

# Objective Reuse of Heritage Products

April 30, 2012

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Prepared for:

National Reconnaissance Office

14675 Lee Rd.

Chantilly, VA 20151-1715

Contract No. FA8802-09-C-0001

Authorized by: National Systems Group

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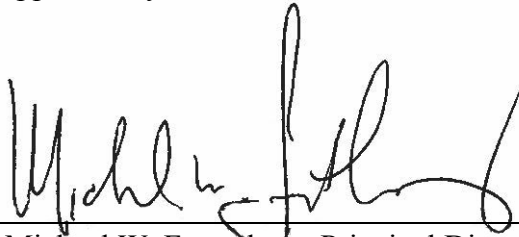
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## Objective Reuse of Heritage Products

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## Executive Summary

In an optimal situation, the term “heritage” (as it relates to systems) means that a heritage item is of the same design, components, materials, processes, and manufacturer as its predecessor and will be applied, integrated, and operated in an environment that is identical to its predecessor. This all or nothing set of conditions for defining heritage is not the likely scenario under which complex systems are developed. The range, which lies between meeting all of the conditions above and none of the conditions above, is vast, yet the term “heritage” has been used across this spectrum. This guidance, derived from real-world industry experience, provides an objective method to address this challenge.

Developers of space flight equipment often look for opportunities to reuse heritage products instead of developing new equipment. Based on existing knowledge of the heritage product, reuse can provide benefits to the development effort, such as reduced risk due to fewer “unknown-unknowns” and reduced development activity (design, fabrication, and verification), which can translate into decreased development cost, schedule, and contingencies (interfaces, mass, volume, power, and environmental). Due to these benefits for complex high-reliability space equipment developments, heritage product reuse planning and processes should be an integral part of the space system development process.

However, heritage product reuse needs to be treated with caution for several reasons. Reusing existing hardware, equipment, and/or designs can constrain the design options at the next higher level of integration; i.e., interfaces. Also, reuse decisions are typically made early in the development process, often prior to system-level preliminary design, before requirements have been finalized. As a result, the development planning may assume reuse benefits that are not realized due to subsequent system-level design. This can result in inadequate resources identified for heritage product redesign, rework, and re-verification needed to accommodate the maturing design. This can lead to programmatic issues (increased cost and schedule), high-risk technical compromises, or both. Finally, if the reuse decision is not revisited as the system-level development matures, then needed heritage hardware modifications may not be identified, resulting in technical deficiencies that may not be identified until the next level of integration or, of more concern, on orbit.

To help mitigate these concerns, objective criteria to evaluate heritage hardware are presented in the form of a Heritage Readiness Level rating matrix. This tool is intended for use by those involved in heritage hardware reuse during space flight development and is based on industry best practices. Discussion of the programmatic challenges associated with evaluating reuse opportunities throughout a program’s lifecycle is presented based on the application of this guidance.

This document supersedes TOR-2009(8546)-8604, Rev. A and TOR-2010(8591)-19, which were written to address aspects of assessing the reuse of heritage and legacy products.



## Acknowledgements

This document has its origin in two previous Aerospace TORs produced as collaborate efforts of the National Security Space Mission Assurance Improvement Workshop. This forum was organized to enhance mission assurance processes and supporting disciplines by utilizing an issues-based approach through collaboration between industry and government across the U.S. space program community. This approach engages relevant subject matter experts to share best practices across the community, yielding valuable Mission Assurance guidance products.

This document was created from the many contributions of government and aerospace industry personnel. The authors express deep appreciation to those individuals and their representative organizations that enabled their participation. In particular, the authors would like to thank the following organizations:

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## 1. Introduction

### 1.1 Background

Developers of space flight equipment often look for opportunities to reuse heritage products as opposed to developing new equipment. Accordingly, heritage product reuse planning and processes are an integral part of the space system development process. However, there is no common approach across the space community to ensure a consistent assessment and risk evaluation of heritage products. The guidance contained herein was created to fill that void.

Heritage and legacy designs are expected to cost less, work better, and be more reliable, but these assumptions at times have proven invalid. While it is common practice in the space industry to use heritage products, certain problems with this practice persist. Poor assumptions are sometimes made regarding the heritage hardware suitability for new programs. Proposals tout the value of heritage and legacy, but use has produced unintended consequences. Program schedules and budgets subsequently come under pressure to accommodate subtle differences in application, design, mission environment, and late arriving failure data. Mission failures can result from erroneous assumptions about the applicability of the requirements, configurations, performance, and reliability of heritage and legacy elements.

These conditions have led to situations where industry and government have been surprised when a previously designed and developed product did not work as intended in a follow-on effort or in a new application or mission. When decisions regarding the reuse of products are based on inadequate examination of the heritage system applicability, this can lead to: misplaced confidence and aggressive assumptions (such as shortcuts in test) about the cost and schedule benefits of reuse; requirements/design modification and associated changes in verification methods; inaccurate assumptions for the behaviors of heritage designs causing interface problems, complex configurations, performance impacts, and operations errors.

The term “heritage” lacks a common and industry-wide approach to objectively apply criteria to assess the hardware pedigree. This often leaves decisionmakers without appropriate tools and methods to make decisions regarding the reuse of heritage hardware. The lack of a space industry standard approach for evaluating the reuse of heritage products has resulted in guidance on the subject from industry/government teams. This document is a synthesis of that guidance, primarily in the area of using objective criteria to evaluate a program’s reuse decisions associated with heritage hardware. As opportunities develop to employ this guidance, refinements will be possible particularly with respect to providing examples and greater user advice.

### 1.2 Applicability to Hardware

This document identifies and defines the objective criteria required to assess the applicability of an existing qualified product (heritage hardware) for a new application (heritage reuse) and to quantify the program level risk associated with the reuse decision. Although the objective criteria and processes discussed in this document could apply to multiple levels of hardware products from complex parts to subsystems, the focus of this document is at the flight unit level.

The intent of the heritage readiness level (HRL) score is to have a standard method to communicate the technical and programmatic risks associated with reuse of heritage products. The heritage reuse assessment determines the degree to which previously qualified heritage hardware requirements envelop the new flight unit’s application, requirements, and design margins.

The tasks involved in performing the heritage hardware reuse assessment include a thorough evaluation of the new program's unit requirements, a mapping of those unit requirements into the candidate heritage hardware capabilities, an analysis of heritage hardware existing versus current use requirements and a supporting risk assessment.

Calculation of the HRL score for a proposed hardware unit is most valuable if accomplished during the early phases of a program (i.e., proposal, concept development, and architectural definition, etc.) and then revisited if changes occur. This process is performed whenever reuse is being considered or as necessary throughout the program lifecycle. It is important to know as much as possible, as early as practical, about the feasibility, benefits, and risks of reusing products.

System functions and requirements must still be proven, even if the capability is provided by a reuse product. Neither this decision process, nor the application of a reuse product, obviates or reduces the need for a verification and validation (V&V) process. The approach to V&V may leverage the analysis and rationale collected as a part of this decision process. However, it is not the intent of this guidance to suggest how V&V of reused products (or systems that employ them) should be accomplished.

### **1.3 Applicability to Software**

For any software project, it is common to consider software reuse: as a means of reducing the development effort since less software and/or software artifacts would have to be produced; and as a means of improving quality, when the reused software is well known. Reused software may include commercial-off-the-shelf (COTS), acquirer or developer furnished software from another program, or products from a software library. Note that the term "reused software" frequently refers to the code only; however, reused software may also include artifacts such as designs, test tools, and documentation.

Reused software, however, may not fully meet the requirements of the project under development and/or the design of the reused software may not be compatible with the new system architecture. As a result, reused software usually requires modification for use in a new system. In the case of COTS, which cannot be modified, or the use of disparate sets of reused software, the development of "glue code" may be required to adapt the COTS product and integrate existing software products, respectively. Accomplishing these modifications can be made even more challenging in situations for example, where documentation is of poor quality or missing, the original operational environment and intended use of the reused code differs from that of the new system, or the new project team lacks experience with the reused software. Furthermore, the likelihood of latent defects, as well as unintended or emergent behaviors even in operational code, requires additional testing to minimize uncertainties. It is for this reason that reused software should be essentially treated as new, particularly with respect to integration and test.

Collectively, these challenges generally require greater effort than expected to effectively employ reused software. These challenges also suggest that the key criteria for evaluating the potential reuse software products are somewhat different from that of heritage hardware. Through V&V, the functionality and performance of hardware for a given state (a known and measurable configuration of the physical and environmental condition such as thermal or spectrum) can be determined with certainty. For software, there is no equivalent to this "known configuration" when the software is executing. While the "static" configuration (the suite of software and data sets) may be known, the state or "dynamic" configuration during execution (running software and evolving data sets) inherently means that the functionality and performance are constantly changing. Whereas hardware has real-world limits that can reasonably bound or predict the possible states during operation,

software interacts with other systems, the real world, through sensing and with people. Applying reused code in a new system initiates a new set of dynamic interactions, creating a possible explosion of new states for the software. It is for this very reason that previously demonstrated performance (or anything similar to qualification which carries significant weight in the selection of heritage hardware) is of little to no importance in the selection of software to reuse. What's important for software is the level of understanding about the software item, particularly through the use of tools, documentation and/or direct knowledge from experienced staff.

There is at least one additional key difference in the treatment of heritage hardware and reused software. Heritage hardware is often perceived as a means to leverage existing items, and introduce savings by reducing effort to "prove" the functionality/performance of that item. Reused software is perceived as a means to leverage existing solutions/capabilities, but there is no implicit assumption that the reused item can be used without proof, the savings occur upfront, in not having to resolve the problem, not in reduced V&V. Therefore, the remainder of this document focuses solely on hardware. However, section 6 contains references for reusing software.



## 2. Overview

Briefly stated, the heritage hardware reuse assessment objectively quantifies the degree of compliance of a heritage flight unit with new program's requirements and the risk involved in making the unit ready for reuse.

The assessment reviews objective evidence about the subject unit relative to the requirements of the new target program in order to determine the compliance of the unit with applicable requirements. In addition, any supplemental activities necessary to achieve compliance are identified and become part of the reuse assessment. The unit can also be rated on each criterion (i.e., technical parameter and evaluation measures) and the results rolled up into an overall HRL score that can be used to communicate the unit's readiness for reuse. Figure 1 is an overview of the HRL rating matrix with the key elements identified. The next sections will discuss the tier assessment approach, in which ratings are done at varying levels using the corresponding labeled technical parameters. The HRL rating matrix is presented herein as a tool to support this heritage hardware reuse assessment process with discussion of how and when to use this tool.

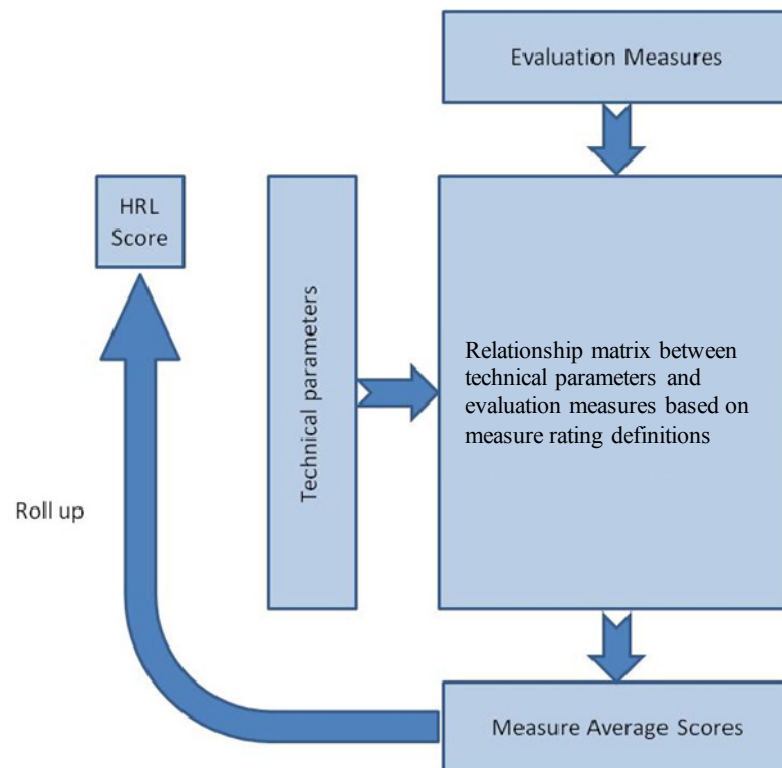


Figure 1. HRL rating matrix overview.

### 2.1 Tiered Approach to Reuse Assessment

The tiered approach provides for assessments to be performed and communicated at several levels of detail. Each successive tier provides more specific insight and requires more specific investigation. A program can choose the assessment tier based on factors such as the type of decision to be supported by the assessment and resource availability (schedule, funding, information, and technical experts). Confidence in the reuse assessment should be significantly greater for a Tier 3 assessment with 177 objective criteria versus a Tier 2 assessment with 25 criteria, or a Tier 1 used to evaluate the

5 top-level objective criteria. The potential reasons for choosing a particular tier level during the program lifecycle are discussed below.

### **2.1.1 Tier 1 Assessment**

A Tier 1 assessment deals with broad criteria and is designed to support high-level reuse decisions, such as narrowing the field among a range of design options. A Tier 1 assessment is not designed to provide specific insight to support a final reuse decision.

The Tier 1 assessment relies on a small number of objective criteria, that were carefully chosen and based on industry and government shared lessons learned. Tier 1 assessment focuses on highlighting how reuse will involve any of the following five risk area. (See Appendix A, Table A-1.)

1. Performance: Are the performance requirements more stringent?
2. Design: Will a design change be required?
3. Environmental: Will the environmental exposure be more severe?
4. Manufacturing: Will manufacturing be done differently from the heritage manufacturing?
5. Program Controls: Does the program require more stringent controls that affect the practicality of reuse?

### **2.1.2 Tier 2 and Tier 3 Assessment**

Tiers 2 and 3 involve more specific criteria and provide more precise conclusions about the reuse. (See Appendix A, Tables A-2 and A-3.) For example, a Tier 1 assessment might identify that a unit design change is required, while a Tier 3 assessment will provide detail as to which requirements necessitate the design change and what activities will be necessary as a result. An example of a completed Tier 1, 2, and 3 assessments can be found in Appendix B, Tables B-1, B-2, and B-3.

## **2.2 Assessment Timing**

Reuse assessment should be timed to support program decisions. The following are examples of decision and planning events for which the program should consider obtaining reuse assessments.

1. Requirements development. Use information about heritage units to develop program requirements which achieve mission objectives and also obtain the benefits of hardware reuse.
2. Design development. For unit selection trade studies, compare reuse assessments among alternatives heritage and new units.
3. Program planning. Determine activities necessary to incorporate heritage hardware into the new program. Complete detailed cost estimation, staffing, scheduling, and set aside appropriate programmatic reserves based on uncertainties.
4. Proposal preparation. Perform reuse assessments in order to document and communicate the extent of unit compliance and the activities involved in reuse.
5. Program baselining. Perform reuse assessment to ensure all factors have been addressed in final requirements, design configuration, and program planning.



6. Program execution milestones. Reassess planning assumptions as the program matures. Review aspects of planning, design and verification, and possibly make revisions to accommodate changes in the program or system-level requirements and design.

Adequate readiness assessment and reuse planning need to be completed prior to the new program's authority to proceed (ATP) to enable detailed cost estimating, staffing, and scheduling. Proper reuse planning, including appropriate programmatic reserve based on uncertainty, will minimize risk associated with technical compromises due to lack of resources.

Throughout the program lifecycle, the planning assumptions for heritage hardware reuse (like new flight unit development) need to be re-examined in light of the maturing nature of the program. Aspects of planning, design and verification of heritage hardware reuse, and flight unit development need to be reviewed and possibly changed to accommodate changes in the program or system-level requirements and design.

### **2.3 Hardware Certification/Heritage Review**

The qualification to baseline application requirements and the associated flight usage history of the proposed reuse unit need to be assessed to confirm/certify its heritage. To examine the qualification of the proposed reuse unit with regard to its baseline application requirements, the unit qualification data (including its qualification certificate) can be evaluated in accordance with the guidelines of Reference 1. Qualification data is typically the primary objective evidence evaluated against one evaluation measure in the HRL rating matrix. Other evaluation measures will inform areas of deficit in the baseline qualification and of the need for delta-qualification activities. In addition, the flight usage history of the proposed reuse unit is examined as deemed appropriate, with respect to its mission success.



### 3. Objective Criteria

Objective criteria for reuse specify the standards for the subject unit to be deemed ready for reuse. For each program requirement, the standards for reuse readiness are that, (1) the substantiating evidence is objective and completely available, (2) the target program requirements are completely defined, (3) the unit is fully compliant with target program requirements and is substantiated by objective evidence, and (4) no non-recurring activity or adaptation is necessary for reuse. The unit is rated on each of the above points and the results are rolled up into an overall HRL score. Note that these criteria set the standard for complete reuse readiness with the highest HRL score possible, but a heritage unit with a lower HRL score might still provide the best design option compared to the alternatives.

#### 3.1 Heritage Hardware Objective Criteria Assessment

The HRL rating matrix (see Appendix A) establishes a method for quantitatively rating the readiness of heritage hardware for reuse in the new application (i.e., the target program or that program targeting reuse of heritage hardware). To that end, the HRL rating matrix consists of objective criteria as defined by technical parameters (rows) and evaluation measures (columns). The HRL rating matrix supports a comprehensive reuse assessment by capturing a user's evaluation of each technical parameter relative to each of the measures listed below:

1. Is the objective evidence available relative to successful requirements implementation, verification, and space flight operation of the heritage unit? (Measure 1: Heritage Hardware Objective Evidence Availability - rating ranges from "unknown" to "completely available")

The purpose of this measure is to ensure that objective evidence is available for the heritage hardware from a previous program (application). This evidence is necessary to establish the baseline for this hardware unit in consideration for its new application. Previous qualification data is a significant component of the required objective evidence; therefore, if that data does not exist for a specific technical parameter (the rows), there exists a risk in being able to assess the previous performance with respect to the target program's application.

2. Are the target program's requirements completely defined for heritage hardware? (Measure 2: Target Program Requirements Definition - rating ranges from "unknown" to "completely defined")

In order to assess the application of the heritage hardware to the new application, there must be a clear determination of the new program's requirements. If any requirements are undetermined for the target program, then a clear assessment cannot be made and an associated risk will exist in determining the applicability of the heritage hardware.

3. Does the heritage hardware objective evidence indicate compliance with the target program's requirements, including verification method compliance? (Measure 3: Heritage Hardware Compliance to Target Program—rating ranges from "unknown" to "completely compliant")

This is the technical assessment of the heritage design, function, and performance, against the target program's requirements and constraints.

4. What is the extent of activity required for the heritage hardware to meet the target program's requirements? (Measure 4: Heritage Hardware Activity for Target Program - rating ranges from "extensive activity required" to "no activity required")

When the other three HRL rating matrix measures above (1, 2, and 3) indicate that either information, testing, performance or previous qualification data is sufficiently lacking, this is the technical or programmatic assessment of the work (analysis, testing, redesign, etc.) necessary to ensure compliance with the new target program requirements and environments.

Of course, as is true of any process or assessment tool, the HRL rating matrix results are as good as the information provided as input. Even though the HRL score can be used for decision making throughout the program, the score itself should be generated and reviewed with the support of appropriate subject matter experts (SMEs). The parameters needing to be measured for reuse assessment and planning are technical and may be subtle. Determining the applicability of heritage hardware requires a detailed review of objective evidence.

### **3.2 Objective Criteria Assessment Responsibilities**

Use of the objective criteria is not intended to replace or take precedence over existing processes such as qualification reviews, delta qualification planning, etc. The objective criteria assessment is a synthesis process and provides a mechanism to collect and integrate information that is more than likely generated from existing processes and key personnel. For example, identifying reuse issues may be the role of the hardware responsible engineer and supported by specialty engineering and SMEs. Functional representatives from systems engineering, mission assurance, specialty engineering, program design, manufacturing, and program management, along with process representatives such as Qualification Review Board, all may have a role in providing information critical to the assessment.

## 4. Generating the Heritage Readiness Level (HRL) Score

### 4.1 Introduction to HRL Tool

It is recommended that the HRL rating matrix be implemented as a spreadsheet for ease of use for data entry and scoring calculation/display. As a note, a Microsoft® Excel tool is available from The Aerospace Corporation upon request which has worksheets both for data entry and for display of scoring results. To fill out the HRL rating matrix, place a numeric rating in the matrix cells for each technical parameter (within each row) relative to each evaluation measure (within each column) using the rating definitions for each measure (shown at the top of each column). When entering ratings for technical parameters, the use of numeric ratings that range from 1 to 9 allows for simple averaging. Definitions for ratings 1, 5, and 9 have been provided.

The overall HRL score\* is, by default, the average of all the matrix cells in which a numeric value is inserted. The HRL tool allows the user to select “NA” for any technical parameter, including those items highlighted in yellow and listed with either (Tier 1) or (Tier 2) nomenclature. Technical parameters rated as NA will not be included the HRL score calculation. This tool will allow for using different weighting for measures and/or technical parameters. Appendix A, Tables A-1, A-2 and A-3 present the technical parameters that would be evaluated for Tier 1, 2 or 3 assessments respectively with all objective criteria being equally weighted. That is, each of the four measures is weighted at 0.25 and each of the five technical parameter categories is weighted at 0.20.

\*The HRL score is located in the top row, first column of the HRL rating matrix. HRL score definitions are:

- 9- Heritage Hardware complies with Target Program Requirements (HH c/w TPR) in all cases; no activity required for reuse except acceptance testing.
- 8- HH c/w TPR in all cases; minimal additional activity required for reuse.
- 7- HH c/w TPR in most cases; minimal additional activity required for reuse.
- 6- HH c/w TPR in most cases; moderate additional activity required for reuse.
- 5- HH c/w TPR in some cases; moderate additional activity required for reuse.
- 4- HH c/w TPR in some cases; significant additional activity required for reuse.
- 3- HH c/w TPR in few cases; significant additional activity required for reuse.
- 2- HH c/w TPR in few to no cases; major activity required for reuse.
- 1- HH c/w TPR in few to no cases; no apparent benefit for reuse.

### 4.2 HRL Rating Matrix Utilization

A program can tailor the technical parameters, evaluation measures, weighting of parameters/ measures and scoring definitions to meet their needs. Any tailoring should be clearly documented and communicated throughout the program to avoid misunderstanding. Also, any tailoring should be approved by the customer, especially if the HRL score is being used as a basis for competitive selection of a supplier. Given the flexibility of the HRL tool, special attention should be exercised when using HRL scores for comparison. The documented tailoring provides a means to determine the extent to which comparisons can be made and/or areas that need normalization to enable comparisons. Therefore, use of this tool should be clearly described in a program’s reuse plan (or equivalent).

The HRL rating matrix is a tool that can be used by the program for early trade studies and proposal planning relative to multiple heritage hardware options, as well as used for final reuse decisions. By rating only Tier 1 and/or Tier 2-level technical parameters against the evaluation measures, the program can get a preliminary assessment of the heritage hardware reuse risks. This preliminary assessment can be useful in performing trade studies or proposal planning often done early in the program before all the SMEs are available to perform a complete assessment. However, rating of all the technical parameters against each evaluation measure should be done by the appropriate SMEs prior to the final reuse decision, e.g., entrance criteria for heritage hardware reuse reviews. NOTE - In this case, the Tier 1 and Tier 2 “technical parameters” would simply be categories that summarize the average scores of the detailed technical parameters.

Relative to verification, it is assumed that each technical parameter for the heritage hardware was verified using a specified verification method (e.g., analysis, test, inspection, demonstration, and qualification by similarity, etc.). It is also assumed that each technical parameter for the target program is required to be verified using a specified verification method. Based on these assumptions, when entering numeric ratings for Measure 3 in the matrix, SMEs should consider the compliance of the heritage hardware to the target program’s requirements and the specified verification method for each requirement.

Once the HRL score has been determined using the objective criteria from the matrix, this score can be used to communicate the relative risk of reuse. If the HRL rating matrix is used consistently on a program, then the overall score can be the basis for trade-offs between development options; e.g., newly developed hardware option versus one heritage hardware option versus another heritage hardware option, etc.

## 5. Acronym List

ATP	Authority to Proceed
CDRL	Contract Data Requirement List
COTS	Commercial-Off-The-Shelf
DPA	Destructive Physical Analysis
EIDP	End Item Data Package
ERB	Engineering Review Board
ESD	Electrostatic Discharge
E3	Electromagnetic Environmental Effects
EH&S	Environment, Health, and Safety
EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility
FRB	Failure Review Board
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
GIDEP	Government-Industry Data Exchange Program
GSE	Ground Support Equipment
HW	Hardware
HRL	Heritage Readiness Level
MTBF	Mean-Time Between Failure
P/N	Part Number
QRB	Qualification Review Board
RFP	Request for Proposal
ROM	Rough Order of Magnitude
SME	Subject Matter Expert
SOW	Statement of Work
STE	Special Test Equipment
SW	Software
TOR	Technical Operating Report
UVF	Unverified Failure
V&V	Verification & Validation





## 6. Reference Documents

1. The Aerospace Corporation Technical Operating Report, TOR-2010(8591)-20, Flight Unit Qualification Guidelines, 30 June 2010
2. Space and Missile Systems Center Standard, SMC-S-012, Software Development for Space Systems, 13 June 2008
3. The Aerospace Corporation Technical Operating Report, TOR-2004 (3909)-3537, Software Development Standard for Space Systems, Rev B, 11 March 2005
4. Space and Missile Systems Center Standard, SMC-S-013, Reliability Program for Space Systems, 13 June 2008
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6. Space and Missile Systems Center Standard, SMC-S-016, Test Requirements for Launch, Upper-Stage and Space Vehicles, 13 June 2008
7. The Aerospace Corporation Technical Operating Report, TOR-2004(8583)-1, Rev A, Test Requirements for Launch, Upper-Stage and Space Vehicles, 6 Sept 2006
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9. The Aerospace Corporation Technical Operating Report, TOR-2007(8583)-6414, Volume 1, Rev A, Technical Reviews and Audits for Systems, Equipment, and Computer Software, 30 January 2009



## 7. Definitions

**Flight Unit**: A complex assembly specified and designed to perform specific functions in launch and/or space mission of a spacecraft, capable of being fabricated repeatedly.

**Flight Unit Qualification**: The formal verification (by tests, analyses, inspections, demonstrations and/or similarity) of design requirements including margin, product robustness, and workmanship.

**Heritage Hardware**: A product (e.g., complex part, unit, assembly, subsystem, or system) whose design has previously undergone qualification and flown.

**Heritage Readiness Level (HRL) Score**: A numeric rating (e.g., a value between 1 and 9) which quantitatively indicates the likelihood a heritage product will meet program requirements and enhance program success, mission success, and predictability with low risk.

**Objective Criteria**: The standard against which heritage hardware is assessed or the state required for the hardware to be deemed fully ready for reuse. As it relates to heritage hardware reuse, an individual objective criterion sets a bar for complete reuse readiness within the context of the specific criterion.

**Objective Evidence**: Product specific information, analysis and data, such as drawings, design, manufacturing records, parts, materials, test results, flight history, requirements documentation, qualification and verification records, waivers, anomaly resolutions, etc.

**Qualification**: Test, analyses, inspection, demonstration conducted to demonstrate satisfaction of design requirements including margin and product robustness for designs that have no demonstrated history. A full qualification validates the planned acceptance program, in-process stress screens and retest environmental stresses resulting from failure and rework.

**Qualification Certified**: A decision based on the completeness and applicability of the qualification data associated with hardware begin consider for reuse.

**Qualification by Similarity**: An approach to apply the qualification history (test, analysis, inspection, demonstration) of a previously used hardware item to meet the qualification requirements for reusing that hardware on a different system or mission.

**Reuse**: The utilization of a previously developed product. Typically the intent of reuse is to avoid duplication of development, tooling or qualification test (i.e., costs and schedule) by the application of existing hardware or software products that have been previously used.

**Reuse Plan**: A summary of the steps required to perform necessary product development and risk mitigation. The plan outlines actions needed to replicate the unchanged portions of the product, and minimize risk in portions that require modification. Such a plan may be contained in existing documentation and/or accomplished by existing processes.

**Review**: A review is a forum and a process to provide assurance that the most satisfactory approach, plan, or design has been selected, that a configuration item has been produced to meet the specified requirements, or that a configuration item is ready. Reviews communicate an approach, demonstrate an ability to meet requirements, or establish status.



## **Appendix A. Heritage Readiness Level Rating Matrix**



Table A-1. HRL Rating Matrix–Tier 1

Heritage Hardware Nomenclature & P/N: _____ & _____								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters	Applicable—Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability—Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.	Measure 3: Heritage Hardware Compliance to Target Program –Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.
			<b>NOTES:</b> 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries.  2. Complete set of technical parameters can be used to support final reuse decisions		<b>Measure 1 Rating definitions:</b> 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	<b>Measure 2 Rating definitions:</b> 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	<b>Measure 3 Rating definitions:</b> 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	<b>Measure 4 Rating definitions:</b> 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			<b>Measure Weighting &gt;&gt;&gt;</b>		<b>0.25</b>	<b>0.25</b>	<b>0.25</b>	<b>0.25</b>
-			<b>Measure Average Scores &gt;&gt;&gt;</b>		-	-	-	-
-	<b>0.2</b>	-	<b>Performance (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
-	<b>0.2</b>	-	<b>Design (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
-	<b>0.2</b>	-	<b>Environmental (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
-	<b>0.2</b>	-	<b>Manufacturing (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
-	<b>0.2</b>	-	<b>Program Controls (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>

\* HRL Score Definitions

- 9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing.
- 8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse.
- 7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse.
- 6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse.
- 5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse.
- 4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse.
- 3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse.
- 2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse.
- 1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.

Table A-2. HRL Rating Matrix–Tier 2

Heritage Hardware Nomenclature & P/N: _____ & _____								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable–Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program– Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			Measure Weighting >>>		0.25	0.25	0.25	0.25
-			Measure Average Scores >>>		-	-	-	-
-	0.2	-	Performance (Tier 1)	Yes	Select	Select	Select	Select
		-	Requirements (Tier 2)	Yes	Select	Select	Select	Select
		-	Flight history (Tier 2)	Yes	Select	Select	Select	Select
-	0.2	-	Design (Tier 1)	Yes	Select	Select	Select	Select
		-	Interfaces (Tier 2)	Yes	Select	Select	Select	Select
		-	Physical Requirements (Tier 2)	Yes	Select	Select	Select	Select
		-	Systems Safety (Tier 2)	Yes	Select	Select	Select	Select
		-	Structural (Tier 2)	Yes	Select	Select	Select	Select
		-	Maintainability (Tier 2)	Yes	Select	Select	Select	Select
		-	Reliability (Tier 2)	Yes	Select	Select	Select	Select
		-	Parts and Materials (Tier 2)	Yes	Select	Select	Select	Select
-	0.2	-	Environmental (Tier 1)	Yes	Select	Select	Select	Select
		-	Thermal (Tier 2)	Yes	Select	Select	Select	Select
		-	Dynamics / Statics (Tier 2)	Yes	Select	Select	Select	Select
		-	EMC / EMI / ESD (Tier 2)	Yes	Select	Select	Select	Select
		-	Survivability (Tier 2)	Yes	Select	Select	Select	Select
-	0.2	-	Manufacturing (Tier 1)	Yes	Select	Select	Select	Select
		-	Processes (Tier 2)	Yes	Select	Select	Select	Select
		-	Construction, Safety & Human Factors (Tier 2)	Yes	Select	Select	Select	Select
		-	Delivery (Tier 2)	Yes	Select	Select	Select	Select
		-	Manufacturer Consistencies (Tier 2)	Yes	Select	Select	Select	Select
-	0.2	-	Program Controls (Tier 1)	Yes	Select	Select	Select	Select
		-	Residual Risk (Tier 2)	Yes	Select	Select	Select	Select
		-	Data/Configuration Management (Tier 2)	Yes	Select	Select	Select	Select
		-	Engineering Processes and Tools (Tier 2)	Yes	Select	Select	Select	Select

\* HRL Score Definitions

- 9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing.
- 8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse.
- 7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse.
- 6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse.
- 5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse.
- 4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse.
- 3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse.
- 2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse.
- 1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.



Table A-3. HRL Rating Matrix–Tier 3

Heritage Hardware Nomenclature & P/N: _____ & _____								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable– Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			Measure Weighting >>>		0.25	0.25	0.25	0.25
-			Measure Average Scores >>>		-	-	-	-
-	0.2	-	Performance (Tier 1)	Yes	Select	Select	Select	Select
		-	Requirements (Tier 2)	Yes	Select	Select	Select	Select
		-	Mechanical	Yes	Select	Select	Select	Select
		-	Thermal	Yes	Select	Select	Select	Select
		-	Electrical	Yes	Select	Select	Select	Select
		-	Electrical-Mechanical	Yes	Select	Select	Select	Select
		-	Electronic	Yes	Select	Select	Select	Select
		-	Radio Frequency	Yes	Select	Select	Select	Select
		-	Other (e.g. Security Threats)	Yes	Select	Select	Select	Select
		-	Measure / command / telemetry	Yes	Select	Select	Select	Select
		-	Flight history (Tier 2)	Yes	Select	Select	Select	Select
		-	Performance on orbit	Yes	Select	Select	Select	Select
		-	Anomalies	Yes	Select	Select	Select	Select
		-	Latent HW / SW bugs	Yes	Select	Select	Select	Select
		-	Operational signatures & constraints	Yes	Select	Select	Select	Select
-	0.2	-	Design (Tier 1)	Yes	Select	Select	Select	Select
		-	Interfaces (Tier 2)	Yes	Select	Select	Select	Select
		-	Functional	Yes	Select	Select	Select	Select
		-	Physical	Yes	Select	Select	Select	Select
		-	Mechanical	Yes	Select	Select	Select	Select
		-	Thermal	Yes	Select	Select	Select	Select
		-	Electrical	Yes	Select	Select	Select	Select
		-	Electronic	Yes	Select	Select	Select	Select
		-	Radio Frequency	Yes	Select	Select	Select	Select
		-	Software	Yes	Select	Select	Select	Select
		-	Human	Yes	Select	Select	Select	Select
		-	User	Yes	Select	Select	Select	Select
		-	GSE	Yes	Select	Select	Select	Select
		-	STE	Yes	Select	Select	Select	Select
		-	Fixturing	Yes	Select	Select	Select	Select

## Heritage Hardware Nomenclature &amp; P/N: \_\_\_\_\_ &amp; \_\_\_\_\_

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable– Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	Other	Yes	Select	Select	Select	Select
		-	<b>Physical Requirements (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Dimension	Yes	Select	Select	Select	Select
		-	Weight	Yes	Select	Select	Select	Select
		-	Center of gravity	Yes	Select	Select	Select	Select
		-	Storage	Yes	Select	Select	Select	Select
		-	<b>Systems Safety (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Physical constraints	Yes	Select	Select	Select	Select
		-	Hazards	Yes	Select	Select	Select	Select
		-	Stored Energy	Yes	Select	Select	Select	Select
		-	On-ground & On-orbit Safety	Yes	Select	Select	Select	Select
		-	Inhibits	Yes	Select	Select	Select	Select
		-	Standards	Yes	Select	Select	Select	Select
		-	<b>Structural (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Quasi-static loads	Yes	Select	Select	Select	Select
		-	Margins of safety	Yes	Select	Select	Select	Select
		-	Factor of safety	Yes	Select	Select	Select	Select
		-	Mounting loads	Yes	Select	Select	Select	Select
		-	Thermal loads and stresses	Yes	Select	Select	Select	Select
		-	<b>Maintainability (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Personnel access	Yes	Select	Select	Select	Select
		-	Line of sight	Yes	Select	Select	Select	Select
		-	Mean time to repair (ground)	Yes	Select	Select	Select	Select
		-	Mean time to restore (flight)	Yes	Select	Select	Select	Select
		-	<b>Reliability (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Design life	Yes	Select	Select	Select	Select
		-	Mission life	Yes	Select	Select	Select	Select
		-	Operational reliability (MTBF)	Yes	Select	Select	Select	Select
		-	Mission reliability (Probability of success)	Yes	Select	Select	Select	Select
		-	Inherent availability	Yes	Select	Select	Select	Select
		-	Operational availability	Yes	Select	Select	Select	Select
		-	Redundancy architecture	Yes	Select	Select	Select	Select
		-	Baseplate operating temperature	Yes	Select	Select	Select	Select
		-	Part electrical / thermal stresses	Yes	Select	Select	Select	Select

## Heritage Hardware Nomenclature &amp; P/N: \_\_\_\_\_ &amp; \_\_\_\_\_

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable– Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	FMEA / FMECA adequacy	Yes	Select	Select	Select	Select
		-	Single point failure (retention rationale)	Yes	Select	Select	Select	Select
		-	Failure mode propagation constraint	Yes	Select	Select	Select	Select
		-	Common cause failure potential	Yes	Select	Select	Select	Select
		-	Functional fault analysis inputs	Yes	Select	Select	Select	Select
		-	Critical items list	Yes	Select	Select	Select	Select
		-	Worst case analysis	Yes	Select	Select	Select	Select
		-	Wearout constraints	Yes	Select	Select	Select	Select
		-	Duty cycle	Yes	Select	Select	Select	Select
		-	Life limiting factors	Yes	Select	Select	Select	Select
		-	<b>Parts and Materials (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Parts/materials list	Yes	Select	Select	Select	Select
		-	Part obsolescence	Yes	Select	Select	Select	Select
		-	Part long lead	Yes	Select	Select	Select	Select
		-	Part quality factors (production/vendor change)	Yes	Select	Select	Select	Select
		-	Part/material failure history / supplier defects	Yes	Select	Select	Select	Select
		-	Part duty cycle	Yes	Select	Select	Select	Select
		-	Part/material life limiting factors	Yes	Select	Select	Select	Select
		-	Part derating (margin)	Yes	Select	Select	Select	Select
		-	Part thermal, electrical environmental stresses	Yes	Select	Select	Select	Select
		-	Part stress conditions	Yes	Select	Select	Select	Select
		-	Part class	Yes	Select	Select	Select	Select
		-	Part/material screening	Yes	Select	Select	Select	Select
		-	Part statistical quality factors (lot sampling)	Yes	Select	Select	Select	Select
		-	Part burn-in	Yes	Select	Select	Select	Select
		-	Part DPA	Yes	Select	Select	Select	Select
-	0.2	-	<b>Environmental (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	<b>Thermal (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Storage thermal analysis	Yes	Select	Select	Select	Select
		-	Pre-flight ground handling	Yes	Select	Select	Select	Select
		-	Transportation	Yes	Select	Select	Select	Select
		-	Launch	Yes	Select	Select	Select	Select
		-	Assent	Yes	Select	Select	Select	Select
		-	Transfer orbit	Yes	Select	Select	Select	Select

Heritage Hardware Nomenclature & P/N: \_\_\_\_\_ & \_\_\_\_\_

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable— Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability— Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	Beginning of life deployments	Yes	Select	Select	Select	Select
		-	On-orbit	Yes	Select	Select	Select	Select
		-	Thermal cycling	Yes	Select	Select	Select	Select
		-	Thermal vacuum cycling	Yes	Select	Select	Select	Select
		-	Thermal balance	Yes	Select	Select	Select	Select
		-	<b>Dynamics / Statics (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Pre-flight ground handling	Yes	Select	Select	Select	Select
		-	Transportation	Yes	Select	Select	Select	Select
		-	Launch assent	Yes	Select	Select	Select	Select
		-	Transfer orbit	Yes	Select	Select	Select	Select
		-	Beginning of life deployments	Yes	Select	Select	Select	Select
		-	On-orbit	Yes	Select	Select	Select	Select
		-	Sine Vibration	Yes	Select	Select	Select	Select
		-	Random Vibration	Yes	Select	Select	Select	Select
		-	Acoustic	Yes	Select	Select	Select	Select
		-	Shock	Yes	Select	Select	Select	Select
		-	Structural Loads	Yes	Select	Select	Select	Select
		-	<b>EMC / EMI / ESD (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Lightning susceptibility (launch site, vehicle)	Yes	Select	Select	Select	Select
		-	Parts substitutions affecting E3 performance	Yes	Select	Select	Select	Select
		-	Grounding, bonding, and shielding	Yes	Select	Select	Select	Select
		-	ESD Susceptibility (on-orbit charging, tribo-elec.)	Yes	Select	Select	Select	Select
		-	Conducted Susceptibility	Yes	Select	Select	Select	Select
		-	Conducted Emissions	Yes	Select	Select	Select	Select
		-	Radiated Susceptibility	Yes	Select	Select	Select	Select
		-	Radiated Emissions	Yes	Select	Select	Select	Select
		-	<b>Survivability (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Radiation hardness assurance	Yes	Select	Select	Select	Select
		-	Radiation total ionizing dose environments	Yes	Select	Select	Select	Select
		-	External interfaces (e.g., thermal)	Yes	Select	Select	Select	Select
		-	Protective features, shielding, vulnerable paths	Yes	Select	Select	Select	Select
		-	Parts substitutions affecting survivability	Yes	Select	Select	Select	Select
		-	Single event effects	Yes	Select	Select	Select	Select
		-	Natural / man-made micrometeoroid fluence	Yes	Select	Select	Select	Select

Heritage Hardware Nomenclature & P/N: \_\_\_\_\_ & \_\_\_\_\_

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable— Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability— Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	Venting	Yes	Select	Select	Select	Select
		-	Outgassing	Yes	Select	Select	Select	Select
		-	Contamination	Yes	Select	Select	Select	Select
-	0.2	-	<b>Manufacturing (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	<b>Processes (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Process applicability/changes	Yes	Select	Select	Select	Select
		-	Bonding	Yes	Select	Select	Select	Select
		-	Cleaning	Yes	Select	Select	Select	Select
		-	Soldering	Yes	Select	Select	Select	Select
		-	Welding	Yes	Select	Select	Select	Select
		-	Standards	Yes	Select	Select	Select	Select
		-	<b>Construction, Safety &amp; Human Factors (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Identification	Yes	Select	Select	Select	Select
		-	Markings	Yes	Select	Select	Select	Select
		-	Workmanship	Yes	Select	Select	Select	Select
		-	Interchangeability	Yes	Select	Select	Select	Select
		-	Safety EH&S	Yes	Select	Select	Select	Select
		-	Hazardous materials	Yes	Select	Select	Select	Select
		-	Human factors	Yes	Select	Select	Select	Select
		-	Standards	Yes	Select	Select	Select	Select
		-	<b>Delivery (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Handling	Yes	Select	Select	Select	Select
		-	Protective handling containers	Yes	Select	Select	Select	Select
		-	Perseverations & packaging	Yes	Select	Select	Select	Select
		-	Connector protection	Yes	Select	Select	Select	Select
		-	Marking	Yes	Select	Select	Select	Select
		-	Cleanliness	Yes	Select	Select	Select	Select
		-	Transportation	Yes	Select	Select	Select	Select
		-	<b>Manufacturer Consistencies (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Manufacturer	Yes	Select	Select	Select	Select
		-	Facility	Yes	Select	Select	Select	Select
		-	Equipment	Yes	Select	Select	Select	Select
		-	Active line	Yes	Select	Select	Select	Select
		-	Key personnel	Yes	Select	Select	Select	Select

Heritage Hardware Nomenclature & P/N: \_\_\_\_\_ & \_\_\_\_\_

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable— Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability— Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	Labor Rules	Yes	Select	Select	Select	Select
		-	Management	Yes	Select	Select	Select	Select
		-	Special Test Equipment (STE)	Yes	Select	Select	Select	Select
		-	Specialized training / education	Yes	Select	Select	Select	Select
		-	Interfacing tools and equipment	Yes	Select	Select	Select	Select
		-	Sparing	Yes	Select	Select	Select	Select
		-	Original development team members	Yes	Select	Select	Select	Select
-	0.2	-	<b>Program Controls (Tier 1)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	<b>Residual Risk (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Deviations	Yes	Select	Select	Select	Select
		-	Waivers	Yes	Select	Select	Select	Select
		-	FRB Actions/UVF	Yes	Select	Select	Select	Select
		-	ERB Actions	Yes	Select	Select	Select	Select
		-	QRB Actions	Yes	Select	Select	Select	Select
		-	Configuration Management	Yes	Select	Select	Select	Select
		-	Senior Mgmt Review Actions	Yes	Select	Select	Select	Select
		-	GIDEP Alerts	Yes	Select	Select	Select	Select
		-	Risk Board	Yes	Select	Select	Select	Select
		-	Lessons Learned	Yes	Select	Select	Select	Select
		-	<b>Data/Configuration Management (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	End Item Data Package (EIDP)	Yes	Select	Select	Select	Select
		-	Requirements documents	Yes	Select	Select	Select	Select
		-	Design data	Yes	Select	Select	Select	Select
		-	Analyses	Yes	Select	Select	Select	Select
		-	Test procedures	Yes	Select	Select	Select	Select
		-	Test reports	Yes	Select	Select	Select	Select
		-	Product cert documents	Yes	Select	Select	Select	Select
		-	Qualification certificate documents	Yes	Select	Select	Select	Select
		-	Other component history documentation	Yes	Select	Select	Select	Select
		-	<b>Engineering Processes and Tools (Tier 2)</b>	<b>Yes</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>	<b>Select</b>
		-	Engineering development validated tools	Yes	Select	Select	Select	Select
		-	Design notes	Yes	Select	Select	Select	Select
		-	Revision notes	Yes	Select	Select	Select	Select
		-	Simulators and Modeling	Yes	Select	Select	Select	Select

**Heritage Hardware Nomenclature & P/N: \_\_\_\_\_ & \_\_\_\_\_**

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  <b>NOTES:</b> 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable– Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  <b>Measure 1 Rating definitions:</b> 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  <b>Measure 2 Rating definitions:</b> 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  <b>Measure 3 Rating definitions:</b> 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  <b>Measure 4 Rating definitions:</b> 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		-	Design maturity	Yes	Select	Select	Select	Select
		-	Design modification feasibility	Yes	Select	Select	Select	Select

**\* HRL Score Definitions**

- 9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing.
- 8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse.
- 7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse.
- 6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse.
- 5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse.
- 4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse.
- 3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse.
- 2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse.
- 1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.





## Appendix B. How to Complete the HRL Matrix—An Example

This appendix provides an example of a heritage reuse assessment and HRL index determination. The example is generic and no manufacturer or corresponding proprietary data will be discussed. It is assumed that a heritage reuse committee, analyst, and component responsible engineer have been organized to conduct the heritage reuse assessment.

The example used is a Propulsion Subsystem Service valve. In this example, a service valve design has been qualified on Program A that has not yet flown, and a design variant that has been qualified and flown on Program B. Program C wishes to claim heritage and qualify the service valve by design similarity to Program A and B. The existing service valve manufacturer has recently sold the design to another company and the new owner has moved the manufacturing line to another regional area.

The example heritage reuse assessment uses the three-tier objective criteria model to develop an average HRL by tier. The user is expected to accumulate the key objective evidence that relates to the objective criteria that is being scored. As you recall, Tier 1 has 5 technical parameters (i.e., categories), Tier 2 has 20 technical parameters, and Tier 3 has 177 technical parameters. Each technical parameter is scored 1 thru 9, or not applicable, if appropriate. Tier scores represent the average of the scores contained within the Tier group.

The Tier 1 heritage reuse assessment is a rough order of magnitude assessment based on 5 summary technical parameters (see Table B-1). The resulting Tier 1 HRL of 7 provides insight that some additional activity will be required to reuse this item, but the confidence in a Tier 1 assessment is low since it is based on a top-level assessment of objective criteria. It is obvious that a more detailed assessment will be required to clearly identify the additional activity required.

The Tier 2 heritage reuse assessment is more perceptive and provides a HRL of 6 (see Table B-2). It does provide more insight into the objective criteria summary categories that may prevent a complete qualification by design similarity (a.k.a., Qual by Similarity) to Programs A and B qualification compliance evidence.

The Tier 3 assessment also provides an HRL of 6 (see Table B-3). This detailed assessment identifies the exact qualification of design and workmanship processes and any weaknesses or unknowns that need to be addressed by the Program C qualification review board and costed within the Program C basis of estimate.

Table B-1. HRL Scoring for Propulsion Valve–Tier 1

Heritage Hardware Nomenclature & P/N: <u>Propulsion Service Valve</u> & <u>XYZ-123-456</u>								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  <b>NOTES:</b> 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries.  2. Complete set of technical parameters can be used to support final reuse decisions	Applicable–Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  <b>Measure 1 Rating definitions:</b> 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition– Target program requirements are completely defined for heritage hardware.  <b>Measure 2 Rating definitions:</b> 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program–Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  <b>Measure 3 Rating definitions:</b> 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program– Extent of activity for heritage hardware to meet target program requirements.  <b>Measure 4 Rating definitions:</b> 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			<b>Measure Weighting &gt;&gt;&gt;</b>		<b>0.25</b>	<b>0.25</b>	<b>0.25</b>	<b>0.25</b>
<b>7</b>			<b>Measure Average Scores &gt;&gt;&gt;</b>		<b>5</b>	<b>9</b>	<b>6</b>	<b>6</b>
<b>1</b>	<b>0.2</b>	<b>7</b>	<b>Performance (Tier 1)</b>	<b>Yes</b>	<b>5</b>	<b>9</b>	<b>7</b>	<b>7</b>
<b>2</b>	<b>0.2</b>	<b>8</b>	<b>Design (Tier 1)</b>	<b>Yes</b>	<b>7</b>	<b>9</b>	<b>7</b>	<b>9</b>
<b>2</b>	<b>0.2</b>	<b>8</b>	<b>Environmental (Tier 1)</b>	<b>Yes</b>	<b>7</b>	<b>9</b>	<b>7</b>	<b>7</b>
<b>1</b>	<b>0.2</b>	<b>5</b>	<b>Manufacturing (Tier 1)</b>	<b>Yes</b>	<b>3</b>	<b>9</b>	<b>3</b>	<b>3</b>
<b>1</b>	<b>0.2</b>	<b>6</b>	<b>Program Controls (Tier 1)</b>	<b>Yes</b>	<b>5</b>	<b>9</b>	<b>5</b>	<b>5</b>
<b>* HRL Score Definitions</b> 9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing. 8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse. 7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse. 6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse. 5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse. 4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse. 3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse. 2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse. 1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.								

Table B-2. HRL Scoring for Propulsion Valve–Tier 2

Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries.  2. Complete set of technical parameters can be used to support final reuse decisions	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. YES or NO	Measure 1: Heritage Hardware Objective Evidence Availability– Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available. 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program – Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program– Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			Measure Weighting >>>		0.25	0.25	0.25	0.25
6			Measure Average Scores >>>		5	9	5	6
1	0.2	7	Performance (Tier 1)	Yes	5	9	5	7
		9	Requirements (Tier 2)	Yes	9	9	9	9
		4	Flight history (Tier 2)	Yes	1	9	1	5
1	0.2	7	Design (Tier 1)	Yes	6	8	6	6
		6	Interfaces (Tier 2)	Yes	9	5	5	5
		9	Physical Requirements (Tier 2)	Yes	9	9	9	9
		8	Systems Safety (Tier 2)	Yes	7	9	7	7
		7	Structural (Tier 2)	Yes	7	7	7	7
		7	Maintainability (Tier 2)	Yes	5	9	5	7
		6	Reliability (Tier 2)	Yes	5	9	5	5
		6	Parts and Materials (Tier 2)	Yes	3	9	5	5
1	0.2	6	Environmental (Tier 1)	Yes	5	9	5	6
		7	Thermal (Tier 2)	Yes	5	9	5	7
		6	Dynamics / Statics (Tier 2)	Yes	5	9	5	5
		NA	EMC / EMI / ESD (Tier 2)	No	NA	NA	NA	NA
		NA	Survivability (Tier 2)	No	NA	NA	NA	NA
1	0.2	5	Manufacturing (Tier 1)	Yes	4	8	5	5
		6	Processes (Tier 2)	Yes	3	9	5	5
		6	Construction, Safety & Human Factors (Tier 2)	Yes	5	9	5	5
		7	Delivery (Tier 2)	Yes	5	9	7	7
		2	Manufacturer Consistencies (Tier 2)	Yes	1	5	1	1
1	0.2	6	Program Controls (Tier 1)	Yes	4	9	4	5
		6	Residual Risk (Tier 2)	Yes	5	9	5	5
		7	Data/Configuration Management (Tier 2)	Yes	5	9	5	7
		5	Engineering Processes and Tools (Tier 2)	Yes	3	9	3	3

**Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456**

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence Availability-- Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.	Measure 2: Target Program Requirements Definition--Target program requirements are completely defined for heritage hardware.	Measure 3: Heritage Hardware Compliance to Target Program -- Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.	Measure 4: Heritage Hardware Activity for Target Program-- Extent of activity for heritage hardware to meet target program requirements.
			<p align="center"><b>NOTES:</b></p> <p>1. Tier 1 &amp; 2 technical parameters can be used for heritage hardware options' early trade studies &amp; proposal planning OR as category summaries.</p> <p>2. Complete set of technical parameters can be used to support final reuse decisions</p>		<p><b>Measure 1 Rating definitions:</b>                      1 - Not available or unknown.                      5 - Partially available.                      9 - Completely available                      NA - not applicable</p>	<p><b>Measure 2 Rating definitions:</b>                      1 - Not defined or unknown.                      5 - Partially defined.                      9 - Completely defined                      NA - not applicable</p>	<p><b>Measure 3 Rating definitions:</b>                      1 - Not compliant or unknown.                      5 - Partially compliant.                      9 - Completely compliant                      NA - not applicable</p>	<p><b>Measure 4 Rating definitions:</b>                      1 - Extensive activity required or unknown.                      5 - Moderate activity required.                      9 - No activity required                      NA - not applicable</p>
<p><b>* HRL Score Definitions</b></p> <p>9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing.</p> <p>8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse.</p> <p>7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse.</p> <p>6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse.</p> <p>5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse.</p> <p>4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse.</p> <p>3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse.</p> <p>2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse.</p> <p>1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.</p>								

Table B-3. HRL Scoring for Propulsion Valve–Tier 3

Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456								
Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence Availability–Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition–Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program– Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program–Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
			Measure Weighting >>>		0.25	0.25	0.25	0.25
6			Measure Average Scores >>>		5	8	5	5
1	0.2	6	Performance (Tier 1)	Yes	5	8	5	7
		NA	Requirements (Tier 2)	No	NA	NA	NA	NA
		9	Mechanical	Yes	9	9	9	9
		9	Thermal	Yes	9	9	9	9
		NA	Electrical	No	NA	NA	NA	NA
		9	Electrical-Mechanical	Yes	9	9	9	9
		NA	Electronic	No	NA	NA	NA	NA
		NA	Radio Frequency	No	NA	NA	NA	NA
		NA	Other (e.g. Security Threats)	No	NA	NA	NA	NA
		NA	Measure / command / telemetry	No	NA	NA	NA	NA
		NA	Flight history (Tier 2)	No	NA	NA	NA	NA
		4	Performance on orbit	Yes	1	9	1	5
		3	Anomalies	Yes	1	5	1	5
		4	Latent HW / SW bugs	Yes	1	9	1	5
		NA	Operational signatures & constraints	No	NA	NA	NA	NA
1	0.2	6	Design (Tier 1)	Yes	6	8	6	7
		NA	Interfaces (Tier 2)	No	NA	NA	NA	NA
		9	Functional	Yes	9	9	9	9
		9	Physical	Yes	9	9	9	9
		7	Mechanical	Yes	9	5	5	7
		7	Thermal	Yes	9	5	5	7
		7	Electrical	Yes	9	5	5	7
		NA	Electronic	No	NA	NA	NA	NA
		NA	Radio Frequency	No	NA	NA	NA	NA
		NA	Software	No	NA	NA	NA	NA
		NA	Human	No	NA	NA	NA	NA
		NA	User	No	NA	NA	NA	NA
		NA	GSE	No	NA	NA	NA	NA
		3	STE	Yes	1	5	1	5
		NA	Fixturing	No	NA	NA	NA	NA

Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence <b>Availability</b> —Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.  Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program—Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.  Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		NA	Other	No	NA	NA	NA	NA
		<b>NA</b>	<b>Physical Requirements (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		9	Dimension	Yes	9	9	9	9
		9	Weight	Yes	9	9	9	9
		NA	Center of gravity	No	NA	NA	NA	NA
		7	Storage	Yes	9	5	7	7
		<b>NA</b>	<b>Systems Safety (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		9	Physical constraints	Yes	9	9	9	9
		7	Hazards	Yes	9	5	7	7
		NA	Stored Energy	No	NA	NA	NA	NA
		1	On-ground & On-orbit Safety	Yes	1	1	1	1
		NA	Inhibits	No	NA	NA	NA	NA
		9	Standards	Yes	9	9	9	9
		<b>NA</b>	<b>Structural (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	Quasi-static loads	Yes	5	5	5	7
		9	Margins of safety	Yes	9	9	9	9
		9	Factor of safety	Yes	9	9	9	9
		NA	Mounting loads	No	NA	NA	NA	NA
		6	Thermal loads and stresses	Yes	5	5	5	7
		<b>NA</b>	<b>Maintainability (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		9	Personnel access	Yes	9	9	9	9
		NA	Line of sight	No	NA	NA	NA	NA
		5	Mean time to repair (ground)	Yes	1	9	1	7
		NA	Mean time to restore (flight)	No	NA	NA	NA	NA
		<b>NA</b>	<b>Reliability (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		9	Design life	Yes	9	9	9	9
		4	Mission life	Yes	1	9	1	5
		NA	Operational reliability (MTBF)	No	NA	NA	NA	NA
		3	Mission reliability (Probability of success)	Yes	1	9	1	1
		NA	Inherent availability	No	NA	NA	NA	NA
		NA	Operational availability	No	NA	NA	NA	NA
		NA	Redundancy architecture	No	NA	NA	NA	NA
		NA	Baseplate operating temperature	No	NA	NA	NA	NA
		NA	Part electrical / thermal stresses	No	NA	NA	NA	NA

Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters <b>NOTES:</b> 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence Availability—Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.	Measure 3: Heritage Hardware Compliance to Target Program—Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.
					Measure 1 Rating definitions: 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	Measure 2 Rating definitions: 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3 Rating definitions: 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4 Rating definitions: 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		NA	FMEA / FMECA adequacy	No	NA	NA	NA	NA
		NA	Single point failure (retention rationale)	No	NA	NA	NA	NA
		7	Failure mode propagation constraint	Yes	5	9	5	7
		NA	Common cause failure potential	No	NA	NA	NA	NA
		NA	Functional fault analysis inputs	No	NA	NA	NA	NA
		6	Critical items list	Yes	5	5	5	7
		8	Worst case analysis	Yes	9	7	7	7
		NA	Wearout constraints	No	NA	NA	NA	NA
		NA	Duty cycle	No	NA	NA	NA	NA
		9	Life limiting factors	Yes	9	9	9	9
		<b>NA</b>	<b>Parts and Materials (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	Parts/materials list	Yes	5	9	5	5
		6	Part obsolescence	Yes	5	9	5	5
		6	Part long lead	Yes	5	9	5	5
		3	Part quality factors (production/vendor change)	Yes	1	9	1	1
		5	Part/material failure history / supplier defects	Yes	1	9	5	5
		NA	Part duty cycle	No	NA	NA	NA	NA
		6	Part/material life limiting factors	Yes	5	9	5	5
		NA	Part derating (margin)	No	NA	NA	NA	NA
		NA	Part thermal, electrical environmental stresses	No	NA	NA	NA	NA
		NA	Part stress conditions	No	NA	NA	NA	NA
		NA	Part class	No	NA	NA	NA	NA
		4	Part/material screening	Yes	1	9	1	5
		4	Part statistical quality factors (lot sampling)	Yes	1	9	1	5
		NA	Part burn-in	No	NA	NA	NA	NA
		NA	Part DPA	No	NA	NA	NA	NA
<b>1</b>	<b>0.2</b>	<b>6</b>	<b>Environmental (Tier 1)</b>	<b>Yes</b>	<b>5</b>	<b>9</b>	<b>5</b>	<b>6</b>
		<b>NA</b>	<b>Thermal (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		7	Storage thermal analysis	Yes	5	9	5	7
		NA	Pre-flight ground handling	No	NA	NA	NA	NA
		NA	Transportation	No	NA	NA	NA	NA
		6	Launch	Yes	5	9	5	5
		6	Assent	Yes	5	9	5	5
		6	Transfer orbit	Yes	5	9	5	5

Heritage Hardware Nomenclature & P/N: Propulsion Service Valve & XYZ-123-456

Heritage Readiness Level (HRL) Rating Matrix								
HRL Score *	Weighting for Tier 1 Technical Parameters	Technical Parameter Average Scores	Technical Parameters  NOTES: 1. Tier 1 & 2 technical parameters can be used for heritage hardware options' early trade studies & proposal planning OR as category summaries. 2. Complete set of technical parameters can be used to support final reuse decisions	Applicable - Some items may not be relevant, in which case "No" should be selected below and the columns to the right left blank. <b>YES or NO</b>	Measure 1: Heritage Hardware Objective Evidence <b>Availability</b> —Objective evidence available relative to successful requirements implementation, verification and space flight operation of heritage hardware on previous program.  <b>Measure 1 Rating definitions:</b> 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	Measure 2: Target Program Requirements Definition—Target program requirements are completely defined for heritage hardware.  <b>Measure 2 Rating definitions:</b> 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	Measure 3: Heritage Hardware Compliance to Target Program—Heritage hardware objective evidence indicates compliance with target program requirements, including verification method compliance.  <b>Measure 3 Rating definitions:</b> 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	Measure 4: Heritage Hardware Activity for Target Program—Extent of activity for heritage hardware to meet target program requirements.  <b>Measure 4 Rating definitions:</b> 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		NA	Beginning of life deployments	No	NA	NA	NA	NA
		6	On-orbit	Yes	5	9	5	5
		7	Thermal cycling	Yes	5	9	5	7
		7	Thermal vacuum cycling	Yes	5	9	5	7
		7	Thermal balance	Yes	5	9	5	7
		<b>NA</b>	<b>Dynamics / Statics (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		NA	Pre-flight ground handling	No	NA	NA	NA	NA
		NA	Transportation	No	NA	NA	NA	NA
		6	Launch /assent	Yes	5	9	5	5
		6	Transfer orbit	Yes	5	9	5	5
		NA	Beginning of life deployments	No	NA	NA	NA	NA
		6	On-orbit	Yes	5	9	5	5
		NA	Sine Vibration	No	NA	NA	NA	NA
		7	Random Vibration	Yes	5	9	5	7
		NA	Acoustic	No	NA	NA	NA	NA
		6	Shock	Yes	5	9	5	5
		5	Structural Loads	Yes	5	5	5	5
		<b>NA</b>	<b>EMC / EMI / ESD (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		NA	Lightning susceptibility (launch site, vehicle)	No	NA	NA	NA	NA
		NA	Parts substitutions affecting E3 performance	No	NA	NA	NA	NA
		NA	Grounding, bonding, and shielding	No	NA	NA	NA	NA
		NA	ESD Susceptibility (on-orbit charging, tribo-elec.)	No	NA	NA	NA	NA
		NA	Conducted Susceptibility	No	NA	NA	NA	NA
		NA	Conducted Emissions	No	NA	NA	NA	NA
		NA	Radiated Susceptibility	No	NA	NA	NA	NA
		NA	Radiated Emissions	No	NA	NA	NA	NA
		<b>NA</b>	<b>Survivability (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		NA	Radiation hardness assurance	No	NA	NA	NA	NA
		NA	Radiation total ionizing dose environments	No	NA	NA	NA	NA
		NA	External interfaces (e.g., thermal)	No	NA	NA	NA	NA
		NA	Protective features, shielding, vulnerable paths	No	NA	NA	NA	NA
		NA	Parts substitutions affecting survivability	No	NA	NA	NA	NA
		NA	Single event effects	No	NA	NA	NA	NA
		NA	Natural / man-made micrometeoroid fluence	No	NA	NA	NA	NA



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		NA	Venting	No	NA	NA	NA	NA
		NA	Outgassing	No	NA	NA	NA	NA
		NA	Contamination	No	NA	NA	NA	NA
<b>1</b>	<b>0.2</b>	<b>4</b>	<b>Manufacturing (Tier 1)</b>	<b>Yes</b>	<b>3</b>	<b>8</b>	<b>3</b>	<b>3</b>
		<b>NA</b>	<b>Processes (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	Process applicability/changes	Yes	3	9	5	5
		6	Bonding	Yes	3	9	5	5
		6	Cleaning	Yes	3	9	5	5
		6	Soldering	Yes	3	9	5	5
		6	Welding	Yes	3	9	5	5
		6	Standards	Yes	4	9	5	5
		<b>NA</b>	<b>Construction, Safety &amp; Human Factors (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	Identification	Yes	5	9	5	3
		6	Markings	Yes	5	9	5	3
		6	Workmanship	Yes	5	9	5	3
		6	Interchangeability	Yes	5	9	5	3
		6	Safety EH&S	Yes	5	9	5	5
		4	Hazardous materials	Yes	1	9	3	1
		6	Human factors	Yes	5	9	5	5
		6	Standards	Yes	5	9	5	5
		<b>NA</b>	<b>Delivery (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		7	Handling	Yes	5	9	5	7
		NA	Protective handling containers	No	NA	NA	NA	NA
		NA	Perseverations & packaging	No	NA	NA	NA	NA
		NA	Connector protection	No	NA	NA	NA	NA
		NA	Marking	No	NA	NA	NA	NA
		NA	Cleanliness	No	NA	NA	NA	NA
		NA	Transportation	No	NA	NA	NA	NA
		<b>NA</b>	<b>Manufacturer Consistencies (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		3	Manufacturer	Yes	1	9	1	1
		3	Facility	Yes	1	9	1	1
		3	Equipment	Yes	1	9	1	1
		3	Active line	Yes	1	9	1	1
		3	Key personnel	Yes	1	9	1	1

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		1	Labor Rules	Yes	1	1	1	1
		3	Management	Yes	1	9	1	1
		3	Special Test Equipment (STE)	Yes	1	9	1	1
		3	Specialized training / education	Yes	1	9	1	1
		3	Interfacing tools and equipment	Yes	1	9	1	1
		3	Sparing	Yes	1	9	1	1
		1	Original development team members	Yes	1	1	1	1
<b>1</b>	<b>0.2</b>	<b>6</b>	<b>Program Controls (Tier 1)</b>	<b>Yes</b>	<b>5</b>	<b>9</b>	<b>5</b>	<b>5</b>
		<b>NA</b>	<b>Residual Risk (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	Deviations	Yes	5	9	5	3
		6	Waivers	Yes	5	9	5	3
		6	FRB Actions/UVF	Yes	5	9	5	3
		6	ERB Actions	Yes	5	9	5	3
		6	QRB Actions	Yes	5	9	5	3
		7	Configuration Management	Yes	7	9	7	3
		NA	Senior Mgmt Review Actions	No	NA	NA	NA	NA
		NA	GIDEP Alerts	No	NA	NA	NA	NA
		6	Risk Board	Yes	5	9	5	3
		6	Lessons Learned	Yes	5	9	5	3
		<b>NA</b>	<b>Data/Configuration Management (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		6	End Item Data Package (EIDP)	Yes	5	9	5	5
		9	Requirements documents	Yes	9	9	9	9
		7	Design data	Yes	5	9	5	7
		7	Analyses	Yes	5	9	5	7
		7	Test procedures	Yes	5	9	5	7
		7	Test reports	Yes	5	9	5	7
		7	Product cert documents	Yes	5	9	5	7
		7	Qualification certificate documents	Yes	5	9	5	7
		7	Other component history documentation	Yes	5	9	5	7
		<b>NA</b>	<b>Engineering Processes and Tools (Tier 2)</b>	<b>No</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
		3	Engineering development validated tools	Yes	1	9	1	1
		5	Design notes	Yes	3	9	3	3
		6	Revision notes	Yes	5	9	5	5
		3	Simulators and Modeling	Yes	1	9	1	1

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Heritage Readiness Level (HRL) Rating Matrix								
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					<b>Measure 1 Rating definitions:</b> 1 - Not available or unknown. 5 - Partially available 9 - Completely available NA - not applicable	<b>Measure 2 Rating definitions:</b> 1 - Not defined or unknown. 5 - Partially defined. 9 - Completely defined NA - not applicable	<b>Measure 3 Rating definitions:</b> 1 - Not compliant or unknown. 5 - Partially compliant. 9 - Completely compliant NA - not applicable	<b>Measure 4 Rating definitions:</b> 1 - Extensive activity required or unknown. 5 - Moderate activity required. 9 - No activity required NA - not applicable
		6	Design maturity	Yes	5	9	5	5
		4	Design modification feasibility	Yes	1	9	1	5
<b>* HRL Score Definitions</b> 9 - Heritage hardware complies with target program requirements in all cases; no activity required for reuse except acceptance testing. 8 - Heritage hardware complies with target program requirements in all cases; minimal additional activity required for reuse. 7 - Heritage hardware complies with target program requirements in most cases; minimal additional activity required for reuse. 6 - Heritage hardware complies with target program requirements in most cases; moderate additional activity required for reuse. 5 - Heritage hardware complies with target program requirements in some cases; moderate additional activity required for reuse. 4 - Heritage hardware complies with target program requirements in some cases; significant additional activity required for reuse. 3 - Heritage hardware complies with target program requirements in few cases; significant additional activity required for reuse. 2 - Heritage hardware complies with target program requirements in few to no cases; major activity required for reuse. 1 - Heritage hardware complies with target program requirements in few to no cases; no apparent benefit for reuse.								



## Appendix C. User Guide

The main body of this document provides tools and methods to enhance decision making related to the use of heritage products. There are benefits to heritage and legacy systems, but realizing those benefits requires rigorous evaluation of the proposed reuse product capability against the new applications requirements. Supply chain managers need to oversee the configuration management systems of suppliers. Systems engineers need to take great care in applying heritage or legacy designs. Test engineering needs to test the design and the assumptions. Program managers need to anticipate the impacts of system complexity and manage the unknowns. Customers need to understand the challenges faced by system integrators and users need to accommodate the subtle difference in using follow-on designs.

There are many situations to apply these tools and methods, several of which the authors have directly supported. This appendix is a collection of lessons learned that to date, have resulted from using this document:

- Programmatically, to enhance customer decision making related to heritage product before and during program execution. See Section 1 below.
- During an assessment to evaluate the risk exposure as a result of heritage product decisions. See Section 2 below.

Each section contains the objective and a series of recommendations (to include example contract language and documentation content where appropriate). As additional applications of this document occur, this section will be updated to reflect new lessons.

### 1. Programmatic Application (Contractual Lessons Learned):

#### a. In a Request for Proposal (RFP)

- i. An objective of the RFP language is to ensure that the proposal contains the necessary and sufficient information to evaluate the soundness of the supplier's approach to reuse before awarding the contract. The proposal information is an opportunity for the customer to assess the supplier's approach for incorporating and correspondingly handling the risk associated with using heritage items. The content of an approach is summarized below under "Reuse Plan" or equivalent.
- ii. The response to the RFP/proposal is an early opportunity for the customer/government buyer to obtain detailed information about proposed reuse and potential program execution risks. Adequate information must be provided to allow for an informed acquisition and development decision.

#### b. In a Statement of Work (SOW)

- i. An objective of the SOW language could be to ensure that the supplier (and appropriate team members/partners) conduct actions consistent with the intent of this guidance (e.g., adherence to a plan, manage risk, and report progress, etc.) to execute a reasonable and sound supplier's approach to applying reuse products. These actions could include any of the following:
  1. Manage reuse hardware development in accordance with a "Reuse Plan" or equivalent.

2. Monitor/track the qualification certified status of reused hardware items.
  3. Integrate reuse activities with existing plans (e.g., Risk Management Plan) and processes (e.g., discrepancy reporting and technical and management reviews).
  4. Example language (i.e., exemplars extracted from programs applying this document as guidance):
    - a. *The contractor and all team members shall perform and manage reuse hardware unit development in accordance with the Reuse Plan (CDRL X-XXX).*
    - b. *The contractor shall develop and maintain Document X (and/or a repository). The Document X (and/or a repository) shall contain data, and references to analyses, that support qualification assessments and reuse decision process for all hardware units.*
    - c. *The contractor shall generate and track metrics associated with progress on achieving qualification certified status.*
- ii. An objective of the SOW language could be to enable a “heritage” review/audit of the reuse hardware products. These actions could include any of the following:
    1. Disposition and characterization of the reuse products in accordance with the “Objective Criteria,” as listed in Appendix A and provide the supporting evidence.
    2. Providing data and/or information to enable an independent disposition and characterization of the reuse products in accordance with the “Objective Criteria,” as listed in Appendix A.
- c. To define documentation such as a “Reuse Plan” or equivalent (suggested contents; request at proposal time is recommended).
    - i. A description of how the supplier’s heritage/reuse process will disposition and characterize the reuse products to inform an assessment consistent with the “Objective Criteria,” as listed in Appendix A. Suggested components:
      1. The criteria and supporting artifacts that captures the rationale and assumptions of the reuse decisions supporting how it was or will be determined if:
        - a. sufficient information is known about the reuse product.
        - b. the effort, both in time and dollars, required to understand the pedigree/performance of the reuse product is beneficial to the program.
        - c. a reuse product is the correct choice for providing a capability required by the target program.
        - d. the effort, both in time and dollars, required to align the pedigree/ performance of the reuse product to the target program is beneficial to the program.

- ii. A description of how the supplier's heritage/reuse plan, once established, will be revisited throughout the program to ensure that program changes or reuse product differences do not invalidate the original decision.
- iii. A description of how the supplier's heritage/reuse process will be applied within the organization and to supporting/interfacing organizations (i.e., partners and/or subcontractors) throughout the development lifecycle.

## 2. Heritage Product Assessment:

- a. Finding the objective evidence to evaluate Measures (1-2 of the HRL Rating Matrix).
  - i. The material necessary to complete HRL Measures 1-2 may exist in a myriad of places.
  - ii. It is not recommended that specific documents or other artifacts be requested unless it is known that these items will contain the necessary information. Therefore prior to requesting materials to conduct the assessment, it is recommended that the offerer review the HRL matrix and identify the documents or other artifacts that will provide the information necessary to complete the matrix.
- b. Informing Risk using the information in Measures 1–3 of the HRL Rating Matrix.
  - i. Lower ratings in any of Measures 1–3 indicate that there is some unknown related to heritage item's pedigree, the target environment, and the ability of the heritage item to meet the target program needs.
  - ii. If there is a potential adverse consequence for proceeding with a heritage item, with this unknown, that consequence should be translated to a technical risk or programmatic risk (cost/schedule).
  - iii. Raising a rating from a lower to higher value requires effort and if this effort is not accounted for in the program plan under consideration, there is a programmatic risk (cost/schedule) associated with removing that unknown.
- c. Ensuring a connection between risk identification and the risk management process.
  - i. The ratings derived for Measure 4 indicate the level of effort necessary to resolve gaps identified in Measure 3. The gaps should be mitigated by the program/project risk management process.