National Aeronautics and
Space Administration

SLS-STD-038

REVISION A

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SPACE LAUNCH SYSTEM PROGRAM (SLSP) DESIGN MODEL DELIVERY STANDARD

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REVISION AND HISTORY PAGE

Status	Revision No.	Change No.	Description	Effective Date
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NOTE: Updates to this document, as released by numbered changes (Change XXX), are identified by a black bar on the right margin.

TABLE OF CONTENTS

PARAGRAPH **PAGE**

1.0 INTRODUCTION 5
1.1 Purpose 5
1.2 Scope 5
1.3 Change Authority/Responsibility 5
2.0 DOCUMENTS 6
2.1 Applicable Documents 6
2.2 Reference Documents 6
3.0 KEY INFORMATION TO BE INCLUDED WITH DESIGN MODEL DELIVERABLES 7
3.1 Design Model Identifier (DMID) 8
3.2 Version/Revision 8
3.3 Release Date 8
3.4 Name 8
3.5 Classification 8
3.6 Statement of Intended Use 8
3.7 SLSP Element/Subsystem 8
3.8 Scope/Milestone 8
3.9 Model Point of Contact (POC) 9
3.10 Dependencies 9
3.11 Technical Description of Model 9
3.12 Assumptions 9
3.13 Operational Phase 9
3.14 Verification 9
3.15 Validation 9
3.16 Results Uncertainty 10
3.17 Results Robustness 10
3.18 Limitations 10
3.19 Input Pedigree 10

3.20 Use History....11

3.21 Conservatism....11

APPENDIX

APPENDIX A ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS....13

APPENDIX B OPEN WORK....15

APPENDIX C REFERENCE: COMMERCIAL CREW DEVELOPMENT (CCDEV) LANGUAGE FOR MODELING AND SIMULATION....16

APPENDIX D CHECKLIST OF DELIVERY DATA....17

TABLE

TABLE B2-1. TO BE RESOLVED ISSUES....15

FIGURE

FIGURE 3.21-1. EXAMPLE TO ILLUSTRATE REDUCTION IN CONSERVATISM WITH DESIGN MATURITY....12

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to state a minimum set of information which must be included with any design model delivery submitted (for Space Launch System (SLS) design activity), as identified and approved by an SLS discipline lead engineer (DLE), lead systems engineer (LSE), or chief engineer (CE). This standard provides a consistent, standardized approach for design model delivery, and supports a repeatable, quality process for delivering design models. In this document, the term "design model" includes mathematical models, computational models, and simulations (the definitions of these terms, as defined by NASA-STD-7009, NASA Standard for Models and Simulations, can be found in the glossary of this document).

1.2 Scope

Modeling and simulation will be used on the SLS Program for design activity, performance analysis, flight software design, and verification and validation (V&V). When math models, computational models, or simulations (as defined by NASA-STD-7009) are used to generate deliverable data for design or design verification, a minimum set of information establishing the credibility of each model will be included with any design model deliverable (for example, data from a design model, or the design model itself). That minimum set of information is defined in Section 3 of this Delivery Standard.

This Standard applies only to models and simulations delivered for use in SLS design and development activity; it addresses models and simulations used through Phase D (System Assembly, Integration & Test, Launch) up to but not including first flight. The elements will control their internal critical models per SLS-STD-038 or meet the intent with an equivalent implementation of NASA-STD-7009. Section 3.21 of SLS-STD-038 is not applicable for the Element internal critical models.

The process of designating and managing design models is further defined in SLS-PLAN-003, SLS Systems Engineering Management Plan. The technical organization developing any design model is responsible for assuring its quality.

Flight software, being managed separately in accordance with the SLS Software Development Plan, is not addressed by this document.

1.3 Change Authority/Responsibility

The NASA office of primary responsibility (OPR) for this document is Marshall Space Flight Center (MSFC)/EV74.

Proposed changes to this document shall be submitted by an SLS Project change request (CR) to the appropriate SLS Board for disposition. All such requests shall adhere to SLS-PLAN-008, SLSP Configuration Management Plan.

2.0 DOCUMENTS

2.1 Applicable Documents

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein. Unless otherwise stipulated, the most recently approved version of a listed document shall be used. In those situations where the most recently approved version is not to be used, the pertinent version is specified in this list.

SLS-PLAN-003	SLS Systems Engineering Management Plan (SEMP). Version: Baseline, 11/17/2011.
SLS-PLAN-008	SLSP Configuration Management Plan. Version: C, 4/4/2013.
SLS-PLAN-004	SLSP Data Management Plan. Version : B, 5/2/2013.

2.2 Reference Documents

The following documents contain supplemental information to guide the user in the application of this document.

NASA-STD-7009	NASA Standard for Models and Simulations. Version: Baseline, 2/11/2008.
SLS-PLAN-173	SLS Program Modeling and Simulation Plan. Version: Baseline, 5/15/2013.

3.0 KEY INFORMATION TO BE INCLUDED WITH DESIGN MODEL DELIVERABLES

The following information must be included with any submitted Design Model deliverable for the SLS Program. All items are applicable to the design certification submittal of each model. The amount and type of content necessary from Elements for deliveries prior to certification model development will include a minimum sub-set as shown below:

Model Identifier and Name
Model version or Revision designation
Statement of Intended Use
Model POC (and contact information)
Model Assumptions and use Limitations

Design models prior to DCR delivery from the Elements will be maintained with CM control under appropriate Element modeling plans and consistent CM systems. Typically, early "test" versions (Released for Information) of the models/data would be made available to the SLS SE&I end user to assure that the model is complete and appropriate (in format and content) for the end user utilization. Models delivered formally to SLS SE&I from the Elements will have Element CE and EDLE concurrence prior to final (Released for Technical Use) transmission to SLS SE&I.

Any additional model data that is necessary prior to DCR delivery should be defined in the DRD (i.e. model sensitivity). If additional data is necessary or available prior to DCR delivery, it will be included in the model delivery package. Informal model substantiation data, appropriate to the program maturity, that is needed prior to DCR is expected to be obtained by the responsible EDLE and included in the delivery package.

Prior to DCR, and in the case that the DRD is not specific, informal model substantiation data will be provided with each delivery for the following:
• If applicable, a set of input/output model test cases that span the validity range of the model for verifying that a model has been implemented correctly (if the model is a look up table, a statement of the interpolation method and direction for table exceedance (hold last value, extrapolate, etc.) is sufficient, if a model is a number, NA is appropriate)
• If applicable, model uncertainties (include distribution type, mean, and standard deviation).
• Assessment of Conservatism (may be engineering judgment prior to DCR)
Prior to DCR, and in the case that the DRD is not specific, other informal model substantiation data will be provided upon request. It is expected that such data/model information appropriate to the program maturity would be obtained by the responsible EDLE and included in the delivery package. Examples of potential requests are listed below.
• Assessment of Robustness
• Verification and validation information appropriate to the maturity of the model/program
• Preliminary assessment of remaining meta data
Formal delivery for DCR will include the following:

3.1 DMM Unique Identifier

The developer will state the DMID, a unique identifier that will be assigned to the design model upon its designation as a design model by the SLS Chief Engineer or designee. The design model identifier will be used to track all the design models being used by the SLS Program.

3.2 Version/Revision

The developer will state the version number; this should be a unique tracking number assigned by the developer of the model to track changes to the model.

3.3 Release Date

The developer will include the release date when the design model is delivered for the specific use.

3.4 Name

The developer will provide the "design model name," a title given to the design model by its owner or developer (e.g., "SLS Launch Vehicle Ascent Aerodynamics" or "SLS Ascent Aerodynamic Heating"). Also, note any element-level configuration or designation name applied to the design model for internal use and tracking.

3.5 Classification

Developer will provide a Form MSFC-4511, SLS Data Concurrence Sheet, or a comparable Element form, at the time the model is presented for review. The purpose of this 4511 is to establish whether or not the model is Sensitive But Unclassified (SBU), subject to ITAR/EAR restrictions, is proprietary, or contains limited rights data. For this purpose, the signature blocks in the table labeled "Program/Engineering Concurrence" do not have to be filled. Only the Date, Title, Developing Office, SBU Assessment, and CER Assessment blocks are necessary.

3.6 Statement of Intended Use

The developer will provide a statement of how the design model is to be employed. The intended use should describe the system and environmental elements to be modeled and/or the data to be produced by the model.

3.7 SLSP Element/Subsystem

The developer will list the major element(s), subsystem(s), or process(es) of the SLS Program to which the model applies.

3.8 Scope/Milestone

The developer will list the SLS Program life cycle phase(s) of the design and analysis process for which a design model is used (i.e., Preliminary Design Review (PDR), Critical Design Review (CDR), Design Certification Review (DCR), Design Requirements Verification, and Design

Requirements Validation.) This should include the instances when a design model needs to be reassessed to ensure integrity of the system design is maintained.

3.9 Model Point of Contact (POC)

The developer will provide the name of the NASA technical representative designated by the DLE or element discipline lead engineer (EDLE) who is primarily responsible for the design model. This person is also responsible for tracking design model configuration changes. The developer will include person's role in the SLS Program, location/org code, telephone number, and working email address.

3.10 Dependencies

The developer of the Design Model who receives and uses inputs from other Design Models needs to list all dependencies. Dependent Design Models rely on other Design Models, or the output from other Design Models, for their input. List any other Design Models that are inputs to this Design Model. For models delivered by Elements, this model dependency will be covered in "Input Pedigree".

3.11 Technical Description of Model

Developer will include a qualitative summary of aspects, details, cases, steps, conditions, and states. The developer of the Design Model who receives and uses critical inputs from other Design Models needs to determine how the use of the critical inputs affects the design, verification, validation, operation, or mission success of the SLS Vehicle. Describe statistical methods and outputs, or rationale for the use of deterministic methods. Reference the specific Data Requirements Description (DRD) that is associated with the Design Model.

3.12 Assumptions

The developer will provide the set of technical premises (i.e., the physics, mathematical theories, abstract concepts, hypotheses, and simplifications) upon which development or implementation of a design model is based.

3.13 Operational Phase

The developer will list the operational phase(s) (e.g., manufacturing, ground operations, flight/mission phase) associated with the intended use of the design model.

3.14 Verification

Developer will include a summary assessment of the Design Model's verification. Model Verification is the process of determining that a computational model accurately represents the underlying mathematical model and its solution from the perspective of the intended uses of the M&S. It includes a set of input/output model test cases that can be used to verify that a model has been implemented correctly, and that span the range of validity of the model. Verification measures the correctness of (a) the mathematical understanding of the underlying physics, (b) the translation (i.e., program code that does the computational effort) of the physics-to-mathematics

into a model, and (c) the effects and sensitivities of dependent and independent variables on other variables of the model, so that results are indicative of the hardware/system performance. Details of model verification may be provided by reference to other specific reports.

3.15 Validation

Developer will include a summary assessment of the Design Model's validation. Model Validation is the process of determining the degree to which a model or a simulation is an accurate representation of the real world from the perspective of the intended uses of the model or the simulation. It is a measure of how well the model or simulation represents the reality of interest by correlating M&S results to (a) real-world data, or (b) experimental or test data, or (c) comparable model or simulation results, or (d) some combination of (a), (b), and (c). Details of model validation may be provided by referencing other specific reports.

3.16 Results Uncertainty

Developer will include an assessment of the Design Model's results uncertainty. List unknowns (uncertainty and variability), derivation of current values and future reduction schedules if known. Uncertainty is defined as (a) the estimated amount or percentage by which an observed or calculated value may differ from the true value; or (b) A broad and general term used to describe an imperfect state of knowledge or a variability resulting from a variety of factors including, but not limited to, lack of knowledge, applicability of information, physical variation, randomness or stochastic behavior, indeterminacy, judgment, and approximation. Uncertainty for a particular model includes both the inherent variability as well as the variability inserted in order to cover for lack of design maturity. The latter variability should decrease in the model deliveries as the design matures. Each model's outputs must either quantify the uncertainties or result in outputs that reflect the magnitude and statistics of the uncertainties. The model metadata identifies the sources of the uncertainties.

3.17 Results Robustness

Developer will include an assessment of the Design Model's results robustness. The purpose of considering robustness is to garner an understanding of the sensitivities of the real-world system to potential changes in variables and parameters of the system. Robustness is concerned with how the results of an M&S analysis change as a result of changes in the parameters, variables, and conditions.

3.18 Limitations

The developer will provide the boundary set of parameters for which the design model is usable based on its pedigree, appropriateness, assumptions, and uncertainties; the limits of use or operation; and the confinements or restrictions on using the design model that must be understood by design model users.

3.19 Input Pedigree

For models that take input data, the developer will provide the history, traceability, or pedigree of an input data set which asserts that the current modeling effort has some agreement or correlation with what has been acceptable input data in the past and is relevant to the current situation. Include the uncertainty of input data.

3.20 Use History

The developer will provide the history, heritage, legacy, or pedigree of modeling methodology that asserts that the current modeling effort has some basis in what has been acceptable in the past and is relevant to the current situation (e.g., an extensive database may exist in the automotive industry, but it might not be applicable in an aerospace situation). The developer will also provide an assessment of the model's currency or obsolescence with respect to the present state of the art.

3.21 Conservatism

Developer will include an assessment of the Design Model's conservatism. Conservatism is the difference in uncertainty between the current model and the uncertainty (best estimate) that is still expected to exist on flight day. Supply information concerning input conservatisms, modeling conservatisms, and/or output conservatisms, as applicable for each model. Conservatisms do not need to be derived for nonlinear processes where the information is not otherwise known.

Report on all of the following that apply to the particular model in question:

- Use of "uncertainty factors": values, determined by the use of a multiplication factor, that result in uncertainties larger than the expected value for flight day. (The expected value is the real predicted value, with a 50% confidence.)

- Use of stacked variations: use of methods that combine sources of variation using a worst on worst approach, which yields values greater than design values derived by statistical methods

- Statistical approaches: use of k-sigma procedures for small sample sets, confidence levels and intervals, percentage captures for the data supporting a model.

- Designing to requirements - designing to levels (wind speeds, temperatures, etc) that are unlikely to be realized.

Supplying this information should not result in added scope of analysis. It should be simply reporting the methods that are being used.

Figure 3.21-1 is a notional example illustrating conservatism in a parameter value over time. The "True Value" series shows the best estimate of the parameter's value, including known uncertainties resulting from sources such as manufacturing variation or flight day conditions. The application of factors explained in this section's definition of conservatism may result, early

in the program, in a relatively wide envelope between lower and upper bounds in which the parameter's true value is expected to occur. As the design matures and knowledge is gained, successive models and analyses would be expected to reflect less built-in conservatism, resulting in a tightening of the bounds toward the uncertainty (best estimate) that is still expected to exist on flight day.

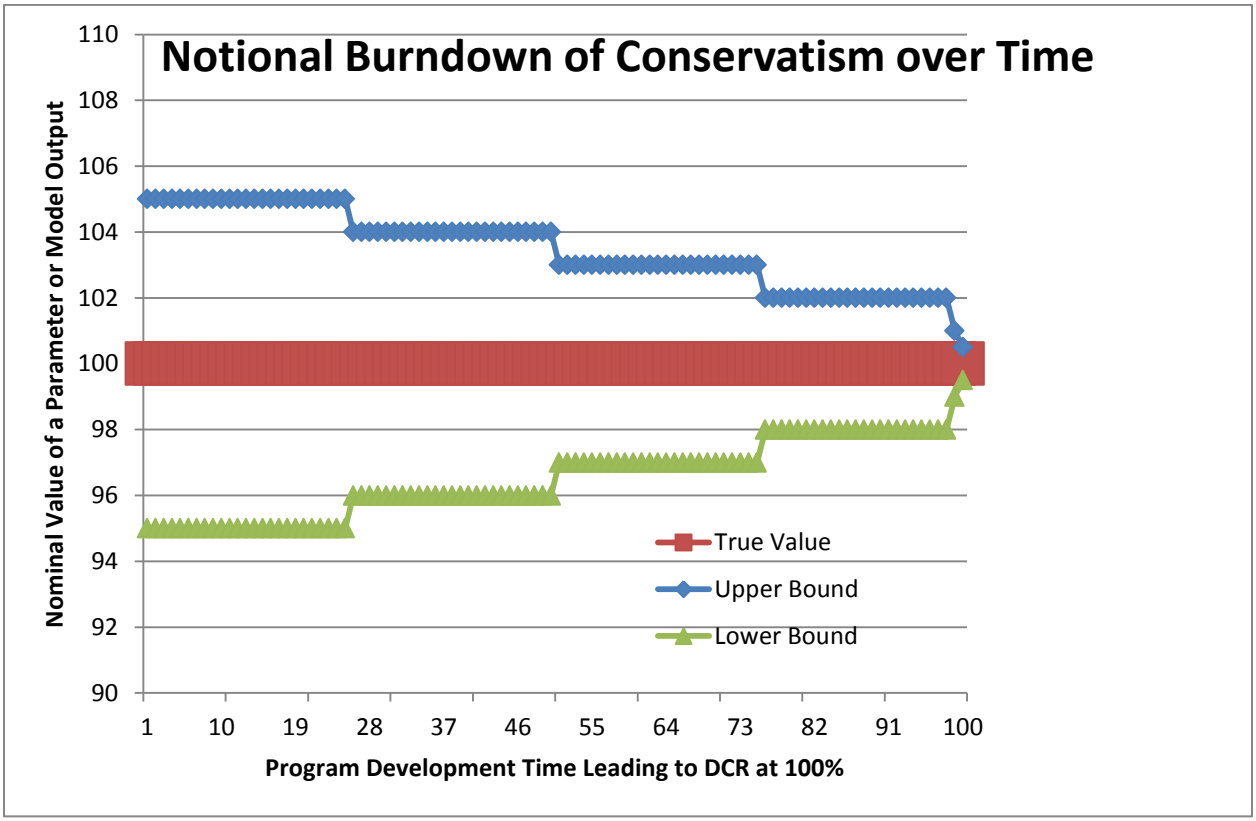

FIGURE 3.21-1, EXAMPLE TO ILLUSTRATE REDUCTION IN CONSERVATISM WITH DESIGN MATURITY

APPENDIX A
ACRONYMS AND ABBREVIATIONS AND GLOSSARY OF TERMS

A1.0 ACRONYMS AND ABBREVIATIONS

CCDEV	Commercial Crew Development
CDR	Critical Design Review
CE	Chief Engineer
CR	Change Request
DCR	Design Certification Review
DLE	Discipline Lead Engineer
DMID	Design Model Identifier
DRD	Data Requirements Description
EDLE	Element Discipline Lead Engineer
LSE	Lead Systems Engineer
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
OPR	Office of Primary Responsibility
PDR	Preliminary Design Review
POC	Point of Contact
SDR	System Definition Review
SEMP	Systems Engineering Management Plan
SLS	Space Launch System
SLSP	Space Launch System Program
SRR	System Requirements Review
STD	Standard
TBD	To Be Determined
TBR	To Be Resolved
V&V	Verification and Validation

A2.0 GLOSSARY OF TERMS

Term	Description
Computational Model	The numerical representation of the mathematical model. Source: NASA-STD-7009 (Approved 7-11-2008).
Conceptual Model	The collection of abstractions, assumptions, and descriptions of physical processes representing the behavior of the reality of interest

Term	Description
	from which the mathematical model or validation experiments can be constructed. Source: NASA-STD-7009 (Approved 7-11-2008).
Design Model	For SLS purposes, this term means a math model, computational model, or simulation delivered to the Program for the purposes of specifying design characteristics, specifying design implementation, or verifying that the design meets requirements.
Math Model	The mathematical equations, boundary values, initial conditions, and modeling data needed to describe the conceptual model. Source: NASA-STD-7009 (Approved 7-11-2008).
Simulation	The imitation of the characteristics of a system, entity, phenomena, or process using a computational model. Source: NASA-STD-7009.

APPENDIX B
OPEN WORK

B1.0 TO BE DETERMINED

Table B1-1 lists the specific to be determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBD item is sequentially numbered as applicable (i.e., **<TBD-001>** is the first undetermined item assigned in the document). As each TBD is resolved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

B2.0 TO BE RESOLVED

Table B2-1 lists the specific to be resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within carets. The TBR issue is sequentially numbered as applicable (i.e., **<TBR-001>** is the first unresolved issue assigned in the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

Table B2-1. To Be Resolved Issues

TBR	Section	Description

APPENDIX C
REFERENCE: COMMERCIAL CREW DEVELOPMENT (CCDEV) LANGUAGE FOR MODELING AND SIMULATION

The following statement was approved by the NASA Chief Engineer, Michael Ryschkewitsch, on the use of modeling and simulation in another current NASA program, Commercial Crew Development (CCDEV):

"Documentation related to any models or simulations whose analysis results are used to make critical decisions regarding design, development, manufacturing, and ground or flight operations that may impact human safety or Program-defined mission success criteria will be reviewed. Of particular interest are the methods and procedures used (a) for determining (through risk assessments) which software models and simulations influence critical decisions and (b) for assessing and communicating the credibility of model/simulation analysis results based on factors such as verification, validation, input pedigree, results uncertainty quantification, results robustness, and use history."

APPENDIX D
CHECKLIST OF DELIVERY DATA

This checklist may optionally be used to aid in preparation of model delivery data.

_____1. Design Model Identifier (DMID)

_____2. Version/Revision

_____3. Release Date

_____4. Name

_____5. Classification

_____6. Statement of Intended Use

_____7. SLSP Element/Subsystem

_____8. Scope/Milestone

_____9. Model Point of Contact (POC)

_____10. Dependencies

_____11. Technical Description of Model

_____12. Assumptions

_____13. Operational Phase

_____14. Verification

_____15. Validation

_____16. Results Uncertainty

_____17. Results Robustness

_____18. Limitations

_____19. Input Pedigree

_____20. Use History

_____21. Conservatism