenance Time can be minimised by optimising the logistics system to minimise the delay in deploying the required Manpower to the point of need.

22.3.3 Any shortfall in Manpower Performance will likely result in extended Active Repair Time, and may result in further premature failures if repair actions are not completed correctly. It is therefore important to provide effective training with an understanding of the Human Factors element, so that all personnel will operate, maintain, and repair the system efficiently (see Efficacy of Training Metric).

22.4 Impact on Cost of Ownership

Where Manpower Availability and Performance refer to the User there is little if any impact on Cost of Ownership. However, where resources are provided by the commercial sector the costs become more evident, in terms of the cost of contractor logistic support.

23 TECHNICAL SUPPORT AVAILABILITY

23.1 Definition

23.1.1 Technical Support availability is concerned with the availability of the right Technical Support to the User, in the right place at the right time.

23.1.2 It includes the spectrum of support from a simple help-line to a full Contracting for Capability programme.

23.2 Impact on Intrinsic Availability

23.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

23.2.2 Technical Support Availability has no effect on Intrinsic Availability.

23.3 Impact on Operational Availability

23.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements.

23.3.2 It is unlikely that Technical Support will provide the complete solution to achieving high Operational Availability. Assuming therefore that Technical Support has constraints, the effectiveness of this support, and its impact on Operational Availability, is related to the scale of the support package.

23.3.3 The key to achieving high Operational Availability is to articulate the operational requirements well enough to attract a sufficient amount of support. This becomes increasingly important with increased reliance on commercial Technical Support.

23.3.4 Any delay following a failure due to the unavailability of the required Technical Support will reduce the Operational Availability of the system. Total Maintenance Time is minimised when the required Technical Support is immediately available at the time of failure. The cost of providing '24/7' technical support must be assessed against the consequence of failure.

23.4 Impact on Cost of Ownership

Increased reliance on commercial Technical Support can attract high costs but often to the benefit of increased Operational Availability. The cost of providing Technical Support should be balanced against the impact of mission failure.

24 EFFICACY OF TRAINING

24.1 Definition

The effectiveness of the training provided to users and maintainers of a system.

24.2 Impact on Intrinsic Availability

24.2.1 Intrinsic Availability is the product of the Mission Reliability and Maintainability of a system.

24.2.2 Efficacy of Training has no effect on Intrinsic Availability.

24.3 Impact on Operational Availability

24.3.1 Operational Availability is the product of Intrinsic Availability and Logistic Support Arrangements

24.3.2 Efficacy of Training is an attribute of the impact on a system of the personnel who use and maintain it. Effective training of users can help to maintain a system at acceptable levels of performance whilst reducing user induced failures of the system. Effective training of maintainers will optimise Active Repair Time, and should reduce the probability of further maintenance induced failures of the system.

24.3.3 The effectiveness of training affects Operational Availability because the efficient conduct of maintenance, and correct system operation, are important factor in sustaining a system's performance. Where for example reliability is relatively poor, efficient operation and maintenance techniques, reliant on trained / skilled Users, can deliver acceptable levels of availability. However, this should not be seen as the solution to inherently poor reliability.

24.4 Impact on Cost of Ownership

Whilst there is a cost associated with developing and delivering comprehensive and effective training to all users and maintainers, it is likely that this will be outweighed by the cost saving of optimal in-service manpower performance.