Sample Reliability Language for DoD Acquisition Contracts

"The single most important step necessary to correct high suitability failure rates is to ensure programs are formulated to execute a viable systems engineering strategy from the beginning, including a robust RAM program, which includes reliability growth, as an integral part of design and development."

(Report of the Defense Science Board Task Force on Developmental Test & Evaluation, May, 2008)

Enclosures:

1. Section C Statement of Work Reliability Language and Tailoring Instructions

2. Section L Proposal Instructions Reliability Language

3. Section M Evaluation Factors for Award Reliability Language

4. Checklist for Evaluating Reliability Program Plans

Section C Statement of Work Reliability Language and Tailoring Instructions

Instructions for Use and Tailoring

- The sample language below is appropriate for both TD and SDD contracts. The Reliability Program Plan should address the entire life cycle but the contractor's execution of the plan is of course limited to the contract period of performance.
- It is assumed that the quantitative reliability requirements, OMS/MP, FD/SC, and other requirements (e.g., schedule requirements) are specified elsewhere in Section C (e.g., in the System Specification or Purchase Description).
- The sample language should be tailored to each specific program. There are tailoring notes embedded in the sample language for the Program Manager's use. If there will be a down-select at the end of the contract based, in part, on demonstrated or projected reliability, language explaining this should also be included where appropriate.
- It should be noted that this sample language is an intensive reliability engineering and growth program that is fully integrated with Systems Engineering. Specific Reliability Activities described below cannot logically be deleted.

Sample Language

Reliability Program. The contractor shall implement and execute each of the Reliability Activities as described below to ensure achievement of the reliability requirements established in the System Specification [TAILOR].

1. Reliability Program Plan (RPP). The contractor shall develop and follow a RPP in order to achieve the following four objectives (1) understand the customer/user's requirements, (2) design for reliability, (3) produce reliable systems, and (4) monitor and assess field reliability. The RPP shall, at minimum, employ each of the Reliability Activities herein and shall address reliability funding, schedule, outputs, and staffing.

2. System Reliability Model. The contractor shall develop a reliability model for the system. At minimum, the system reliability model shall be used to (1) generate and update the reliability allocations from the system level down to lower indenture levels, (2) aggregate system-level reliability based on reliability estimates from lower indenture levels, (3) identify single points of failure, and (4) identify reliability-critical items and areas where additional design or testing activities are required in order to achieve the reliability requirements. The system reliability model shall be updated whenever new failure modes are identified, failure definitions are updated, operational & environmental load estimates are revised, or design and manufacturing changes occur throughout the life cycle. Detailed component stress and damage models shall be incorporated as appropriate.

3. Systems-Engineering Integration. The contractor shall implement a sound systems-engineering process to translate customer/user needs and requirements into suitable

systems/products while balancing performance, risk, cost, and schedule. The contractor shall (1) incorporate the Reliability Activities described herein as an integral part of a disciplined and documented systems engineering process and plan, (2) submit the potential reliability improvements identified during the execution of the Reliability Activities to the appropriate engineering organizations, (3) monitor and evaluate the reliability impact of changes to the design or manufacture of the system, (4) manage and control reliability critical items, and (5) ensure adherence to design rules that impact reliability, including derating, electrical, mechanical, and other guidelines.

4. System-Level Operational & Environmental Life-Cycle Loads. The contractor shall estimate and periodically update the operational & environmental loads (e.g., mechanical shock, vibration, and temperature cycling) that the system is expected to encounter in actual usage throughout the life cycle. These loads shall be estimated for the entire life cycle which will typically include operation, storage, shipping, handling, and maintenance. The estimates shall be verified to be operationally realistic with measurements using the production-representative system [TAILOR] in time to be used for Reliability Verification. If the load information identified in the System Specification [TAILOR] is insufficiently detailed regarding the actual operational & environmental loads the system will encounter throughout the life cycle, the contractor shall seek access to customer assets (e.g., test courses or vehicles that the system will be integrated with) in order to obtain the needed specifics.

5. Life-Cycle Loads on Assemblies, Subassemblies, and Components. The contractor shall estimate the life-cycle loads that subordinate assemblies, subassemblies, components, commercial-off-the-shelf (COTS), non-developmental items (NDI), and government-furnished equipment (GFE) will experience as a result of the product-level operational & environmental loads estimated above. These estimates and updates shall be provided to teams developing assemblies, subassemblies, and components for this system. These estimates shall also be provided to teams selecting and integrating items not specifically developed for this system, which may include COTS, NDI, and GFE, as well as assemblies, subassemblies, and components. These estimates of life-cycle loads shall be refined periodically as the system-level loads are updated and/or as the design evolves. The teams that receive initial estimates shall be provided with these updated estimates. Eventually the estimates shall be verified with measurements (e.g., from instrumented systems/products used under operationally-realistic conditions).

6. Identify and Characterize Failure Modes and Mechanisms. The identification of failure modes and mechanisms shall start immediately after contract award. The estimates of life-cycle loads on assemblies, subassemblies, and components obtained above shall be used as inputs to engineering- and physics-based models in order to identify potential failure mechanisms and the resulting failure modes. The teams developing assemblies, subassemblies, and components for this system shall identify and confirm through analysis, test, or accelerated test the failure modes and distributions that will result when life-cycle loads estimated above are imposed on these assemblies, subassemblies, and components. The teams selecting and integrating items not specifically developed for this system (which may include COTS, NDI, and GFE, as well as assemblies, subassemblies,

and components) shall identify and confirm, through analysis, test, or accelerated test, the failure modes and distributions that will result when these life-cycle loads are imposed on these items. Failure modes that may be induced by user or maintainer error shall be identified and confirmed through analysis, test, or accelerated test. Failure modes and distributions that may be induced by manufacturing variation or errors shall be identified and confirmed through analysis, test, or accelerated test. These failure modes and distributions shall be updated as the design and the manufacturing processes evolve, if FDSC identified in the System Specification [TAILOR] is updated, and when the life-cycle operational & environmental loads are updated. These updates shall continue after the system is fielded.

All failures that occur in either test or the field shall be analyzed until the root cause failure mechanism has been identified. Identification of the failure mechanism provides the insight essential to the identification of corrective actions, including reliability improvements. Predicted failure modes/mechanisms shall be compared with those from test and the field.

7. Closed-Loop Failure-Mode Mitigation. The contractor shall have an integrated team, including suppliers of assemblies, subassemblies, components, COTS, NDI, and GFE, as applicable, analyze all failure modes arising from modeling, analysis, test, or the field throughout the life cycle in order to formulate corrective actions.

Failure modes shall be mitigated by one or more of the following approaches:

- eliminating the failure mode,
- reducing its occurrence probability or frequency,
- incorporation of redundancy, and/or
- mitigation of failure effects (e.g., fault recovery, degraded modes of operation, providing advance warning of failure).

The contractor shall aggressively mitigate failure modes to ensure the reliability requirements are successfully verified and do not degrade in production or in the field. Failure modes that are expected to occur during the system life cycle shall be included in the system reliability model.

The contractor shall employ a mechanism (e.g., a Failure Reporting, Analysis, and Corrective Action System or a Data Collection, Analysis, and Corrective Action System) for monitoring and communicating throughout the organization
(1) descriptions of test and field failures,
(2) analyses of failure mode and root-cause failure mechanism,
(3) the status of design and/or process corrective actions and risk-mitigation decisions,
(4) the effectiveness of corrective actions, and
(5) lessons learned.

The failure modes monitored by this mechanism shall map to the customer-supplied Failure Definitions and Scoring Criteria (FDSC); this mechanism shall be accessible by the customer.

8. Reliability Assessment. The model developed in System Reliability Model shall be used, in conjunction with expert judgment, in order to assess if the design (including COTS, NDI, and GFE) is capable of meeting reliability requirements in the user environment. If the assessment is that the customer's requirements are infeasible, the contractor shall communicate this to the customer. The contractor shall allocate the reliability requirements down to lower indenture levels and flow them and needed inputs down to its subcontractors/suppliers.

The contractor shall assess the reliability of the system periodically throughout the life cycle using the System Reliability Model, the life-cycle operational & environmental load estimates generated herein, and the FDSC. Reliability assessments shall be made based on data from analysis, modeling & simulation, test, and the field, and shall be tracked as a function of time and compared against reliability allocations and customer reliability requirements. For complex systems/products, or when the customer requires this [TAILOR], the assessment strategy shall include reliability values to be achieved at various points during development. The contractor shall monitor and evaluate the reliability impact of changes to the design or manufacture of the system. The implementation of corrective actions shall be verified and their effectiveness tracked. Formal reliability growth methodology shall be used where applicable (e.g., when failure modes are discovered and addressed with a test-analyze-and-fix process that is applied to complex assemblies) in order to plan, track, and project reliability improvement.

9. Reliability Verification. The contractor shall plan and conduct activities to ensure that the achievement of reliability requirements is verified during design. The strategy shall ensure reliability does not degrade during production or in the field. The contractor shall develop and periodically refine a Reliability Requirements Verification Strategy/Plan that is an integral part of the systems-engineering verification and is coordinated and integrated across all phases. The verification shall be based on analysis, modeling & simulation, testing, or a mixture, and shall be operationally realistic. The verified System-Level Operational & Environmental Life-Cycle Loads as well as the FDSC shall be used. Additional customer requirements identified in the System Specification, if any (e.g., reliability qualification testing, testing in customer facilities, customer-controlled, customer-scored testing), shall be included [TAILOR]. The customer will review and approve the strategy/plan [TAILOR].

10. Failure Definitions. The contractor shall understand the FDSC and shall develop the system to meet reliability requirements when these failure definitions are used and the system is operated and maintained by the user. The contractor shall identify and mitigate human errors that may occur when actual users operate and maintain the system.

11. Technical Reviews. The contractor shall conduct technical interchanges with the customer/user in order to compare the status and outcomes of Reliability Activities,

especially the identification, analysis, classification, and mitigation of failure modes. The contractor shall conduct reliability reviews that promote an understanding of the user environment in which the system will operate and to assure progress toward achieving the reliability requirements. The conduct and scheduling of reliability technical reviews shall be integrated with the program's systems engineering reviews as set forth in the Integrated Master Plan/Integrated Master Schedule. Reliability reviews should begin early in the system development process and continue through production and deployment. Technical reviews shall include participation by reliability subject matter experts using the process provided in the program's Systems Engineering Plan for selecting peer reviewers independent of the program.

12. Methods and Tools. The contractor shall implement each of these Reliability Activities with appropriate reliability design and development methods and tools. Information on a variety of reliability methods and tools may be found in the DoD Guide for Achieving Reliability, Availability, and Maintainability, 3 Aug 2005. The contractor shall select appropriate methods and describe them in the RPP. The customer may elect to review, comment and negotiate regarding the methods selected by the contractor. The contractor shall identify and employ a set of design-reliability Best Practices. The contractor shall execute all of the Reliability Activities set forth herein using the approaches, methods, and tools described in the customer-approved RPP.

13. Outputs and Documentation. The contractor shall provide the customer with continuous access to the status and outputs of the Reliability Activities. The progressive achievement of the four RPP objectives shall be documented and periodically updated in the form of a Reliability Case. The contractor shall submit documentation for customer review and approval as specified by the Reliability Activities paragraphs.

CDRL items:

- Reliability Program Plan
- Reliability Requirements Verification Strategy/Plan
- Reliability Case

Section L Proposal Instructions Reliability Language

Instructions for Use

The rationale for requesting a draft Reliability Program Plan with the offeror's proposal is that the Statement of Work reliability language mandates an intensive reliability engineering and growth program that is fully integrated with Systems Engineering. It is expected that this will require additional resources compared to previous development contracts and the offeror needs to recognize and plan for this from the beginning if it is to occur. The government should evaluate the draft plan, negotiate if need be, and approve it before contract award.

Sample Language

The offeror shall develop and follow a Reliability Program Plan (RPP) in order to achieve the following four objectives (1) understand the customer/user's requirements, (2) design for reliability, (3) produce reliable systems/products, and (4) monitor and assess user reliability. The RPP shall, at minimum, employ each of the twelve Reliability Activities described herein. The RPP is initially prepared in response to the Request for Proposals and is updated and coordinated with the customer when appropriate.

The proposed RPP shall:

- Provide visibility into the management and organizational structure of those responsible and accountable (both offeror and customer) for the conduct of Reliability Activities over the entire life cycle.
- Define all resources required to fully implement the reliability program.
- Include a coordinated schedule for conducting all Reliability Activities throughout the system life-cycle.
- Include detailed descriptions of all Reliability Activities, functions, documentation, processes, and strategies required to ensure system reliability maturation and management throughout the system life cycle.
- Document the procedures for verifying that planned activities are implemented and for both reviewing and comparing their status and outcomes.
- Manage potential reliability risks due, for example, to new technologies or testing approaches.
- Flow reliability allocations and appropriate inputs (e.g., operational & environmental loads) down to subcontractors and suppliers.
- Include contingency-planning criteria and decision-making for altering plans and intensifying reliability improvement efforts.

<u>System Reliability Model</u>:
Describe

(1) the methods and tools that will be used to build and refine the system reliability model,

(2) the extent to which detailed component stress and damage models will be incorporated in the system reliability model,
(3) how the system reliability model will be updated as the system design evolves, as failure modes are identified, as failure definitions are updated, and as operational & environmental loads are updated throughout the life cycle, and
(4) how the system reliability model will be used to identify reliability-critical items and to identify areas where additional design or testing activities are required in order to achieve the specified reliability requirements.

Systems-Engineering Integration:
Describe
(1) how it will be ensured that the Reliability Activities are an integral part of the systems-engineering process,
(2) how reliability-improvement actions will routinely be incorporated into the design and manufacture of the system,
(3) how the reliability impact of system design changes and supplier change notices will be monitored and evaluated,
(4) how reliability-critical items will be managed and controlled, and
(5) how it will be ensured that design rules that impact reliability, including derating, electrical, mechanical, and other guidelines, are adhered to.

System-Level Operational & Environmental Life-Cycle Loads:
Describe
(1) how and when the offeror will develop, refine, and verify that the estimates of system-level operational & environmental life-cycle loads are operationally realistic, and
(2) requirements, if any, for access to customer assets.

Life-Cycle Loads on Subsystems, Assemblies, Subassemblies, and Components:
Describe
(1) how and when the offeror will prepare, refine, and verify estimates of the life-cycle loads that subordinate assemblies, subassemblies, components, commercial-off-the-shelf, non-developmental, and customer-furnished items will experience as a result of system-level operational & environmental loads,
(2) how and when teams (a) developing assemblies, subassemblies, and components or (b) selecting and integrating items not specifically developed for this system, will receive these estimates and updates.

Identify and Characterize Failure Modes and Mechanisms:
Describe
(1) how and when failure mechanisms and modes that may result when the estimated life-cycle loads are imposed on the system will be identified for items specifically developed for this system as well as for items being selected and integrated into it,
(2) how and when failure modes that may be induced by manufacturing variation and errors will be identified,
(3) how and when user- and maintainer-induced failure modes will be identified, and
(4) how the offeror will ensure that test and field failures are analyzed to root cause.

Closed-Loop Failure-Mode Mitigation:
Describe

(1) strategies for monitoring, assessing, and communicating the status of test and field failures throughout the organization,
(2) strategies for identifying, developing, and approving design and/or process corrective actions to eliminate root failure causes throughout the system life cycle,
(3) how the implementation of corrective actions will be verified and their effectiveness tracked,
(4) how lessons learned will be documented, reviewed, and communicated, and
(5) how root-cause analysis of test and field failures will be used to improve the reliability of the system.

Reliability Assessment:

Perform a feasibility assessment as described in the Reliability Assessment section of the Statement of Work and provide it with the draft RPP submitted in response to this RFP. Describe

(1) how and when reliability assessments will be performed (including, when applicable, customer-specified reliability values that must be achieved at various points during development),
(2) which assessment methods will be used, and
(3) how design and process changes will be documented, monitored, and evaluated for their impact on reliability.

Reliability Verification:

Describe

(1) the strategy for verifying the satisfaction of customer reliability requirements under operationally-realistic conditions and as an integral part of the systems-engineering verification,
(2) the activities to be performed and processes to be used that will ensure that inherent reliability levels are not degraded during subsequent phases of the system life cycle.

Failure Definitions:

Describe how the failure definitions and scoring criteria will be used during development to minimize the occurrence of failures in the field when actual users operate and maintain the system.

Technical Reviews:

Describe how and when technical interchanges and reviews will be conducted including detailed, independent peer reviews.

Methods and Tools:

Describe

(1) the methods and tools that will be used to implement the Reliability Activities, and
(2) the design-reliability Best Practices to be used and how adherence to them will be ensured.

Outputs and Documentation:

Describe how and when the status and outputs of the Reliability Activities will be documented and how continuous customer access will be provided.

Section M Evaluation Factors for Award Reliability Language

Instructions for Use

If credible quantitative reliability estimates are available that employ essentially the same OMS/MP and FD/SC, these estimates should be used for proposal evaluation. Otherwise, or in addition, the sample language below may be used.

Sample Language

One evaluation factor is the proposed Reliability Program Plan.

Note:
The Checklist for Evaluating Reliability Program Plans (Enclosure 4) may be used to assist with this process.

Checklist for Evaluating Reliability Program Plans

Reliability Program Plan (RPP)

- Implements with appropriate methods, tools, and Best Practices, the Reliability Activities described herein in order to accomplish the four objectives?
- Includes procedures for verifying planned Reliability Activities are implemented?
- Manage risks due to new technologies?
- Includes decision-making criteria and plans for intensifying reliability-improvement efforts?
- Periodic updates coordinated with customer/user?

System Reliability Model

- Build & refine model throughout the life cycle?
- Routinely update model as failure definitions are updated, failure modes are identified, operational & environmental load estimates are updated, and as design or manufacturing changes are made?
- Detailed component stress & damage models included?
- Model used to (1) update allocations, (2) aggregate reliability, (3) ID single points of failure, (4) identify reliability-critical items and the need for additional design or testing activities?

Systems-Engineering Integration

- Reliability Activities integral to system engineering process throughout life cycle?
- Reliability-improvement actions routinely incorporated during design, production, and in the field?
- Reliability impact of design changes and supplier change notices monitored & evaluated throughout the life cycle?
- Manage and control reliability-critical items?
- Design rules that impact reliability adhered to?

System-Level Operational & Environmental Life-Cycle Loads

- Develop and periodically update load estimates throughout life cycle?
- Estimates verified on instrumented systems/products with operationally-realistic conditions applied in time for Reliability Verification?
- Use estimates in reliability modeling, assessment, verification?
- Coordinate estimates with Systems Engineering?

Life-Cycle Loads on Assemblies, Subassemblies, and Components

- Develop and periodically update these load estimates based on operational & environmental loads applied at the system-level?
- Verify load estimates on instrumented systems/products/assemblies with operationally-realistic conditions applied?
- Flow down estimates and updates to designers, integrators of commercial-off-the-shelf (COTS), non-developmental items (NDI), government-furnished equipment (GFE), and suppliers?

- Use estimates to identify failure modes & mechanisms, and in assessments and verification?

Identify and Characterize Failure Modes & Mechanisms

- Identify failure modes & mechanisms throughout the life cycle?
- Begin to identify failure modes & mechanisms as soon as development begins using realistic life-cycle operational & environmental loads in conjunction with engineering- and physics-based models?
- Teams developing assemblies, subassemblies, and components for system identify and confirm failure modes and distributions with analysis, test, or accelerated test?
- Teams selecting/integrating assemblies, subassemblies, and components for system (including COTS, NDI, and GFE) identify and confirm failure modes and distributions with analysis, test, or accelerated test?
- Identify and confirm failure modes induced by manufacturing variation and errors?
- Identify and confirm failure modes induced by user or maintainer errors?
- All test and field failures analyzed to root cause?

Closed-Loop Failure-Mode Mitigation

- Analyze and map to the customer-specified Failure Definitions and Scoring Criteria (FDSC) all failure modes in order to formulate corrective actions throughout the life cycle?
- Aggressively mitigate failure modes until reliability requirements are met?
- Employ a mechanism for monitoring and communicating the implementation and effectiveness of corrective actions that is accessible by the customer?
- Include failure modes that may occur during the life cycle in the system reliability model?

Reliability Assessment

- Assess reliability requirements feasibility using the System Reliability Model in conjunction with expert judgment?
- Reliability requirements allocated to lower indenture levels and flowed to subcontractors/suppliers?
- Periodically assess reliability of system throughout the life cycle using the reliability model, the life-cycle operational & environmental load estimates, and the customer-specified FDSC?
- Reliability values to be achieved at various points in the program included?
- Reliability assessments from analysis, modeling & simulation, test, and the field tracked as a function of time and compared to allocations and customer reliability requirements?
- Monitor and evaluate the implementation of corrective actions as well as other changes to the design or manufacture of the systems/product that may impact reliability?
- All assessments include COTS, NDI, and GFE?

Reliability Verification

- Develop and periodically refine a Reliability Requirements Verification Strategy/Plan that is an integral part of the systems-engineering verification and is coordinated and integrated across all phases?
- Strategy ensures reliability requirements will be verified during design and will not degrade during production or in the field?
- Includes reliability values to be achieved at various points during development?
- Verification based on analysis, modeling & simulation, testing, or a mixture, and operationally realistic?
- Verified System-Level Operational & Environmental Life-Cycle Loads will be used?
- Customer-specific requirements, if any, included?

Failure Definitions

- Understand customer-specified FDSC?
- Design to avoid failures due to user or maintainer errors?
- RPP integrates customer-specified FDSC with (1) system reliability model, (2) ID of failure modes & mechanisms, (3) closed-loop failure-mitigation process, (4) reliability assessment, and (5) reliability verification throughout life cycle?

Technical Reviews

- RPP specifies how and when technical reviews will be conducted throughout the life cycle?
- Conduct periodic interchanges with customer/user that promote understanding of operational environment?
- Technical reviews scheduled and conducted to (1) assure progress towards achieving reliability requirements, (2) verify that planned Reliability Activities are implemented, and (3) compare status and outcomes of Reliability Activities?
- Independent peer review conducted by SMEs?
- Conduct & participate in reviews with customer/user that address identification, analysis, classification, and mitigation of failure modes?

Methods & Tools

- Reliability Activities implemented with methods & tools from RPP?
- Reliability Best Practices implemented and adhered to?
- Changes in methods, tools, or Best Practices included in RPP update and approved by customer?

Outputs and Documentation

- Planning for RPP updates?
- Continuous customer access to status and outputs from all Reliability Activities?
- Outputs appropriately scheduled and documented in Reliability Case?