Procedures and Guidelines

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TITLE: Branch Head

Responsible Office: 574 / Propulsion Branch

Title: Design of S/C Propulsion Systems

1 PURPOSE

This procedure defines guidelines for the design of spacecraft chemical propulsion hardware for spaceflight use. Employees will use this process in support of the design development, validation and review of GSFC products.

2 REFERENCE

GPG 8730.4 The GSFC Quality Manual
GPG 1310.1 Establishing Customer Requirements
GPG 8700.1 Design Planning and Interface Management
GPG 8700.2 Design Development and Configuration Control
GPG 8700.3 Design Validation
GPG 8700.4 Technical Review Program

3 SCOPE

This procedure defines guidelines for the design of spacecraft chemical propulsion hardware for spaceflight use. This procedure applies to spacecraft propulsion systems that use “earth storable” monopropellant hydrazine or bipropellant fuel/oxidizer as propellants. This procedure applies to the Product Design Team (PDT) members in the Applied Engineering and Technology Directorate (AETD) providing spacecraft hydrazine propulsion hardware for spaceflight to GSFC projects covered by the scope of the GSFC Quality Management System.

4 DEFINITIONS

a. Spacecraft Chemical Propulsion Hardware - Components, assembled set of components (component modules) and assembled components/modules (system) that function as unit to exert propulsive force to the spacecraft by converting chemical energy into kinetic energy.

b. Propellant Feed System Hardware - Components used to store propellants/pressurants (tank), minimize particulate contamination (filter), isolate propellant supply (isolation valve, pyrotechnic isolation valve, check valve), monitor pressure (pressure transducer), control pressure (pressure regulator) and facilitate service of propellants and pressurant (fill/drain or service valve).

c. Thruster/Valve Assembly (TVA) – An assembly consisting of propellant flow control valve(s) (hydrazine thruster valve or fuel/oxidizer valves) and a chemical reaction chamber (thruster) that produce propulsive force. The TVA is generally referred to as a "thruster".

5 AUTHORITIES AND RESPONSIBILITIES

5.1 AETD Employees: All AETD employees are responsible for adherence to this procedure

5.2 Product Design Lead (PDL): The PDL, in concurrence with the Customer, is responsible to determine and document in the design plan (See GPG 8700.1 and GPG 8700.2) which steps identified as "optional" in this procedure guideline shall be implemented. The PDL, in concurrence with the Customer, shall have the authority to waive design requirements stated in this document. Such waivers shall be documented.

6 IMPLEMENTATION

The design process for spacecraft chemical propulsion flight hardware is described in the following paragraphs. Unless otherwise noted, the approach and sequence used to implement the procedural steps are at the discretion and responsibility of the PDL.

6.1 DEFINE PRODUCT SYSTEM REQUIREMENTS

The design process of spacecraft chemical propulsion system flight hardware is initiated with an agreement between the Customer and PDL on the systems level requirements and scope of the product design.

6.2 DEFINE PDT ORGANIZATION

The PDL shall be responsible to:

a. Develop the PDT organization structure, including logistic support
b. Assign duties & responsibilities to qualified personnel
c. Review Customer requirements, scope of the product design, and document derived requirements with the PDT
d. Develop a schedule for the design activities
e. Develop a labor and cost resources budget
f. Establish a method to maintain communication with customers and PDT for technical interchange and status reporting
g. Establish a method to define, document and control the configuration and technical design interfaces

6.3 PERFORM DESIGN TRADE STUDIES

The PDT shall perform design trade studies to meet the Customer's systems level requirements. The data delivered to the Customer will include, as a minimum, design options and recommendation that meet the systems level requirements, mass, power, volume, cost comparisons and development status of the proposed technology.

6.4 PERFORM PRELIMINARY DESIGN & ANALYSIS

The PDT shall perform, as a minimum, the following preliminary propulsion system analyses:

a. Performance Analysis
b. Fluid Analysis, including plume impingement torque & heating, slosh, pressure drop, and surge pressure
c. Preliminary Component Layout Drawings
d. Structural Loads & Stress Analysis
e. Thermal Analysis
f. Reliability Analysis
g. Tank Fracture Control Analysis
h. Contamination Control Analysis
i. Residual Fuel/Oxidizer Analysis

6.5 DEVELOP QUALITY MANAGEMENT PLAN

The PDT shall develop, as a minimum, the following plans to assure compliance of the spacecraft propulsion system flight hardware design with the Customers requirements:

a. Range Safety Design Compliance Plan
b. Quality Assurance and Product Validation Plans
c. Reliability, Risk Assessment/Mitigation Plans
d. STS Safety Compliance Plan (STS launch)

6.6 DEVELOP "MAKE OR BUY" PLAN

The PDT shall perform a "Make or Buy" analysis and develop the propulsion component/system specification, selection, cost and delivery schedule plan. In addition to factors, such as the product need date, procurement cycle, cost, and identification of long-lead items, the analysis should consider:

a. "Buy" options: product or service procured from commercial vendor versus product or service provided by other NASA Centers, government agencies, and university sectors
b. Use of new designs versus existing designs

6.7 DEVELOP PRODUCT VALIDATION PLAN

The PDT shall develop test requirements to validate that the flight hardware, components and assembled system will meet mission requirements provided by the Customer. The Product Validation Plan for the propulsion flight hardware should include the following test options, as a minimum:

a. Inspection (e.g., component records, material traceability, design requirements, electrical design, workmanship, envelope, alignment, ID, cleanliness)
b. Proof pressure test
c. External (parent material, weld, joints) & internal (seal) leak test
d. Gas flow impedance test
e. Surge pressure test (surge suppression orifice sizing)
f. Electrical tests (e.g., polarity, resistance, ground, valve response & signatures, calibrations)

g. Alignment
h. Environmental tests (e.g., vibration, thermal)

6.8 DEVELOP MANUFACTURING PLAN

Based on the 'Make or Buy' Plan, the PDT shall develop manufacturing plans and procedures including:

a. Fabrication plans & procedures (including, cleaning, passivation, bending, welding, contamination control, soldering)
b. Plans & procedures to assemble the component modules and the propulsion system
c. Plans & procedures to integrate the propulsion system hardware into the spacecraft

6.9 CONDUCT PEER PRELIMARY DESIGN REVIEW

The PDL shall organize and conduct a Peer Preliminary Design Review of the propulsion system design. The following elements will be included for review:

a. Mission requirements, including traceability to the Customer's systems level requirements and derived requirements
b. Propulsion system preliminary analyses and design
c. Component status (e.g., history, qualification, similarity)
d. Preliminary assembly and test sequence, including GSE design required for the assembly, test and spacecraft integration of the propulsion system.
e. Physical properties (e.g., mass, volume, power)
f. Preliminary verification test matrix

6.10 DEVELOP FINAL DESIGN

Based on the assessment of the Peer Preliminary Design Review 'action items & issues', the PDL shall meet with the Customer to determine changes that need to be incorporated into the propulsion hardware preliminary design. The design, analyses, Quality Management Plan, 'Make or Buy' Plan, Product Verification Plan, and Manufacturing Plan will be refined, as necessary, to meet the Customer's requirements.

6.11 CONDUCT PEER CRITICAL DESIGN REVIEW

The PDL shall organize and conduct a Peer Critical Design Review of the modified propulsion system design. The following elements will be included for review:

a. Mission requirements, including traceability to the Customer's systems level requirements and derived requirements
b. Propulsion System Analyses
c. Component status (e.g., history, qualification, similarity)
d. Final assembly and test sequence, including final design of GSE required for the assembly, test and spacecraft integration of the propulsion system
e. Physical properties (e.g., mass, volume, power)
f. Verification test matrix

6.12 INCORPORATE FINAL DESIGN CHANGES

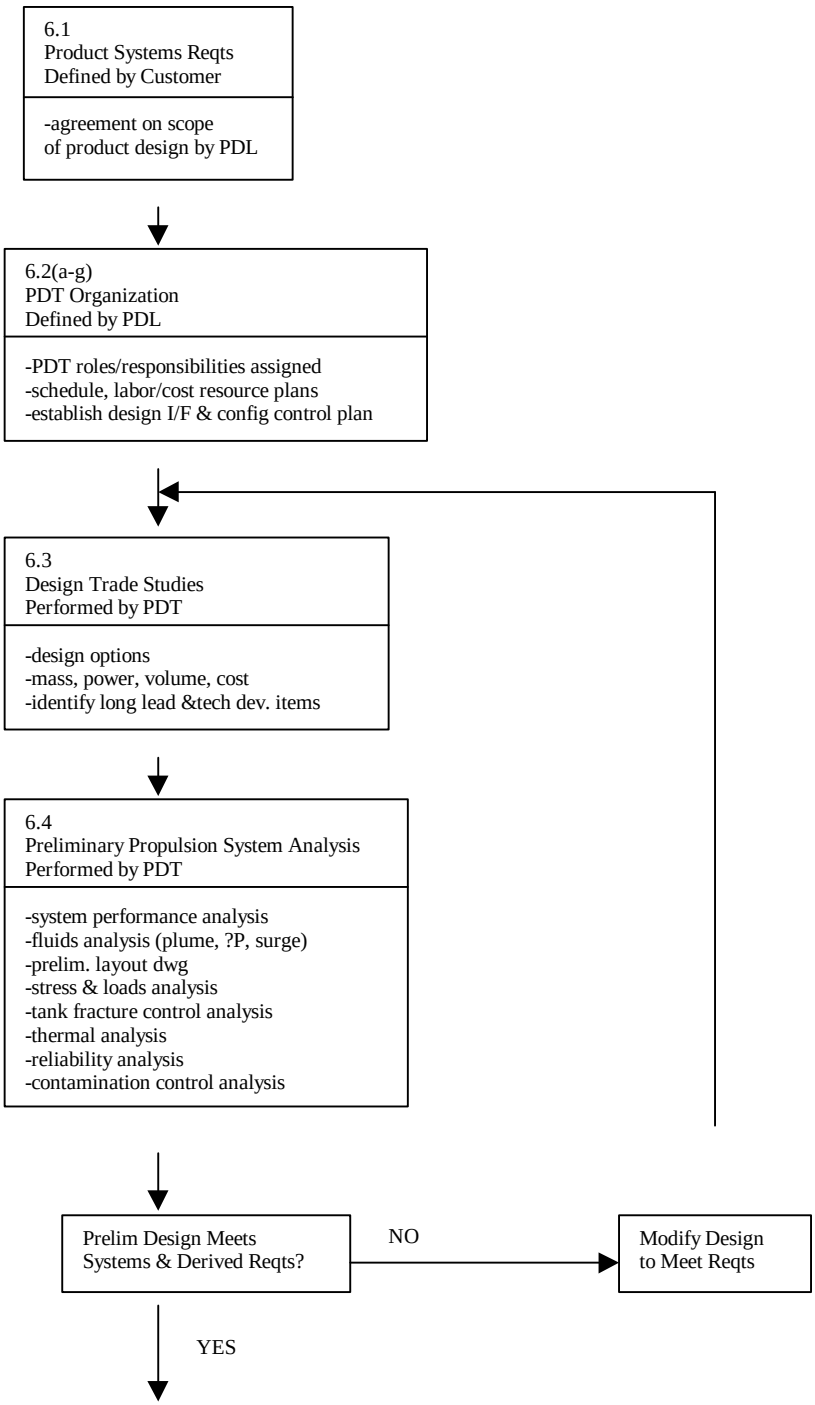
Based on the assessment of the Peer Critical Design Review 'action items & issues', the PDL shall meet with the Customer to determine changes that need to be incorporated into the propulsion hardware final design. The design, analyses, Quality Management Plan, 'Make or Buy' Plan, Product Verification Plan, and Manufacturing Plan will be refined, as necessary, to meet the Customer's requirements.

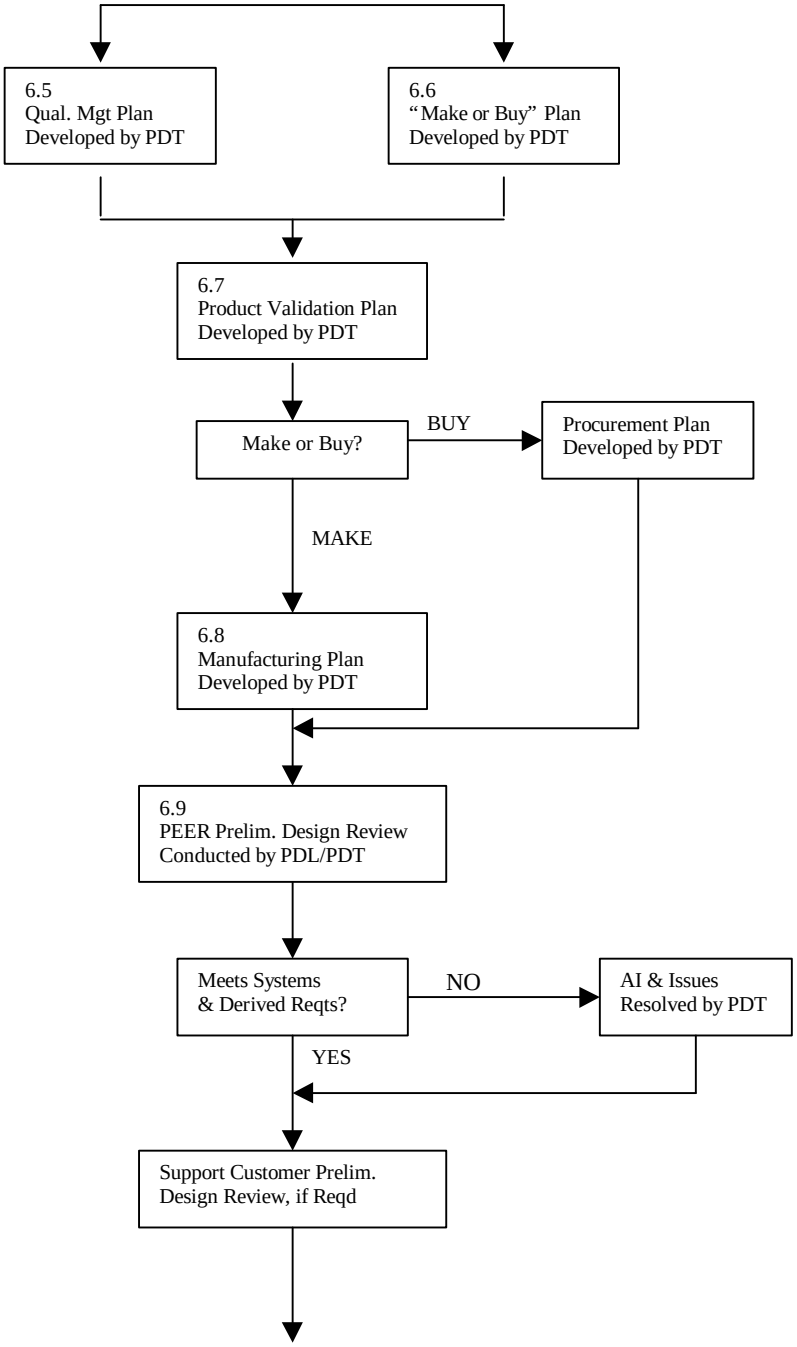
6.13 RELEASE DESIGN PRODUCT

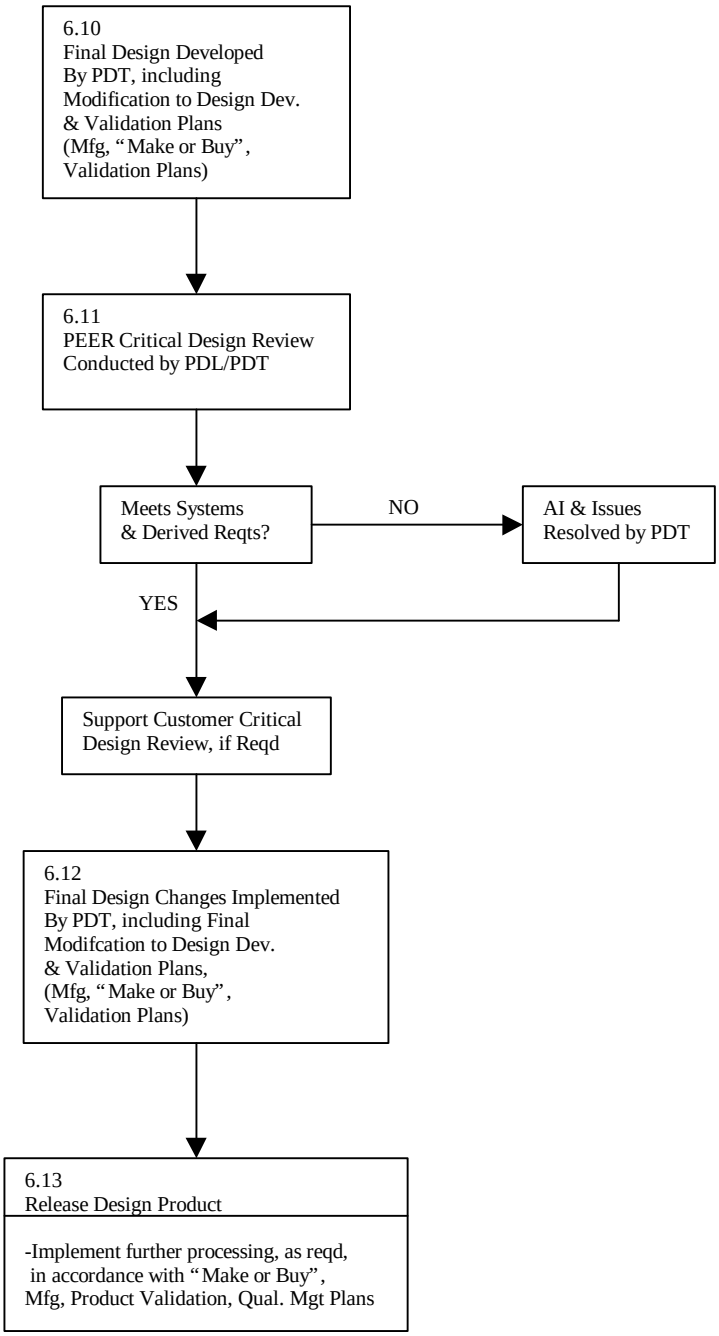
The PDL shall document successful completion of the final design of the spacecraft chemical propulsion flight hardware. The PDL shall release the design product for further processing in accordance with the 'Make or Buy' Plan, Manufacturing Plan, Product Verification Plan and Quality Management Plan.

7 FLOW DIAGRAM

DESIGN OF SPACECRAFT
LIQUID CHEMICAL PROPULSION SYSTEM HARDWARE




6.5
Qual. Mgt Plan
Developed by PDT
6.6
"Make or Buy" Plan
Developed by PDT
6.7
Product Validation Plan
Developed by PDT
Make or Buy?
BUY
Procurement Plan
Developed by PDT
MAKE
6.8
Manufacturing Plan
Developed by PDT
6.9
PEER Prelim. Design Review
Conducted by PDL/PDT
Meets Systems
& Derived Reqts?
NO
AI & Issues
Resolved by PDT
YES
Support Customer Prelim.
Design Review, if Reqd


6.10
Final Design Developed
By PDT, including
Modification to Design Dev.
& Validation Plans
(Mfg, "Make or Buy",
Validation Plans)
6.11
PEER Critical Design Review
Conducted by PDL/PDT
Meets Systems
& Derived Reqts?
NO
AI & Issues
Resolved by PDT
YES
Support Customer Critical
Design Review, if Reqd
6.12
Final Design Changes Implemented
By PDT, including Final
Modifcation to Design Dev.
& Validation Plans,
(Mfg, "Make or Buy",
Validation Plans)
6.13
Release Design Product
-Implement further processing, as reqd,
in accordance with "Make or Buy",
Mfg, Product Validation, Qual. Mgt Plans

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	12/08/1998	Initial Release