LEAFLET 1

THE CASE FOR R&M

(Developing and Presenting Evidence to Build Confidence in the Level of System R&M)

CONTENTS

1. INTRODUCTION

The R&M Case is a major element of the MoD's current R&M policy. It accords fully with the ideals of the Smart Acquisition which envisages a much closer working relationship between the MoD and its contractors and suppliers. It is therefore something that cannot be ignored by anyone involved in the acquisition of defence equipment. It was formally introduced by Issue 4 of Defence Standard 00-40, Part 1 in October 1999 which also set out three objectives for the management of R&M. The objectives were and remain as follows:

- Understanding the R&M requirements
- Planning to achieve the requirements
- Demonstrating the achievement of the requirements.

2. WHAT IS THE BEST WAY TO ASSURE THE RELIABILITY AND MAINTAINABILITY OF A SYSTEM?

2.1 Traditionally, within the MoD, we have relied on trials based on statistical sampling to gain confidence that a contractor is delivering the R&M we require; but how representative is the R&M that we see in these trials of what we shall see in service? By necessity the trials have been of limited duration and may only test a limited range of functionality in a limited range of environments. As the levels of reliability that we expect to see increase, the duration of the trials required to give the same level of statistical confidence likewise increase, understandably become very expensive, and their value for money questionable. Why do we test for R&M so late in the project? Presumably so that we can test a design most representative of what will be delivered, while successful completion of the trials can also constitute a milestone for contractual payment. However it does mean that any remedial action will be conducted when it is most expensive and most difficult to find an effective modification.

2.2 Instead of placing a limited hurdle for the system just before delivery, shouldn't we be looking for confidence that all aspects of the requirements were being achieved (or had been achieved) at a point in the project where remedial action, where necessary, could be taken effectively and economically? The object of an R&M Case is to do just this; but it must not be seen as being just of advantage to the customer, it is also a way of formalising best design (including R&M) practice in the contractual chain. The MoD has moved away from a prescriptive approach to contracting for R&M 10 years ago, towards expecting contractors to determine what they consider to be an appropriate, effective and sufficient process. The R&M Case reinforces that move as it requires the contractor to assess what has to be done and to plan for and conduct regular reviews and evaluation of progress throughout the programme. Each of these reviews will be against progress towards defined targets or success criteria and will indicate where plans need to be amended if necessary.

3. WHAT IS A RELIABILITY AND MAINTAINABILITY CASE?

It is the evidence, assumptions and arguments employed in the specification, design, development and modification of a system that can be used to provide confidence in the system's level of reliability and maintainability. The evidence is likely to include data from a range of sources. The relevance of all the evidence and assumptions must be argued convincingly before it can be included in the R&M Case. This approach also encourages the identification and management of risks to R&M. In addition to the results of tests, analysis, etc, the development and management of the R&M strategy will be an important contributor to confidence, particularly in the early stages of a project.

4. WHAT IS IT ALL ABOUT?

4.1 Setting R&M Requirements

To ensure traceability of the requirements, the evidence, assumptions and arguments employed in setting those R&M requirements should ideally be brought together to form an initial R&M case. In this way anyone working on the project (especially any contractor trying to design a system to meet the requirements) can fully understand the background to those requirements.

4.2 Progressive Assurance

4.2.1 Once the requirements have been set, the next step is to design a programme to select and develop a solution. It is the Contractor's responsibility to develop a strategy and plan for the achievement of R&M. The plan must ensure that the strengths and weaknesses of all potential solutions are analysed and assessed against the requirements, that the planned development of a selected solution is appropriate to achieving the requirements and that progress in that direction is monitored. This monitoring must include a review and evaluation of the programme so that it can be amended if it appears that the requirements may not be achieved. The establishment of the programme and the subsequent work to it form the Progressive Assurance of R&M.

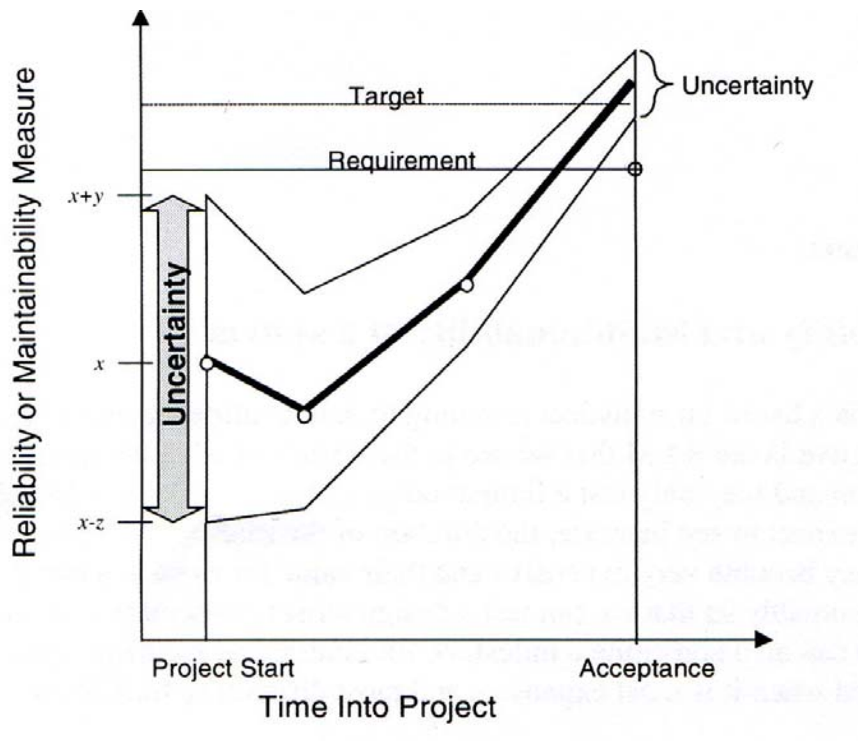

Figure 1 – Uncertainty Throughout the Project Phases

4.2.2 The initial analysis determines a 'point estimate' of the reliability and of the maintainability of a solution. As the evidence available at that stage may be limited the point estimate will probably have a wide 'range of uncertainty'. In other words, the point estimate may be 'x', but the actual value may be as high as 'x+y' or as low as 'x-z'. As the programme progresses, more should be known about the reliability and maintainability and so the band of uncertainty should diminish, whether or not the point estimate increases or decreases. The programme of activities and development should be aimed at ensuring that, by the end of the programme, the point estimate is high enough and the band of uncertainty tight enough to give a high level of confidence that the requirements will be exceeded. To assist in monitoring progress, 'success criteria' are defined at set points in the programme. At these points actual achievement can then be compared with planned achievement.

4.2.3 The concept of Progressive Assurance is illustrated in Figure 1.

4.3 Body of Evidence

4.3.1 The data that can be used to form evidence of a system's R&M can come from a myriad of sources. Figure 2 illustrates some typical sources and possible links with any assumptions that are being made to produce R&M claims. This is particularly important in the early stages of a programme when measureable evidence is limited. It is important to understand that some data will almost certainly have to be adjusted to make it appropriate to the system, its users and its environments. When this occurs the reasoning behind these adjustments and arguments which support the data, must be recorded.

4.3.2 A useful technique in planning the R&M activities that will produce the data is the identification of the project's R&M risks and what has to be done to remove, avoid or mitigate them.

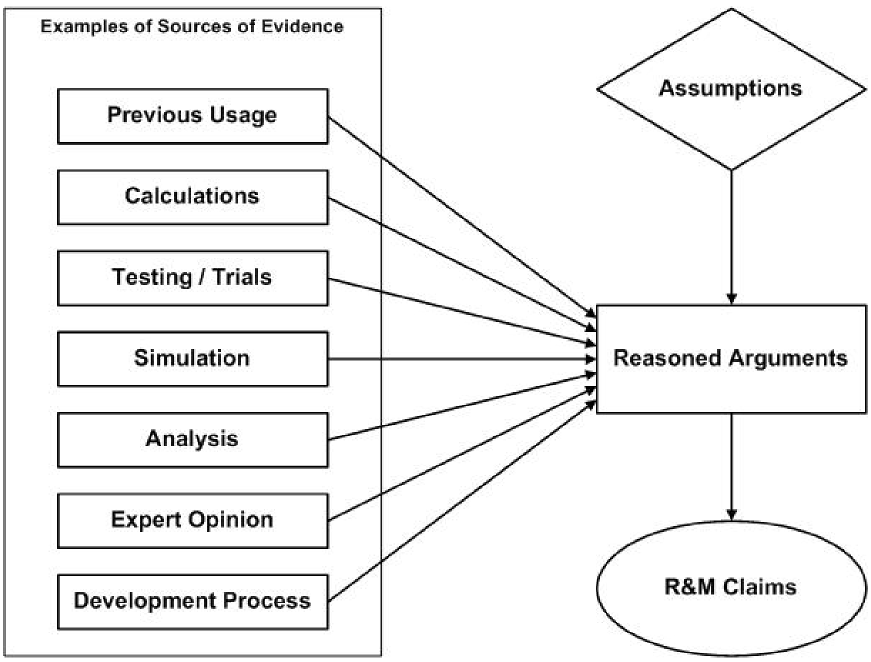

Figure 2 – Gathering and Processing Data

4.4 R&M Case Report

Because the volume of evidence used in the R&M Case and the range of sources are likely to be large, it is often impractical that the Case can be brought together in a single document and that a summary report will be produced, referring to the sources, and document the arguments and claims. This document and subsequent updates is called the R&M Case Report. The contract may define points in the programme at which copies of the R&M Case Report will be supplied to the customer.

5. THE DEVELOPMENT CYCLE OF A RELIABILITY AND MAINTAINABILITY CASE

5.1 Defence Standard 00-40, recognises that the system procurer has a duty to explain the background to the R&M requirements. This background information includes details of the mission (duty cycle, usage scenario, etc.), the environment, the user, the maintainer, what constitutes a failure, and the basis for the measurement of R&M. This set of information forms the initial R&M Case which will be developed to support the User Requirements Document (URD) and the System Requirements Document (SRD) and forms part of the Invitation to Tender (ITT).

5.2 The contractor's R&M Case starts with their draft R&M Case in response to the ITT, which is formalised once a contract has been let. By the end of the contract the R&M Case should provide all the necessary level of confidence that the contract's R&M requirements have been achieved.

5.3 When the system enters service, the in-service manager maintains the R&M Case as a record of the systems in-service R&M achievement and to ensure that the Case reflects any changes to the equipment's use or configuration. In the event of a contract being placed for a major 'mid-life' update, the in-service R&M Case would be submitted to the Contractor on which to base their future R&M Case submissions.

6. THE FORMAT OF A RELIABILITY AND MAINTAINABILITY CASE

There is no standard template for an R&M Case or Case Report. It is highly unlikely that it will be physically possible to bring all the base data to be used in arguments and evidence together in one document. However it must be possible to trace all claims through such evidence and arguments back to the base data. The R&M Case Report is a 'readable' summary of the strategy, a record of all decision and why they were made, the progress made to date, and other conclusions. It need also directs the reader to the source data, analysis, etc. enabling them to form their own conclusions and support those being tendered.

7. CONCLUSION

The R&M Case approach reflects what is considered to be best practice by both the MoD and industry. It provides a powerful tool to build and establish confidence and must be seen to be of equal value to both customer and contractor. Partnering, the closer relationship between customer and contractor, is a key element of the Smart Acquisition. An effective R&M Case requires and encourages effective partnering as all involved with the project must work closely together. It does not alleviate the need to model, develop, grow, trial, fix, etc. a design as necessary to achieve compliance but it does enable it to be achieved in a more cost effective and efficient manner.

ATTACHMENT G1/1

FREQUENTLY ASKED QUESTIONS

1 How are they defined?

R&M Case is defined as "A reasoned, auditable argument created to support the contention that a defined system satisfies the R&M requirements."

R&M Case Report is defined as "A summary of the R&M Case, which provides sufficient detail to allow a decision whether to proceed from one phase of a project cycle to the next; or accept a milestone or other project measure or not."

2 Who 'Owns' the R&M Case?

Throughout the life of a system the ownership of the R&M Case will change a number of times as illustrated in Figure 1.

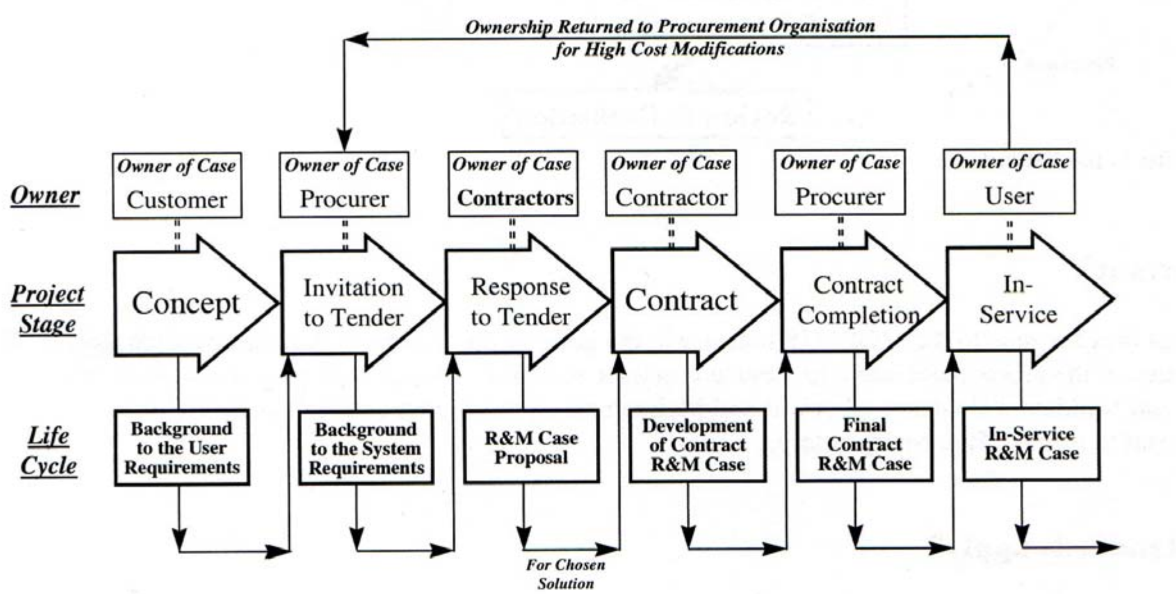

Figure 1 - An Example of the Life Cycle and Ownership of an R&M Case

3 What are Success Criteria?

Success criteria are a fundamental element of the R&M Case as they are used to define the activities and evidence necessary to provide confidence that the requirements are being, or have been, met. They are there to let you know if the project is where you thought it ought to be at a given stage or time in the development programme. At any particular stage in a project a success criterion is the definition of the level of confidence that should have been achieved by then. The level of confidence will be defined in terms of the point estimate of

R&M and the width of the band of uncertainty; these measures will be argued on the basis of the data and evidence available. At the planning stage, success criteria will be set for identifiable points in the programme. When these points are reached actual achievement can be compared with the plan and the plan adjusted and remedial action taken if the actual achievement falls short.

4 What is the link between the R&M Case and the R&M Plan; is a separate R&M Plan still necessary?

In the past the R&M Plan was often seen as a deliverable to the MoD, to explain how the contractor was going to undertake the R&M tasks prescribed to them. In the Progressive Assurance and R&M Case approach, the R&M Plan is the result of the contractors own analysis of what they believe has to be done to mitigate the risks and produce the evidence that will give them and the MoD confidence that the R&M requirements have been, or will be achieved. The diagram below illustrates how the R&M Plan and the R&M Case compliment each other. While each would be ineffective without the other, for convenience they can be a separate document.

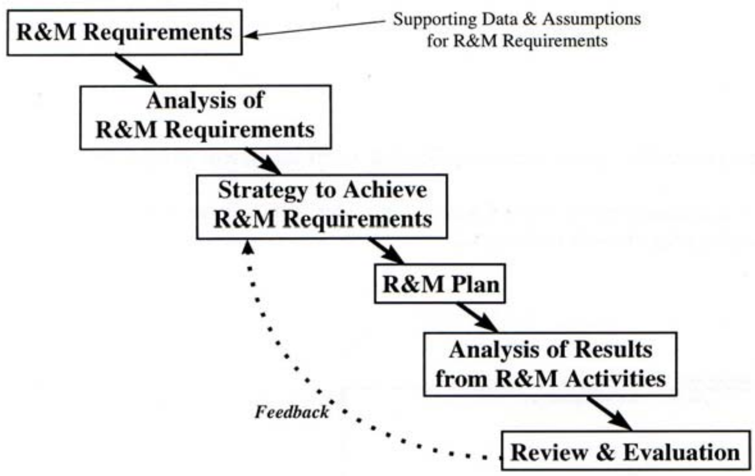

Figure 2 - Where the R&M Plan and R&M Case Co-exist

5 Is the name important?

The R&M Case concept is not unique to the MoD. US Industry in the guise of the Society of Automotive Engineers (SAE) have recognised the value of the process and intent to include it in their standards. The SAE propose to use the terms Reliability Assurance and Validation Evidence (R-AVE) and Maintainability Assurance and Validation Evidence (MAVE) as US industries tend to manage R & M separately.

6 Which Defence Standards apply?

Def Stan 00-40, R&M Part 1: Management Responsibilities and Requirements for Programmes and Plans;

Def Stan 00-42, R&M Assurance Guidance Part 3: R&M Case.

The DStan website can be accessed at: www.dstan.mod.uk

7 Where can I obtain further advice and assistance?

Further information about this and other R&M techniques can be found on the Acquisition Operating Framework (AOF) website: http://www.aof.mod.uk

or from the TLS Reliability Team:

Help Desk: 030 679 37755

Email: desjctls-pol-rela@mod.uk

ATTACHMENT G1/2

EXAMPLE INITIAL R&M CASE

1. INTRODUCTION

The aim of the Initial R&M Case is to create a reasoned, auditable submission to support the contention that the system being acquired by the Customer will satisfy the capability for which it is being procured. It must include the R&M parameters of the required system, together with their measurable baseline. The R&M requirements should include the anticipated system usage and its environment.

It should be created by the Customer having consulted all the R&M stakeholders to ensure that the requirements are captured fully. Specialist advice and the use of R&M modelling techniques will probably be necessary. The Purchaser should at this time begin identifying R&M risks to be included in the overall project risk register.

In the absence of specific direction from the Customer and Purchaser, the onus will be on the Contractor to take the initiative and propose R&M design targets and measurement base. A Contractor's best efforts are likely to result in a compromise, and unlikely to satisfy the Customers requirements fully unless the Contractor and their design team are conversant with the Customers specific needs and the capability gap to be filled.

In the example, for simplicity, a fictitious General Purpose Utility Vehicle is being acquired in a number of variants however the example could be equally applied to the majority of acquisitions.

2. INITIAL R&M CASE

2.1 Section 1: System Description

There is a Tri-service requirement for the transportation of personnel, general stores and ammunition on deployed operations. The requirement for the transportation of personnel, general stores and ammunition stems from the increasing emphasis on expeditionary operations and the need to sustain deployments in bare or austere conditions.

Studies have concluded that the requirements can be provided by 4 variants of General Purpose Utility Vehicles (GPUV) comprising; 1 Tonne, 1 Tonne ((Protected), 2 Tonne and 2 Tonne Self-Loading.

The capability and the availability of the existing fleet are considered inadequate for future operations. Poor reliability coupled to tactical stores and ammunition distribution shortfalls and the inability to comply with current regulations have necessitated the partial replacement of the current fleet.

The new vehicles must be compatible with the manoeuvre warfare requirements and possess the necessary operational and vehicle characteristics to survive and remain effective in the battlefield environment. It is essential the new vehicle fleet has good reliability and complies with current and proposed legislation.

2.2 Section 2: Requirements and Constraints

The Availability, Reliability and Maintainability Requirements for the GPUVs are summarised below and relate to vehicles deployed on operation with a complete equipment schedule and the crew's personal equipment.

Operational Availability (A_o)

Maximum levels of equipment availability are required by the military commander during operations in the field in order to achieve military goals. The necessary levels of operational availability stem initially from Operational Analysis to determine capability needs and numbers within predicted operational scenarios. The amount of time the equipment is available for use by the user is dependent on how often the mission critical elements of the equipment fail, the time taken to effect a repair, the supply of spares and maintenance resources. The practicality of meeting this operational need is therefore dependent on the underlying reliability and maintainability of the equipment design and the efficiency of the supply chain and repair organisation.

General Purpose Utility Vehicle	**Operational Availability (A_o)**
1 Tonne	97.6 %
1 Tonne ((Protected)	96.8 %
2 Tonne	96.8 %
2 Tonne (Self-Loading)	96.8 %

Table 1 – General Purpose Utility Vehicle Operational Availability Requirements

The operational availability required for each of the GPUV is shown in Table 1 above and are considered achievable, in theatre, if a 24 hour logistic supply time for spares supply is assumed and the following R&M targets are met. The detail of how the A_o requirement has been derived and the basis for the R&M requirements stated below are given at Annex A to this R&M Case.

Reliability Requirements

Reliability Requirements of the 1 Tonne General Purpose Utility Vehicle:

- Duty Cycle. The Duty Cycle for the 1 Tonne General Purpose Utility Vehicle is at Annex B to this R&M Case (see Serial A.2.9).

- Mission Reliability. For the whole equipment, the 1 Tonne General Purpose Utility Vehicle is to have at least a 91.63% probability of completing a Duty Cycle without a mission failure. Within this, the vehicle automotive system is to have a 93.5% probability, and the special to role system a 98% probability. This equates to a whole equipment probability of 11.4 Mean Missions Between Failure (MMBF), of which the automotive system is to achieve 14.9 MMBF and the special to role system 49.5 MMBF.

- Legislative Reliability. The 1 Tonne General Purpose Utility Vehicle is to have at least a 90.5% probability of completing a Duty Cycle without a legislative failure. This equates to 10 mean missions between legislative failures.

- Basic Reliability. The 1 Tonne General Purpose Utility Vehicle is to have at least a 72% probability of completing a Duty Cycle without a basic failure. This equates to 3 mean missions between basic failures.

Reliability Requirements for the 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading) General Purpose Utility Vehicle:

- Duty Cycle. The Duty Cycles for the 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading), General Purpose Utility Vehicles are at Annexes C, D and E respectively.

- Mission Reliability. For the whole equipment, the 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading), General Purpose Utility Vehicles are to have at least a 91.14% probability of completing a Duty Cycle without a mission failure. Within this, the vehicle automotive system is to have a 93% probability, and the special to role system a 98% probability. This equates to a whole equipment probability of 10.8 Mean Missions Between Failure (MMBF), of which the automotive system is to achieve 13.8 MMBF and the special to role system 49.5 MMBF.

- Legislative Reliability. The 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading), General Purpose Utility Vehicles is to have at least a 95.12% probability of completing a Duty Cycle without a legislative failure. This equates to 20 mean missions between legislative failures.

- Basic Reliability. The 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading), General Purpose Utility Vehicles are to have at least a 61 % probability of completing a Duty Cycle without a basic failure. This equates to 2 mean missions between basic failures.

Failure Definitions

The following failure criteria shall be applied to the all the GPUV variants:

- Mission Failure is any incident which would prevent the GPUV from safely starting and successfully completing a Duty Cycle. One (Qty 1) unscheduled maintenance intervention, not exceeding 30 minutes, is permitted by the crew (having no specialist maintenance training) using on board tools and spares carried with the vehicle per Duty Cycle.

- Legislative Failure. is defined as any unsatisfactory equipment condition which would result in the vehicle contravening the Road Traffic Act 1988.

- Basic Failure or maintenance related failure. is defined as any unsatisfactory equipment condition which requires unscheduled maintenance intervention to restore the equipment to its design and performance build standard. It excludes scheduled maintenance but includes those action which are necessary to correct faults identified during scheduled maintenance.

- All Mission Failures which require unscheduled maintenance intervention shall also be counted as Basic Failures.

The following types of failure are to be discounted:

- Failure of a component that has been allowed to exceed its specified life.

- Failure resulting from misuse, accident, human error or maintenance which is not in accordance with defined schedules.

Classification of Failures, and Incident Sentencing should be carried out in accordance with Def Stan 00-44.

Maintainability Requirements

The following maintainability requirements shall be applied to all the GPUV types and variants:

- The Active Corrective Maintenance Time (ACMT) at Level 1, using the vehicle CES tools, must not exceed 30 minutes.

- The Mean Active Corrective Maintenance Time (MACMT) for Level 2 unscheduled maintenance is to be no greater than 2 hours, with 95% of all maintenance taking no more than 4 hours.

- The MACMT for Level 3 unscheduled maintenance is to be no greater than 4 hours with 95% of all maintenance taking less than 8 hours.

- Levels 2 and 3 maintenance tasks are to be limited to no more than two trained maintenance tradespersons (or three if a MHE operator is needed) requiring no special tools and test equipment, other than those agreed by the LSA, and will be to no greater depth than sub-assembly exchange. Information on maintenance levels can be found in the Use Study.

Durability Requirements

The service life of all variants of GPUV shall be 20 years based on an annual usage of 24 Duty Cycles for the 1 Tonne General Purpose Utility Vehicle and 48 Duty Cycles for the 1 Tonne (Protected) and 2 Tonne General Purpose Utility Vehicles and the 2 Tonne (Self-Loading), General Purpose Utility Vehicles.

Currently there is no intention to conduct a mid-life update and/or overhaul although the equipment shall be considered for modifications to meet the Services needs.

2.3 Section 3: Risk

Current commercial designs of this type of GPUV are built for road use and are unlikely to be reliable when employed in an 'off road' environment. It seems likely, therefore, that no 'Commercial Off the Shelf' (COTS) equipment will be offered to meet this requirement. The supplier's strategy therefore will be to substantially modify an existing design or build a new vehicle from existing components both of which shall require considerable design effort. The relatively short time scale of this acquisition may place additional challenging demands on the contractor to execute a viable development programme to provide evidence that a new or modified design of equipment meets the R&M requirements.

The achievement of System Acceptance for the GPUV project is reliant on a robust R&M Case to demonstrate the R&M requirements have been met. The acceptance process may stall, if the evidence from the R&M Case does not show clearly that the new equipment is compliant.

The 'off road' use of GPUV poses technical risks for:

- Strength of design of critical components.
- Locking mechanisms on fasteners and fixings.
- Seals against water and dirt ingress on critical sub-systems.
- Water and dirt ingress into braking systems.
- Protection of cables pipes and connectors.
- Protracted vehicle engine idling or running at part load (when winching and loading) may cause engine problems.
- Water may pose a corrosion risk to the GPUV.
- The effects of long term storage must be considered in the development of any proposed design to ensure the reliability is not compromised.

A comprehensive list of R&M risks shall be compiled by the Contractor and included in his Project Risk Register. The Contractor's Reliability Programme Plans shall show how it is intended to counter and mitigate those risks.

2.4 Section 4: Assumptions

For design and development purposes it should be assumed that when winching and self-loading the GPUV will remain static and operated on level ground.

2.5 Section 5: Recommendations

Comprehensive analysis of the Duty Cycle to ascertain usage patterns, input loads and environmental conditions should be undertaken to enable the Contractor to ensure that the equipment design will perform reliably under operational conditions.

Stress modelling should be carried out by the Contractor, using the measured input loads (from the analysis above), to ensure that the strength of design of mission critical sub-systems and components is adequate to meet the needs of the mission, and have the durability to continue to function for the design life of the equipment.

A structured analysis of potential failure modes should be undertaken by the Contractor to ensure that all interface and integration issues are addressed and are not overlooked as causes of unreliability.

Adequate Test and Evaluation evidence shall be generated to provide an engineering and statistical confidence that the design shall achieve the R&M requirement.

Further Test and Evaluation evidence should be provided to confirm that the production process has not degraded the reliability of the equipment, and that the quality of production equipment remains consistent through out the production run.

Evidence shall be provided that the specified maintenance and repair times can be achieved in the field and that any special tools, test equipment and guidance manuals are fit for purpose.

Relevant field or warranty data from other users of the supplied design may be used to contribute to the R&M evidence, within the R&M Case.

The Contractor should assess what other evidence will stem from none R&M related tasks he will be undertaking during the program which may support the contention of R&M compliance and include these within the evidence matrix for the R&M Case.

The MOD and the Contractor should work together to develop the structure and content of the R&M Case. The R&M Case should focus on the R&M Risks identified by the Contractor and MOD and how those risks will be mitigated within the programme. The detail of how to weight and assess evidence provided by the R&M Case 'Matrix of Evidence' should be developed early in the project through the auspices of the R&M Panel.

2.6 Section 6: Annexes

Annex A – Justification for Operational Availability and Reliability Requirements.

Annex B – Duty Cycle for 1 Tonne General Purpose Utility Vehicle.

Annex C – Duty Cycle for 1 Tonne General Purpose Utility Vehicle (Protected).

Annex D – Duty Cycle for 2 Tonne General Purpose Utility Vehicle.

Annex E – Duty Cycle for 2 Tonne General Purpose Utility Vehicle (Self-Loading).

2.7 Section 7: References

Def Stan 00-40 Part 1	Management Responsibilities and Requirements for Programme and Plans.
Def Stan 00-42 Part 3	Assurance Guide R&M Case.
Def Stan 00-44	Data Collection and Classification.

General Purpose Utility Vehicle System Requirement document issued with Invitation To Tender (ITT).

ILS Statement of Work document issued with ITT.

Annex A to Example Initial R&M Case

Justification for Operational Availability and Reliability Requirements

Inherent availability is the availability determined when maintenance and operational conditions are assumed to be ideal. Inherent availability (A_i) is obtained from:

$$Availability_{(i)} = \frac{Uptime}{Uptime + Downtime}$$

Where: Uptime = Mean time between failures (MTBF)

Downtime = Mean time to repair (MTTR) + Mean time for scheduled maintenance (MTSM).

If equipment never failed, its MTBF would be infinite and Ai would be 100%. Likewise if it took no time at all to repair, MTTR would be zero and again the Ai would be 100%. Figure A1 demonstrates that a given level of Ai can be achieved with different values of R and M. As reliability decreases, better maintainability is needed to achieve the same availability and vice versa.

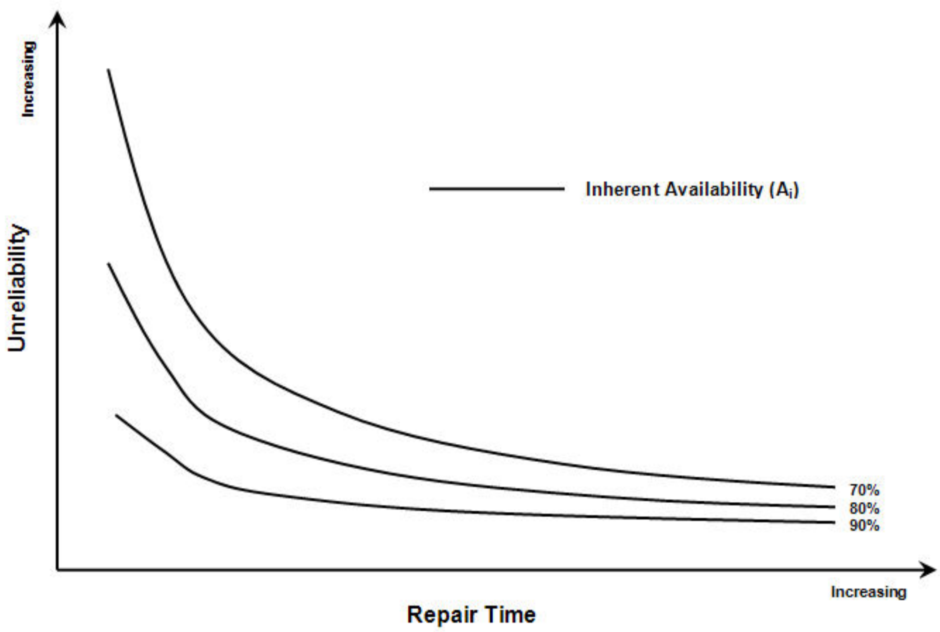

Figure A1 – A Level of Inherent Availability Achieved by Different Combinations of Unreliability and Repair Time

This complementary relationship is important because it means that trade-offs can be made between the two requirements when the end objective is a given availability. For example, if achieving a given level of reliability is too costly or technically difficult, it may be possible to achieve a given availability by increasing the maintainability requirement (by reducing the allocated times to repair) and vice versa. If for no other reason than this, the maintainability and reliability engineers must work hand-in-hand with the User to ensure that the product meets the availability requirement within practical, achievable levels of R&M.

The MTTR is a function of unscheduled maintenance carried out at either 1st, 2nd or 3rd level or a combination of them. Consolidated MTTR figures are not quoted in the Users Requirement but times are given for the Active Corrective Maintenance Time (ACMT) at Level 1 (30 minutes) and the Mean Active Corrective Maintenance Times (MACMT) for non mission essential Level 1 repairs and Level 2 unscheduled maintenance. These MACMTs are to be no greater than 2 hours, with 95% of all repairs taking no more than 6 hours. The MACMT for Level 3 unscheduled maintenance is to be no greater than 4 hours with 95% of all repairs taking no more than 12 hours. The definition of which measure should be used is a question that should be considered by an R&M Panel. (Note: The 95% figures were subsequently modified following advice from the Project ILSM, see Maintainability Requirements)

Scheduled maintenance is assumed to be an average of 30 minutes per Duty Cycle.

Only mission failures initially affect User availability and thus only mission reliability levels are considered here. It needs to be appreciated that a combination of basic failures could result in a mission failure however often basic failures can be repaired at the convenience of the User retaining the capability for operational use. Table A2 gives the Mission reliability levels specified in probability of completing the Duty Cycle for the complete vehicle, automotive system and Special to Role systems, together with the mean missions between failures (MMBF) and mean time between failures (MTBF) based on their respective duty cycles.

GPUV	**Complete Vehicle**			**Automotive System**			**Special to Role Eqpt**		
	Rel (%)	**MMBF**	**MTBF (hrs)**	**Rel (%)**	**MMBF**	**MTBF (hrs)**	**Rel (%)**	**MMBF**	**MTBF (hrs)**
1 Tonne	91.63	11.44	549.1	93.5	14.88	714.2	98.0	49.50	2375.9
1 Tonne (P)	91.14	10.78	258.7	93.0	13.78	330.4	98.0	49.50	1188
2 Tonne	91.14	10.78	258.7	93.0	13.78	330.4	98.0	49.50	1188
2 Tonne(SL)	91.14	10.78	258.7	93.0	13.78	330.4	98.0	49.50	1188

Table A2 – Mission Reliability

These levels of reliability are between 1.9% and 3.2% greater than previously specified. However, when considered against those recently recorded in service under similar conditions and circumstances they compare favourably. The shortage of suitable vehicles necessitating the excessive usage of an aging fleet has resulted in reduced reliability and increased maintenance. Where vehicles have been employed within their design envelope their achievement has been encouraging often exceeding their design specification.

The exception is the requirement for the 1 Tonne General Purpose Utility Vehicle ((Protected) where currently there is not a suitable vehicle to enable a constructive comparison. Similar vehicles used in NE Europe and the Balkans, with few exceptions, proved reliable when employed in the temperate and winter climates of these regions but did not experience the characteristic heat and dust of current operations. The majority of failures currently experienced with medium and heavy wheeled vehicles have not resulted from excessive temperature or dust but from the weight increase of additional armour or operations over terrain beyond the design envelope.

While this requirement is challenging it is not considered unrealistic and has been surpassed in a number of similar previous acquisitions. The commonality of the variants and the required fleet size provides ample opportunities for development while the duty cycles have been tailored from 3 years of recorded usage in theatre. Analysis of the capability verses fleet sizes, parameters of the proposed R&M specification and the available funding, supports the contention that this requirement is appropriate and the capability sustainable.

Previous reliability predictions on the winching and self-loading equipment compare favourably with in-service and their commercial equivalent suggesting the requirements are reasonable and should be achievable.

Using the inherent availability equation specified at the beginning of Annex A and the MTTR and MTBF given above, the inherent availability for each of the vehicles can be calculated. Table A3 below shows the result.

GPUV	**Inherent Availability**	
	Level 1 & 2 MACMT	**Level 3 MACMT**
1 Tonne	99.55%	99.28%
1 Tonne (P)	99.04%	98.48%
2 Tonne	99.04%	98.48%
2 Tonne (SL)	99.04%	98.48%

Table A3 – Inherent Availability

In practice the time necessary to repair failures will also include the time to report and recover the failure, make resources available, obtain spares and then return the equipment into service. Collectively this time is called logistic delay and when included in the availability calculations provide the operational availability of the equipment. Operation availability is defined as:

$$Availability_{(Op)} = \frac{Uptime}{Uptime + Downtime + Logistic\ Delays}$$

To take into account the distributions of the various times which determine Operational Availability, thousands of calculation would be required using the equation above, therefore a simulation model is generally used. To predict the Operational Availability of the GPUV variants the System Availability Model (SAM) was employed and populated with the information from Table A2 and the various duty cycles. As no information was available regarding logistic delay, the simulation was run with 4 different delay times to examine the effect upon availability. The results from these simulations are given in Tables A4 and A5:

GPUV	Delay = 1 hr	Delay = 5 hrs	Delay = 10 hrs	Delay = 24 hrs
1 Tonne	99.6%	99.2%	98.7%	97.8%
1 Tonne (P)	99.3%	98.5%	97.7%	96.8%
2 Tonne	99.3%	98.5%	97.7%	96.8%
2 Tonne (SL)	99.3%	98.5%	97.7%	96.8%

Table A4 – Predicted Operational Availability Resulting from Level 1 and 2 Corrective Maintenance

GPUV	Delay = 1 hr	Delay = 5 hrs	Delay = 10 hrs	Delay = 24 hrs
1 Tonne	99.4%	99.0%	98.6%	97.6%
1 Tonne (P)	98.8%	98.1%	97.5 %	96.8%
2 Tonne	98.8%	98.1%	97.5 %	96.8%
2 Tonne (SL)	98.8%	98.1%	97.5 %	96.8%

Table A5 – Predicted Operational Availability Resulting from Level 3 Corrective Maintenance

It can be seen from Table A4 and Table A5 that Logistic Delay has a far greater influence on the Operational Availability of each GPUV variants than their respective inherent reliability or the maintenance times at the different levels of corrective maintenance. These Operational Availability predictions have been used to determine the Availability Requirements in Table 1 and being the worst case are thought to be achievable.

Annex B to Example Initial R&M Case

Duty Cycle for 1 Tonne General Purpose Utility Vehicle

The 1 Tonne General Purpose Utility Vehicle Duty Cycle is as follows:

Duration. The Duty Cycle covers a 48 hour period without servicing, replacement or replenishment (except for one permitted refuelling stop and between duty cycles), other than routine halt parade maintenance and daily checks.

Base Vehicle State. During the Duty Cycle the system shall be carrying all CES and associated items appropriate to its role. A full complement of crew and their equipment, is to be assumed at all times.

Capacity. The Duty Cycle refers to fully laden and unladen states. These states are defined as follows:

Laden – carrying 1x 1 tonne loaded NATO pallet.

Unladen – as detailed for the Base Vehicle State.

Endurance. Each Duty Cycle requires 500 km of driving over varied terrain, including hills with a gradient of 25% (1 in 4), of which 50% will be on metalled roads, 30% on firm tracks and 20% cross-country. The vehicle will travel 50% of the distance fully laden and 50% of the distance unladen.

Loading and Unloading. The vehicle will be loaded and unloaded by appropriate MHE from ground level on flat terrain.

Winching. The vehicle without assistance will perform 1 self-recovery on a 12.5% (1 in 8) uphill gradient on firm track.

Standby. When the 1 Tonne General Purpose Utility Vehicle is not moving, loading, unloading or winching, it will occupy a hide position with the radio and other essential systems in continuous operation. Radios will be operated on a Send/Receive/Standby ratio of 1:9:50. The engine may be run periodically to recharge batteries.

Cooking. The vehicle shall facilitate the preparation of 2x hot meals and 4x hot beverages (1x meal and 2x beverages per person) each 24 hour period. The vehicle shall be fitted for, but not with, 24 volt Boiling Vessel (GFE item).

Annex C to Example Initial R&M Case

Duty Cycle for 1 Tonne General Purpose Utility Vehicle (Protected)

The 1 Tonne General Purpose Utility Vehicle (Protected) Duty Cycle is as follows:

Duration. The Duty Cycle covers a 24 hour period without servicing, replacement or replenishment (refuelling is permitted between duty cycles), other than routine halt parade maintenance and daily checks.

Base Vehicle State. During the Duty Cycle the system shall be carrying all CES and associated items appropriate to its role. A full complement of crew and their equipment is to be assumed at all times.

Capacity. The Duty Cycle refers to fully laden and unladen states. These states are defined as follows:

Laden – carrying 1x 1 tonne loaded NATO pallet.

Unladen – as detailed for the Base Vehicle State.

Endurance. Each Duty Cycle requires 200 km of driving over varied terrain, including hills with a gradient of 25% (1 in 4), of which 50% will be on metalled roads, 30% on firm tracks and 20% cross-country. The vehicle will travel 50% of the distance fully laden and 50% of the distance unladen.

Loading and Unloading. The vehicle will be loaded and unloaded by appropriate MHE from ground level on flat terrain.

Winching. The vehicle without assistance will perform 1 self-recovery on a 10% (1 in 10) uphill gradient on firm track.

Standby. When the 1 Tonne General Purpose Utility Vehicle ((Protected) is not moving, loading, unloading or winching, it will occupy a hide position with the radio and other essential systems in continuous operation. Radios will be operated on a Send/Receive/Standby ratio of 1:9:50. The engine may be run periodically to recharge batteries.

Cooking. The vehicle shall facilitate the preparation of 2x hot meals and 4x hot beverages (1x meal and 2x beverages per person) each 24 hour period. The vehicle shall be fitted for, but not with, 24 volt Boiling Vessel (GFE item).

Annex D to Example Initial R&M Case

Duty Cycle for 2 Tonne General Purpose Utility Vehicle

The 2 Tonne General Purpose Utility Vehicle Duty Cycle is as follows:

Duration. The Duty Cycle covers a 24 hour period without servicing, replacement or replenishment (refuelling is permitted between duty cycles), other than routine halt parade maintenance and daily checks.

Base Vehicle State. During the Duty Cycle the system shall be carrying all CES and associated items appropriate to its role. A full complement of crew and their equipment is to be assumed at all times.

Capacity. The Duty Cycle refers to fully laden, half laden and unladen states. These states are defined as follows:

Laden – carrying 2x 1 tonne loaded NATO pallets.

Half Laden – carrying 1x 1 tonne loaded NATO pallet.

Unladen – as detailed for the Base Vehicle State.

Endurance. Each Duty Cycle requires 250 km of driving over varied terrain, including hills with a gradient of 20% (1 in 5), of which 50% will be on metalled roads, 30% on firm tracks and 20% cross-country. The vehicle will travel 50% of the distance fully laden, 25% of the distance half laden and 25% of the distance unladen.

Loading and Unloading. The vehicle will be loaded and unloaded by appropriate MHE from ground level on flat terrain.

Winching. The vehicle without assistance will perform 1 self-recovery on a 10% (1 in 10) uphill gradient on firm track.

Standby. When the 2 Tonne General Purpose Utility Vehicle is not moving, loading, unloading or winching, it will occupy a hide position with the radio and other essential systems in continuous operation. Radios will be operated on a Send/Receive/Standby ratio of 1:9:50. The engine may be run periodically to recharge batteries.

Cooking. The vehicle shall facilitate the preparation of 2x hot meals and 4x hot beverages (1x meal and 2x beverages per person) each 24 hour period. The vehicle shall be fitted for, but not with, 24 volt Boiling Vessel (GFE item).

Annex E to Example Initial R&M Case

Duty Cycle for 2 Tonne General Purpose Utility Vehicle (Self-Loading)

The 2 Tonne General Purpose Utility Vehicle (Self-Loading) Duty Cycle is as follows:

Duration. The Duty Cycle covers a 24 hour period without servicing, replacement or replenishment (refuelling is permitted between duty cycles), other than routine halt parade maintenance and daily checks.

Base Vehicle State. During the Duty Cycle the system shall be carrying all CES and associated items appropriate to its role. A full complement of crew and their equipment is to be assumed at all times.

Capacity. The Duty Cycle refers to fully laden, half laden and unladen states. These states are defined as follows:

Laden – carrying 2x 1 tonne loaded NATO pallets.

Half Laden – carrying 1x 1 tonne loaded NATO pallet.

Unladen – as detailed for the Base Vehicle State.

Endurance. Each Duty Cycle requires 250 km of driving over varied terrain, including hills with a gradient of 20% (1 in 5), of which 50% will be on metalled roads, 30% on firm tracks and 20% cross-country. The vehicle will travel 50% of the distance fully laden, 25% of the distance half laden and 25% of the distance unladen.

Loading and Unloading. The vehicle without assistance will perform 2x full (2x loaded 1 tonne NATO pallets) self-loads and unloads from ground level on flat terrain.

Standby. When the 2 Tonne General Purpose Utility Vehicle (Self-Loading) is not moving, loading, or unloading, it will occupy a hide position with the radio and other essential systems in continuous operation. Radios will be operated on a Send/Receive/Standby ratio of 1:9:50. The engine may be run periodically to recharge batteries.

Cooking. The vehicle shall facilitate the preparation of 2x hot meals and 4x hot beverages (1x meal and 2x beverages per person) each 24 hour period. The vehicle shall be fitted for, but not with, 24 volt Boiling Vessel (GFE item).

3. SUMMARY

It can be seen from this example of an Initial R&M Case that no attempt has been made to solutionise but to present the evidence and arguments to support the contention that the requirements being sort are justifiably reasonable and arguably achievable. A Contractor may not agree with the assumptions and the arguments being made but the evidence should be the most appropriate available at the time and any Contractor would be obliged to present the case differently should they disagree.

The R&M parameters of the required system, together with their measurable baseline, anticipated system usage and its environment have all been included. Perceived risks have also been included together with any assumptions and recommendations on how any Contractor may choose to mitigate risk while providing confidence in their proposed solution.

ATTACHMENT G1/3

EXAMPLE R&M CASE REPORT DURING DEVELOPMENT

1. INTRODUCTION

This R&M Case Report is an example of what could be provided for a system that has undergone a reasonable amount of development; prototypes have been built and tested, and the project is in the transition from development to manufacture. Referenced documents, trial reports, relevant minutes of meeting etc would usually accompany the case report to provide the reader with the opportunity to evaluate the evidence and argument for themselves should they so wish. It should be noted from this example that it is not necessary to produce tomes of documentation when the evidence and arguments supporting the contention of compliance is readily available from the work already undertaken as part of the development programme.

The R&M Case Report should provide sufficient evidence and argument to provide the informed reader with a warm feeling that the R&M aspects of the project are being suitably managed without the need to digest each supporting document. Should the reader require additional information or be less informed then the documents and reports should be appropriately referenced and readily available.

2. R&M CASE REPORT

2.1 Section 1: System Description

The system has been developed to provide a common interface between the Tri-service New and Legacy C^3I Data Integrity equipment. This new equipment comprising a single printed electronic circuit housed in a cast alloy container with suitable mountings, has no user interface and is connected using existing cables.

The system has been developed to meet the requirements of the development contract[1]. A schematic of the system[2] and details of the system interfaces to the platform[3] and other systems[4] are given in the associated documents. A full block diagram, showing sub-functionality relationships are given in the system description document[5].

<u>Usage:</u> the system has been designed to meet the agreed usage[6] which has been expanded from the original Use Study to take full account of the on going OA work. The expected in-service life is 7 years. This study has been presented to the R&M stakeholders and was agreed as being representative of expected usage by the R&M panel[7].

<u>Environment:</u> the system has been developed to meet all agreed environmental conditions[8] which were developed based on the MOD specified environmental conditions modified by our experience of similar systems and the expected deployment areas and our knowledge of the environments in those areas. These assumptions have been fully discussed with the MOD[9].

Build Standard: following the prototype trials[10] we are currently modifying the design[11]. This report is based on the prototype design plus the expected results of these modifications. The impact of the modifications will be monitored to ensure that the desired improvement is achieved. Full details of the design standards, drawings and specifications are included in the Master Record Index[12].

Personnel Skill Levels and Training: the system has been designed to be supported and operated by personnel as described in the Use Study.

Maintenance Policy: this is as described in the LORA which fully reflects the different maintenance routines which will be required in the different operating scenarios.

2.2 Section 2: R&M Requirements

The initial requirements of 100% Reliability[13] have been fully analysed by ourselves and after detailed discussions with the authority following our expansion of the usage, and the development of clear failure definitions[14] which have been agreed[14]; the system shall achieve not less than:

- "98% probability of achieving level 2 functionality when required over an operational deployment of 2 years; provided the maintenance support is as agreed";
- "95% probability of achieving level 1 functionality when required over an operational period of 3 weeks; provided the system is in the 100% functioning state at the start of this period;
- Any loss of level 1 functionality will be recoverable within 1hr (50%tile) & 1 day (99%tile) under the stated support conditions (including assumed logistic delays).

These figures are based on our predictive work[15] which has been baselined against similar systems[16]. The prototype trials have provided us with every confidence that we shall achieve these performance levels.

The proposed reliability metric is a simple reliability based methodology derived from the number of "unscheduled maintenance actions" and days that the systems are deployed.

2.3 Section 3: R&M Risk Areas

We have operated an R&M risk register[17] as a subset of our main risk register (thus ensuring that R&M risks do not get swamped by other risk areas), but that critical risks can influence management. Through proactive addressing of the risks, we have managed to mitigate the majority of the risks. The only remaining critical R&M risks are:

- Transition to Production: although it should be noted that the prototypes were produced using the same production processes to that proposed for the final build;
- Software Reliability: the phase 2 and 3 software will be added to the system at a later date; software is always a problem.

These risks are addressed in the plan for the next stage.

There are two risks to the R&M performance of the system which remain with the MOD:

- Use Not As Expected: if the mission profile, or area of operation varies from that agreed;
- Change in Operational Use: if new missions or areas of operation are introduced.

We recommend that the MOD review the agreed work to eliminate the first risk and that the R&M Case is kept live, so that any future change in operational use can be assessed for R&M impact, before due to misadventure, it becomes a topic of discussion in the public domain.

2.4 Section 4: R&M Strategy

In order to mitigate risks our R&M strategy for the future is to implement the following processes:

- DRACAS, this will be a continuation of the system already in place and will be used to capture all events and observations, these will be reviewed continuously and the progress in closing out "issues" will be used as a performance metric;
- Full QA will be applied to our manufacturing process with inspections at the points identified by the preliminary FMECA[18];
- We will monitor the performance of the first systems to enter service to ensure usage is representative of that specified, and performance is as demonstrated during development and acceptance;
- Any necessary changes to design, or the proposed systems, will be fully evaluated to ensure there is no impact on the R&M characteristics.

2.5 Section 5: R&M Evidence

Throughout the programme to date we have progressively built up evidence to show that the system will meet the contracted requirements. This has been reported in previous progress reports[19].

Evidence to support our argument that the R&M characteristics will meet the requirements, developed since the last report is:

- The Prototype Trial[10] conducted in accordance with the R&M Plan, had only 6 attributable failures against a maximum allowable 7 failures, and these have been entered into the DRACAS for further investigation. This indicates that our predictions are accurate and supports the contention that the requirements will be achieved;
- We have eliminated the R&M weakness, of a single, non repairable health monitoring card identified by the FMECA[20], by the addition of a parallel card which not only improves the reliability, but improves the amount of health data we can collect. If one out of the two cards fail, it will be possible to operate on one card, although the additional data collection facility will be lost.

2.6 Section 6: R&M Claims

The initial modelling indicated that the R&M characteristics would be met, this modelling was calibrated against existing systems. The prototype trials have further supported this view as the prototypes performed as expected, demonstrating that our predictive techniques are good. Our predictions are that the system will exceed the requirements providing an additional margin for error.

All of our work has been formally discussed to the satisfaction of the MOD at Project Progress Meetings and at Project Reviews and therefore we are confident that we will meet the requirement.

2.7 Section 7: Limitations on Use

Any usage of the system outside of the "expected usage" may have an impact on the R&M characteristics, this change can only be quantified when the proposed change in use is understood.

2.8 Section 8: Conclusions and Recommendations

The system will meet the user requirement and therefore the system should enter production.

2.9 Section 9: References

The following specifications, documents, reports etc. are referenced in this R&M Case Report:

1. Contract Reference …… dated …...
2. Schematic
3. Platform Interface Specification
4. System Interface Specifications
5. System Description Document Version 4.2
6. System Usage Report dated ……
7. R&M Panel Meeting Minutes dated …...
8. Environmental Conditions to be Meet by the System In-service
9. Telecon Smith/Jones dated ……
10. Trials Report Reference …… dated ……
11. Proposed Modifications
12. MRI Issued dated ……
13. ITT and SRD Reference …… dated ……
14. Failure Definitions
15. Modelling Report Reference …… dated ……
16. Modelling Calibration Report Reference …… dated ……
17. Risk Register

18. Preliminary FMECA
19. Progress Reports and R&M Review Minutes
20. FMECA Report dated ……

3. SUMMARY

With very little additional effort this example R&M Case has been drafted on less than four sides of A4 paper. This has been achieved by using material, evidence and argument that has already been captured, recorded and analysed as part of the equipment development programme and appropriately referred to, warts as well, when presenting the case for compliance.

Intentionally this example has been kept to a minimum to illustrate that the R&M Case is about quality, not quantity, which in this example has been delivered by the quality of the referenced material. In practice the trials and modelling reports, FMECA and so forth when properly written and presented with constructive objectives, conclusions and recommendations etc. deliver the arguments for compliance. The R&M Case merely links this evidence with appropriate arguments and assumptions together.

ATTACHMENT G1/4

EXAMPLE IN-SERVICE R&M CASE REPORT

1. INTRODUCTION

This R&M Case Report is an example of what could be provided for a system that has been in service for a number of years and has been in use on a regular basis by the Service User. Originally it was delivered to specification with a number of caveats all of which were addressed to the satisfaction of the customer within the first year in service.

The R&M Case Report should provide stakeholders with an overview of the systems R&M achievement during the previous agreed period of time together with a list of those R&M related issues which are currently compromising its capability. Together with sufficient appropriate evidence and argument the R&M Case Report should also enable stakeholders to make informed decisions on how to address any such shortfalls.

2. R&M CASE REPORT

2.1 Section 1: Introduction

This is the 4th Guardsman Mk II Perimeter Radar R&M Case Report and summarises the usage and R&M achievement of the Guardsman Mk II Perimeter Radar during the past twelve months. Previous outstanding R&M issues and risks are addressed together with their solution. New issues and current risks and potential opportunities are also included.

This R&M Case report will provide an input to the Guardsman Mk II Perimeter Radar annual Supportability Review.

2.2 Section 2: System Description

The Guardsman Mk II Perimeter Radar is a self-contained man portable intruder radar with a range exceeding 450 meters designed preliminarily for local area defence. The passive aerial array and advanced electronics integration enable sophisticated intruder identification with minimum false alarm rate while providing ease of operation and extended battery life. The system having a detection arc of 140 degrees can be cascaded with two or more other equipments to provide all round area defence surveillance system operated by one person.

The system which has been in service for approximately 4 years is liked by the User and has performed well. Full usage and incident reporting has been mandated since development and a comprehensive Data Recording and Corrective Action system (DRACAS) has been maintain by the Equipment Support Manager (ESM).

2.3 Section 3: Requirements and Constraints

Operational Availability (A_o)

The operational availability required for each Guardsman Mk II Perimeter Radar, including all CES items, is a minimum of 97.7% assuming any logistic delay no greater than 24 hours (total) over any consecutive 45 day period.

Reliability Requirements

Reliability Requirements of the Guardsman Mk II Perimeter Radar:

- Duty Cycle. The Guardsman Mk II Perimeter Radar shall operate continuously in a static mode at full power from a set of fully charged serviceable batteries for a period of 24 hours at an ambient temperature of 7 degrees centigrade without recharge.

- Mission Reliability. For the whole equipment, the Guardsman Mk II Perimeter Radar shall have at least a 98.2% probability of completing a Duty Cycle without a mission failure. This equates to a whole equipment probability of 55 Mean Missions Between Failures (MMBF).

- Basic Reliability. For the whole equipment, the Guardsman Mk II Perimeter Radar shall have at least a 90.48% probability of completing a Duty Cycle without a maintenance related or basic failure. This equates to a whole equipment probability of 10 Mean Missions Between Failures (MMBF).

Failure Definitions

The following failure criteria shall be applied to the Guardsman Mk II Perimeter Radar:

- Mission Failure. is any incident which would prevent the Guardsman Mk II Perimeter Radar from completing a Duty Cycle without interruption.

- Basic Failure. or maintenance related failure is defined as any unsatisfactory equipment condition which requires unscheduled maintenance intervention to restore the equipment to its design and performance build standard. It excludes scheduled maintenance but includes those action which are necessary to correct faults identified during scheduled maintenance.

- All Mission Failures which require unscheduled maintenance intervention shall also be counted as Basic Failures.

- Discounted Failures. failures resulting from misuse, accident, human error or maintenance which is not in accordance with defined schedules.

- Classification of Failures, and Incident Sentencing. should be carried out in accordance with Def Stan 00-44.

Maintainability Requirements

The following maintainability requirements shall be applied to all the Guardsman Mk II Perimeter Radar:

- The Active Corrective Maintenance Time (ACMT) at Level 1, using tools provided with the CES, must not exceed 20 minutes.
- The Mean Active Corrective Maintenance Time (MACMT) for Level 2 unscheduled maintenance is to be no greater than 2 hours, with 95% of all maintenance taking no more than 4 hours.
- The MACMT for Level 3 unscheduled maintenance is to be no greater than 4 hours with 95% of all maintenance taking less than 8 hours.
- Levels 2 and 3 maintenance tasks are to be limited to one trained maintenance tradesperson requiring no special tools and test equipment, other than those agreed by the LSA, and will be to no greater depth than sub-assembly exchange.

Durability Requirements

The service life of the Guardsman Mk II Perimeter Radar shall be 12 years based on an annual usage of 180 Duty Cycles.

Currently there is no intention to conduct a mid-life update and/or overhaul although the equipment shall be considered for modifications to meet the Services needs.

2.4 Section 4: Deployment and Achievement

Deployment

During the reporting period 23 Guardsman Mk II Perimeter Radar have been deployed and operated in a static mode totalling 957.03 Duty Cycles equating to an average usage of 41.61 Duty Cycles or 998.64 hours per equipment.

Additionally during the reporting period 3 Guardsman Mk II Perimeter Radar have been deployed and operated in a mobile mode totalling 37.42 Duty Cycles equating to an average usage of 12.47 Duty Cycles or 299.36 hours per equipment.

Achievement

During the reported period 409 incidents were recorded on the Guardsman Mk II Perimeter Radar DRACAS[1], of which 382 were sentenced[2,3,4,5] as attributable and 27 as recording action only.

Of these 382 attributable incidents 11 were classified as Mission Critical Failures and 379 as basic or maintenance relevant failures.

During the reported period the Guardsman Mk II Perimeter Radar achieved a Mission Reliability of 98.9% (against a requirement of 98.2%) equating to 90.4 MMBF (55 MMBF) and a Basic Reliability of 68.3% (90.48%) equating to 2.62 MMBF (10 MMBF).

The total recorded maintenance workload during the reported period was 746.35 hours of which 708.73 hours contributed to Level 2 maintenance and 37.62 hours to Level 3. These times do not include those attributed to logistic delay.

During the reported period the Guardsman Mk II Perimeter Radar achieved an Operational Availability in excess of the 97.7% requirement for any consecutive 45 day period. This was achieved by optimising the deployment of equipment and completing the majority of maintenance when the equipment was not required for use. On 7 occasions the User was denied an operational Guardsman Mk II Perimeter Radar for a period greater than 20 minutes.

Shortfalls in Basic or Maintenance Related Reliability remains a major concern. While system availability is being achieved it is at the cost of an unacceptable logistic overhead.

2.5 Section 5: Incidents, Issues and Risks

Incidents

The top ten reported incidents during this period are summarised in Table 1.

Serial		**Assembly**	**Failure Mode**	**Mode**	**Qty**
Current	**Previous**				
1	1	Battery (Power)	Failing to hold sufficient charge for Duty Cycle	S	41
2	3	Control Cable 100m	Damaged connectors	S	17
3	2	Power Toggle Switch	Intermittent operation	S, M	11
4	4	Tripod	Unstable on soft ground	S	7
5	8	Range Selection Knob	Becomes loose with little use.	S, M	6
6	27	Amplifier Assembly Cover Catches	External Damage	S	4
7		Power Regulation PEC	Damaged power regulation thyristor	M	4
8	15	Aerial Assembly Retaining Pin	Corrosion	S, M	3
9		Amplifier Assembly	Ingress of moisture	S, M	3
10	38	Display Case EMC Gasket	Damage	S, M	3

S = Static M = Mobile

Table 1 – Top Ten Reported Incidents

a) Power Battery Fails to Hold Sufficient Charge for the Duty Cycle:

- Issue. The 100AH Power Batteries are failing to hold sufficient charge requiring them to be replaced and recharged more frequently than planned. This is resulting in an increased logistic overhead to replace those batteries in use which are heavy and bulky to transport; then to charge them with the limited resources available.

- Solution. These batteries have been in use for approximately 4 years and are beyond their useful life. An initial order for 60 new batteries has been placed and is expected to be available to the User within 5 weeks. A three year maintenance order is currently being negotiated to provide an additional 20 new batteries per year.

b) 100m Control Cable damage:

- Issue. The 100m Control Cable which provides the connectivity to enable a number of equipments to be remotely controlled by a single operator are being damaged due to operational constraints. These cables which can be daisy chained together to provide greater range connect the radar equipment usually sited towards the perimeter of a secured area to a central hub are being snagged and damaged by passing foot and vehicular traffic.

- Solution. In accordance with current policy and guidance cables should be appropriately routed or buried where they may be prone to damage from passing traffic or from direct or indirect compromise by an enemy[6]. To be repeated in Kit Magazine.

c) Power Toggle Switch Intermittent Operation;

- Issue. A number of incidents have been reported where the Power Switch has needed to be operated a number of times before the equipment could be switched on and/or off. Investigation of failed switches has shown that a small quantity of fine sand has inhibited the switch roller from functioning correctly[7]. The switch is not a sealed assembly.

- Solution. A replacement sealed switch is currently being trialled and hopefully will be available shortly as a direct replacement. Current stocks of spare switches will be withdrawn when the replacement becomes available. A nylon protective cover was considered as an interim solution but for the limited gain offered was not thought worthy of the time and effort involved in its adoption.

d) Instability of the Tripod in Soft Ground:

- Issue. Radar horizontal alignment is conducive with the maintenance of detection clarity. In the past 2.5 years there has been a number of incidents reports where this alignment has been compromised suggesting that the Tripod was inadequate for the weight of the radar. Previous investigation by the manufacturer[8] has not support this contention because the symptom could not be reproduced however recent evidence from the field suggests that the cause may be external to the equipment.

- It was recently reported that pins supporting the guys securing aerial arrays frequently vibrate loose due to armoured tracked vehicles passing in close proximity. It is now considered that a similar effect may be causing the pointed foot of the Tripod to penetrate the ground resulting in the loss of horizontal alignment.

- Arrangements are now being made to attempt to replicate these events with the appropriate Trials and Development Unit. If this is successful the manufacturer has proposed to modify the individual feet of the Tripod to prevent similar ground penetration[9].

e) Range Selector Knob Becoming Loose:

- Issue. The Range Selector Knob becomes loose with little use. Securing the knob with the screw provided seems only to provide a temporary solution. Investigation has shown that the 2.5mm screw securing the knob should be fitted with a spring washer[10]. Unfortunately this spring washer has been omitted from the illustrated parts list although fitted originally as part of the development. When the spring washer is not fitted the securing screw ‘bottoms out’ within the switches threaded shaft preventing adequate tension to retain the knob.

- Solution. Fit spring washer, steal, electroplated, 2.5mm (xxxx-xx-xxx-xxxx) between the head of the securing screw and knob as required during maintenance. The AESP is in the process of being amended.

f) Amplifier Assembly Cover Catch Damage:

- Issue. Investigation has shown that during the reporting period 4 Amplifier Assembly Cover Catches were replaced due to their inability to retain the cover securely. The secure retention of the cover is important to protect the equipment from the elements in particular moisture, dust and fine sand. Three of the catches were returned for investigation[11] each of which bore an excessive quantity of teeth abrasions similar to those found on bull nose pliers. While it is appreciated that engineers will occasionally improvise with repairs it is considered that perhaps on these occasions they have been somewhat over zealous.

- It is important to retain the integrity of the sealing of all the covers employed on the Guardsman Mk II Perimeter Radar. Should the cover not be correctly fitted undue force is required to engage the catch fully which is thought to have occurred in these instances, stressing the retaining lug. Quantity 19 spare catches are held in store and only 7 catches have been issued in the past 2 years. Users and maintainers need to be reminded of the correct procedures for the operation and maintenance of the system.

g) Power Regulation PEC Failure:

- Issue. In the reporting period 4 Power Regulation PECs have been reported as failing. Investigations have shown that in each instance the same power regulation thyristor had short circuited in 2 instances severely damaging the electronic circuit board with excessive heat. In the previous 3 years only one other Power Regulator PEC had failed again due to a short circuited power regulation thyristor.

- On all 5 occasions further investigations found that the radar had been deployed in the mobile mode taking its power from the vehicle electrical supply[12]. Investigations are on going.

h) Aerial Assembly Retaining Pin Corrosion:

- Issue. Instances are still being reported of corrosion to the Aerial Assembly Retaining Pin.

- Previous investigation[13] found that the corrosion was a result of an inferior plating process during initial manufacture and that damaged or suspect pins had been subsequently replaced. It is thought that a number of equipments may have slipped through the net and/or that suspect pins had not been removed from stock and reduced to scrap as directed.

- A request has been made for damaged pins to be returned for investigation to ensure that the current solution is effective and that pins subsequently manufactured are not exhibiting similar damage.

i) Amplifier Assembly Ingress of Moisture:

- Issue. In the first 6 months of the reporting period a number of instances were reported where desiccators fitted to Amplifier Assemblies showed pink and the possible presence of moisture; and not blue as required.

- Investigation found that these and other equipment were being returned to the User without appropriate drying prior to sealing due to the heavy workshop throughput at the time and the lack of suitable drying equipment. The availability of suitable drying equipment and the appropriate sealing of equipment is being monitored at workshop level.

j) Display Case EMC Gasket Damage:

- Issue. There is an increased incidence of gasket damage being reported. The gasket which sits in a machined rebate in the Display Case front edge provides EMC integrity when correctly fitted and appropriately torque loading. In each incident the gasket has been found to be twisted and/or crushed resulting from incorrect assembly.

- The gasket which has a small cross sectional area and is flexible by nature is easily stretched when removed from the case making it more difficult to re-fit. This is explained in detail in the AESP guidance together with the need to allow the gasket to ‘settle’ prior to re-fitting when its removal was unavoidable.

- Units have already been reminded of the maintenance and care of replaceable gaskets[14].

Issues

The two issues that are causing most concerns are the large number of maintenance related failures attracting repair and the significant increase in the number of Power Regulation PEC failing.

Initial analysis of the Guardsman Mk II Perimeter Radar DRACAS shows few trends either in the type of incidents being reported, the mode of operation when the incident occurred or the scenario in which the system was being employed at the time. In any other circumstances it could easily be thought that many of the incidents could be attributed to the User however because in excess of 60% of equipments are operated remotely at any one time this seems unlikely. The analysis of incidents against holding units and individual operators likewise showed few trends to prompt meaningful investigation.

Investigation has highlighted that neither the physical siting of the radar or the actual time of the incident are accurately recorded. The incident reporting process is currently being examined and Users have already been requested to provide greater details when reporting incidents.

Power Regulation PEC failures have only been recorded in association with mobile deployment pointing the finger squarely at the host installation. What currently is not understood is the quality of power being provided by military vehicles and presently a task is underway to record the cleanliness of vehicle power. The results of this survey will be published for the benefit of all those who use vehicle power as the power source for their equipment. It is hoped that this survey shall also provide a way forward to resolving this Power Regulation PEC issue.

Other issues which are being addressed include the repair turn round time of a number of LRU's from industry, the short supply of User replaceable items and the delay in the provision and publication of the 2nd Power Amplifier Stability Modification. A detailed of these and other issues with associated mitigation activities is attached to this report[15].

Risks

All the risks associated with the Guardsman Mk II Perimeter Radar are recorded in the Project Risk Register. The current top three R&M risks are:

- Power Regulation PEC failures;
- Maintenance workload;
- Ongoing PDS funding.

In the reporting period the only Power Regulation PEC's to fail have been those when the radar has been used in a mobile mode and its power taken from the host vehicle. It may be coincidental but it is thought that the failures are the result of 'dirty power' being provided by the vehicle and the combination of high transient voltage spikes from the vehicle electrical supply and inadequate protection within the equipment PSU resulting in the thyristor being damaged. An investigation is presently being carried out to measure the voltage provided by a number of small and medium utility vehicles including the recording of voltage ripple and voltage spikes on supply lines using an oscilloscope. This monitoring should be completed within the next 2 weeks and an initial report published 2 weeks later.

Present Basic or Maintenance Related Reliability is poor and has created an unnecessary logistic burden and overhead. The current maintenance workload is unsustainable and is only being contained at the detriment of other electronic equipment. It is suspected that many of the failures are User induced however until the siting of unattended remote equipment is understood and any tampering unintentional or otherwise has been determined it is difficult to make an informed decision about how to resolve this issue. Steps have been taken already as a precautionary measure to reinforce the emphasis during training of equipment husbandry; and in-service of operator management and comprehensive incident reporting.

There are presently 15 months remaining of the current 3 years PDS contract and 11 months remaining on the CLS LRU maintenance contract. While both these contracts are the domain of the Project Team/ILSM as financial support gets squeezed on an annual basis any reduction in PDS and maintenance support will inevitably have a knock on effect to R&M and in turn capability. Little can be done presently to influence future expenditure however resolving the current unreliability issues would go a long way to reducing any impact this may have in the future.

2.6 Section 6: Conclusions

The Guardsman Mk II Perimeter Radar is performing well in service, is preferred to other intruder detection systems by the User being light to transport and easy to set up and operate. It has its issues but nothing so major that cannot be resolved in the short to medium term.

The issues of Power Regulation PEC damage and poor Basic Reliability have been discussed in detail, neither of which is insurmountable. However, it is thought that User training would benefit from improvements in some areas, as could the reporting of incidents.

While Mission Reliability has exceeded expectations, annual usage is less than that previously envisaged providing a future opportunity to extend the in-service life of the equipment should this rate of current usage continue.

2.7 Section 7: Recommendations

It is recommended that this annual R&M Case Report for the Guardsman Mk II Perimeter Radar is accepted and that the management and mitigation of the current issues and risks are supported.

2.8 Section 8: References

1. Guardsman Mk II Perimeter Radar DRACAS Report Reference …… dated ……
2. Minutes 13th Incidence Sentencing Committee for the GPR Mk II dated …...
3. Minutes 14th Incidence Sentencing Committee for the GPR Mk II dated …...
4. Minutes 15th Incidence Sentencing Committee for the GPR Mk II dated …...
5. Minutes 16th Incidence Sentencing Committee for the GPR Mk II dated …...
6. Guidance on the Laying and Routing of Over-ground Cables V2.0 dated ……
7. Power Toggle Switch Premature Failure Report Reference …… dated ……
8. Report into the GPR Mk II Loss of Aerial Horizontal Alignment Reference …… dated
9. Minutes of the 22nd GPR Mk II PDS Working Group dated ……
10. Range Selector Knob Investigation Report Reference …… dated ……
11. Amplifier Assembly Cover Catch Damage Report Reference …… dated ……
12. Interim - Power Regulation PEC Failure Report Reference …… dated ……
13. Aerial Assembly Retaining Pin Corrosion Report Reference …… dated ……
14. Maintenance and Care of EMC and other Flexible Gaskets Reference ……dated ……
15. Issues List Reference …… dated ……

3. SUMMARY

This R&M Case Report has been written as a stand alone document and sufficiently detailed to enable the reader to obtain an informed overview of the equipment's achievement over the described period without the need to research further. It contains a brief equipment overview; R&M related requirement and usage profile together with, in this instance, the top ten issues recently affecting its capability.

An outline of each issue is provided together with the actual or proposed solution. Where the issue has yet to be resolved, this is supplemented with the actions already taken to resolve the issue together with the timescale it is likely to be achieved in. References to reports have been included to enable readers to research further should they so wish. These reports would accompany the publication of the R&M Case Report on preferred media for hard copy or hyperlinked within the Defence Intranet.

Other than the content relating to Requirements and Constraints which have been gleaned from previous reports and was originally taken from the equipment requirement the majority of this R&M Case Report has been a direct output from the equipment DRACAS suitably filtered to provide the information required. All the references are documents linked directly to the DRACAS making them readily available for inclusion with the report.

The format of the R&M Case Report is one to suit the equipment or system being reported on. When reporting on larger or more complex systems, sub-dividing the reports by the system boundaries, or having more than one report may make reporting easier. Such boundaries may be physical, functional, or contractual where equipment or sub-systems are being managed and/or maintained by industry. Should a new capability be fitted to the host system or a current capability enhanced, that capability may warrant an R&M Case Report in its own right, perhaps not for the future life of the system but for sufficient time to ensure it delivers the agreed capability within the constraints of the contracted requirements.