Space Flight Operations Contract

Product Development Plan
for
Flight Systems Analysis
PDP MS4-002

December 11, 2002
Revision C

DRD-1.1.1.1-f

Contract NAS9-20000

United Space Alliance

Product Development Plan
for
Flight Systems Analysis
PDP MS4-002

December 11, 2002

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REVISION LOG

REV LTR	CHANGE NO	DESCRIPTION	DATE
		Baseline	03/31/97
A		Incorporates changes required for transition from NASA to USA process management.	07/03/97
B		Incorporates changes resulting from transition of LSEAT responsibilities from System Integration to MOD, the elimination of the AFSIG and transition to the Space Shuttle Engineering Integration Group (SSEIG), consolidation of the applicable Flight Design Criteria and Constraints subsections with the Flight Verification/Margins Assessment and Post-Flight Data Analysis subsections, and textural clarifications. This revision also includes the changes driven by the findings and observations of the August 1998 audit.	11/01/99
C		Updated to clarify documentation of Boeing and USA processes, update organizational names and correct references. Incorporates description of update FRV ascent flight design kickoff and ascent flight design freezepoint processes.	12/11/02

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LIST OF EFFECTIVE PAGES

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PREFACE

This Product Development Plan for Flight Systems Analysis PDP MS4-002 was prepared by the United Space Alliance (USA) and USA prime subcontractor, Boeing NASA Systems.

The primary responsibility is with USA Systems Integration, a department of Program Integration.

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OVERVIEW

The specific activities covered by this Product Development Plan (PDP) consist of three general areas of flight systems analysis tasks. The first area, Section 3.1 thru Section 3.5, is the preflight systems analysis activities in support of the systems integration flight preparation process requirements. The second area, Section 3.6, is the launch support related activities. The third area, Section 3.8, consists of the post-flight related tasks in support of the next flight preparation process and Flight-Derived Dispersion (FDD) maintenance activities.

1.0 SCOPE

This PDP has been prepared pursuant to Data Requirements Description (DRD) 1.1.1.1-f, Space Flight Operations Product Development Plans. This PDP characterizes the work efforts required by the National Aeronautics and Space Administration (NASA), United Space Alliance (USA) and Boeing to deliver products to satisfy program integration requirements. It contains descriptions of: processes followed, products delivered, and acceptance criteria; NASA and USA organizational responsibilities which include oversight responsibilities for USA, and oversight and insight responsibilities for NASA; and conditions which are in-family or out-of-family. Any changes made to the processes used in performing the requirements of this PDP shall be coordinated with the appropriate technical panel and concurred with by the Space Shuttle Engineering Integration Group (SSEIG) and ICB (as required).

The specific tasks covered by this PDP are shown in the following table:

PDP Section	Sub-Contract No. 1970483303 WBS	SFOC SOW NAS9-20000	Task Title
3.1	1.2.2.1	1.2.2.1	Shuttle Mass Properties
3.2	1.2.2.1	1.2.2.2	TDDP Generation and Distribution
3.4	1.2.2.1	1.2.1.6	Analytical S/W and Database Maintenance
3.5	1.2.2.1	1.2.1.2 1.2.2.3	FRV/Margins Assessment
3.6	1.2.2.1	1.2.1.6	DOSS Preflight/DOL Support
3.8	1.2.2.1	1.2.1.1 1.2.2.3	Post-Flight Data Analysis/Evaluation

The products associated with this PDP are shown below:

PDP Section	DRD or PDRD No.	Product
3.1	1221a	Shuttle Weight, Performance, and Integrated Mass Properties Database and Status Reports
3.2	1222a	Trajectory Design Data Package (TDDP)
3.2	1222b	Trajectory Design Data Package (TDDP) Change Notices
3.2	N/A	Ascent Flight Design Kick-off Briefing
3.2	N/A	Ascent Flight Design Tag-Up Briefing
3.2	N/A	Ascent Flight Design Freeze Point Briefing
3.5	SC010 *	FRV/FMA Groundrules Briefings to SIRB
3.5	SC008 *	RSRM Burn Rate Acceptability Evaluation
3.5	SC007 *	Flight Cycle/OCTF GN&C and Performance Margin Briefing
3.5	1212a	Element Heating and Loads Environments Data Files and Letters
3.5	N/A	Data Package For Program Integration FRR
3.5	SC010	Update FRV Groundrules Briefing
3.5	SC007	Update FRV Results Briefing
3.6	1216a	DOSS Flight-Specific Products
3.6	1216b	DOSS Non-Flight-Specific Products
3.8	SC003 *	Quick-Look Post-Flight Report, Post-Flight Data Availability Letter
3.8	SC009 *	Flight Performance Reconstruction Briefing
3.8	1211a	Flight-Derived Dispersions Database Update
3.8	1223a	Adjusted RSRM Block Motor Model Update
3.8	1223b	MPS Inventory Budget Update

NOTE: All Procurement Data Requirements Descriptions (PDRDs) (deliverables from Boeing to USA) are also DRDs (deliverables from USA to NASA) except those noted with an asterisk (*), which are deliverable from Boeing to USA.

2.0 DOCUMENTATION

2.1 APPLICABLE DOCUMENTS

Program documentation defining the procedures, methodologies, and processes to be used in the development of the products covered by this PDP are shown below. The current versions of the following documents are applicable to this PDP and shall be used as described in the specific process descriptions.

Document Number	Document Title
ICD-E-MCC-010B (Latest Version)	External Interface Control Document, JSC/MCC/FADS-Boeing and CCAFS, Operational Communications DOLILU II ICD for Space Shuttle Missions
ICD-I-FDD-017 (Latest Version)	Internal Interface Control Document, Flight Design and Dynamics, Ascent Discipline, Ascent Subsystem, USA/Boeing Day-of-Launch Function
JSC 25187, Appendix A	Flight Production Generic Templates
NSTS 07700, Volume III	Flight Definition and Requirements Directive
NSTS 07700, Volume IV - Book 1	Configuration Management Requirements Book 1 - Requirements
NSTS 07700, Volume X	Flight and Ground System Specification
NSTS 08117, Appendices M, R	Requirements and Procedures for Certification of Flight Readiness
NSTS 08209, Volume I	Shuttle Systems Design Criteria Volume I, Shuttle Performance Assessment Databook
NSTS 08209, Volume IV	Shuttle Systems Design Criteria Volume IV, Generic Ascent Flight Design Requirements
NSTS 08209 Volume V, (Retired)	Shuttle Systems Design Criteria, Volume V, Critical Math Model Document NOTE: Replaced with the Critical Math Model Database Web Site (CMMDB)
NSTS 08329 Volume VIII	DOLILU II Definition and Requirements Document Volume VIII - DOLILU Operations Support Plan

Document Number	Document Title
NSTS 09095	Detailed Shuttle Systems Weight and Performance Summary Report
RSS00HB190 (Latest Version)	System Integration Engineering Analysis Process Configuration Management Overview
SFOC-PM0072	Product Development Plan for United Space Alliance Program Integration Certification of Flight Readiness Process PDP MS8-005
SFOC-PM0461 (Latest Version)	Interface Control Document, Trajectory Design Data Package (TDDP) Electronic File Format
SSD92D0050 (Latest Version)	Requirements Definition Document for Post-Flight Analysis/Reconstruction
SSD93D0492 (Latest Version)	Flight Margins Assessment Criteria Document
SSD95D0205 (Latest Version)	Program Integration Flight Preparation Process Definition Document
SSD95D0334 (Latest Version)	Flight Readiness Verification Criteria Document
SSD95D0369 (Latest Version)	MPS Propellant Inventory Generation Program

2.2 REFERENCE DOCUMENTS

Reference documents used in the development of the PDP products are identified as additional sources of related material for informational purposes only.

Document Number	Document Title
ICD-I-FDD-018, Volume I - Book 1	Trajectory Design Data Package Electronic File Format
NSTS 08329, Volume VI	DOLILU II Definition and Requirements Document, DOLILU II Quality Assurance Rules

3.0 PRODUCT DEVELOPMENT ACTIVITIES

3.1 SHUTTLE MASS PROPERTIES

The Shuttle mass properties activity shall consist of development and maintenance of an integrated mass properties database based on the latest program-approved configuration for all Shuttle elements (Orbiter, Space Shuttle Main Engine [SSME], External Tank [ET], Solid Rocket Booster [SRB], crew equipment, propellants, Space Transportation System (STS) operator, and non-propulsive consumables) and customer defined baseline reference missions (e.g., generic Space Station). Weekly program management status reports for all flights baselined in NSTS 07700, Volume III, Flight Definition and Requirements Directive shall be provided. Customized management reports shall be provided to USA and others. These include down weights, performance projections, and special reports, as required. Mission-specific integrated mass properties data shall be generated for inclusion in Trajectory Design Data Packages (TDDPs), Cargo Integration Review (CIR) assessments, and Flight Planning and Stowage Review assessments to support ascent flight design. Integrated assessments of all issues pertaining to down weights, performance, and Center of Gravities (CGs) in support of the USA Systems Integration Review Board (SIRB), NASA SSEIG, Flow Review Working Group, Integrated Product Teams, and Program Requirements Control Boards (PRCBs), including Launch Site Requirements Review (LSRR) and Launch Site Flow Review (LSFR) briefings/presentations shall be provided. Boeing shall calculate and provide generic and mission-specific mass properties updates for new and modified Orbiter mission kits. Historical and trend analysis studies for Shuttle Performance Enhancements (PEs) shall be provided. Appendix B, Figure 3-1 summarizes all the inputs and outputs associated with this task.

3.1.1 Process

The Boeing tasks supporting the mass properties task will be described in Section 3.1.1.1 thru Section 3.1.1.10 and consists of the following basic processes:

a. Maintain the Shuttle integrated mass properties database.

b. Publish the Shuttle Systems Weight and Performance Status Report (Greenbook) and Vehicle Summary Weight Statements.

c. Publish the Flight Dynamics Mission Summary (FDMS).

d. Publish the FDMS pocket card.

e. Prepare mission-unique Vehicle Summary Weight Statements.

f. Prepare integrated mass properties assessments for specific milestones and special studies.

g. Provide formal mass properties evaluations of all Payload Integration Plan (PIP) Annex I Change Requests (CRs) and Flight Definition and Requirements Directive (FDRD) CRs, as required.

h. Calculate generic and mission-specific mass properties for new and modified mission kits.

i. Prepare data for the Flight Operations Plan (FOP) mass properties update process.

The USA mass properties and performance related tasks will be described in Section 3.1.1.11, and the NASA mass properties and performance related tasks will be described in Section 3.1.1.12.

3.1.1.1 Shuttle Integrated Mass Properties Database Development Process

All mass properties are entered by Boeing so that the latest approved configuration is maintained. The process is as follows:

a. Mass properties data received from any source are assessed for completeness and general accuracy. Problems are resolved with the supplier before acceptance.

b. Any data that must be converted from source supplied units to system required units is processed before entry into the database.

c. Mass properties are maintained as flight-unique entries (delta records) - weight to the nearest pound and CGs to the nearest tenth of an inch.

d. Weight changes are entered and maintained as individual change records to provide change traceability between quarterly Greenbooks.

e. Fluids data is extracted from cyclical Orbiter consumables reports and integrated with current Hardware (H/W) changes to provide timely downweights.

f. Results of simulations run against published TDDPs are integrated with current H/W changes to provide timely performance margins.

g. Mass properties are calculated for mission equipment kit installation configurations and incorporated in the integrated database.

h. Performance projections for ascent design changes are incorporated for each mission.

3.1.1.2 Shuttle Systems Weight and Performance Status Report (Greenbook) and Vehicle Summary Weight Statements Process

The following process is performed by Boeing:

a. The Greenbook Summary Weight Reports must be compiled and published electronically each Tuesday. Once each quarter, a more comprehensive Greenbook (NSTS 09095, Detailed Shuttle Systems Weight and Performance Summary Report), which includes delta record tables, is published.

b. The database is locked, changes summed by flight, and performance margin re-calculated.

c. The performance adjustment is incorporated into the database as detailed change records.

d. The reports are generated by executing a Software (S/W) program which combines all elements according to pre-programmed rules and stores them in USA and NASA-approved formats.

e. Those error conditions that can be detected by S/W are checked and messages written. Many problems cannot be detected by S/W; therefore, a thorough Quality Assurance (QA) procedure is performed at this time.

f. Errors detected in element inputs are elevated to USA management for resolution.

g. Any errors found are corrected and the process restarted at Step c.

h. The Greenbook and Vehicle Summary Weight Statements are released electronically for public access.

3.1.1.3 FDMS Process

The following process is performed by Boeing:

a. This report is compiled and published each Wednesday.

b. A program is executed which selects required data from the released Greenbook, appends a “Notes” file, and flags limit violations. The results are stored in a USA and NASA-approved format.

c. A review of the week’s mass properties changes is made to determine if any updates are required to the Notes section. If violations exist, and USA Systems Integration and Flight Operations are informed, the Notes are updated to reflect planned actions (fluids, ballast, etc.). If unique mass properties conditions occurred that are deserving of visibility, the Notes section is updated.

d. The report program is re-executed to incorporate the changes and the results reviewed by a second person. When the results are deemed correct, the report is released electronically for public access.

3.1.1.4 FDMS Pocket Card Process

The pocket card is a brief management summary of the first eight flights manifested in the NSTS 07700, Volume III. It is compiled and produced every other Wednesday by the following process.

a. The FDMS is downloaded from the Integrated Management Information Center (IMIC) computer to a local Personal Computer (PC) in text format.

b. An EXCEL macro is run to extract data from pre-selected fields and format it for reproduction.

c. After two-sided copying on to card stock, the cards are cut and attached to individual office distribution lists.

d. The cards are delivered to each USA and NASA office per the distribution list.

3.1.1.5 TDDP Mass Properties Process

Mass properties for each TDDP are unique and require different levels of data fidelity (e.g., estimated, calculated, actual, etc.). The specific processes are as follows:

a. Scheduled TDDPs

1. If configuration changes have been approved since the weekly Greenbook or significant weight/CG changes have been approved and are required for the TDDP, the database is updated and the individual flight is locked.

2. A program is executed to compile the Vehicle Summary Weight Statement for the single flight using the following Tuesday's Greenbook date. No further changes are allowed to that flight until the next Greenbook is published.

3. The Vehicle Summary Weight Statement is reviewed and, when deemed correct, is released electronically for public access.

b. Special Studies TDDPs

1. If mass properties requiring an unapproved configuration are requested, the latest released mass properties for the flight are copied to a "WHATIF" file.

2. This file is updated with the requested data and a program executed against it to compile a Vehicle Summary Weight Statement.

3. After review, the report is submitted for publication in the TDDP.

3.1.1.6 Integrated Mass Properties Assessments and Special Studies

These tasks are performed as follows:

a. After receipt of the list of new or revised items, determine which items require further investigation and initiate a search for the data.

b. Performance changes

1. Sum weight changes and calculate the resulting performance margin.

2. Calculate performance change for Specific Impulse (Isp)/thrust, Reusable Solid Rocket Motor (RSRM), and burn rates and Propellant Mean Bulk Temperature (PMBT), etc.

c. CG changes

    1. Copy current flight with similar configuration into a WHATIF file and modify.

    2. Execute single flight mass properties program and review results.

d. Deliver Vehicle Summary Weight Statement or prepare and deliver charts, as required.

3.1.1.7 Evaluate PIP Annex I and FDRD CRs

These tasks are performed as follows:

a. PIP Annex I CRs

    1. All CRs are reviewed for mass properties impacts.

    2. Follow Step a thru Step c of Section 3.1.1.6, if required.

    3. Respond in writing, or by phone if constrained by time limits, according to CR procedures.

b. FDRD CRs

    1. All CRs are reviewed for mass properties impacts.

    2. Follow Step a thru Step c of Section 3.1.1.6.

    3. Deliver results to customer.

3.1.1.8 Historical and Trend Analysis Studies

These tasks are performed semi-annual as follows:

a. Research the data.

b. Perform analyses.

c. Provide results to the customer.

3.1.1.9 Calculation of Mission Kit Mass Properties

Boeing shall provide and maintain preliminary and calculated generic and mission-specific mass properties for new and modified mission kits as follows:

a. Review configuration for each manifested flight based upon:

    1. Mission Equipment Cargo Support Launch Site Installation (MECSLSI) drawing

    2. Crew compartment configuration drawing

    3. Cargo arrangement drawing

b. Update mass properties of existing mission kits for specific missions (weight may not change but location can).

c. Review preliminary drawings to estimate mass properties for revisions and/or new mission kits.

d. Update mass properties database.

e. Monitor revisions to drawings and replace estimated with calculated mass properties as drawings are released and changes are made.

f. Update mass properties of mission kits with actual weights obtained prior to shipment of parts and/or from KSC weight logs.

3.1.1.10 FOP Mass Properties Update Process

The FOP mass properties updates shall be done, if required, after the FOP, to update fluid quantities and hard ballast requirements only, and is accomplished as follows:

a. Preliminary mass properties updates (including the data file name to be used) will be delivered to Boeing five days before the FOP, by USA-Flight Design.

b. At the FOP, or immediately following, a signed flight initialization data package detailing any changes to the original submittal will be delivered to Boeing, by USA-Flight Design.

c. Changes will be made to the original TDDP mass properties and an electronic file, containing the Vehicle Summary Weight Statement will be generated.

d. Appropriate mass properties personnel will QA the results and sign a hardcopy of the results.

e. A phone call will be made to the originator informing him of the availability of the data.

f. An e-mail message will be sent to USA, NASA, and the originator to verify the job is complete. Delivery is due two days after the FOP.

g. The vehicle weight summary statement hardcopy will be stored for future reference.

3.1.1.11 USA Related Tasks

The following are the associated activities performed by the USA Systems Integration Office.

3.1.1.11.1 Technical Integration

a. Resolve mission configuration issues and approve, when required, incorporation of pending “unofficial” changes into the mass properties database, via e-mail or letter.

(Example: late changes to launch date, payload content, and/or SSME assignments)

b. Resolve noncompliance of managers reserve policy (performance and longitudinal CG) and other defined constraints. (Examples: crew module total mass, landing weight, CG envelopes)

c. Coordinate and approve mass properties feasibility and special study requests.

d. Prepare and present the International Space Station performance reference mission revisions and control weight and status briefing to Space Shuttle Program (SSP), as required.

e. Review actual delivered element weight and CGs versus control values to verify compliance.

3.1.1.11.2 Configuration Management

a. Approve database access requests and electronic distribution changes.

b. Approve database and format changes internal to USA organizations and subcontractors.

3.1.1.12 NASA Related Tasks

The following are the associated activities performed by the NASA Systems Integration Lead for Shuttle mass properties and performance:

3.1.1.12.1 Technical Integration

a. Assist in resolution of external data source issues. Emphasis is placed on Day-of-Launch (DOL) TDDP inputs. (Examples: late and/or incorrect inputs, actual weighing discrepancies, control weight violations)

b. Concur on resolution of out-of-family conditions.

c. Coordinate process improvements that involve external organizations external to Space Flight Operations Contract (SFOC).

3.1.1.12.2 Configuration Management

a. Approve process changes or changes to the mass properties database application that impact content, change traceability, or report format impacting organizations external to SFOC.

b. Approve changes to electronic interface requirements external to SFOC.

3.1.2 Products

The product produced by this process is:

PDRD 1221a, Shuttle Weight, Performance, Integrated Mass Properties Database and Status Reports

3.1.3 Product Acceptance Criteria

Products must be completed and delivered on time, in accordance with applicable systems integration (also known as [aka] Artemis) schedules and PDRD technical content requirements. Product quality is determined acceptable by completing required internal reviews. Flight products (not feasibility and special studies cases) must contain only SSP approved requirements, except for USA or NASA authorized deviations.

Product quality and timeliness metrics shall be reported for the products defined in this section using USA Performance Measurement System (PMS).

3.1.4 Oversight and Insight Responsibilities

3.1.4.1 USA Oversight Responsibility

USA shall provide the oversight of the mass properties process performing the tasks as described in Section 3.1.1.11. USA shall inform NASA of any out-of-family conditions, via e-mail, from the Director of Systems Integration and maintain insight into the analysis and closure of any such conditions.

3.1.4.2 NASA Oversight and Insight Responsibility

NASA shall provide the specific oversight of the mass properties process through the performance of the tasks, as described in Section 3.1.1.12. In addition, NASA shall maintain insight into the mass properties task through reviews, observations of the process, mission products, documentation, and metrics. NASA can initiate audits of the mass properties process to enhance their insight, to support the correction of process failures resulting in the violation of quality or schedule provisions of the applicable standard/Maximum Error Rates (MERs), or to support the resolution of out-of-family conditions.

3.1.5 Out-of-Family Conditions

An out-of-family condition exists for:

a. Post-flight reconstruction results that show differences between predicted versus reconstructed mass properties outside of the historic database.

b. Differences in actual element weighing results versus predicted that are outside of historic database.

c. Element weight or performance control parameters outside established control limits, as defined in NSTS 07700, Volume X, Flight and Ground System

Specification. (Examples: RSRM propellant burn rate, SSME Isp, element control weight violations)

d. Uncorrected degradation of product quality and/or timeliness.

e. Late/Incorrect external inputs that result in degraded product quality and/or timeliness. (Example: L-9 day RSRM PMBT prediction)

3.2 TDDP GENERATION AND DISTRIBUTION

This activity produces specified TDDPs. These packages are documents used to initiate and provide updates for each of the flight design cycles defined in JSC 25187, Appendix A, Flight Production Generic Templates. All data released in standard TDDPs shall be traceable to approved SSP CRs, unless a TDDP deviation form is requested by, and signed by, NASA/MS.

3.2.1 Process

The Boeing tasks supporting the TDDP generation and distribution process consists of integrating information, verifying the integrity of the data, and distributing the approved package. This process is shown in Appendix B, Figure 3-2. The USA TDDP related tasks are described in Section 3.2.1.7. The NASA TDDP related tasks are described in Section 3.2.1.8.

3.2.1.1 TDDP Formats

For each Space Shuttle mission, a series of TDDPs are produced. The TDDPs support a variety of mission design activities including: STS mission planning, consumables analysis, I-Loads definition, mission performance assessment, DOL support activities, and post-flight ascent trajectory reconstruction. They are published at various points during each mission's processing flow according to a mission-specific schedule, which complies with the flight production generic templates.

Successive TDDPs for any given mission contain data with increasingly greater fidelity to the actual vehicle configuration, mass properties, and systems performance; however, all TDDPs are produced according to the following basic format:

a. Abbreviated data description

b. Purpose

c. List of significant changes from previous TDDP

d. Mission requirements

e. Vehicle configuration

f. Mass properties

g. SSME performance characteristics

h. Reusable Solid Rocket Motor (RSRM) performance characteristics

i. Main Propulsion System (MPS) propellant inventory

j. Ascent trajectory design criteria

k. References

The following three electronic data files are generated for each TDDP released:

File1: Keyword file

File 2: Mass properties/MPS budget file

File 3: Formatted TDDP file

The TDDP keyword file and the mass properties/MPS budget file formats are defined by SFOC-PM0461, Interface Control Document, Trajectory Design Data Package (TDDP) Electronic File Format (latest version). The formatted TDDP file is an electronic version of the entire TDDP document.

3.2.1.2 TDDP Databases

TDDP databases fall into two categories; those which are generic in nature, formally published in other documents, and merely referenced in the TDDP (reference Appendix B, Table 3.1), and those which have the data fully contained within the TDDP itself (reference Appendix B, Table 3.2). In general, data that are relatively stable are baselined in official program documentation that seldom changes. Data that change from mission to mission, or newly approved data that have not been formally documented, are contained in the TDDP. These databases reside within, and are kept current by, TDDP Integration at Boeing. For any given TDDP, some datasets may fall into either category, depending on their pedigree and maturity. For data that are both contained within the TDDP and formally documented elsewhere, the TDDP takes precedence, as it is more responsive to fast moving requirement changes.

3.2.1.2.1 RSRM Performance Data

The RSRM performance data are updated for the PMBT, burn rate, and inert/propellant weights.

a. The initial PMBT is for the 15th of the launch month and updated to the launch day for the Flight Readiness Verification (FRV) TDDP. At Launch Minus (L-) 9 days, a letter is received from Thiokol Propulsion stating the PMBT to be used in the DOL TDDP.

b. The initial burn rate is extracted from the most recent updated RSRM propellant burn rate predictions letter from Thiokol Propulsion and converted from a PMBT of 60°F to 70°F for entry in the data file. This value is changed when the performance information summary is received at L-75 days.

c. Inert and propellant weights are extracted from the SRB quarterly mass properties reports and updated from the SRB preflight predicted mass properties report received at L-30 days.

3.2.1.2.2 SSME Performance Data

SSME performance data are received from the Boeing MPS Analysis Group in the form of “assessment tags.” These performance tags represent an adjustment from the data supplied by the SSME project in order to account for engine performance as determined through the ascent trajectory reconstruction process.

The assessment tags contain data for both specific SSME identification numbers and a generic set designated as “official average.” For the purpose of TDDP generation, these two types of assessment tags are utilized as follows:

a. For generic studies and initial TDDP deliveries prior to the FRV TDDP, the generic official average tags are used. This precludes engine-specific performance characteristics from affecting ascent trajectory I-Load design in the face of numerous engine assignment swaps as a mission progresses towards launch.

b. For the FRV TDDP and subsequent TDDP releases, engine-specific performance tags are used in conjunction with the mission-specific SSME assignments baselined in the FDRD. If SSME tags are unavailable for a specific engine number or the FDRD shows the SSME assignment as “to be determined”, the official average tags are used for that particular engine only.

c. For the Flight Readiness Review (FRR) TDDP and subsequent TDDP releases, updated engine-specific performance tags are used. The updated tags, which are received at L-63 days for each mission, include an adjustment based upon an analysis of the performance characteristics observed during the previous flight of each of the three engines.

3.2.1.3 Mass Properties

A description of the generation of mass properties is given in Section 3.1.

3.2.1.4 TDDP Development

TDDP development is essentially a continual process involving database maintenance, including data accuracy and currency verification. When a specific mission is entered into the FDRD (NSTS 07700, Volume III), a mission folder is created to contain any flight-specific data and other documentation that will be needed to produce a TDDP. One of the first items needed is a mission-specific flight production schedule, which is baselined shortly after a mission is defined in the FDRD. The flight production schedule defines specific TDDP delivery requirements. These delivery requirements are tracked via the TDDP scheduling system and mass properties/TDDP status calendar. Construction of a particular TDDP begins approximately two weeks prior to its

scheduled release. Data requirements are checked against the TDDP product definition, as indicated in Appendix B, Table 3.3. In the process of assembling a draft TDDP, any missing or out-of-date data are identified and a reference check is performed to ensure that proper authorization is in hand for use of any recently received data. Issues related to TDDP input data or reference documentation are discussed at the weekly Mass Properties/TDDP Tag-Up Meeting. Data source conflicts or other issues are brought to the attention of USA Systems Integration for resolution.

3.2.1.4.1 Ascent Flight Design Kick-off

The Ascent Flight Design Kick-off supports the first TDDP delivery for each mission. Presentation charts containing proposed TDDP content are developed and briefed by Boeing at the USA SIRB. The Ascent Flight Design Kick-off is scheduled at least one week prior to the due date for the Pre-CIR TDDP. The presentation charts include, but are not limited to, the following information:

a. Flight definition

b. Ascent performance margin estimate

c. Proposed ascent flight design

d. PE items

e. Schedule leading to Ascent Flight Design Freeze Point (AFDFP)

f. Concurrences and recommendation

Following the Ascent Flight Design Kick-off presentation, the SIRB Chair indicates board approval of the proposed flight design via his signature on the Mission Requirements Definition, a form provided by Boeing which summarizes the mission's requirements and design.

3.2.1.4.2 Ascent Flight Design Freeze Point

The AFDFP is an SSP milestone that supports the TDDP to be used for development of mission-specific ascent and entry I-Loads. The process, which leads to the SSP baselining of mission-specific ascent flight design criteria at the NASA Integration Control Board (ICB), is initiated approximately six weeks prior. Presentation charts containing proposed ascent flight design criteria are first developed and initially briefed by Boeing at the USA SIRB Ascent Flight Design Tag-up. The presentation charts include, but are not limited to, the following information:

a. Flight definition

b. Proposed flight design

c. PE items

d. Ascent performance margin status and projections

e. Concurrences and recommendation

Following the Ascent Flight Design Tag-up presentation, the SIRB Chair indicates board approval of the proposed flight design via his signature on the Mission Requirements Definition, a form provided by Boeing which summarizes the mission's requirements and design. An SSP CR containing the proposed flight design is then prepared by Boeing and submitted, along with updated presentation charts, to the appropriate USA Flight Manager for processing. One week prior to the ICB scheduled for the AFDFP, CR evaluations are collected and summarized on the final presentation charts.

3.2.1.5 Verification and Approval

A draft TDDP is distributed to each member of the Boeing TDDP Review Team prior to the review with USA. A review meeting is then scheduled where any remaining technical or typographical discrepancies are identified. Following the review, a final TDDP is prepared for review by USA Systems Integration. The Boeing TDDP Review Team is available at the time of the USA review to answer any questions that may arise and implement any directed changes to the TDDP. Upon notification that the TDDP has been signed by the USA Systems Integration Project Manager, the TDDP is released. The TDDP electronic data files are produced and made available to the user community. An electronic version of the complete TDDP document is then distributed.

3.2.1.6 Distribution

TDDPs are sent out on the day of release to a USA Systems Integration/NASA controlled distribution list. The distribution list is modified for each release to include the mission-specific Mission Operations Directorate Flight Design Manager and the USA Ascent Mission Engineer. Most are transmitted electronically, although a few hardcopies are produced for local archives and for distribution to those for which an electronic distribution method is not available. Past TDDP releases may also be sent out by either means, upon request.

3.2.1.7 USA Related Tasks

The following are the associated activities performed by the USA Systems Integration Lead for TDDPs:

a. Technical integration

   1. Resolve mission configuration issues and approve, when required, incorporation of pending unofficial changes into the TDDP database. (Example: late changes to launch date, SSME assignments, etc.)

   2. Provide direction concerning changes affecting mission, such as, engine assignments, propellant budgets, weight changes, schedules, etc.

   3. Conduct internal reviews of TDDP content and approve for release.

   4. Coordinate and approve TDDP feasibility and special study requests.

b. Configuration management

1. Approve database access requests and electronic distribution changes.
2. Approve changes to the TDDP database application that impact content or report format.
3. Approve the Ascent Flight Design Kick-off at the SIRB for each mission.
4. Approve the Ascent Flight Design Tag-up at the SIRB for each mission.

3.2.1.8 NASA Related Tasks

The following are the associated activities performed by the NASA Lead for TDDPs:

1. Resolve external data source issues external to SFOC. Emphasis is placed on DOL TDDP inputs. (Example: late and/or incorrect inputs, such as, RSRM propellant PMBT)
2. Coordinate process improvements that involve organizations external to SFOC.
3. Approve the AFDFP for each mission.

3.2.2 Products

Types of TDDP related products required by the PDRD:

a. TDDP Document

b. TDDP Change Notices

c. Ascent Flight Design Kick-off Briefing

d. Ascent Flight Design Tag-Up Briefing

e. PM009 AFDFP Briefing

3.2.2.1 Trajectory Design Data Package (PDRD 1222a)

Specific TDDP products, the generic delivery times in terms of “Launch Minus Days”, and the data requirements for each, are given in Appendix B, Table 3.3. TDDPs produced for the ISS standardization flight production template have different delivery requirements than those produced for the 1-cycle or 2-cycle templates. The 2-cycle template consists of both an engineering cycle and a flight cycle.

3.2.2.2 Trajectory Design Data Package Change Notice (DRD 1222b)

The L-3 Change Notice to the DOL TDDP is the only regularly scheduled TDDP Change Notice. Other TDDP Change Notices are released on an as-needed basis. They are designed to convey important design data to the ascent flight design community that has either changed since TDDP publication or was published in error.

The Change Notices consist of only those portions of a TDDP containing the data of interest.

3.2.3 Product Acceptance Criteria

Products completed and delivered error free and on time, in accordance with applicable Flight Production Schedules and DRD technical content requirements.

Product quality and timeliness shall be reported for the products defined in this section using the USA/PMS.

3.2.4 Oversight and Insight Responsibilities

3.2.4.1 USA Oversight Responsibility

USA shall provide the general oversight to the TDDP process and perform the tasks as described in Section 3.2.1.7 and subordinate paragraphs. In addition, USA shall inform NASA of any out-of-family conditions, via e-mail from the Director of Systems Integration, and maintain insight into the analysis and closure of any such conditions.

3.2.4.2 NASA Oversight and Insight Responsibility

NASA shall provide the specific oversight of the TDDP process through the performance of the tasks, as described in Section 3.2.1.8 and subordinate paragraphs.

In addition, NASA shall maintain an insight into the TDDP task through reviews, observations of the process, mission products, and metrics.

NASA can initiate audits of the TDDP process to enhance their insight, to support the correction of process failures resulting in the violation of quality or schedule provisions of the applicable standards/MERs, or to support the resolution of out-of-family conditions.

3.2.5 In/Out-of-Family Conditions

The generation of all TDDPs is considered to be in-family.

An out-of-family condition exists for:

a. Uncorrected degradation of product quality and/or timeliness.

b. Late/Incorrect inputs from organizations external to SFOC that jeopardize product quality and/or timeliness. (Example: L-9 day RSRM PMBT prediction)

c. TDDP content error significantly impacting flight design or systems performance.

3.3 (DELETED)

3.4 ANALYTICAL S/W AND DATABASE MAINTENANCE

At Boeing, incorporate flight critical corrections, changes, and updates into the Space Shuttle Vehicle (SSV) databases for math models and computer programs to maintain proper system and data configuration to support the flight analysis tasks. These models/programs include:

a. Ascent loads S/W, databases, and models.

b. Flight control and effectors programs.

c. Ascent performance and Guidance, Navigation and Control (GN&C) trajectory and I-Load verification update programs.

d. MPS budget database.

e. Vehicle aerodynamic model/databases.

f. Ascent aero and plume heating models for elements and integrated vehicle.

Changes are incorporated under configuration control procedures per Engineering Analysis Process Request (EAPR).

This task also includes: the operation and maintenance of the configuration control system; workstation system administration support for analytical programs and databases; and user support for Shuttle integrated vehicle certification databases and critical math models.

3.4.1 Process

The Boeing effort contained in this task principally consists of two basic processes discussed in the following paragraphs.

3.4.1.1 S/W and Database Change Process

This effort is performed by the engineering personnel in support of configuration control requirements. Configuration control is required on FRV/Flight Margins Assessment (FMA) and DOLILU Operations Support System (DOSS) activities only. Selected certification S/W or databases are placed under configuration control subject to the joint approval of NASA and USA.

a. Identify required S/W, database, script, and/or documentation updates. These changes are driven by: Operational Increment (OI) updates, math model updates, certification activities, development tasks, action/issue/anomaly resolution, user requested improvements/enhancements, annual critical math model review activity, or additional flight data being added to existing databases.

b. Obtain technical approval to make the required change. This would consist of a short technical explanation of the desired change to the appropriate Boeing task management and USA and NASA technical forum.

c. Generate the actual S/W, database, script, or documentation update. This step includes the required stand-alone testing necessary to verify that the change performs as expected. This is performed with an engineering copy of the baselined version of the S/W, database, or script. The required documentation updates are provided as redlines.

d. Summarize the change including test results, associated documentation updates and SSP CRs required to coordinate changes across the Shuttle Program.

e. Prepare the EAPR if the changes affect configuration controlled S/W, database, or script item. Coordinate the EAPR with the Configuration Control Group. Obtain all the required department and management approvals.

f. Once the changes are recompiled under configuration control, verify that these changes are correct and return the EAPR to the Configuration Management Group.

g. Obtain final program approval of the actual change, SSP CRs, and any associated documentation updates.

h. Perform any required integrated testing within Boeing and/or with USA Flight Operations (Ops)/Mission Operations Directorate (MOD).

3.4.1.2 Configuration Control Process

This effort is performed by the Configuration Management Group per the procedures outlined in RSS00HB190, Systems Integration Engineering Analysis Process Configuration Management Overview; Boeing Configuration Management for FMA Flight Readiness Review (FRR) and DOSS.

a. Coordinate with, and assist, engineering personnel in preparation and approval of EAPRs.

b. Update/Recompile configuration controlled S/W, databases, and scripts, as required. Provide reports, as required by management, to verify change incorporation.

c. Perform required testing on DOL S/W or database change, as required by the DOLILU Operations Support Plan (DOSP).

d. Update required documentation, including DOSS manuals and reports.

e. Perform FMA/FRV and DOSS audits, as required, to ensure configuration control integrity.

f. Produce FRR inputs for each mission.

g. Support annual critical math model audit by coordinating with all Boeing responsible groups.

3.4.1.3 USA Database Maintenance Related Tasks

a. Provide technical review (including implementation schedule) for proposed changes, in coordination with the appropriate technical panels.

b. Review Boeing's verification of correct implementation of approved changes.

c. Review EAPR logs for compliance with configuration management procedures (RSS00HB190) prior to each FRR.

d. SRB hold-down stud hang-up statistical correlation database updates.

3.4.1.4 NASA Database Maintenance Related Tasks

a. Review and approve resolution of out-of-family issues.

b. Approve process, math model, and requirement changes.

c. Act as the Office of Primary Responsibility for any changes requiring SSP approval, including ICB/PRCB presentations and action closure.

3.4.2 Products

All products related to this task are delivered under other PDP sections, such as, DOSS, FMA/FRV, and post-flight analysis. Boeing-internal configuration management products, such as EAPRs, are provided to NASA or USA, as requested.

3.4.3 Product Acceptance Criteria

Since all products developed under this task are delivered under other PDP sections, the product acceptance criteria for the applicable PDP sections will apply.

3.4.4 Oversight and Insight Responsibilities

3.4.4.1 USA Oversight Responsibility

USA shall provide the general oversight of the analytical S/W and database maintenance process and perform the tasks as described in Section 3.4.1.3. In addition, USA shall inform NASA of any out-of-family conditions, via e-mail from the Director of Systems Integration, and manage subcontractor effort related to the analysis and closure of any such conditions.

3.4.4.2 NASA Oversight and Insight Responsibility

NASA shall provide the specific oversight of the analytical S/W and database maintenance process through the performance of the tasks, as described in Section 3.4.1.4.

In addition, NASA shall maintain an insight into the S/W and database maintenance task through reviews and observation of the data configuration management process, mission products documentation, and metrics. NASA shall periodically review EAPR logs for compliance with configuration management procedures.

NASA can initiate audits of the S/W and database maintenance process to enhance their insight to support the correction of process failures resulting in the violation of quality or schedule provisions in the applicable standard/MERs, or to support the resolution of out-of-family conditions.

3.4.5 Out-of-Family Conditions

An out-of-family condition would exist for:

a. Off-nominal conditions resulting from database changes beyond certification envelopes.

b. Incorrect implementation of an approved change (S/W, database, etc.).

c. Implementation of S/W, database, or math model modifications made without SSP approval.

3.5 FRV/MARGINS ASSESSMENT

FRV consists of the set of tasks required to show that each flight will operate within the certified capability of all ascent related systems and disciplines for which System Integration is responsible.

a. The systems and disciplines covered by FRV are ascent performance, integrated GN&C, Flight Control System (FCS) stability, SRB separation, ET separation, lift-off clearances, prelaunch/lift-off/ascent loads, ascent heating, and MPS.

b. No-fail (all SSMEs operating) and intact abort modes are covered.

c. The trajectory criteria used to determine flight readiness are found in NSTS 08209, Volume IV, Shuttle System Design Criteria, Generic Ascent Flight Design Requirements. Specific System Integration subsystem criteria are defined in Boeing Report SSD95D0334, Flight Readiness Verification Criteria Document.

d. The FRV TDDP is used for the mission-specific configuration for the base/One Cycle to Flight(OCTF) FRV assessment. The Uplink TDDP is used for the mission-specific configuration for the Update FRV assessment.

e. For second stage trajectory simulations, the flight cycle I-Loads created by USA Flight Operations are used. For first stage, the I-Loads that are designed on DOL, are generated by Boeing using an internal version of Day-of-Launch Ascent Design System (DADS) and a monthly mean wind. Any I-Loads up-linked after the flight cycle is developed will use approved values from the responsible design organizations.

For missions that do not conform to Day-of-Launch I-Loads Update (DOLILU) II/PEs design methods or that do not pass all of the criteria defined to screen subsystem generic certification, FMAs shall be performed. FMAs are detailed mission-specific subsystem analyses and may include any or all of the subsystems listed above depending on the criteria exceeded. If an FMA is required for any technical area, the activity will be performed in accordance with SSD93D0492, Flight Margins Assessment Criteria Document. In addition, mission-specific dispersion protection may need to be generated for use on DOL.

The FRV task interfaces with many others: it receives input data from the TDDP/mass properties tasks; it provides trajectory simulation set-up for the DOSS/DOL, post-flight analysis and S/W verification tasks; and it receives analytical tool support from the analytical database task. When required, FRV prediction models are updated based on the post-flight reconstruction task results. FRV also shares skills and tools with these tasks and with development tasks and special studies.

3.5.1 Process

The Boeing FRV process can be divided into 14 subtasks discussed in the following sections and described in Appendix B, Figures 3-3, 3-6 thru 3-10, and 3-19.

3.5.1.1 Ascent Flight Design Criteria Verification

The purpose of this process is to verify that the planned mission is consistent with the first stage ascent generic certification. Currently, the DOLILU II/PEs flight design is the only flight design option generically certified. However, the contractor shall maintain the ability to perform a complete FMA for non-DOLILU II/PEs mission designs. The Boeing process for non-standard flight design assessments is illustrated in Section 3.5.1.13 and Appendix B, Figure 3-3.

If a given mission meets the DOLILU II/PE certification criteria and passes all FRV screening criteria, no mission-specific FMAs are required. However, upon customer request, induced environments are generated in order to address potentially anomalous H/W conditions.

If the mission configuration does not meet the ascent flight design criteria, additional analysis is required. The extent of this analysis depends on the exceedance. It could, though not necessarily, include heating, structural loads, MPS, or trajectory analysis.

For verification, the following process is required:

a. Parameters to be verified are specified in the SSD95D0334, Flight Readiness Verification Criteria Document.

b. Acceptable values or ranges for these parameters are specified in NSTS 08209, Volume IV.

c. This check is performed four times:

   1. When the FRV groundrules briefing is being prepared using the flight cycle TDDP.

   2. When the FRV results are presented to the SIRB prior to Shuttle Avionics Software Control Board (SASCB) I-Load approval using the FRV TDDP.

   3. For the System and Cargo Integration FRR using the Uplink TDDP.

   4. Repeat steps above using the Uplink TDDP, Update FRV groundrules, flight cycle I-Load Data Change Requests (DCRs), and USA FDD product ASCT 44 as input data.

3.5.1.2 Ascent Performance Assessment and Heating Check

The purpose of this task is to verify that an adequate ascent performance margin is available for all flights and that the planned mission is within the generic certification environments for aerodynamic and plume heating. The following documents must be utilized: SSD95D0334; NSTS 08209, Volume IV; FRV and subsequent TDDPs; and weekly Weight and Performance Reports (Greenbook). The following process, illustrated in Appendix B, Figure 3-7 is required:

a. Configure the DADS first stage I-Load design tool per the FRV TDDP and the FRV groundrules briefing.

b. Generate mean wind first stage guidance I-Loads using the Solid Rocket Motor (SRM) PMBT for the middle of the launch month.

c. Configure the Ascent Simulation Trajectory Optimization (ASTRO) trajectory simulation per the FRV TDDP and FRV groundrules briefing.

d. Generate a non-dispersed no-fail simulation run for ascent performance prediction and non-dispersed intact abort runs for heating constraint checks.

e. Check all heating limits and constraints per the FRV document SSD95D0334 and NSTS 08209, Volume IV.

f. If an exceedance of a non-dispersed criteria occurs, generate dispersed trajectories and check against dispersed heating limits.

g. Update the ASTRO simulation to the FRR TDDP.

h. Generate a non-dispersed no-fail simulation run for ascent performance prediction.

i. After the FRR TDDP, update the performance prediction, as required, using the weekly Greenbook information (performance partials).

j. Document results and prepare FRR briefing.

k. Repeat Step a thru Step h above, using the Uplink TDDP, Update FRV groundrules, flight cycle I-Load DCRs, and USA FDD product ASCT 44 as input data.

l. Report results of uplink I-Load assessment to SIRB at L-7 days.

3.5.1.3 Second Stage Ascent GN&C Assessment and Separation Generic Certification Check

This task is performed to verify that the second stage trajectory and I-Load design is compatible with mission requirements and that all subsystem constraints and criteria are met and that the lift-off clearance, SRB separation and ET separation are within their generic certification. Second stage ascent, unlike first stage, is not generically certified by DOLILU II and requires more detailed analysis. The following documents must be utilized: SSD95D0334; SSD93D0492, Flight Margins Assessment Criteria Document; NSTS 08209, Volume IV; FRV TDDP; and mission definition and ascent/abort I-Load DCRs. The following process, illustrated in Appendix B, Figure 3-8 is required:

a. Configure the first stage trajectory simulation and the ascent, insertion, orbit, and deorbit second stage simulation per the FRV TDDP and the FRV groundrules briefing, the flight cycle I-Load DCRs and the mission-specific first stage guidance I-Load described in Section 3.5.1.2.

b. Generate no-fail and engine out at lift-off first stage trajectories.

c. Generate the matrix of no-fail and intact abort second stage trajectories described in SSD93D0492 and SSD95D0334.

d. Check all second stage no-fail and intact abort design criteria and constraints per NSTS 08209, Volume IV.

e. Check the no-fail trajectory against the FCS estimators to verify acceptable stability margins.

f. Simulate the ascent crew displays using the flight cycle display loads and the display simulation processor.

g. Evaluate the occurrence selections for each of the I-Load categories that affect second stage ascent per the evaluation criteria in the FMA document. Includes analysis or post processing of the simulations, as necessary.

h. Compute the abort mode boundaries for Return to Launch Site (RTLS), Transatlantic Abort Landing (TAL), Abort-Once-Around (AOA) and Press-to-MECO and verify that the overlap is acceptable.

i. Provide TAL ET Separation (SEP) conditions to the respective groups for analysis.

j. Document all second stage I-Load evaluation results.

k. Audit the I-Loads, mass properties, booster characteristics, and vehicle and launch pad configuration for compliance with lift-off clearance generic certification environments.

l. Audit the I-Loads, mass properties, booster and booster separation motor characteristics for compliance with the SRB SEP generic certification environments.

m. Audit the I-Loads, mass properties, and trajectory design criteria for compliance with the ET SEP generic certification requirements.

n. Check the second stage TAL trajectory ET SEP conditions against the NSTS 08209, Volume IV, ET SEP constraints.

o. Check the vehicle weight and CG requirements, in accordance with the criteria defined in NSTS 07700, Volume III, Paragraph 3.1h, to determine if a mission-specific contingency abort analysis is required. If the mission-specific contingency abort analysis is required, perform the analysis in accordance with SSD95D0334 and mission-specific criteria mutually established with USA.

p. Document all results and prepare the FRR briefing.

q. Repeat Steps a - d, g - i, and k - o, above, using the Uplink TDDP, Update FRV groundrules, flight cycle I-Load DCRs, and USA FDD product ASCT 44 as input data.

r. Document all results and prepare the Update FRV Results Briefing.

3.5.1.4 Integrated MPS

The integrated MPS assessment is performed to verify that the MPS (Orbiter MPS/SSME/ET/KSC ground support equipment) will provide satisfactory systems functional performance to ensure flight readiness. The process, which is illustrated in Appendix B, Figure 3-6 and Figure 3-19 is as follows:

a. Review integrated (MPS) changes (Operational Maintenance and Requirements Document [OMRSD], Launch Commit Criteria [LCC], Flight Rules, Interface Control Document [ICD], S/W, and flight data file) to ensure integrated requirement compatibility and compliance (reference Appendix B, Figure 3-19).

b. Coordinate with element projects, contractors, and technical panels to identify any integrated (MPS) issues or design changes relating mission preparation and flight, and contribute to their resolution (reference Appendix B, Figure 3-19).

c. Develop/Provide SSME tags to be used for ascent performance assessments. Mission-specific tags are delivered in time to support the delivery of the FRR TDDP for that mission. Note: Average tags for each engine type are also provided each

time a mission-specific delivery is made. The update process for average and engine-specific SSME tags is as follows (reference Appendix B, Figure 3-6):

1. Obtain the ground test stand based SSME tag data from Rocketdyne. This ground-based test data reflects any new SSME tag predictions.

2. Convert the Rocketdyne data to assessment data suitable for incorporation into the trajectory simulations. This is performed by adjusting the ground-based data with a set of flight-derived correction factors: Thrust, Isp, Gaseous Hydrogen (GH_2) flow rate, and Gaseous Oxygen (GO_2) flow rate.

3. Boeing MPS then electronically transfers the corrected SSME tag data to Boeing Mass Properties/TDDP Group for incorporation into the TDDP, reference Section 3.2.1.

d. Coordinate with Orbiter hydraulic subsystem and SSME element for integrated hydraulic system functional performance and requirement compliance.

e. Document results and prepare FRR briefing.

3.5.1.5 RSRM Assessment

a. Utilize the MSFC-provided burn rate prediction and case wall thickness letter along with the recent Greenbook database to verify that the combination of burn rate and vehicle lift-off weight is below the required NSTS 08209, Volume IV, Paragraph 3.2.1.8 constraint.

1. Summarize results quarterly at the SIRB and use to evaluate all FDRD CRs.

2. Notify NASA of acceptability post FDRD if data is unavailable to support CR evaluation.

b. Additional assessment is performed to ensure RSRM performance will meet SSP Shuttle Vehicle requirements. The RSRM, performance assessment process is illustrated in Appendix B, Figure 3-9. The following documents must be utilized: NSTS 07700, Volume X; NSTS 08209, Volume I, Shuttle Systems Design Criteria, Shuttle Performance Assessment Databook; and FRR TDDP. The assessment is as follows:

1. Use FRR TDDP inputs to adjust the RSRM block model to generate the mission-specific RSRM adjusted performance prediction and predict thrust imbalance.

2. Verify compliance of RSRM predicted performance and thrust imbalance with NSTS 07700, Volume X; and NSTS 08209, Volume I requirements/margins.

3. Perform comparison of predicted thrust imbalance against NSTS 07700, Volume X specifications and the updated flight-derived 3-sigma imbalance.

4. Document the prediction analysis and prepare FRR briefing.

3.5.1.6 Technical Coordination and Documentation

This activity must comply with the following documents: SSD95D0334; SSD93D0492; NSTS 08209, Volume IV; NSTS 07700, Volume X; and NSTS 08209, Volume I. The process is as follows:

a. Prepare the FRV groundrules briefing. This briefing contains the mission configuration, a preliminary check of DOLILU II/PE compatibility, a list of products, and a schedule. In addition, any non-standard work that is required due to known certification issues is detailed.

b. Report FRV results to SIRB prior to SASCB I-Load approval. This briefing contains a trajectory overview, PEs certification compliance assessment, ascent performance margin and abort boundary verification. Any violations of ascent design criteria are reported as well as any issues with the I-Loads as specified in the flight cycle CRs. If any non-standard assessments were performed, the results are presented.

c. Prepare the Uplink FRV Groundrules Briefing. This briefing contains the mission configuration, a preliminary check of DOLILU II/PEs compatibility, a list of products, and a schedule. In addition, any non-standard work that is required due to known certification issues is detailed.

d. Report Uplink FRV results to SIRB no later than 7 days prior to the scheduled launch date, unless schedule relief is provided by USA. This briefing contains a trajectory overview, PE certification compliance assessment, ascent performance margin and abort boundary verification. Any violations of ascent design criteria are reported as well as any issues with the I-Loads, as specified in the flight cycle CRs and the USA/FDD product ASCT 44. All assessments should encompass all valid performance cases and all valid Orbital Maneuvering Subsystem (OMS) assist dial down cases. If any non-standard assessments were performed, the results are presented.

e. Prepare waivers to the SSP requirements documentation if required. For standard missions these will not normally be required.

f. Present waivers to SSEIG for approval.

g. Update FRV and FMA documents when required.

h. Generate and deliver the RSRM burn rate acceptance criteria briefing to the SIRB.

i. Supply preliminary induced environment data to elements for assessment. Obtain USA product transfer endorsement signature prior to formal transmittal. Prepare and submit Boeing Management Action (MA) contract letters to formally transmit official mission-specific loads and thermal environments directly to Shuttle element for their assessment.

3.5.1.7 Mission Requirements Assessment

The mission requirements assessment process, illustrated in Appendix B, Figure 3-10 is as follows:

a. Review Flight Requirements Documents (FRDs) (FDRD; FRD; PIPs; Flight Rules; Flight Data File; NSTS 07700, Volume X, Flight and Ground System Specification; LCC; etc.), sequential mass properties, and TDDP.

b. Track mission development and design from manifest through landing.

c. Provide system engineering support at LSRR, LSFR, Delta LSFR, PRCB, to identify mission changes that affect flight assessments and readiness.

d. Maintain mission manager configuration and requirements database.

e. Prepare and disseminate mission status information (STS Mission Summary Report, Flight Overview Report, etc.).

f. Status USA and NASA on changes impacting flight assessment and readiness.

g. Coordinate technical review of flight rules CRs and present evaluation to PRCB.

h. Maintain library of program and mission planning, flight requirements, design and flight experience documentation.

i. Prepare mission overview briefing for Orbiter Production Facility Rollout Review and FRR. Present overview briefing at Orbiter Rollout Milestone Review.

3.5.1.8 Prelaunch Loads and Excursions

Prelaunch load and excursion conditions are analyzed to provide design environments for the SSV during Vehicle Assembly Building stacking, rollout to the launch pad, and during on-pad SSME buildup and possible SSME on pad abort. Prelaunch-affected SSV structure has been generically certified with the exception of several low margin areas. The analysis must comply with the following documents: SSD95D0334, SSD93D0492 and Operations and Maintenance Requirements and Specification (OMRS).

a. Review configuration and critical stacking measurements.

b. Perform mission-specific analysis of non-generically certified structure.

c. Define groundwind placards, if required.

d. Document results and prepare FRR briefing.

3.5.1.9 Lift-off Loads

Lift-off load conditions are analyzed to provide design environments for the SSV resulting from the transients associated with SRB ignition. Lift-off loads-affected SSV

structure has been generically certified. The mission-specific effects of payloads on Orbiter lift-off responses are verified by comparing the peak lift-off accelerations calculated at various Orbiter locations as a part of the payload Verification Loads Analysis (VLA) against a certified peak acceleration database. The lift-off loads are acceptable providing that the flight-specific VLA accelerations do not exceed the accelerations listed in the lift-off acceleration database. The analysis shall comply with the FRV criteria defined in SSD95D0334. The process is as follows:

a. Review cargo VLA Orbiter accelerations.

b. Evaluate VLA responses in accordance with SSD950334.

c. If the VLA responses exceed the FRV criteria, perform a mission-specific FMA in accordance with SSD93D0492 and provide results to the Shuttle element through the Loads Panel.

d. Document results and prepare FRR briefing. Included in the FRR briefing will be a statement of any out-of-family condition as a result of post-flight analysis, reference SSD92D0050, Requirements Definition Document for Post Flight Analysis/ Reconstruction, latest version. The FRR briefing will also note the occurrence or absence of SRB hold-down stud hangup from the previous flight.

3.5.1.10 Ascent Loads

In the event of a mission-specific FMA, a launch probability assessment for the mission shall be completed based on the 150 measured wind I-Loads produced for DOLILU II. In addition, the 150 measured wind trajectory conditions must be compared to the loads criteria and constraints given in SSD93D0492, Section 11. The mission-specific loads conditions must be deemed acceptable for flight by the SSP before the flight design target is frozen for DOL.

In addition to launch probability analyses, assessments are performed by special request of the elements. These assessments vary in nature and may include a unique type of launch probability assessment or development of a mission-specific set of loads for an element. Any variation in analysis procedures that are required for a special analysis are reviewed and approved by USA and the appropriate technical panel.

3.5.1.11 Heating

The ascent aerodynamic and plume heating FRV is accomplished by successful verification of the trajectory design criteria defined in NSTS 08209 Volume IV, as performed by GN&C and ascent performance. Mission-specific environments shall be provided upon request from Shuttle elements. The following process is followed:

a. Critical mission-specific trajectory cases are identified and developed by ascent performance.

b. Mission-specific heating environments are determined at critical body points based on element request.

c. Mission-specific heating environment is compared with certification.

d. Mission-specific environment and certification comparison data file and letter are transmitted to the element using procedure defined in Section 3.5.1.6i.

e. Results are summarized for the FRR.

In addition, the results of each mission's post-flight SSME nozzle entry heating analysis is assessed in order to determine whether any SSME nozzle re-use issues exist. (Reference SSD92D0050, latest version.) A summary of this analysis is included in each FRR.

3.5.1.12 Certificate of Flight Readiness (CoFR) Endorsement and FRR Briefings

Build the FRR briefing packages.

a. Mission overview (mission requirements assessment)

b. Performance, GN&C, flight control and separation systems combined briefing

c. Integrated MPS

d. RSRM performance

e. Loads and Dynamics

f. Ascent heating and SSME nozzle entry heating

Present to internal management review and to NASA/USA customers.

3.5.1.13 Ascent Trajectory/Performance Margin Assessments Process

a. This process is utilized if an off-the-shelf I-Load design does not satisfy mission requirements and/or a non-DOLILU II flight design is required. The process, which is illustrated in Appendix B, Figure 3-3 is initiated by USA or NASA as a formal trajectory design/assessment request through an SIRB/SSEIG assigned action item. This follows the ascent flight design kick-off meeting if an off-the-shelf design does not satisfy the mission requirements.

b. Boeing generates a set of design/assessment groundrules, along with a preliminary schedule, which is presented to the SSEIG for approval.

c. Configure the ASTRO trajectory simulation according to the approved groundrules. The following inputs are required:

   1. A TDDP set of mass properties, MPS performance data, and flight design data.

   2. The monthly winds and atmosphere data.

   3. Off-the-shelf Main Engine Cutoff (MECO) targets are normally used, with concurrence from USA flight design focal point.

4. The designated OI flight S/W configuration and ascent I-Loads.

5. Unless otherwise specified in the study groundrules, the S/W and database configurations will be consistent with the flight versions used by DOSS as specified in NSTS 08329, Volume VIII, DOLILU II Definition and Requirements Document, DOLILU Operations Support Plan and the Critical Math Model Database (CMMDB).

d. Generate a new first stage guidance I-Load, if required, using the USA provided DADS (DOLILU II) tool. This is an “as required” step if an off-the-shelf I-Load is not suitable and USA is not planning to build a suitable I-Load for the study. Once generated, these new I-Loads will be sent to USA upon request.

e. Execute the ASTRO trajectory simulation(s). The analysis techniques will be consistent with NSTS 08209, Volume I, Shuttle Systems Design Criteria, Shuttle Performance Assessment Databook, Section 7.

f. Generate the required technical data, results, and briefing. This will consist of trajectory summary output data, individual trajectory parameter output plots, a check of the NSTS 08209 Volume IV, Shuttle Systems Design Criteria, Generic Ascent Flight Design Requirements criteria and constraints, and SIRB briefing.

g. Provide internal technical/management review of the results.

h. Present the results at the SSEIG. The action will either be closed, formally ending the study activity, or follow-up actions will be assigned and the associated follow-on work defined, scheduled, performed, reviewed, and approved.

i. These results also support performance margin reviews at the weekly Greenbook telecons.

3.5.1.14 SIRB/SSEIG Technical Coordination and Meeting Support from Boeing

The activities required to support the SSEIG or SIRB involve the following technical and logistical support activities:

a. Coordinate agenda items through the technical management. These are provided to the USA meeting support coordinator.

b. Review briefing development status, ensuring briefings have the appropriate level of technical review prior to sending out.

c. Transmit the Boeing briefings to the required sites.

d. Make copies for Boeing personnel.

3.5.2 Products

The products produced by this process are:

a. PDRD SC010, FRV/FMA Groundrules Briefing

b. PDRD SC008, RSRM Burn Rate Acceptability Evaluation

c. PDRD SC007, Flight Cycle/OCTF GN&C and Performance Margin Briefing

d. PDRD 1212a, Element heating and loads environments data files and letters

e. Data package for Program Integration FRR

f. PDRD SC010, Update FRV Groundrules Briefing

g. PDRD SC007, Update FRV Results Briefing

3.5.3 Product Acceptance Criteria

Products completed and delivered error free and on time, in accordance with applicable Systems Integration (aka Artemis) schedules and PDRD technical content requirements.

Product quality and timeliness shall be reported for the products defined in this section (with the exception of the element heating and loads environments data files and letters due to the rarity of the delivery of those products) using the USA/PMS.

3.5.4 Oversight and Insight Responsibilities

3.5.4.1 USA Oversight Responsibilities

USA shall provide the general oversight of FRV assessment process. In addition, USA shall inform NASA of any FMAs or out-of-family conditions, via e-mail from the Director of Systems Integration, and maintain insight into the analysis and closure of any such conditions.

This consists primarily of utilizing USA SIRB for technical review and approval. Oversight shall be accomplished by:

a. Review and approval of the FRV groundrules, briefings, the base/OCTF GN&C and Performance Margin Briefing, the Update FRV GN&C and Performance Margin Briefing and any other mission-related SSEIG or NASA board presentations.

b. Review and approval of all Boeing products generated for element use including; the RSRM burn rate acceptability analysis, the element heating and loads environments data files and letter. Provide USA product endorsement for mission-specific environments to be forwarded by Boeing directly to element contractors.

c. Request of additional products or assessments, as required, to address mission schedule or safety.

d. Review all proposed updates to the FRV and FMA criteria documents.

e. Providing direction for delta FRV work, via appropriate contractual mechanisms.

f. Being responsible for all USA operations, requirements, logistics, minutes, agendas, action items, personnel attendance, etc.

g. Provide NASA notification, via e-mail, of any out of family conditions (reference Section 3.4.4.1).

h. Review proposed process changes, NSTS documentation updates, math model updates, or methodology changes including SSME tag update.

3.5.4.2 NASA Oversight and Insight Responsibilities

NASA shall maintain specific oversight of the task through the following:

a. Review and approve all FMA groundrules, and results.

b. Approve all design criteria, constraint, or requirements changes contained in NSTS documentation.

c. Review and approve out-of-family issues.

d. Approve process, math models, and requirement changes.

e. All SSEIG operations, requirements, logistics, minutes, agendas, action items, JSC personnel attendance, etc.

f. Issue resolution and coordination with all SSEIG interfaces, both internal and external.

g. Provide programmatic review and approval, through ICB and/or PRCB, of all requirement changes, NSTS documentation updates, math model updates, or methodology changes, such as, SSME tag updates.

In addition, NASA shall maintain an insight into the FRV process. NASA shall review and concur with all proposed updates to FRV and FMA criteria documents. NASA shall review all products that are transmitted to the element customers. NASA shall review and concur on trajectory assessment results and recommendations at the AFDFP Review. NASA shall maintain an insight into the FRV process, mission products, documentation, and metrics.

NASA can initiate audits of the FRV/FMA process to enhance their insight to support the correction of process failures resulting in the violation of quality or schedule provisions of the applicable standard/MERs, or to support the resolution of out-of-family conditions.

3.5.5 Out-of-Family Conditions

An out-of-family condition would exist for:

a. FMA results which exceed documented constraints and criteria.

b. Any FRV/FMA assessment using undocumented criteria, constraints, or methodologies.

c. Any mission configurations or FRV/FMA results that fall outside certification databases or exceed the NSTS 08209, Volume IV constraints.

d. In-flight anomaly resolution activities.

3.6 DOSS PREFLIGHT/DOL SUPPORT

The objective of the DOSS is to generate and verify DOL I-Loads. The baseline DOLILU II processor generates first stage I-Loads that re-center the trajectory by updating guidance polynomials and the SSME throttle profile. NASA/MOD, with their support contractor USA/Flight Operations, is responsible for the DOSS process. Systems Integration is responsible for defining DOSS requirements. USA/Systems Integration and Boeing support the DOSS process through the performance of:

a. Generic assessments required to develop DOSS requirements.

b. Flight-specific assessments as an independent verification of the DOLILU II I-Loads generated by MOD.

Flight-specific assessments consist of the preflight verification testing through analysis and testing using mission-specific databases and S/W. The generic assessments consist of the DOSS block update integration and associated verification testing. All the flight-specific and generic products, along with the schedule templates are documented in NSTS 08329, Volume VIII.

Interfaces with other DOSS support organizations are outlined in NSTS 08329, Volume VIII. Data formats and transfers are documented in the following ICDs:

a. ICD-I-FDD-017, Internal Interface Control Document, Flight Design and Dynamics, Ascent Discipline, Ascent Subsystem, USA/Boeing, Day-of-Launch Function

b. ICD-E-MCC-010B, External Interface Control Document, JSC/MCC/FADS - Boeing and CCAFS, Operational Communications DOLILU II ICD for Space Shuttle Missions

The interfaces with other tasks performed by Boeing are as follows: The mission-specific database generation is performed under the FRV/FMA task. Generic database updates are generated under either the analytical S/W and database maintenance task or the appropriate development task.

The DOSS support task consists of the integration, verification, and operation of these databases in the DOSS environment. It also includes all of the technical and task management required by the DOSS process.

3.6.1 Process

The support to the DOSS process will be discussed in the following sections and described in Appendix Figure 3-11 and Figure 3-12. The Boeing DOSS related tasks are described in Section 3.6.1.1 and the USA/Systems Integration DOSS related tasks are described in Section 3.6.1.2. The NASA DOSS related tasks are described in Section 3.6.1.3. The NASA/MOD and USA/Flight Design DOSS related tasks are described in NSTS 08329, Volume VIII.

3.6.1.1 Boeing Process to Support the DOSS

a. Technical coordination

The technical coordination portion of the DOSS process consists of the following activities:

1. Coordinating agenda items through the technical management.
2. Preparing technical briefings, CRs, and Change Evaluations (CEs) as required.
   (a) Change requirements for DOSS are defined in NSTS 08329, Volume VIII.
   (b) CR submittal process and requirements are defined in NSTS 07700, Volume IV, Configuration Management Requirements - Book 1, Requirements.
3. Providing briefing development status, ensuring briefings have the appropriate level of technical review prior to transmittal.
4. Transmitting the Boeing briefings to the required sites.

b. Block update implementation

The block update portion of this task consists of the following activities:

1. Coordinating block update change definition with the SSEIG, and affected elements, including USA Flight Ops/MOD, USA System Integration, NASA/Systems Integration, MSFC, and Safety, Reliability and Quality Assurance (SR&QA).
2. Preparing technical briefings, CRs, and CEs, as required, for change definition and approval.
3. Coordinate the technical implementation of the block update changes with Boeing engineering.
4. Update all required documentation.

5. Provide inputs to all test plans.

6. Support all required testing, i.e., dry-runs, Integrated Systems Verification Tests (ISVTs), ops demo's, etc., consistent with the approved test groundrules/plans. Inputs, outputs, S/W, and database configurations will be consistent with the DOSP (NSTS 08329, Volume VIII) unless otherwise specified in the test groundrules/plans.

7. Provide Test Readiness Review (TRR) and Operational Acceptance Review (OAR) briefings to the SSEIG and ICB, as required.

c. Preflight verification

The standard template portion of preflight verification consists of the following activities:

1. Coordinating flight-specific change definition with all affected parties.

2. Preparing briefings, CRs, and CEs, as required.

3. Coordinate the technical implementation of the flight-specific changes by the affected engineering group(s).

4. Ensure that all required documentation updates are completed.

5. Provide inputs to, and support review of, all test groundrules/plans.

6. Support standard testing, i.e., L-3 week, L-2 day tests, etc., consistent with the approved test groundrules/plans. Inputs, outputs, S/W, and database configurations will be consistent with the DOSP (NSTS 08329, Volume VIII) unless otherwise specified in the test groundrules/plans.

7. Provide FRR and L-7 day readiness briefings.

d. DOL support

The DOL portion of the DOSS process consists of the following activities:

1. Coordinating Boeing DOL activities affecting the DOSS, i.e., engineering groups, facilities, local area network support, workstation administrators.

2. Generating all required Boeing data and transmitting it to the USA/Systems Integration (SI) DOSS representative at JSC on time. Inputs, outputs, S/W and database configurations, along with all operational timelines will be consistent with the DOSP (NSTS 08329, Volume VIII).

3. Identify, coordinate, evaluate, and define the technical resolution of DOL processing problems related to Boeing activities.

4. Provide technical, programmatic, and logistical constraint exceedance resolution support.

3.6.1.2 USA/System Integration DOSS Related Tasks

USA/Systems Integration shall support the DOSS process by providing general oversight of the development and implementation of DOSS requirements, by providing support to NASA/MOD during DOLILU operations, and by managing the Boeing DOSS activities. The following activities are performed by the USA Lead for DOSS integration.

a. Technical coordination

    1. Provide direction to Boeing for DOSS changes not requiring NASA CR approval (operation system S/W upgrades, comparison formats, etc.) via the SIRB minutes or letter. Coordinate with the appropriate technical panels, SR&QA, and all affected parties. Closed-loop verification of correct implementation of DOSS changes shall be provided by the preflight EAPR audit.

    2. Provide notification to NASA of any out-of-family or anomalous conditions observed in the DOSS process.

b. Block update implementation

    1. Coordinate block update content and implementation schedule.

    2. Monitor implementation and test schedules, and report to the SSEIG.

    3. Monitor results of ISVTs and operational demonstrations tests.

c. Preflight verification

    1. Concur on test groundrules for all preflight tests.

    2. Monitor standard testing, review results, and report to the Loads and DOLILU Officer (LDO).

d. DOL support

    1. Direct Boeing DOSS DOL support.

    2. Provide independent assessment results to LDO.

3.6.1.3 NASA DOSS Related Tasks

The following are activities performed by NASA/Systems Integration for DOSS integration:

a. Technical coordination

    1. Provide approval for all planned DOSS requirement changes.

    2. Verify that all DOSS requirements are correctly documented.

    3. Direct activities required to resolve out-of-family conditions, anomalies, and process audits affecting System Integration requirements.

b. Block update implementation

   1. Approve block update content and implementation schedule.

   2. Track implementation and test schedules.

   3. Obtain ICB/PRCB approval, as needed, for block update changes.

   4. Chair the OAR meeting, to ensure compliance with program requirements.

c. Preflight verification - not required

d. DOL support - not required

3.6.2 Products

PDRD 1216a, DOSS Flight-Specific Products

PDRD 1216b, DOSS Non-Flight-Specific Products

3.6.3 Product Acceptance Criteria

Products completed and delivered error free and on time, in accordance with applicable Systems Integration (aka Artemis) schedules and PDRD technical content requirements.

Product quality is determined acceptable by completing required internal reviews and obtaining approval at the appropriate USA or NASA chaired panels and boards, and must be technically accurate. All documentation affected by the product must be identified and updated as necessary.

Product quality and timeliness shall be reported for the products defined in this section using the USA/PMS.

3.6.4 Oversight and Insight Responsibilities

3.6.4.1 USA/Systems Integration Oversight and Insight Responsibility

The overall responsibility for the DOSS process resides with NASA/MOD. USA/ Systems Integration shall exercise oversight into the process by performing the tasks as described in Section 3.6.1.2. USA/System Integration shall retain insight into the definition of DOSS requirements.

3.6.4.2 NASA Oversight and Insight Responsibilities

NASA shall maintain an insight into the DOSS preflight/DOL support process through the performance of the tasks as described in Section 3.6.1.3. In addition, NASA shall provide the following specific oversight:

Review and approve all DOSS related changes requiring ICB or PRCB programmatic approval; i.e., process changes, requirement changes, NSTS documentation updates, or methodology changes.

NASA shall maintain further insight into the DOSS preflight/DOL support task through reviews and observation of the DOSS process, mission products, documentation, and metrics. NASA shall review the contractor EAPR log for each flight, as required, to close out PRCBD actions.

NASA can initiate audits of the DOSS preflight/DOL support process to enhance their insight to support the correction of process failures resulting in the violation of quality or schedule provisions of the applicable standard/MERs, or to support out-of-family conditions.

3.6.5 Out-of-Family Conditions

An out-of-family condition would exist for:

Any DOSS process or DOL assessment not compliant with DOSP requirements.

3.7 (DELETED)

The flight/test data requirement, acquisition, and distribution task is a primarily a support task to the post-flight analysis process. As such, it has been included in Section 3.8 of this PDP.

3.8 POST-FLIGHT DATA ANALYSIS/EVALUATION

This activity performs analysis and evaluation of system performance using recorded, down listed, measured, and reconstructed flight data in accordance with SSD92D0050, latest version. The activity consists of the following steps: assess system behavior obtained during the countdown, launch, and ascent phases of each mission; identify anomalies; recommend anomaly resolution plan; and correlate engineering preflight prediction tools. Perform trajectory reconstruction, MPS/RSRM performance assessments, ignition overpressure, wing strain gage, elevon hinge moment analysis, and bodyflap loads reconstruction. Provide a Quick-Look Post-Flight Data Report and update databases. Collect and store functional post-flight analysis/evaluation for availability to the customer. Monitor FDDs, identify program issues, and coordinate resolution of flight systems performance. Provide recommendation for appropriate program use of FDD products. Incorporate additional flights (past flights) into FDD database and confirm/update flight-derived systems dispersion products, and maintain existing trending databases.

In addition, this activity includes the flight and test data requirements definition, data acquisition, and distribution efforts.

3.8.1 Process

This task contains all of the post-flight data requirements definition, data processing, distribution, assessment, and reconstruction activities.

The flight data requirements definition, data processing, distribution, and management processes are described in Figure 3-13 thru Figure 3-16.

The flight data assessment and reconstruction activities develop the Quick-Look Post-Flight Report, the ascent performance post-flight trajectory reconstruction, the FDD updates, the MPS inventory updates, and RSRM block motor adjustments. The flight data assessment and reconstruction processes are described in Figure 3-17 and Figure 3-18. The remaining post-flight activities are well summarized in SSD92D0050, latest version.

The process to adjust the RSRM block motor model based on flight reconstruction is illustrated in Appendix B, Figure 3-4. The FDD development and update process is illustrated in Appendix B, Figure 3-5 and Figure 3-18.

3.8.1.1 Quick-look Post-flight Report Production

a. Monitor launch countdown, recording any anomalous conditions.

b. Distribute Quick-Look Report forms to all Boeing subsystem console operators and to Boeing-KSC focal points for KSC Integration ground systems and LCC.

c. Monitor subsystems for in-flight anomalies.

d. Monitor vehicle performance during launch and ascent.

e. Collect Quick Look Reports from subsystem console operators at Boeing and KSC.

f. Ensure that status is provided on any anomalous condition.

g. Incorporate subsystem input into Post-flight Analysis Report.

h. Distribute Quick-Look Report for internal management review.

i. Electronically distribute the Quick-Look Report for anomalies/problems observed during launch and ascent phases of the mission.

j. Incorporate critical updates and publish an addendum, as required.

3.8.1.2 Ascent Performance Post-Flight Trajectory Reconstruction

The purpose of ascent performance reconstruction is to determine adjustments to predicted systems performance needed to match observed trajectory characteristics. This process identifies performance anomalies and trends and provides a historical base of performance-related systems dispersions. The process is as follows:

a. Data collection

The following information is needed to perform reconstruction and is acquired during the three weeks subsequent to launch and also added to the historical database:

1. TDDP used on DOL.
2. Lift-off time, SRB separation time, MECO time, and adaptive sensed time delta for adjusting throttle and pitch.
3. Guidance mass, SSME thrust, and SSME mass flowrate I-Loads.
4. Prelaunch wind and atmosphere files, as well as L+15 minute wind and L-70 minute atmosphere files.
5. Best Estimate of Trajectory (BET) file.
6. Meteorological Environment Tape (MET) file.
7. Thiokol reconstructed RSRM burn rates and web times.
8. MPS file containing reconstructed thrusts, flow rates, and gimbal angles.
9. Reconstructed MPS loads, residuals, and pressurants.

b. Data examination

Check reasonableness of data and search for anomalous data in BET, MET, MPS, and wind files.

1. Inspect velocity and acceleration data in BET.
2. Inspect temperature, pressure, density, and wind data in MET.
3. Inspect engine vacuum thrust, flow rate, and gimbal angles. Determine mixture ratio, average vacuum thrust, and average Isp.
4. Plot successive in-plane and out-of-plane wind components in order to examine wind behavior prior to and during launch.

c. Mission reconstruction

Reconstructing the ascent portion of a mission consists of the following activities:

1. Determining the average SSME Isp during a prescribed timeframe.
2. Adjusting RSRM web times to best match the observed trajectory.
3. Running an ascent simulation to determine RSRM burn rates and Isp, force and moment collectors needed to match the BET, average SSME thrust, and the Orbiter/ET inert weight.
4. Determining the effect of individual systems dispersions on propellant usage.

5. Performing additional analyses, as required, to better understand any unusual trajectory behavior or phenomena.

6. Comparing predicted trajectory with reconstructed trajectory.

7. Adding systems dispersions to historical database.

d. Dissemination of results

Results of the reconstruction are disseminated by the following activities:

1. Briefing SIRB on results of quick-look reconstruction approximately one week after launch, including inputs from L+4 day photo/video results.

2. Briefing SIRB on results of performance reconstruction four weeks after launch.

3. Generating reconstructed vehicle mass properties file, reconstructed SRM performance file, and MET environment file for Aerodynamics Group.

4. Publishing and distributing post-flight data availability letter.

3.8.1.3 FDD Update

The purpose of the FDD update is to utilize a historical database of each flight's systems dispersions in order to determine a set of knockdowns (loads, aeroheating, plume heating) to vehicle constraints, resulting in defined allowable flight conditions. Also, this database is used to determine the Flight Performance Reserve (FPR) and fuel bias needed to protect for 3-sigma performance variations on normal and RTLS flights, as well as 2-sigma variations on AOA/TAL flights. Based on the trends of selected flight performance parameters, a recommendation may be provided to SSP to update the FDD products, FPR, or MPS inventory. This process is performed under the direction of SSEIG, and is typically conducted after at least 10 new flights have been added to the database since the last FDD update or under special circumstances. The process is as follows:

a. Trajectories

The following trajectories are generated:

1. Apply each flight's set of systems dispersions to a set of baseline trajectories that are representative of the seasons, inclinations, and other flight requirements under which we currently operate (this will be useful for determining the knockdowns described below).

2. Apply 3-sigma systems dispersions to the most sensitive of the 12 baseline trajectories (this will be used to determine FPR).

b. Products

The following products are used for both prelaunch and DOL checks, special studies, and in the case of FPR, as inputs to MPS propellant inventories. They are

derived by analyzing the trajectories mentioned above. These products are documented in a letter at the conclusion of the FDD update process.

1. Loads knockdowns

   q, alpha, beta

2. Aeroheating knockdowns

   (a) 1st stage alpha, beta, and density

   (b) 2nd stage alpha and beta

   (c) Stagnation heat load at 240 seconds

3. Plume heating knockdown (altitude at 118 seconds)

4. DOLILU II Quality Assurance Rules

   (a) S9 Rule (Heating Carpet Constraint)

   (b) S24 Rule (Plume Heating Constraint)

5. Operational FPR

   No-fail, PTA, and RTLS flight modes: with and without PLOAD

c. Approval

   The products of the FDD update are presented in the following order for approval:

   1. Ascent, Thermal, and Loads Panel Chairs, and to their respective panels, if requested

   2. SIRB

   3. SSEIG

   4. ICB (including CR)

   5. PRCB (including CR)

3.8.1.4 Adjusted RSRM Computer File Production Process

a. Adjust the Marshall Space Flight Center (MSFC)-provided block motor model(s) using the following inputs:

   1. MSFC-provided block motor models.

   2. Reconstructed (flight-derived) Isp and thrust.

b. Generate the following required outputs:

   1. A series of adjusted RSRM computer files.

   2. The associated technical briefings needed to obtain MSFC, SSEIG, and ICB concurrence with the update.

   3. A CR to formally update the computer file names in NSTS 08209, Volume V.

The process required to produce the adjusted RSRM computer files (PDRD 1223a) is described in the CMMDB (previously NSTS 08209, Volume V), under math model CMM-00158. This product is updated only when block motor changes and/or reconstructed data warrant. MSFC/Thiokol provides an annual summary of RSRM changes to the SIRB. Boeing provides flight-derived Isp and thrust data as part of the mission-specific reconstruction briefings. The SSEIG is the technical forum in control of when changes need to be assessed and implemented.

3.8.1.5 Main Propulsion System

3.8.1.5.1 MPS Budget Generation Process

The MPS budget inventory is updated as a result of system changes or as is determined desirable based on post-flight trending. Post-flight trending is accomplished by comparing key mission-specific reconstructed MPS parameters to their mean, $\pm$ 3 standard deviation control band, and a 90% confidence interval band about the mean. The eight key parameters are: Liquid Hydrogen (LH_2) and Liquid Oxygen (LO_2) SSME start consumptions, GH_2 and GO_2 mainstage pressurant consumptions, LH_2 and LO_2 SSME shutdown consumptions, and mainstage system inlet and overboard mixture ratios. H/W changes to the integrated MPS system also need to be reviewed for their effect on the MPS propellant budget/inventory.

The process to generate a new MPS budget inventory is described in detail in SSD950369, MPS Propellant Inventory Generation Program. The basic steps are as follows:

a. Prepare a short MPS budget inventory update proposal (briefing) with the groundrules, flight effectivities, etc, for SIRB approval. Present to SSEIG after SIRB approval.

b. Consolidate the individual mission-derived MPS databases and propulsion parameters into a single database, consistent with the approved groundrules.

c. Provide this data to the Ascent Performance Reconstruction Group for their calculation of a new FPR and fuel bias calculation.

d. Account for changes to the operational MPS system, including changes identified by the ET project, Lockheed Martin Manned Space Systems (LMMSS), and Propulsion Systems Integration Group (PSIG). For example; H/W changes, ullage pressure updates, and tanking table revisions.

e. Incorporate all the above inputs into the MPS propellant inventory generation program and perform analysis.

f. Provide a paper copy output for the CR, and an electronic version for transfer to the Boeing TDDP Group and the Boeing Trajectory Groups for review. All versions should be identical in content.

g. Prepare the necessary technical briefings to explain the new MPS budget and obtain approval from MSFC, PSIG, SSEIG, and ICB. A CR accompanies the technical briefing to update NSTS 08209, Volume I, Section 4, as required.

The SSEIG is the technical forum in control of when changes need to be assessed and implemented. The NASA PRCB is the review and approval authority for the MPS budget update and the associated documentation changes.

3.8.1.5.2 Generation of Average Tags for Each SSME Type

The generation of average tags follows the same process as the creation of engine specific SSME tags described in Section 3.5.1.4. However, this process takes into consideration all flight and test data for each engine type as opposed to the data for a specific engine.

3.8.1.6 Flight/Test Data Requirements, Acquisition, and Distribution

The overall purpose of this process is to provide data, data tools and systems, and data support to Boeing engineering analysts to support the post-flight data evaluation.

This task principally consists of eight basic processes discussed in the following paragraphs and described in Figure 3-13 thru Figure 3-16.

a Data requirements definition, documentation, coordination, and submittal.

1. Explicitly define, in terms of instrumentation and data system functionality, the data requirements for each Boeing Analysis Group or analyst, based upon System Integration verification requirements and/or NASA customer requests.

2. Submit or update the appropriate documentation to effect data processing for a given flight or test.

b. Coordinate/Perform transmission of data from providing source site to Boeing facility or computational resource (mainframe, local workstation, or PC computing systems).

c. Perform processing and pre-processing functions on incoming data, including data and media format conversions and execution of analyst-defined data processing programs.

d. Distribute and deliver data via manual delivery, electronic mail, or electronic transmission. Depending upon the specific requirement, any one or combination of these methods may be used to disseminate data.

e. Provide storage of both processed and unprocessed data utilizing the Engineering Data Control Center (EDCC) and associated data processing functions.

    1. Data Storage - The EDCC and its associated data processing groups store data in a variety of different formats on several media. These include data and video tape, film (photo and motion picture), computer disks, and hardcopies.

    2. Data Storage Management - The EDCC and associated data collecting/ processing groups manage the storage of data used by Boeing analysts. Hardcopy data and tape copies are kept for each flight for which they were requested. Data files are stored on-line for the most recent flights of each vehicle. As data ages, or is not used, it is migrated to another storage media or is moved to an on-site or off-site archive facility.

f. Provide for the resolution of data problems. All data problems that are resolvable by Boeing data processing personnel are resolved in-house. For data problems where the EDCC identifies another source processing site as the cause, the appropriate paperwork (or phone, fax, letter, etc.) identifying the problem or anomaly is submitted. The EDCC then coordinates a resolution of the problem (on a teaming basis if needed) with the source data site to attain resolution or understanding of the problem.

g. Support existing S/W and H/W tools and develop new S/W and H/W tools as needed. The Boeing processing groups (primarily the EDCC).

    1. Perform S/W maintenance of existing Boeing-created data tools.

    2. Provide local support for outside vendor S/W tools, as well as the computer H/W and S/W required to utilize these tools.

    3. Provide support to engineering analysts in using various realtime and post-processing S/W tools.

h. Prepare and maintain copies of telemetry and data systems documentation, data availability documentation, ICD, and interface description documentation, as well as examples. This documentation describes the data, as well as data processing logic and media formats used. The EDCC stores these on-site for use by both data personnel and engineering analysts.

3.8.2 Products

DRD SC009, Flight Performance Reconstruction Briefing
DRD 1211a, Flight-Derived Dispersions Database Update
DRD 1223a, Adjusted RSRM Block Motor Model Update

DRD 1223b, MPS Inventory Budget Update
PDRD SC003, Quick-Look Post-Flight Report, Post-Flight Data Availability Letter

3.8.3 Product Acceptance Criteria

Products completed and delivered on time, in accordance with applicable Systems Integration (aka Artemis) schedules and PDRD technical content requirements. Product quality determined acceptable by completing required internal reviews and obtaining approval at the appropriate USA or NASA chaired panels and boards.

Product quality and timeliness shall be reported for the products defined in this section using the USA/PMS.

3.8.4 Oversight and Insight Responsibilities

3.8.4.1 USA Oversight Responsibilities

USA shall provide the general oversight of the post-flight data analysis/evaluation process.

a. Review and approval of post-flight reconstruction results.

b. Provide direction, guidance, schedule requirements, and approval of FDD update activities.

c. Review and approval of Boeing products from post-flight assessment trajectory reconstruction, and FDD activities.

d. Review proposed process changes, NSTS documentation updates, math model updates, FDD database updates, or methodology changes including MPS budgets, and RSRM block motor degradations.

In addition, USA shall inform NASA of any out-of-family conditions, via e-mail from the Director of Systems Integration, and maintain insight into the analysis and closure of any such conditions.

3.8.4.2 NASA Oversight and Insight Responsibilities

NASA shall provide specific oversight of the post-flight data analysis/evaluation process through the performance of the following tasks:

a. Review and approve mission-specific post-flight reconstruction results when out-of-family results are involved.

b. Provide programmatic direction for disposition of reconstruction results that require design changes to protect flight operations system margin requirements.

c. Review and approve all design criteria, constraint, requirement or database changes resulting from post-flight activities including FDD database updates, MPS budgets updates, and RSRM block motor adjustments.

d. Review and approve all proposed model, methodology, S/W, database, and procedural updates to the post-flight/reconstruction process.

e. Review and approve post-flight out-of-family issues.

f. Provide programmatic direction for disposition of reconstruction results that cannot be technically explained.

g. Review and concur with all proposed updates to SSD92D0050.

h. Review and approve mission-unique data acquisition requirements.

i. Resolve data acquisition issues and anomalies between affected elements external to SFOC.

j. Issue resolution and coordination with all required interfaces external to SFOC.

In addition, NASA shall maintain an insight into the post-flight data analysis/evaluation process. NASA shall review and observe the post-flight evaluation process, mission products, and documentation.

NASA can initiate audits of the post-flight data analysis/evaluation process to enhance their insight to support the correction of process failures resulting in the violation of quality or schedule provisions of the applicable standard/MERs, or to support the resolution of out-of-family conditions.

3.8.5 Out-of-Family Conditions

An out-of-family condition would exist for:

a. Unexplained in-flight anomaly conditions identified from analyses of post-flight data.

b. Any significant delay in product delivery caused by external factors or off-nominal operating conditions.

c. System performance significantly outside previous flight experience.

4.0 CoFR ACCOUNTABILITY

Each organization has a role and responsibility in the flight preparation process. This PDP describes processes which contribute to flight preparation and which are necessary for NASA, USA, and Boeing to satisfactorily complete their CoFR. The overall accountability for the flight preparation process responsibilities are described in NSTS 08117, Space Shuttle Requirements and Procedures for Certification of Flight Readiness and the details of the process for USA are presented in SFOC-PM0072, Product Development Plan for United Space Alliance Program Integration Certification of Flight Readiness Process PDP MS8-005, while the Boeing process is presented in SSD95D0205, Program Integration Flight Preparation Process Definition Document. In general, those activities in this PDP which support the CoFR are: development of TDDPs, post-flight analyses, FRV (or FMA), support to DOSS, and assessment of anomalies.

5.0 CONTINUOUS IMPROVEMENT (CI)

The metrics to be used for measuring process improvements for these flight systems analysis tasks can be one or more of the following types: costs, schedule, and quality. Although these types of metrics may already exist for selected milestones, the CI will consider collecting statistics and developing trends over selected time periods. For this set of tasks, the following CI metric concepts are used.

Cost metrics are gathered at a Work Breakdown System (WBS) level to: monitor task progress, monitor task efficiency, monitor ability to respond to peak workloads, and gather historical data for various trending activities.

Quality and schedule metrics will be gathered for those products defined as PDRDs in this PDP, with the exception of the elements heating environments data files and letter. These metrics will be gathered for purposes similar to the cost metrics.

Changes to the established set of metrics (additions or deletions) may be proposed as part of the CI initiative.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

APPENDIX A

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations appear in this Product Development Plan.

AFDFP	Ascent Flight Design Freeze Point
aka	also known as
AOA	Abort-Once-Around
ASTRO	Ascent Simulation Trajectory Optimization
BET	Best Estimate of Trajectory
CCB	Configuration Control Board
CCCD	Crew Compartment Configuration Drawing
CE	Change Evaluation
CG	Center of Gravity
CI	Continuous Improvement
CIR	Cargo Integration Review
CoFR	Certificate of Flight Readiness
CR	Change Request
DADS	Day-of-Launch Ascent Design System
DCR	Data Change Request
DOL	Day-of-Launch
DOLILU	Day-of-Launch I-Loads Update
DOSP	DOLILU Operations Support Plan
DOSS	DOLILU Operations Support System
DRD	Data Requirements Description
EAPR	Engineering Analysis Process Request
EDCC	Engineering Data Control Center
ET	External Tank
FCS	Flight Control System
FDD	Flight-Derived Dispersion
FDMS	Flight Dynamics Mission Summary
FDRD	Flight Definition and Requirements Directive
FMA	Flight Margins Assessment
FOP	Flight Operations Plan
FPR	Flight Performance Reserve
FPSR	Flight Planning and Stowage Review
FRD	Flight Requirements Document
FRR	Flight Readiness Review

FRV	Flight Readiness Verification
FTSOD	Flight Test and Supplemental Objectives Document
GFE	Government Furnished Equipment
GH_2	Gaseous Hydrogen
GN&C	Guidance, Navigation and Control
GO_2	Gaseous Oxygen
H/W	Hardware
ICB	Integration Control Board
ICD	Interface Control Document
IMIC	Integrated Management Information Center
IPT	Integrated Product Team
Isp	Specific Impulse
ISVT	Integrated Systems Verification Test
L-	Launch Minus
LCC	Launch Commit Criteria
LDO	Loads and DOLILU Officer
LH_2	Liquid Hydrogen
LMMSS	Lockheed Martin Manned Space Systems
LO_2	Liquid Oxygen
LSFR	Launch Site Flow Review
LSRR	Launch Site Requirements Review
MA	Management Action
MECO	Main Engine Cutoff
MECSLSI	Mission Equipment Cargo Support Launch Site Installation
MER	Maximum Error Rate
MET	Meteorological Environment Tape
MICB	Mission Integration Control Board
MOD	Mission Operations Directorate
MP	Mass Properties
MPS	Main Propulsion System
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
OAR	Operational Acceptance Review
OCTF	One Cycle to Flight
OI	Operational Increment
OMRS	Operations and Maintenance Requirements and Specifications

OMRSD	Operations and Maintenance and Requirements and Specifications Document
OMS	Orbital Maneuvering Subsystem
Ops	Operations
P/L	Payload
PC	Personal Computer
PDP	Product Development Plan
PDRD	Procurement Data Requirements Description
PE	Performance Enhancement
PIP	Payload Integration Plan
PMBT	Propellant Mean Bulk Temperature
PMS	Performance Measurement System
PRCB	Program Requirements Control Board
PRD	Program Requirements Document
PSIG	Propulsion Systems Integration Group
QA	Quality Assurance
RSRM	Redesigned Solid Rocket Motor Reusable Solid Rocket Motor
RTLS	Return to Launch Site
S/W	Software
SASCB	Shuttle Avionics Software Control Board
SEP	Separation
SFOC	Space Flight Operations Contract
SIRB	Systems Integration Review Board
SODB	Shuttle Operations Data Book
SOW	Statement of Work
SPAD	Shuttle Performance Assessment Databook
SR&QA	Safety, Reliability and Quality Assurance
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SSEIG	Space Shuttle Engineering Integration Group
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSV	Space Shuttle Vehicle
STS	Space Transportation System
TAL	Transatlantic Abort Landing
TDDP	Trajectory Design Data Package
TRR	Test Readiness Review

UPD	Update
UPL	Uplink
USA	United Space Alliance
VLA	Verification Loads Analysis
WBS	Work Breakdown System

APPENDIX B

TASK PROCESS

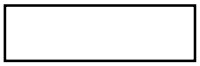
APPENDIX B

TASK PROCESS

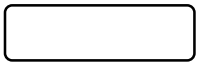
This appendix contains the task process diagrams discussed in the PDP document. The following legend can be used to indicate input data, process activity steps, and output products:

INPUT DATA

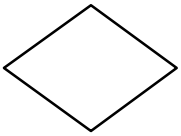
NASA/USA SI INPUT DATA
OR DIRECTION



PROCESS ACTIVITY STEP



NASA ACTIVITY STEP



DECISION STEP/PATH

OUTPUT PRODUCT

TABLE 3.1
GENERIC DATABASES REFERENCED IN TDDP

Name	Source	Section/Paragraph
Aerodynamics	NSTS 08209, Volume I	Paragraph 10.6
Propulsion Performance - MPS -SSME Tags -SSME Start and Shutdown Transients	NSTS 08209, Volume I	Paragraph 5.1
Non-rigid Body Effects -SSME Thrust Structure Deformation	NSTS 08209, Volume I	Section 10.10
RSRM Performance Predictions	NSTS 08209, Volume I	Section 5.4
Propellant Loading - MPS -MPS Propellant Inventory	NSTS 08209, Volume I	Paragraph 4.4.1
Mass Properties -Non-propulsive Consumables Lost During Ascent	NSTS 08209, Volume I	Section 10.7
Maximum Dynamic Pressure - Constraint	NSTS 08209, Volume IV	Paragraph 3.1.2.2-A
Maximum Dynamic Pressure - Criteria	NSTS 08209, Volume IV	Paragraph 3.1.2.2-B
Q-Alpha and Q-Beta -Aerodynamic Angle Targets	NSTS 08209, Volume IV	Paragraph 3.2.1.2
Elevon Schedule	NSTS 08209, Volume IV	Paragraph 3.1.2.4
Minimum Altitude Rate at SRB Separation	NSTS 08209, Volume IV	Paragraph 3.1.2.6
1st Stage Alpha and Beta Aeroheating Limits	NSTS 08209, Volume IV	Paragraph 3.1.2.3
RTLS Heat Load, Heat Rate, and Pilot Press.	NSTS 08209, Volume IV	Paragraph 3.3.2.2
1st Stage Engine-Out Q-Alpha and Q-Beta -Aerodynamic Angle Targets	NSTS 08209, Volume IV	Paragraph 3.3.2.1

TABLE 3.2
DATABASES CONTAINED WITHIN TDDP

Name	Source
Mission Requirements	NSTS 07700, Volume III, Flight Definition and Requirements Directive
RSRM PMBT - Generic	NSTS 08209, Volume I, Shuttle Systems Design Criteria (Section 5.4)
RSRM PMBT - L-9 Day, L-3 Day	Thiokol Propulsion Letter, RSRM-XX (STS-XX) Transmittal of L-X PMBT Prediction
Mass Properties	Mass Properties Database, Boeing (reference Section 3.8 of this PDP)
SSME Performance	SSME Tags Database, Boeing
RSRM Performance - Generic	USA Letter, SRB Quarterly Mass Properties Status Report
RSRM Performance - Predictions	USA , Preflight Mass Properties Report for STS-XX
MPS Propellant Inventory	MPS Propellant Inventory Database, Boeing NSTS 08209, Volume I
Elevon Schedule	NSTS 08209, Volume IV, Shuttle Systems Design Criteria
Ascent Flight Design Criteria	STS-XX Ascent Flight Design Freeze Point (PRCB Directive)

TABLE 3.3
TDDP PRODUCT INPUT REQUIREMENTS

Name	Description	Delivery	Data Requirements
CIR	Pre-CIR Support for MOD/USA Flight Design Assessments	L-387[2]/L-366[1, 3]	FDRD, FRD, Shuttle Payload Integration and Cargo Evaluation (SPICE) (baseline configuration), Ascent Flight Design Kick-off (preliminary first stage ascent flight design criteria), RSRM PMBT for 15th of Launch Month, RSRM Generic Burn Rate, Average SSME Tags, Primary Payload Control Weights
FLT/OCF	Flight Cycle/One-Cycle-To-Flight (supports BASE Cycle)	L-228[2]/L-272[1] L-197 [3]	PRCB Ascent Freeze Point (baselined first stage ascent flight design criteria), FPSR (secondary payload assignments)[2], PRCB Final Bay (mission-specific cargo bay and mid-deck envelope)[1], Primary Payload Status Weights (Annex 1), MECSLSI Drawings (initial release)
FRV	Flight Readiness Verification for Boeing Assessments	L-144[2]/L-204[1] L-129[3]	FRV Groundrules, RSRM PMBT for Launch Date, RSRM Predicted Burn Rate, SSME assignments at LSRR (L-184)[2]
UPD	FRV Update for Boeing-HB Assessments	NA[2,3]/L-150[1]	SSME Assignments at LSRR (L-184)[1]
FRR	Flight Readiness Review Support for MOD and Boeing Assessments	L-56	RSRM Performance Information Summary (L-75), SSME Tags (updated at L-63 from previous flight of each engine)
UPL	Uplink for generation of uplink I-Loads	L-30	Latest Data (all categories).
DOL	Day-of-Launch for DOL Operational Support System (DOSS)	L-08	Actual ET Weight (L-60), SRB Preflight Mass Properties Prediction (L-30), Actual Orbiter Weight (L-10), Actual SSME Weight (L-10), Actual OMS/RCS Loads (L-9), RSRM PMBT Prediction (L-9)
CN	Change Notice to DOL TDDP	L-03	RSRM PMBT Prediction Update (L-3)

[1] For 1-Cycle (Base Cycle) Flight Production Template
[2] For 2-Cycle Flight Production Template
[3] For ISS Standardization Template

FIGURE 3-1
SHUTTLE MASS PROPERTIES WORK PROCESS

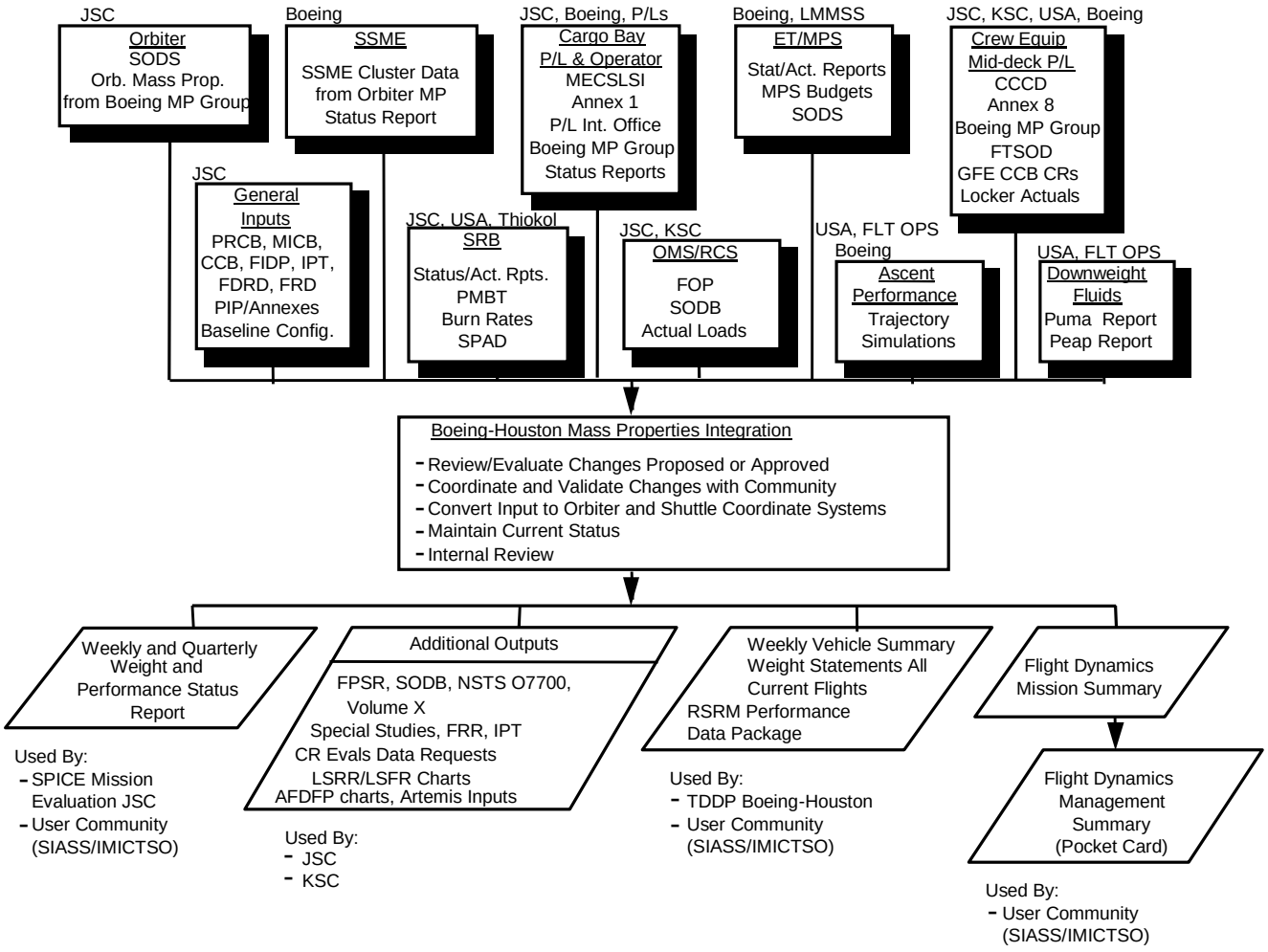


FIGURE 3-2
TDDP DEVELOPMENT PROCESS

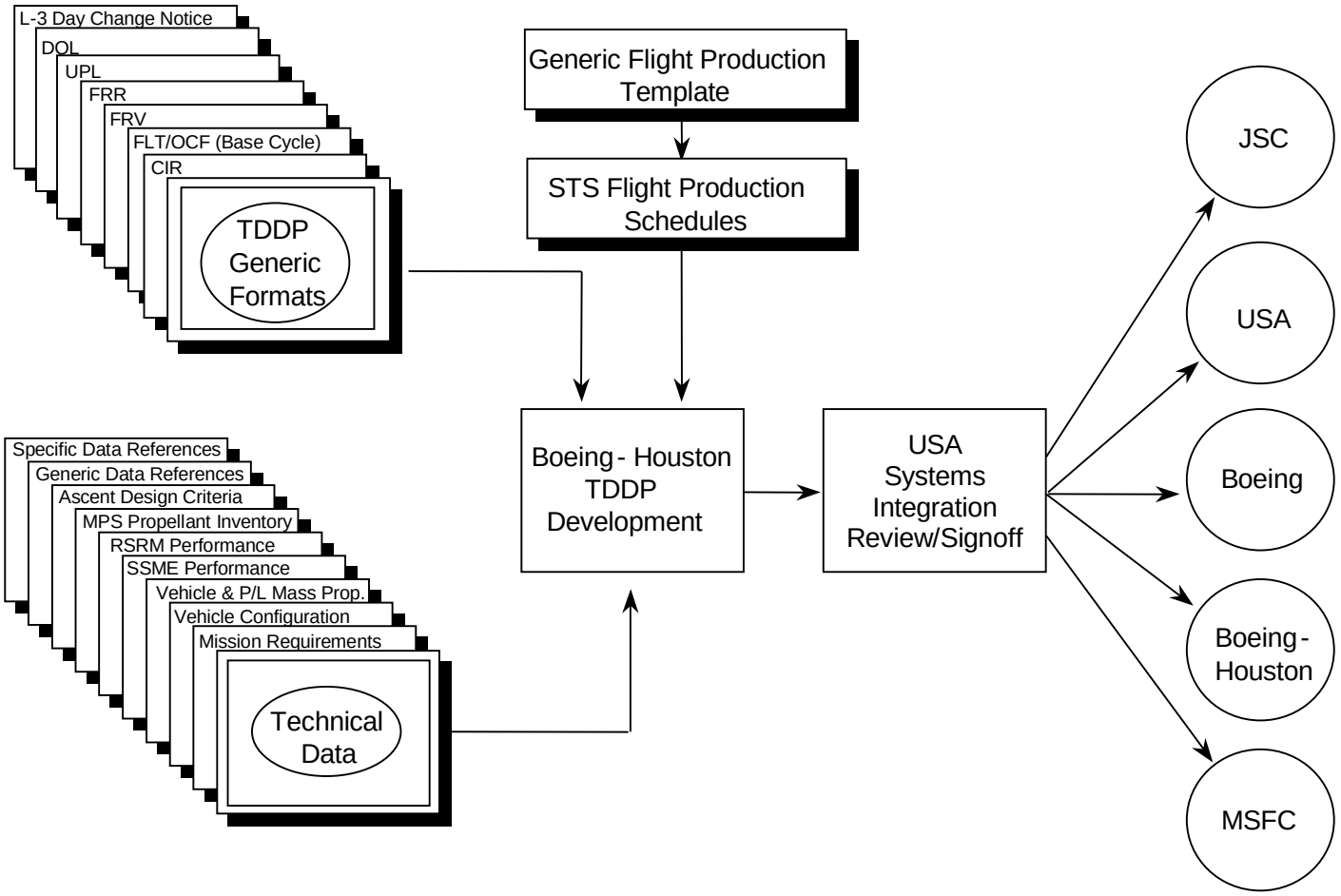


FIGURE 3-3
ASCENT TRAJECTORY/PERFORMANCE MARGIN ASSESSMENT PROCESS

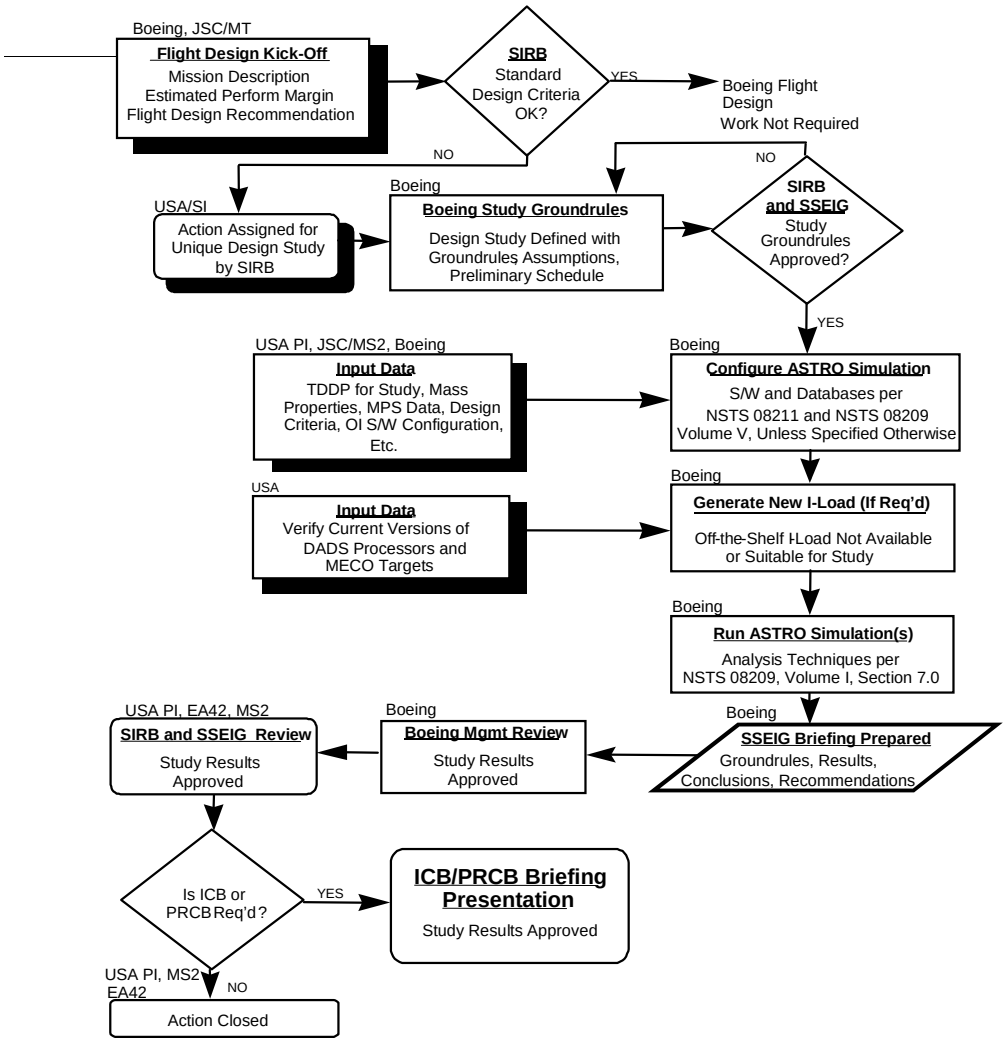


FIGURE 3-4
ADJUSTED RSRM COMPUTER FILE PRODUCTION PROCESS

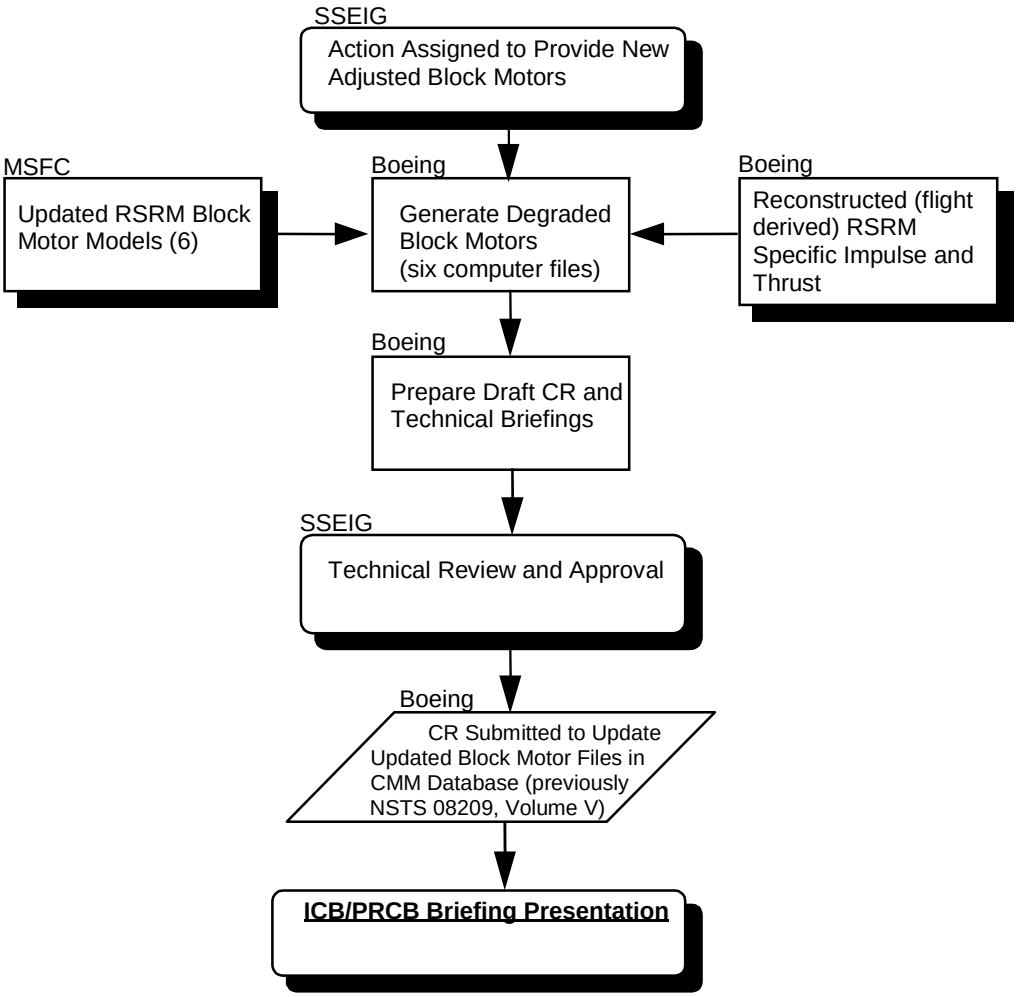


FIGURE 3-5
MPS PROPELLANT INVENTORY GENERATION PROCESS

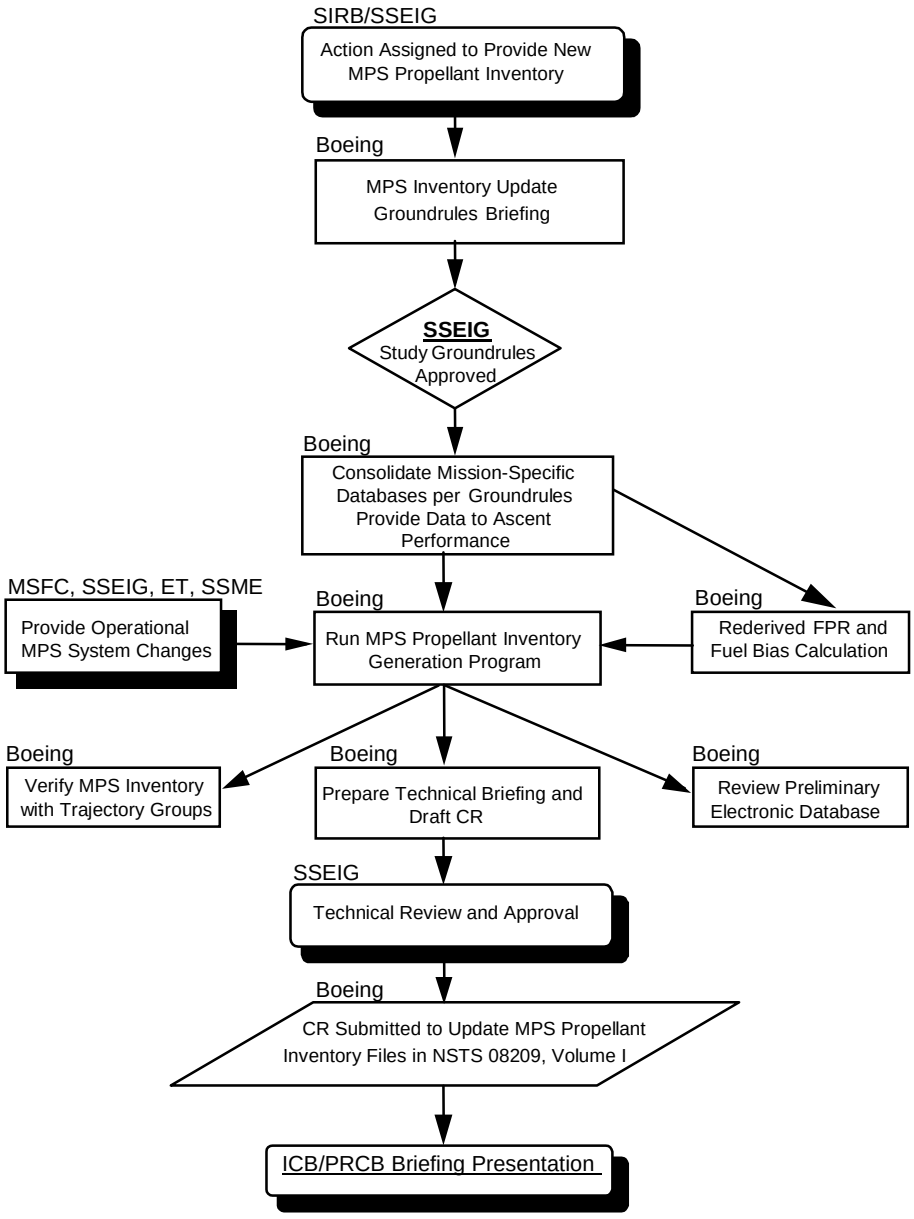


FIGURE 3-6
SSME TAG UPDATE PROCESS

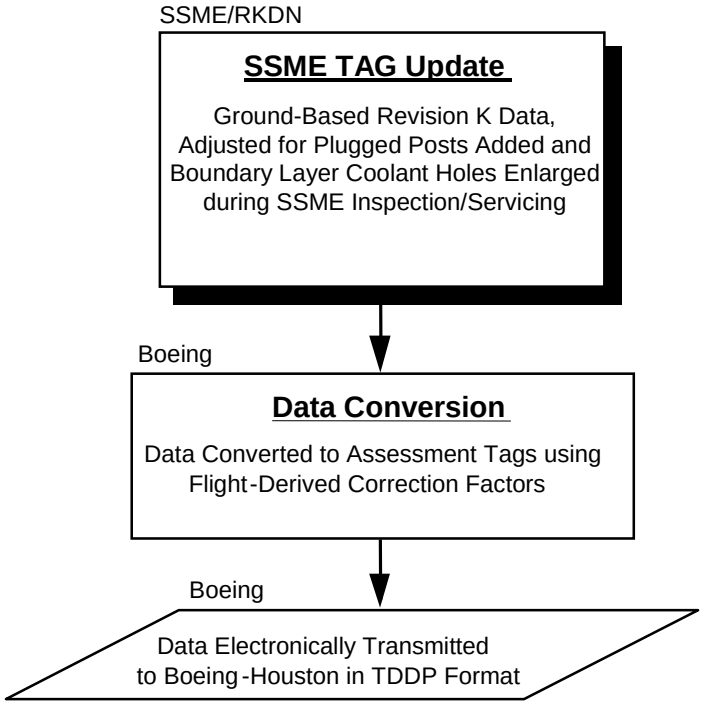


FIGURE 3-7
ASCENT PERFORMANCE ASSESSMENT AND HEATING CHECK PROCESS

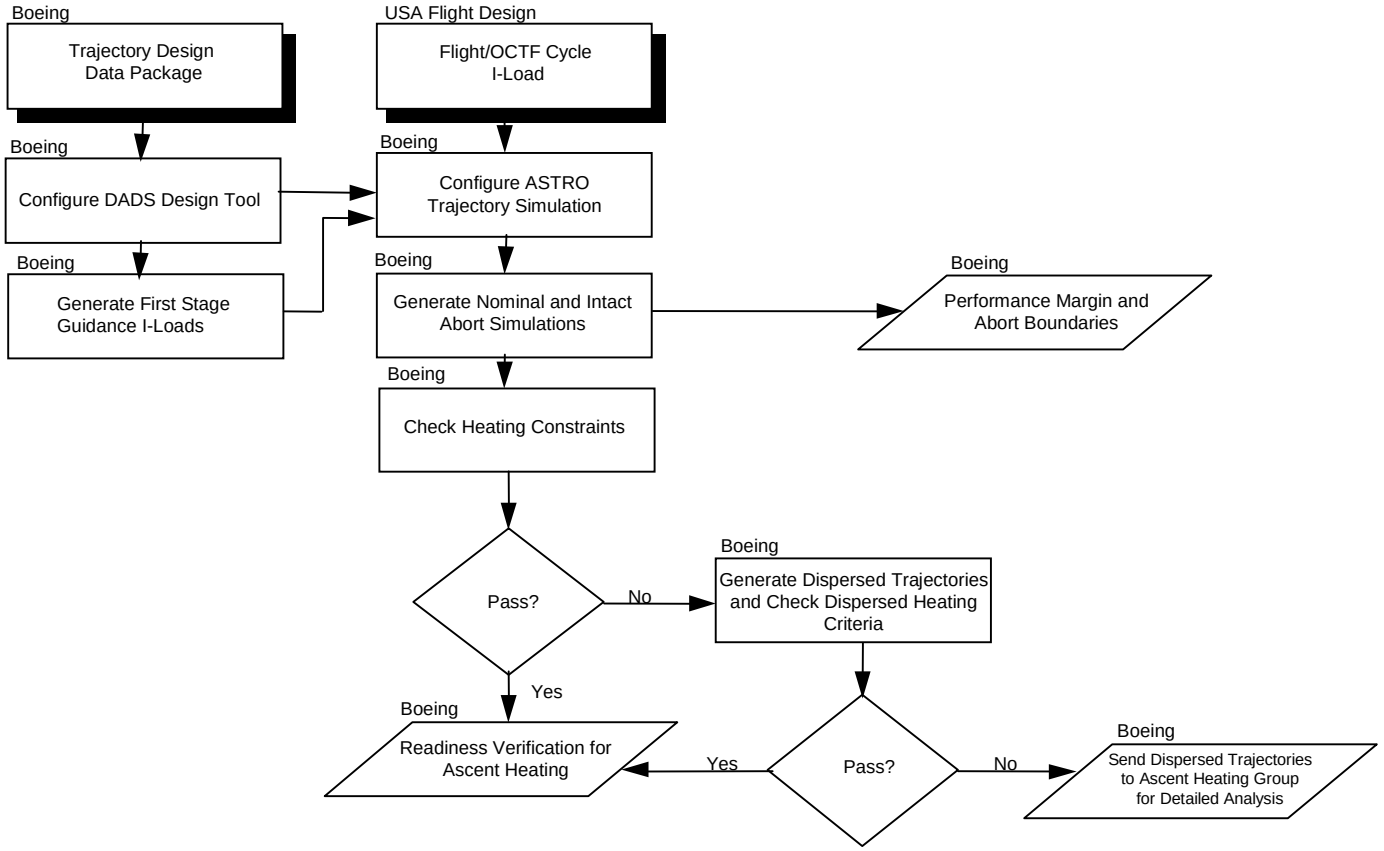
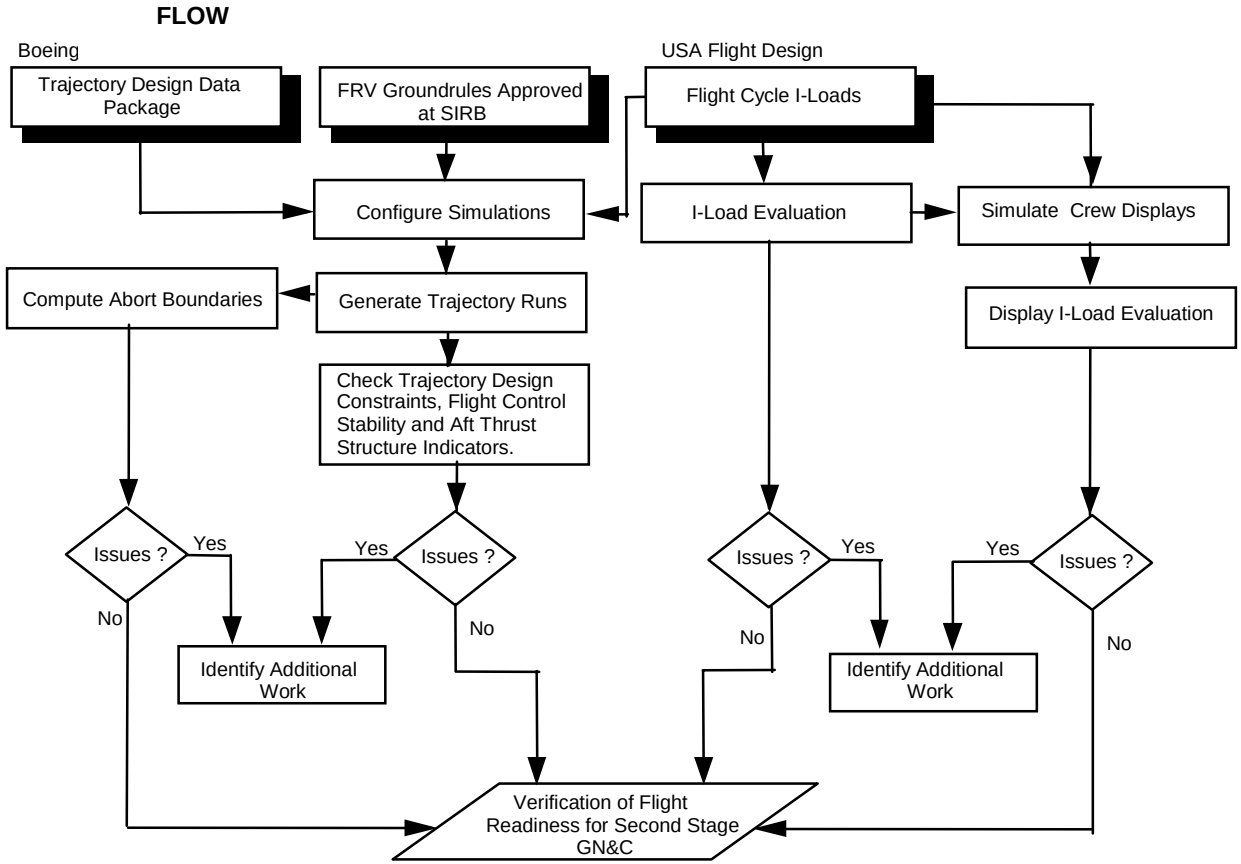


FIGURE 3-8
SECOND STAGE ASCENT GN&C ASSESSMENT PROCESS



Note: All activities Boeing unless otherwise noted.

FIGURE 3-9
RSRM PERFORMANCE ASSESSMENT PROCESS

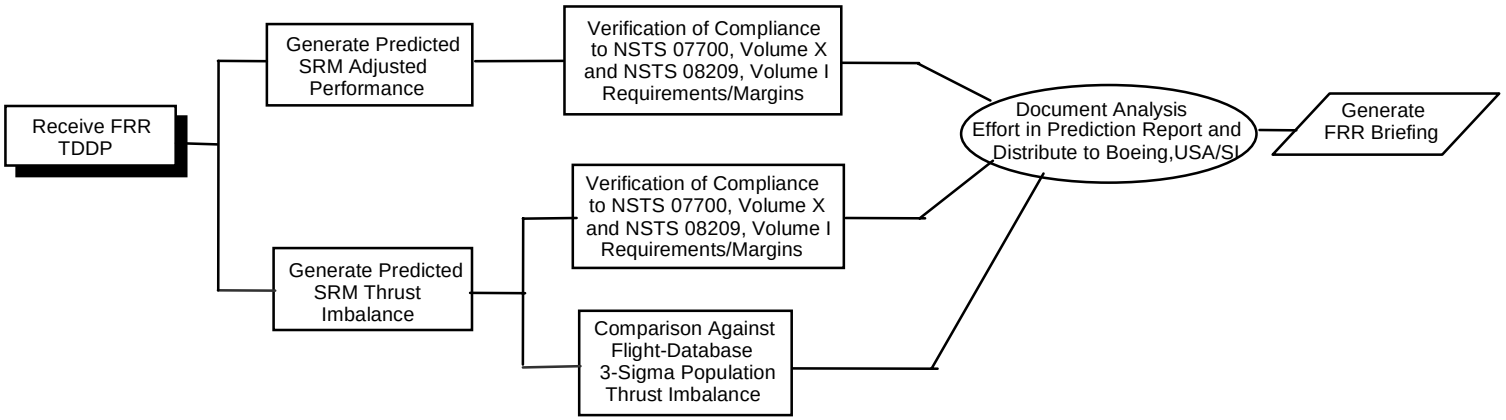
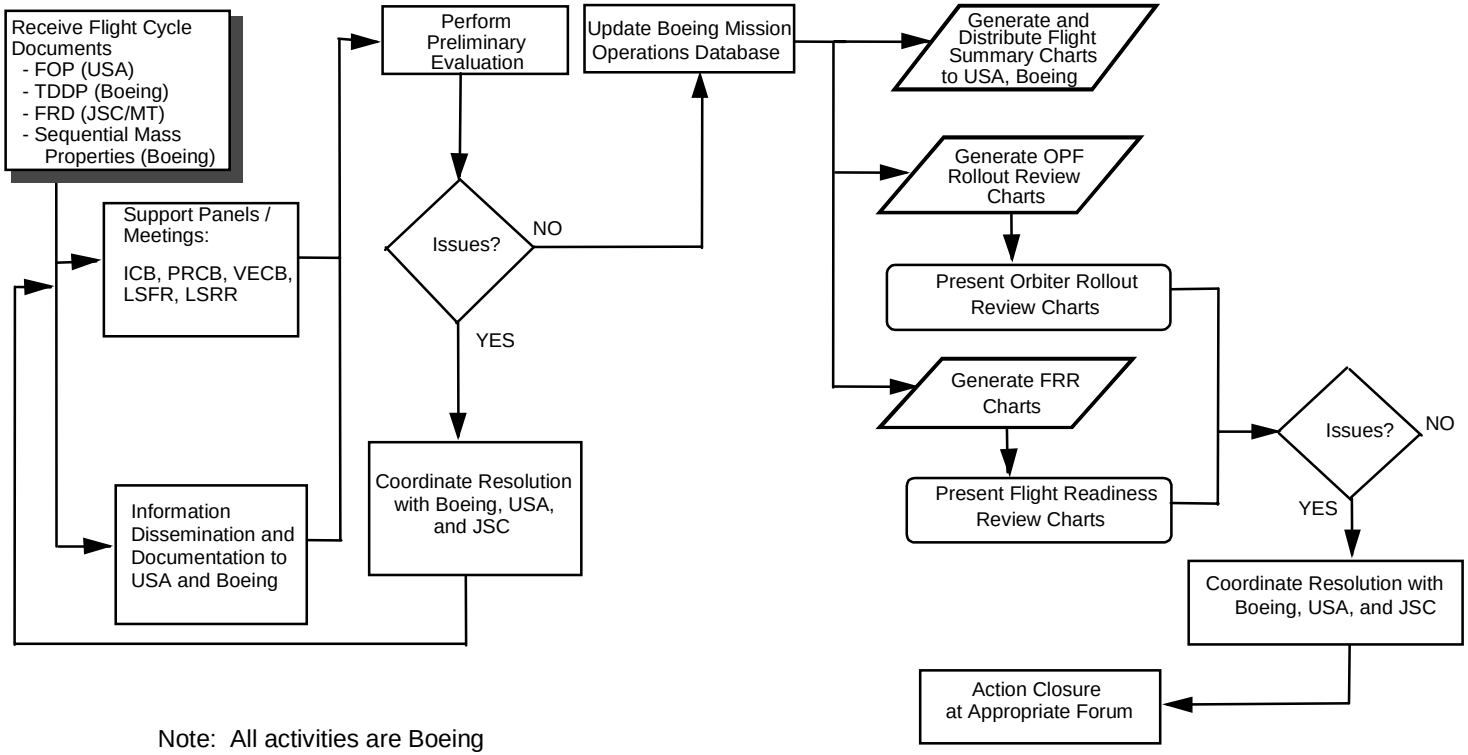


FIGURE 3-10
MISSION REQUIREMENTS ASSESSMENT PROCESS



Note: All activities are Boeing

FIGURE 3-11
DOSS BLOCK-UPDATE IMPLEMENTATION

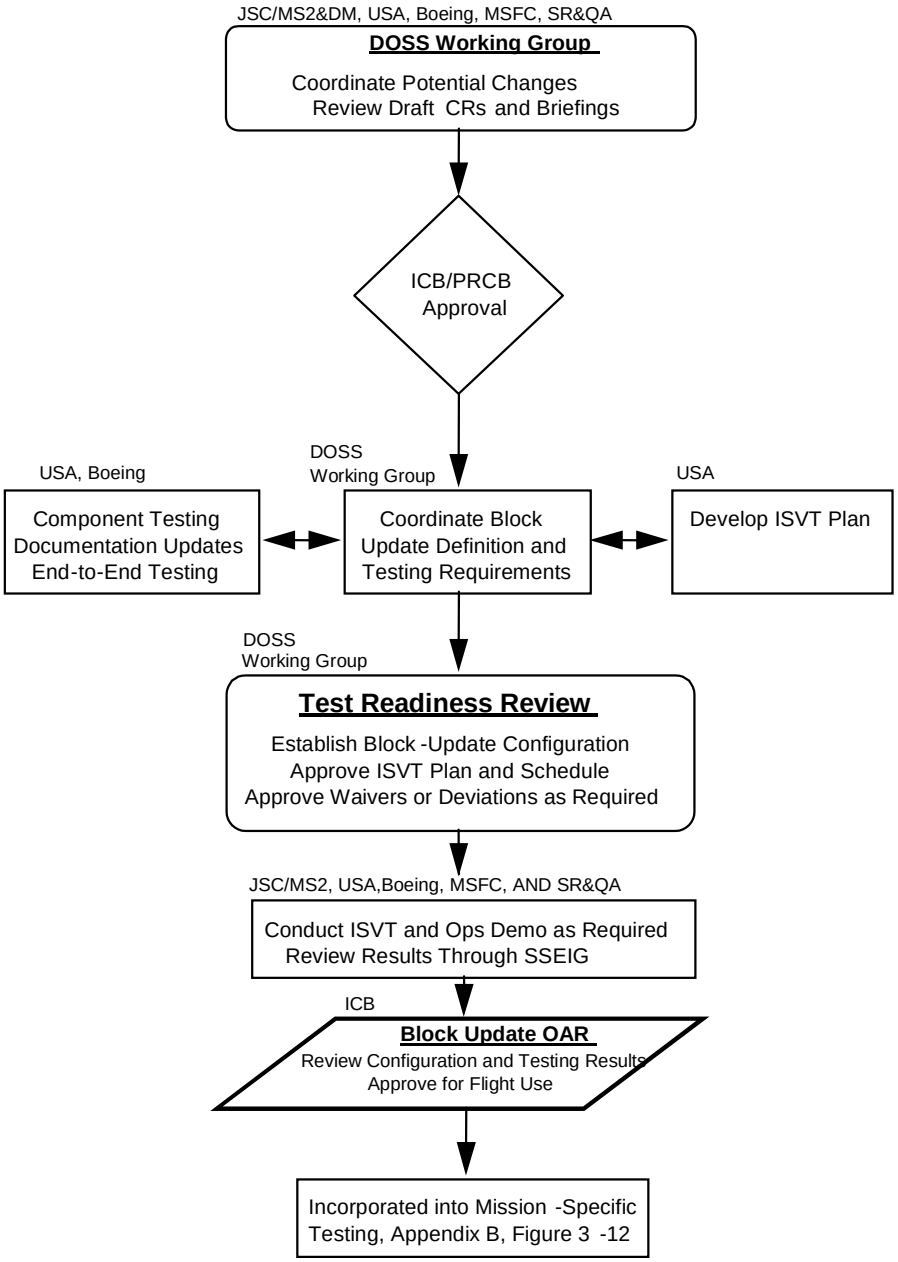


FIGURE 3-12
DOSS PREFLIGHT VERIFICATION PROCESS

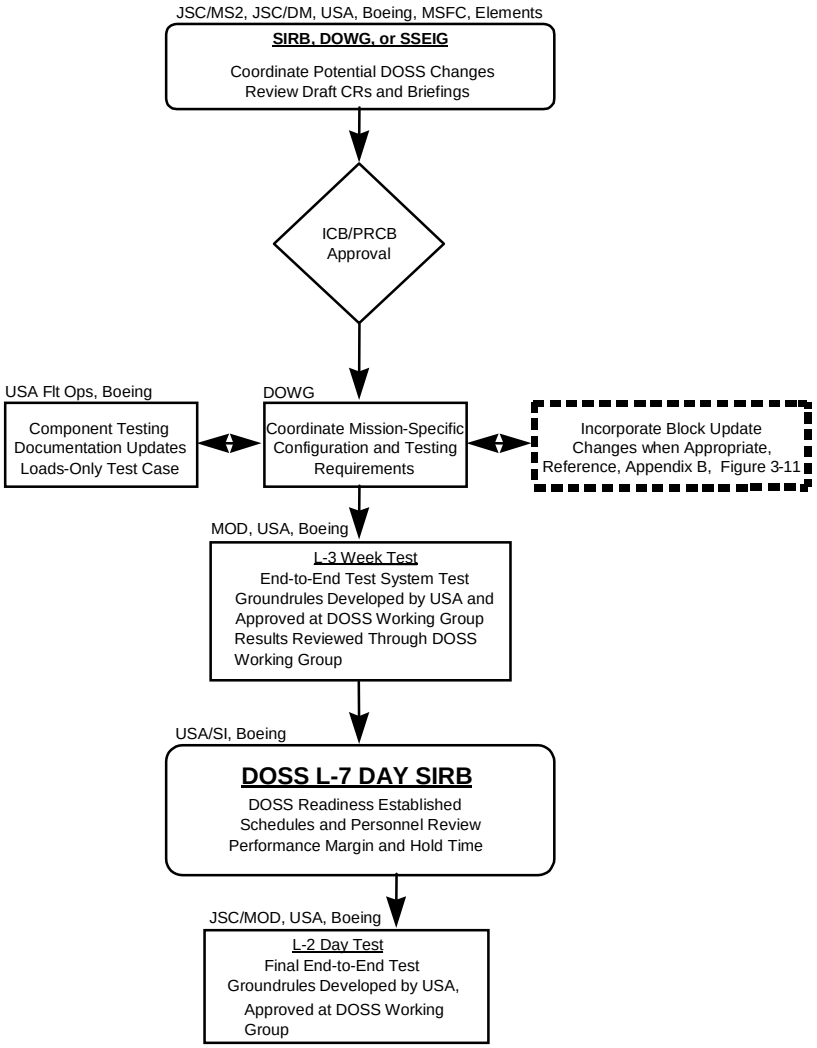


FIGURE 3-13
POST-FLIGHT ANALYSIS AND RECONSTRUCTION
REQUIREMENTS PROCESS

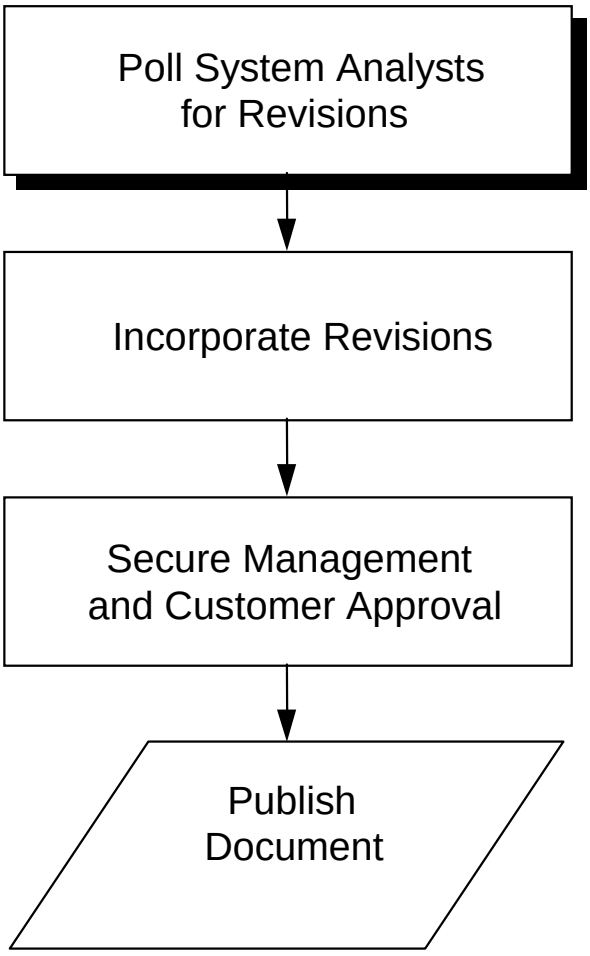


FIGURE 3-14
BOEING PROGRAM REQUIREMENTS DOCUMENT (PRD)
REQUIREMENTS INPUT PROCESS

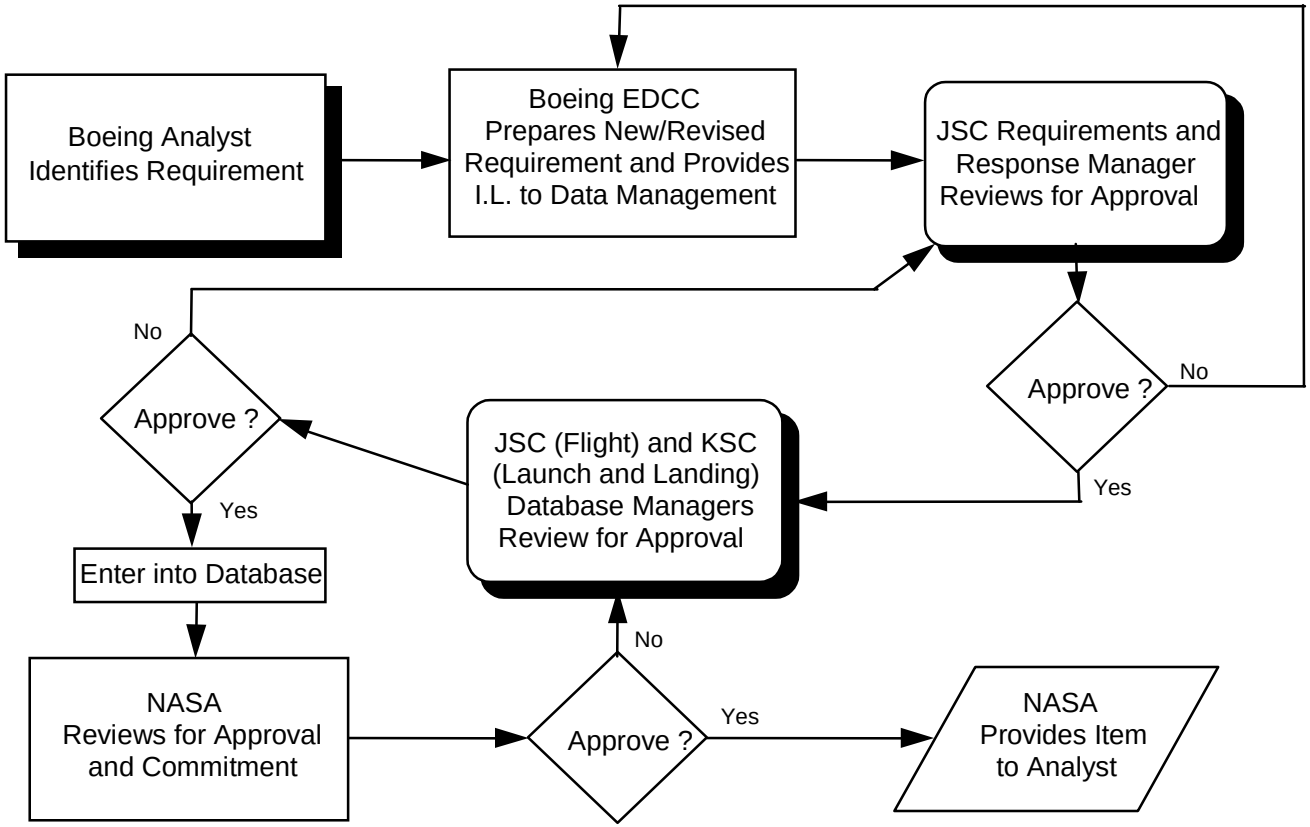


FIGURE 3-15
EVALUATING AND DISPOSITIONING POST-FLIGHT/TEST DATA ANOMALIES PROCESS

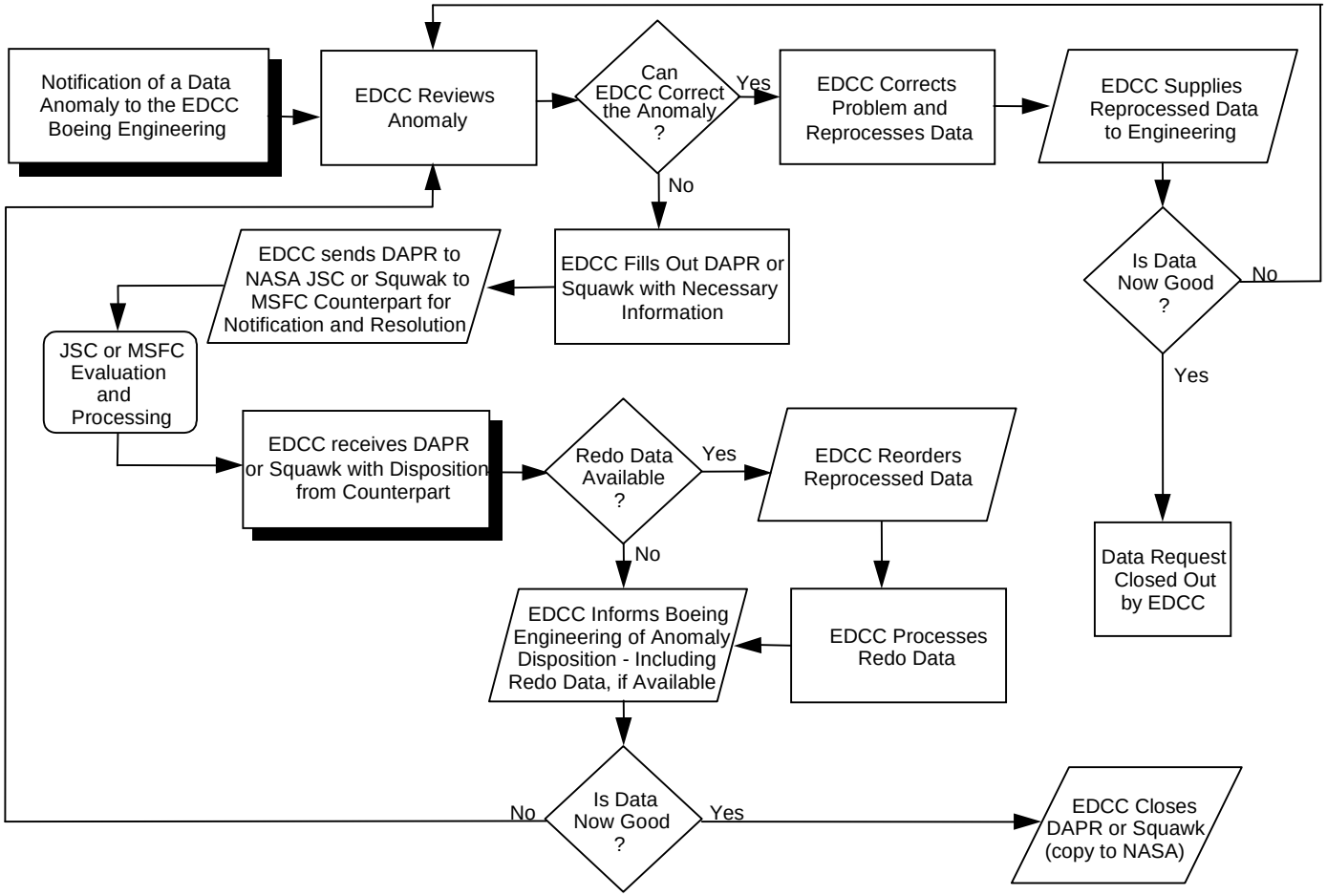
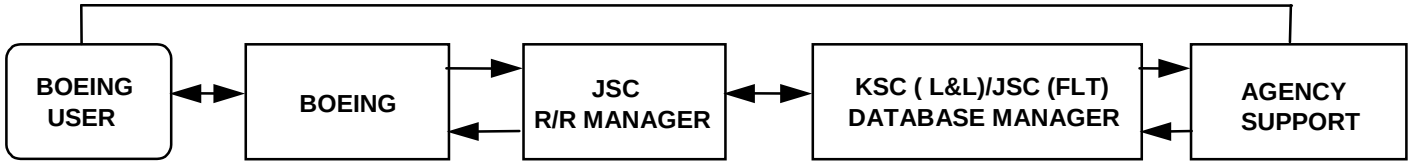


FIGURE 3-16
BOEING PRD REQUIREMENTS INPUT PROCESS



BOEING USER

1. IDENTIFIES REQUIREMENT.
2. COORDINATES WITH BOEING MISSION OPERATIONS, AS REQUIRED.
3. RECEIVES REQUIREMENT ITEM.

BOEING

1. PREPARE NEW/ REVISED PRD REQUIREMENT.
2. SUBMIT REQM'T VIA ASRS TO JSC R/R (REQM'T /RESP) MGR. COORDINATION COPIES ALSO SENT TO PRD COMMUNITY AND OTHERS DEPENDING ON REQM'T.
3. COORDINATE AS REQUIRED.
4. CHANGE REQMT'S BASED ON RESULTS OF SUPPORT COMMITMENT.
5. PREPARE LETTER AND SUBMIT TO DATA MANAGEMENT FOR PRD INPUTS TO COMPLY WITH IRD NO. SE-1769T9B.

JSC R/R MANAGER

1. RECEIVES PRD REQUIREMENT.
2. REVIEWS/ CONCURS AND SUBMITS L&L PRD REQM'T TO KSC DBM MGR FOR DATABASE INPUT. FLIGHT PRD REQMT'S INPUT INTO THE JSC DATABASE.
3. COORDINATE AS REQUIRED.

KSC (L&L)/JSC (FLT) DATABASE MANAGER

1. RECEIVES REQUIREMENT.
2. INPUTS REQUIREMENT IN APPLICABLE DATABASE.
3. SUBMITS REQUIREMENT TO SUPPORT AGENCY FOR REVIEW AND RESPONSE COMMITMENT.
4. RECEIVES SUPPORT AGENCY RESPONSE.
5. INPUTS RESPONSE IN PRD/PSP DATABASE.
6. COORDINATE AS REQUIRED.

AGENCY SUPPORT

1. RECEIVES REQM'T.
2. REVIEWS AND PROVIDES RESPONSE TO PRD/PSP.
3. COMPLIES WITH REQM'T AND PROVIDES ITEM TO USER.
4. COORDINATE AS REQ'D.

FIGURE 3-17
POST-FLIGHT TRAJECTORY RECONSTRUCTION PROCESS

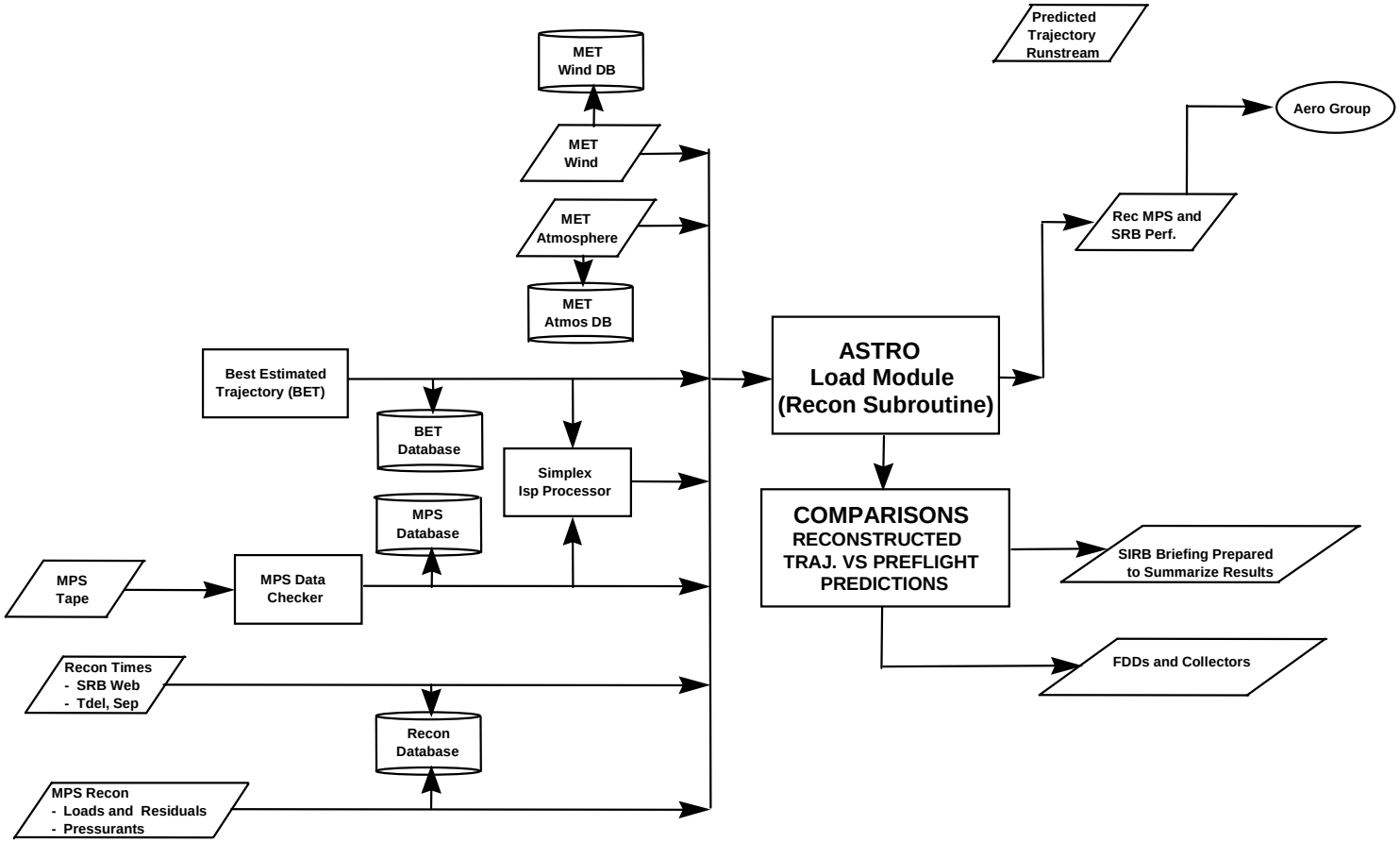


FIGURE 3-18
FDD UPDATE PROCESS

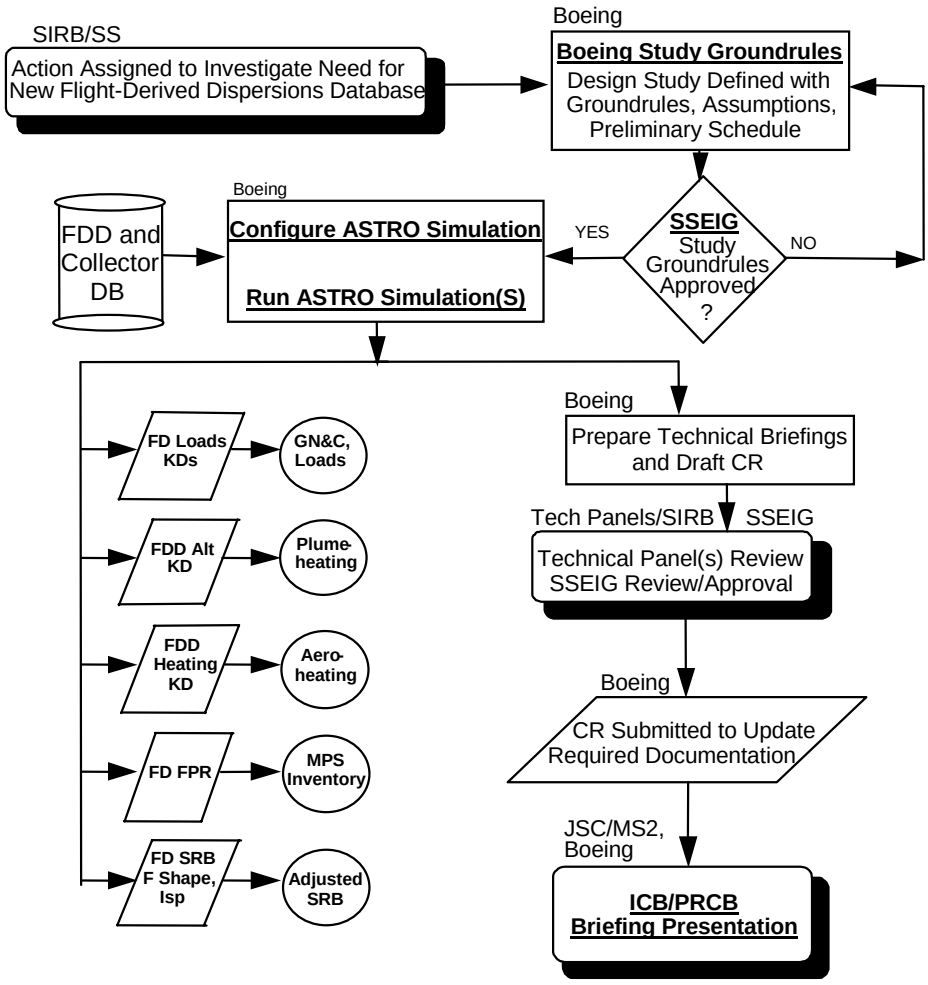
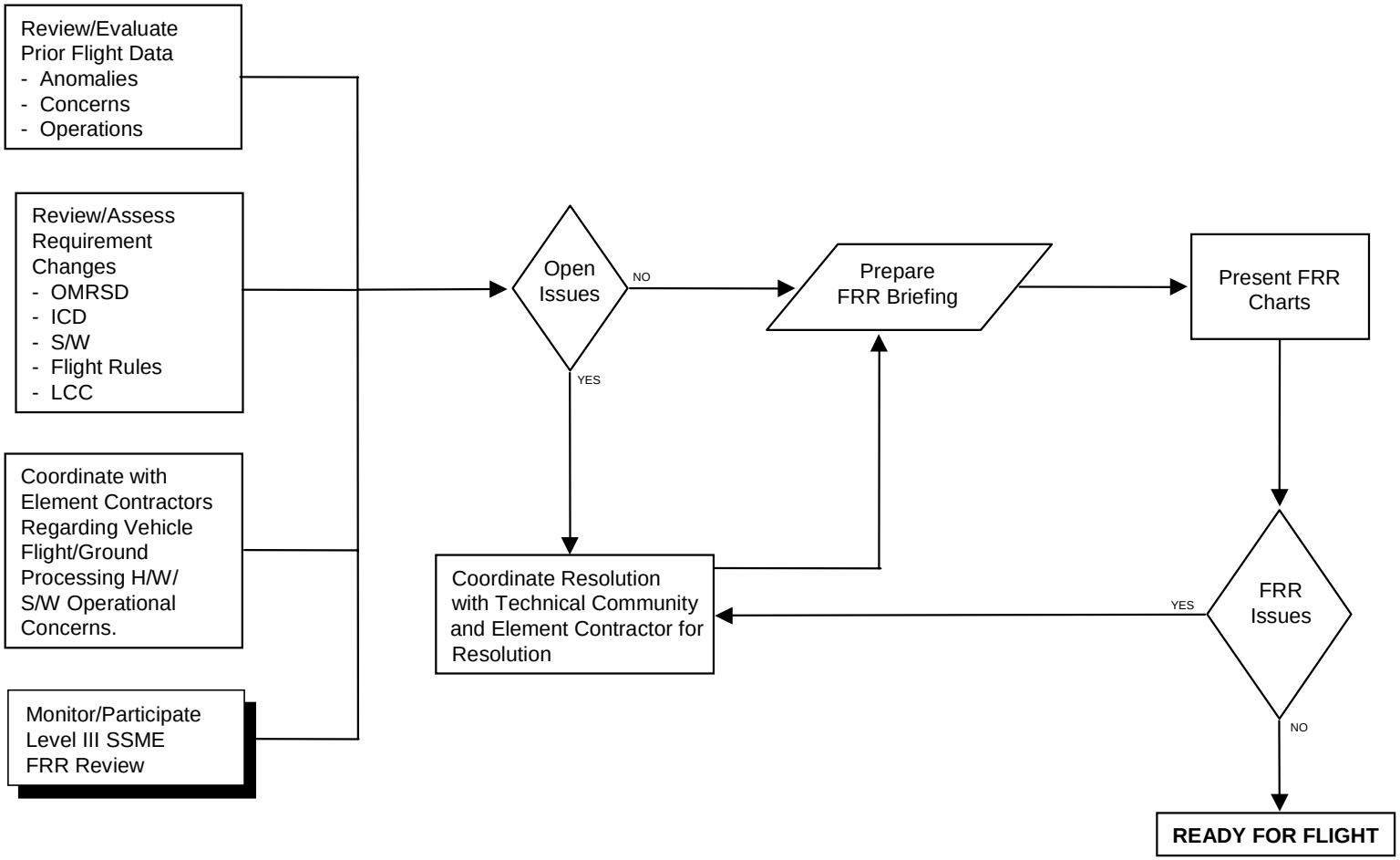


FIGURE 3-19
INTEGRATED PROPULSION FRR ASSESSMENT PROCESS



DRD NUMBER: 1.1.1.1-f DOCUMENT NUMBER: SFOC-PM0069

TITLE: Product Development Plan for Flight System Analysis PDP MS4-002

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